European Commission

Best Environmental Management Practice for the Public Administration Sector

Final draft

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Abstract

This report describes information pertinent to the development of Best Environmental Management Practices (BEMP) for the Sectoral Reference Document for the Public Administration sector, to be produced by the European Commission according to Article 46 of Regulation (EC) No 1221/2009 (EMAS Regulation). The report firstly outlines general facts and figures of the Public Administration sector in the EU and its main environmental aspects. Afterwards, it presents a full set of best environmental management practices which are broadly applicable to local public administrations in different areas of their activities. These range from the environmental management of the office buildings of the public administration and the adoption of green public procurement to services provided by local public administrations (such as water supply and municipal waste water treatment) and, more broadly, how to address the main environmental aspects of the territory administered by the local authority. In this last area, the report covers what municipality can do in the fields of sustainable energy and climate change, mobility, local ambient air quality, reducing and optimising land use, noise pollution, green urban areas, and environmental education and dissemination of information to citizens and businesses.

Table of contents

List of figures

List of tables

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This document is based on and includes content from a number of preparatory studies carried out by ICLEI (Germany), Ambiente Italia (Italy), Lake Constance Foundation (Germany), Bioregional (UK) and Rupprecht Consult (Germany).

Finally, a technical working group, comprising a broad spectrum of experts in environmental issues for public administrations supported the development of the document by providing inputs and feedbacks.

PREFACE

Context and overview

This **Best Practice Report**[1] provides an overview of techniques that are **Best Environmental Management Practices** (BEMPs) in the Public Administration sector. The document was developed by the European Commission's Joint Research Centre (JRC) on the basis of desk research, interviews with experts, site visits and in close cooperation with a Technical Working Group (TWG) comprising experts from the sector. This Best Practice Report provides the basis for the development of the EMAS Sectoral Reference Document (SRD) for the Public Administration sector. The structured process for the development of this best practice report is outlined in the guidelines on the ***"Development of the EMAS Sectoral Reference Documents on Best Environmental Management Practice"*** (European Commission, 2014), which are available online[2].

EMAS (the EU Eco-Management and Audit Scheme) is a management tool for companies and other organisations to evaluate, report and improve their environmental performance. To support this aim and according to the provisions of Art. 46 of the EMAS Regulation (EC No. 1221/2009), the European Commission is producing SRDs to provide information and guidance on BEMPs in several priority sectors, including the food and beverage manufacturing sector.

Nevertheless, it is important to note that the guidance on BEMP is not only for EMAS participants, but rather, it is intended to be a useful reference document for any relevant company that wishes to improve its environmental performance or any actor involved in promoting best environmental performance.

BEMPs encompass techniques, measures or actions that can be taken to minimise environmental impacts. These can include technologies (such as more efficient machinery) and organisational practices (such as staff training).
An important aspect of the BEMPs proposed in this document is that they are proven and practical, i.e.:

- They have been implemented at full scale by several companies (or by at least one company if replicable/applicable by others);
- They are technically feasible and economically viable.

In other words, BEMPs are demonstrated practices that have the potential to be taken up on a wide scale in the food and beverage manufacturing sector, yet at the same time are expected to result in exceptional environmental performance compared to current mainstream practices.

A standard structure is used to outline the information concerning each BEMP, as shown in Table a.

[1] This report is part of a series of 'best practice reports' published by the European Commission's Joint Research Centre covering a number of sectors for which the Commission is developing SRDs on Best Environmental Management Practice. More information on the overall work and copies of the 'best practice reports' available so far can be found at: http://susproc.jrc.ec.europa.eu/activities/emas/

[2] http://susproc.jrc.ec.europa.eu/activities/emas/documents/DevelopmentSRD.pdf

Table a: Information gathered for each BEMP

Category	Type of information included
Description	Brief technical description of the BEMP including some background and details on how it is implemented.
Achieved environmental benefits	Main potential environmental *benefits* to be gained through implementing the BEMP.
Environmental indicators	Indicators and/or metrics used to monitor the implementation of the BEMP and its environmental benefits.
Cross-media effects	Potential *negative* impacts on other environmental pressures arising as side effects of implementing the BEMP.
Operational data	Operational data that can help understand the implementation of a BEMP, including any issues experienced. This includes actual and plant-specific performance data where possible.
Applicability	Indication of the type of plants or processes in which the technique may or may not be applied, as well as constraints to implementation in certain cases.
Economics	Information on costs (investment and operating) and any possible savings (e.g. reduced raw material or energy consumption, waste charges, etc.).
Driving force for implementation	Factors that have driven or stimulated the implementation of the technique to date.
Reference organisations	Examples of companies that have successfully implemented the BEMP.
Reference literature	Literature or other reference material cited in the information for each BEMP.

Sector-specific Environmental Performance Indicators and Benchmarks of Excellence are also derived from the BEMPs. These aim to provide organisations with guidance on appropriate metrics and levels of ambition when implementing the BEMPs described.

- **Environmental Performance Indicators** represent the metrics that are employed by organisations in the sector to monitor either the implementation of the BEMPs described or, when possible, directly their environmental performance.
- **Benchmarks of Excellence** represent the highest environmental standards that have been achieved by companies implementing each related BEMP. These aim to allow all actors in the sector to understand the potential for environmental improvement at the process level. Benchmarks of excellence are not targets for all organisations to reach but rather a measure of what is possible to achieve (under stated conditions) that companies can use to set priorities for action in the framework of continuous improvement of environmental performance.

Sector-specific Environmental Performance Indicators and Benchmarks of Excellence presented in this report were agreed by the TWG at the end of its interaction with the JRC.

Role and purpose of this document

This document is intended to support environmental improvement efforts of Public Administrations by providing guidance on best practices.

Public Administrations can use this document to identify the most relevant areas for action, find detailed information on best practices to address the main environmental aspects, as well as environmental performance indicators and related benchmarks of excellence to track sustainability improvements.

The present Best Practice Report provides the technical basis for the development of the EMAS Sectoral Reference Document (SRD) for the public Administration Sector according to article 46 of the EMAS Regulation.

How to use this document

This document is not conceived to be read from its beginning to the end, but as a working tool for professionals willing to improve the environmental performance of their organisation and who seek for reliable and proven information to do so.

Different parts of the document will be interesting and will apply to different professionals and at different stages.

The best way to start using this document is reading the short section about its structure to understand the content of the different chapters and, in particular, which are the areas for which BEMPs have been described and how these BEMPs have been grouped.

Then, Chapter 1 would be a good starting point for the readers looking for a first general understanding of the sector and its environmental aspects.

Those looking for an overview of the BEMPs described in the document could start from Chapter 15 (Conclusions) and in particular with table 15.1 outlining all BEMPs together with the related environmental performance indicators and benchmarks of excellence, i.e. the exemplary performance level that can be reached in each area.

For the readers looking for information on how to improve their environmental performance in a specific area, it is recommended to start directly at the concrete description of the BEMPs on that topic, which can be easily found through the table of contents (at the very beginning of the document).

STRUCTURE

After the Preface Section, which gives an overview of the framework under which this document was developed, Chapter 1 presents general facts and figures of the Pulbic Administration sector in the EU context and the main environmental aspects identified and addressed in this document. Chapter 2 presents best environmental management practices for sustainable offices. The following chapters, from 3 to 13, focus on areas which public administrations manage directly or have a reasonable influence on. BEMPs in these chapters cover sustainable energy and climate change, mobility, land use, green urban areas, local ambient air quality, noise pollution, water consumption, wastewater management, green public procurement and finally environmental education aand dissemination of information. Chapter 14 instead summarisies a number of emerging techniques, which are measures that if commercially developmed could become BEMPs and support organisation in improving their environmental performance, but are not yet implemented at full scale.
Finally, Chapter 15 summarises the BEMPs presented, highlighting their applicability and the suitable environmental performance indicators. Moreover, the benchamrks of excellence identified are also reported in the final chapter.

Table b: Summary of the structure of the document

	Topics and BEMPs
Chapter 1	General facts and figures of the public administration sector Main environmental aspects
Chapter 2	Best environmental management practices for sustainable offices: - Managing and minimising energy consumption - Managing and minimising water consumption - Managing and minimising waste production - Minimising consumption of paper and consumables - Minimising the environmental impact of commuting and business travel - Minimising the environmental impact of canteens and coffee bars - Minimising the environmental impact of meetings and events organisation

	Topics and BEMPs
Chapter 3	Best environmental management practices for sustainable energy and climate change: - Establishing an inventory of energy consumption and emissions of the territory of a municipality - Establishing and implementing a municipal energy and climate action plan - Establishing and implementing a strategy for climate change adaptation within the territory of the municipality - Implementing energy efficient street lighting - Improve the energy efficiency of public buildings - Improving the energy efficiency of social housing - Achieving energy efficiency in public buildings through ESCo models - Improving the energy performance of existing public buildings through monitoring, energy management and fostering of behavioural change - Implementing district heating and/or district cooling networks - Implementing on-site renewables and mini-CHP on public buildings and social housing - Imposing higher energy efficiency standards and renewable energy requirements in land use planning for new-built and buildings undergoing major renovations through local building regulations and planning permissions - Exemplary role of the public sector - Information and advice services on sustainable energy for citizens and businesses and public-private partnerships - Thermographic surveying of municipalities' built environment
Chapter 4	Best environmental management practices for mobility: - Enacting a Sustainable Urban Mobility Plan - Fostering cycling and walking through cycling infrastructures, bike sharing schemes and promoting walking - Implementing a large scale car sharing schemes - Integrated ticketing for public transport - Improving the uptake of Electric Vehicles in urban areas - Fostering passenger intermodality - Implementing a congestion charge - Limiting free parking spaces in cities - Implementation of logistic service centres
Chapter 5	Best environmental management practices for land use - Limiting urban sprawl into green spaces and agricultural land
Chapter 6	Best environmental management practices for green urban areas, nature and biodiversity: - Establishing and implementing a local biodiversity strategy and action plan - Creating blue-green networks - Fostering the deployment of green roofs and integration with renewables - Giving new environmental value to derelict green areas and fringe areas

	Topics and BEMPs
Chapter 7	Best environmental management practices for local ambient air quality: - Improving local ambient air quality
Chapter 8	Best environmental management practices for noise pollution: - Monitoring, mapping and reducing noise pollution
Chapter 9	Best environmental management practices for waste management
Chapter 10	Best environmental management practices for water consumption: - Deploying full water metering at the household/final user level - Minimising water leakages from the water distribution system
Chapter 11	Best environmental management practices for wastewater management: - Energy efficient waste water treatment achieving full nitrifying conditions - Minimisation of wastewater emissions with special consideration of micropollutants - Anaerobic digestion of sludge and optimal energy recovery - Drying of sludge and incineration according to BAT standards - Retention and treatment of overflows from combined sewer systems and storm water from separate sewer systems - Sustainable urban drainage systems
Chapter 12	Best environmental management practices for green public procurement: - Systematically include environmental criteria in all public procurement
Chapter 13	Best environmental management practices for environmental education and dissemination of information: - Environmental education and information for citizens and businesses
Chapter 14	Emerging techniques
Chapter 15	Conclusions: BEMPs, environmental performance indicators and benchmarks of excellence

SCOPE

The PA sector is made up of about 90,000 organisations throughout Europe, each with their own governance structure. The vast majority of these organisations are concentrated at local level and fall under the competence of local governments. The sector comprises the general government sector plus (quasi) public corporations (Dexia, 2011) and is characterised within Eurostat's classification of economic activities in the European Community primarily according to NACE code O84 (NACE rev. 3): "Public administration and defence; compulsory social security". Other NACE codes are also applicable to the sector, including, but not limited to, A02.0 (forestry, logging, and related service activities), E36 (water collection, treatment and supply), E38 (Sewerage), E39 (Remediation activities), E49.3.1 (urban and suburban passenger land transport), F41.2 (construction of residential and non-residential buildings), etc.

Unless otherwise stated, this study focuses mainly on public local governments, as local authorities are by far the largest group of public administrations in the EU and they offer the highest potential of replicability of best practices across the EU. Moreover this is the level of implementation (i.e. strong service provision role and not only policy role), where best practices are particularly relevant, and the closest to the citizens.

A number of sections of the report, such as best practices for sustainable offices (chapter 2) and green public procurement (chapter 12), as well as some best practices on energy (section 3.2.2, 3.2.4, 3.2.5 and 3.2.7), are however relevant to public administrations at all levels.

1 GENERAL INFORMATION ABOUT THE SECTOR

1.1 Composition of the public sector in Europe

The public administration sector is made up of over 90,000 organisations throughout Europe, each with their own structure, laws and governance style. The vast majority of these organisations are concentrated at local level and fall under the competence of municipalities (about 90,000) (Dexia, 2011). The sector comprises the general government sector plus (quasi) public corporations (OECD, 2011) and is characterised within Eurostat's classification of economic activities in the European Community primarily according to NACE code O84 (NACE rev. 3): "Public administration and defence; compulsory social security". However, other NACE codes are applicable to the sector, including, but not limited to, A02.0 (forestry, logging, and related service activities), E36 (water collection, treatment and supply), E38 (Sewerage), E39 (Remediation activities), E49.3.1 (urban and suburban passenger land transport), F41.2 (construction of residential and non-residential buildings), etc.

NACE codes, however, are problematic when attempting to establish the number of employees within the sector. The codes do not distinguish between public and private activities, but present only totals within a given field. Sectors such as E36 (water collection, treatment and supply) and P (education) are often characterised by a mixture between both public and private employment. This statistical shortcoming means that NACE codes are by and large unsuitable for public administration sector statistics and make it difficult to gauge the true economic relevance of the public administration sector.

1.1.1 Expenditure of the public administration sector in Europe

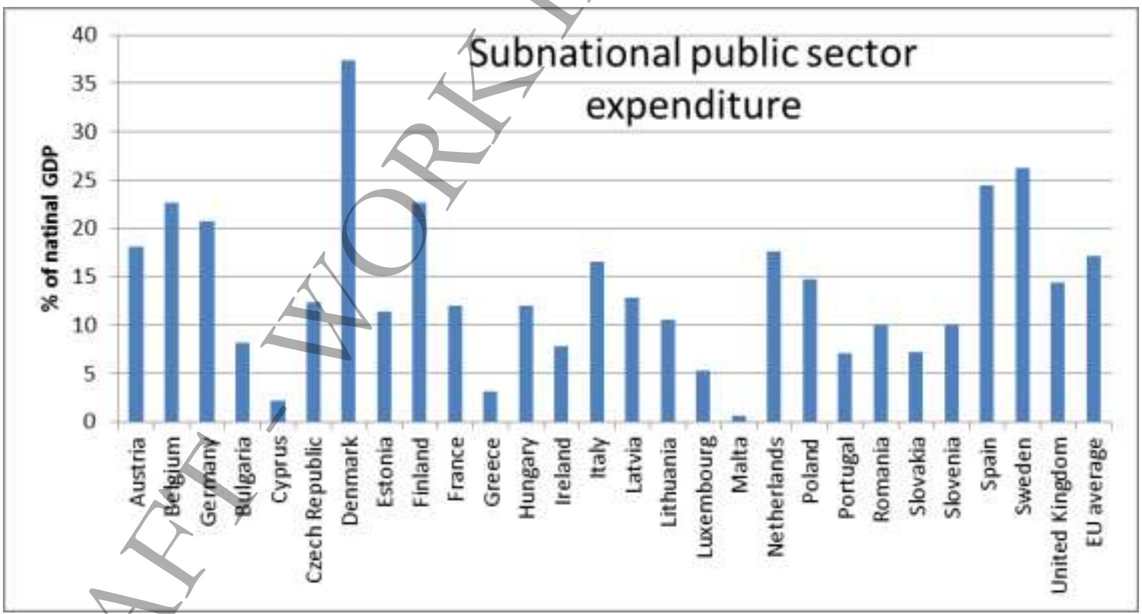

Figure 1-1: Local government expenditure as a percentage of total GDP by country (Dexia, 2010)

Local government expenditure as a percentage of total GDP by country is represented in Figure 1-1. Local government expenditure within the EU-27 stood at EUR 1,671 million (Dexia, 2011). Among the EU-27, in 2010, Denmark had highest share over the GDP of the subnational public sector expenditure (37.4%). The average EU subnational public sector expenditure in 2010 was about 17% of the total GDP. Expenditure outweighed revenue intake at local level, infact, in 2010, the total income of local level governments was EUR 1,591 million (Dexia, 2011).

1.1.2 Public sector employment in Europe

Table 1-1: Public sector employment in EU-27 (Public administration, defence, education, human health and social work activities) (Eurostat, 2015)

GEO/TIME	2010	2011	2012	2013	2014
European Union (28 countries)	54,053.5	54,165.3	54,283.9	54,349.0	55,019.0
Belgium	1,430.2	1,428.5	1,474.1	1,415.7	1,465.2
Bulgaria	570.1	564.8	563.6	566.8	575.1
Czech Republic	964.8	935.1	957.8	977.7	999.0
Denmark	906.7	902.4	896.9	905.0	911.3
Germany	9,864.4	9,930.6	10,104.7	10,191.1	10,364.2
Estonia	130.2	130.4	136.4	135.5	138.8
Ireland	492.1	486.5	487.1	488.0	493.6
Greece	937.6	897.4	840.5	812.7	810.5
Spain	4,047.4	4,121.4	3,975.3	3,806.6	3,877.2
France	7,894.7	7,853.9	7,970.3	8,022.0	8,005.7
Croatia	304.2	279.6	284.3	300.5	333.8
Italy	4,580.5	4,657.0	4,639.3	4,560.7	4,597.2
Cyprus	74.9	75.2	69.4	72.0	77.2
Latvia	193.7	199.7	202.3	203.6	195.7
Lithuania	303.0	299.4	293.2	290.3	292.6
Luxembourg	64.2	67.1	72.5	72.2	75.0
Hungary	875.7	868.2	890.8	923.5	982.9
Malta	41.1	44.4	47.0	46.6	47.4
Netherlands	2,472.6	2,480.8	2,464.6	2,402.6	2,356.4
Austria	919.4	906.2	916.4	945.5	958.9
Poland	3,115.8	3,086.2	3,121.1	3,208.4	3,248.0
Portugal	1,020.7	1,030.7	1,027.2	1,015.1	1,053.7
Romania	1,180.0	1,174.5	1,140.1	1,102.7	1,071.3
Slovenia	192.2	191.9	195.0	188.1	190.7
Slovakia	511.0	509.4	503.5	528.0	553.3
Finland	669.5	690.7	696.7	685.1	688.6
Sweden	1,458.7	1,497.2	1,508.6	1,527.3	1,571.6
United Kingdom	8,838.3	8,856.1	8,805.1	8,955.6	9,084.0

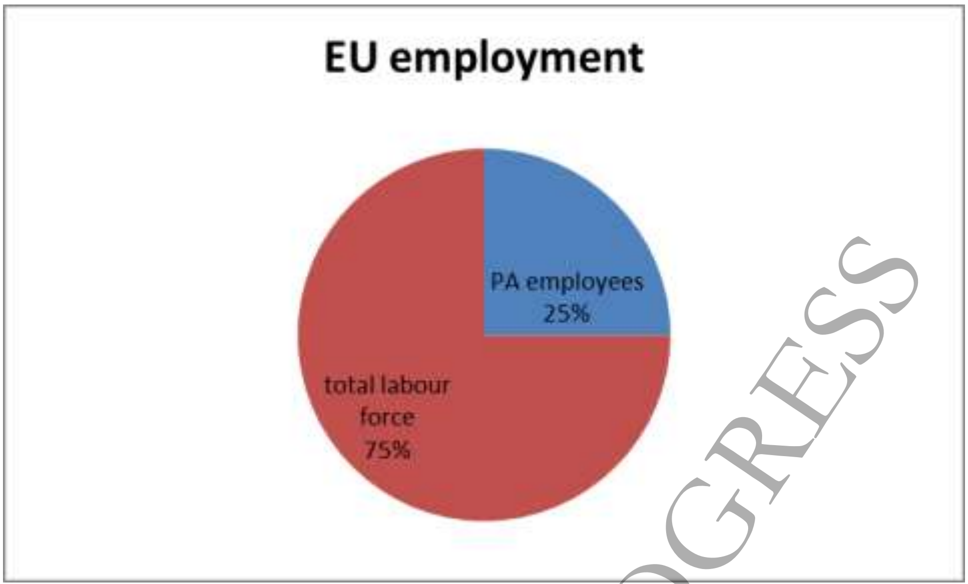

Figure 1-2: Public sector employees against Total labour force in EU-27 (Eurostat, 2015)

As can be seen by the data presented in Table 1.2, the public administration sector is a major employer within the EU-27, accounting for over 55 million employees from a total workforce of 217,768,000 (making up around 25 percent of the Total labour force, as graphically represented by Figure 1.3).

On a purely numeric basis the Germany has the largest public sector employment in Europe, with 13,364,200 state employees (2014). Luxembourg has the smallest with 75,000 state employees (2014). Interestingly both countries employ an almost similar number taken as a percentage of the total labour force, coming in at 26 and 30% respectively (Eurostat, 2015).

As public sector employment data from national statistic agencies varies in scope and date between EU-28 countries, it is therefore difficult to comprehensively analyse public sector employment trends. Table 1-2 show also that public employment is stable in numbers.

1.2 Environmental aspects of the public administration sector

1.2.1 Direct and indirect aspects

In order to define the direct and indirect environmental aspects of public administrations, it is necessary to take into account:

- the different levels of administrations: local, regional, national, European
- the specific thematic focus and competences - especially in the case of regional and national administrations
- the structure and allocation of competences between the national, regional and local level (political framework)

To identify the direct and indirect environmental aspects of all the different political and structural scenarios in the 28 EU Member States would be a study of its own and would burst the scope of this document.
This Section includes a summary describing the direct and indirect aspects of local administrations; regional and national administrations are mentioned only because of their interrelation with local authorities.

Direct environmental aspects are defined as activities, products and services being under direct control of the public administration, for example by the municipality. Indirect environmental aspects are related to those activities of the municipal administration that it does not control completely, but that it can influence to a certain extent. Indirect environmental aspects can result from a municipal administration's interactions with third parties, in particular citizens. The following analysis will show that public administrations have a direct and an indirect influence on most aspects.
Figure 1-4 provides a graphical overview of environmental aspects in a local authority as a spatial positioning of the aspects, while table 2.1 links environmental aspects to services of public administrations and provides the respective NACE-codes for associated services.

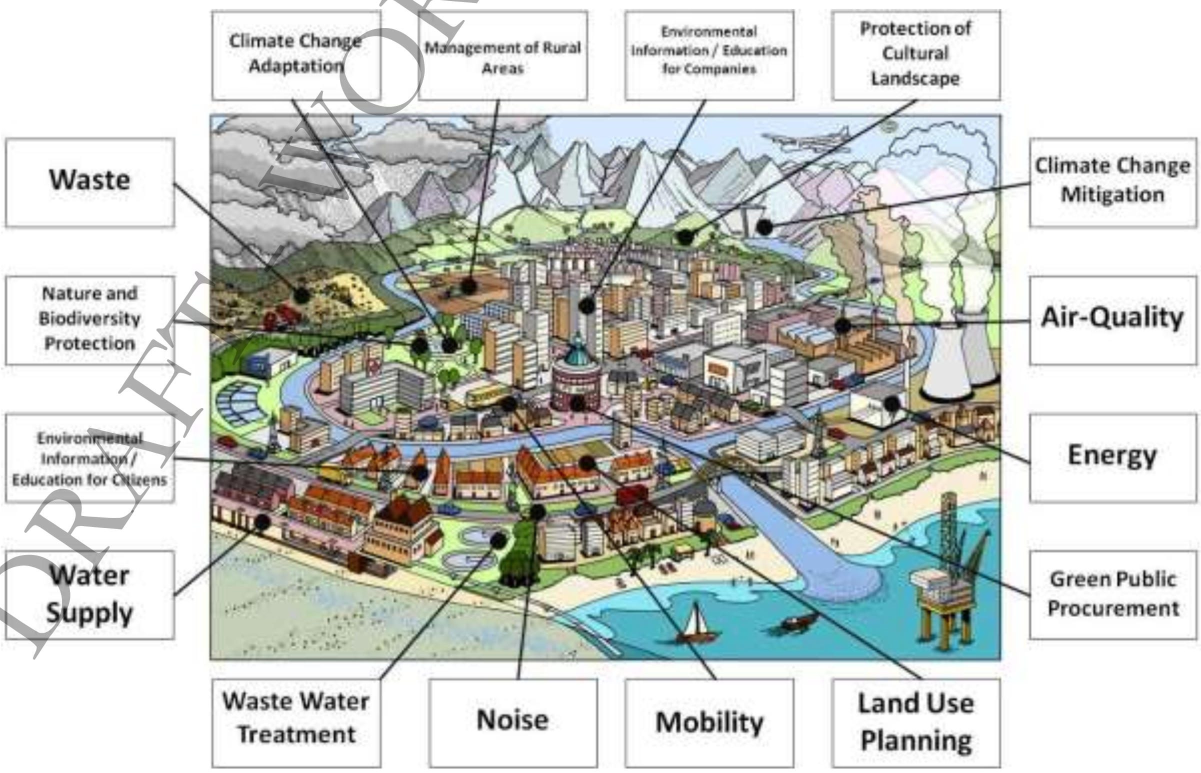

Figure 1-3: Environmental Aspects in Local Authorities

Table 1-2: Main Environmental aspects of services of public administrations with NACE Codes

Environmental Aspect	Service of Public Administrations	Direct / indirect influence	NACE Code (*)
Climate change mitigation and adaptation	Environmental Services Sustainable Health and Social Services Sustainable Economy	Direct + indirect	A 02.0, E 40.1, E 49.3.1, F 41.2
Energy: • Energy consumption • Energy production • Energy supply and distribution • Biodiversity	Environmental Services Sustainable Economy	Direct + indirect	E 40.1
Mobility • Municipal operations • Transportation infrastructure • Public transportation • Inter modality • Local economy	Sustainable Mobility Sustainable Health and Social Services	Direct + indirect	E 49.3.1
Use of land • Urban sprawl • De sealing, green areas • Transport / mobility • Landscape development / water bodies • Energy / climate	Sustainable Land Use Sustainable Green Spaces Sustainable Housing	Direct + indirect	A 02.0, E 36, E 38, E 49.3.1, E 40.1, F 41.2, L68.2.
Nature and biodiversity protection and restoration, protection of cultural landscape • Urban land use planning • Planning and maintenance of green areas • Transport / mobility • Biodiversity in water bodies, agriculture and forestry • Communication, cooperation and organisation	Sustainable Green Spaces Sustainable Leisure Activities	Direct + indirect	A 02.0, F 41.2, E 49.3.1, O92.43
Management of public forest and rural areas, urban forest • Management of public forests • Management of rural areas	Sustainable Leisure Activities Sustainable Economy	Direct aspect	A 02.0
Air quality • Transportation and mobility • Urban climate • Buildings and energy • Enforcement of legislation and monitoring of compliance with	Environmental Services Sustainable Health and Social Services	Direct + indirect	E 40.1, E.49.3.1, F 41.2

legislation			
Noise • Vibration, odour, dust, visual contamination	Sustainable Health and Social Services	Direct + indirect	E 40.1, E.49.3.1, F 41.2, O 92.33
Waste • Waste collection • Waste processing and disposal • Enforcement of legislation and monitoring of compliance with legislation	Environmental Services Sustainable Health and Social Services	Direct + indirect	E 38
Water supply and waste water treatment • Own water consumption • Design and implementation of drinking water supply infrastructure • Design and implementation of waste water collection	Sustainable Water Management Sustainable Health and Social Services	Direct + indirect	E 36
Green public procurement: • Choice and composition of services • Environmental performance and practices of contractors, subcontractors and suppliers	Sustainable Economy	Direct + indirect	
Environmental information /education of citizens: • Formal environmental education • Informal environmental education	Sustainable Education	Direct + indirect	E 92.56, P85, R93.1
Environmental information /education towards companies (global players, SMEs) and other organizations (legislation, promotion /support)	Sustainable Economy	Direct + indirect	P85

1.3 EMAS within the public administration sector

Figure 1-4: EMAS registered organisations by NACE code O84

Figure 1-4 geographically represents EMAS registered organisations under “NACE code O84.11” as reported on the EMAS register (http://www.emas-register.eu/). The list is not exhaustive however, as other organisations within the public administration sector are registered also under other NACE codes and the EMAS register does not explicitly distinguish between public and private organisations. It is therefore near impossible to get a fully accurate description of the scope of EMAS within the sector. Public administrations from 17 EU countries are registered with EMAS, with by far the largest number – almost half of all registrations – being Italian organisations, followed by Spain and Germany. These three countries represent 84% of all EMAS registrations in the sector.

At present public administration sector organisations registered with EMAS constitute less than one percent of the sector, indicating the potential for great expansion. Many public sector organisations already operate an environmental management scheme, and adhere to various environmental policies set out at central government or EU level. EMAS can integrate and streamline these policies and increase visibility of the environmental performance improvements efforts of the sector.

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2 BEST ENVIRONMENTAL MANAGEMENT PRACTICES FOR SUSTAINABLE OFFICES

Chapter structure

This chapter is intended to provide guidance to public administrations in the environmental management of their internal processes (mainly related to their offices) and resources. It starts by briefly introducing the relevant internal processes and reasons for managing them in an integrated, environmentally-friendly and more sustainable way (Chapter introduction). Afterwards, a number of areas for which Best Environmental Management Practices (BEMPs) can help public administrations in this task are introduced (Technique Portfolio) and then presented in detail (Sections 2.1 to 2.7).

Chapter introduction

The internal processes of public administrations are as numerous and varied as public administrations activities, as outlined in Section 1.2. Some of the main activities in which public administrations are engaged are policy making, revenue collection and budgeting, human resource management, and the delivery of municipal services – whether procured or managed internally – such as social housing, transport, education, libraries, leisure, waste collection, emergency services, etc. Not all public authorities undertake all of these activities; indeed, responsibilities for different services are often split between local, regional and national levels and differ due to national legislation and administrative culture, e.g. centralized or decentralized public administration.

What is common to most public administrations, though, is that they employ a considerable number of staff working in offices. The environmental management of offices and of the employees' direct environmental impact is the focus of this chapter. How to improve the environmental management and the environmental performance of a selection of other activities carried out or considerably influenced (e.g. in terms of policy making) by the public administrations is dealt with by the following chapters (Chapters 3 to 14). These have a special focus on municipalities/local authorities.

Ensuring that the environmental sustainability of offices and other employees' direct environmental impact is addressed is an important first step. It does not only decrease the environmental impact of the public administration but also shows to staff and public that the public administration is serious about sustainability and can act as an example and enabler for much larger environmental performance improvements at the scale of the territory on which the public administration acts. Therefore, to some extent, the aspects addressed in this chapter can be considered a pre-requisite for the improvement of environmental performance of policies and services addressed in the following chapters of this report.

Moving towards more environmentally-friendly and integrated processes can bring not only significant positive environmental change but can also lead to a series of other benefits, most importantly a more efficient, effective and sustainable service delivery for citizens' quality of life. Above all, these include the possibility to efficiently use, and partly save, financial resources, to improve working conditions within the public authority and the companies providing goods, works and services to it as well as to raise the profile of the public authority by actively demonstrating a commitment to environmental protection.

Techniques portfolio

This chapter describe techniques for the environmentally-friendly and integrated management of some of the most common internal activities of public administrations: office buildings, and, more generally, the environmental impact of their employees. The main aspects considered are energy and water consumption, and waste generation. Other relevant aspects are the use of paper and consumables in the offices, the impact of commuting and business travel of employees and, also, the environmental impact generated by canteens and coffee bars. Finally, public administrations are also often responsible for the organisation of events and meetings, either hosted at their offices or in other locations, and best practices can be implemented to minimise their environmental impact.

2.1 Managing and minimising energy consumption

Description

Energy consumption (mainly for space heating and cooling) is a key environmental impact of office buildings. Concrete actions regarding improving energy efficiency and generating renewable energy in public buildings are covered under specific BEMPs (see Sections 3.2.2, 3.2.4 and 3.2.7). These include retrofitting the building envelope, optimising heating, ventilation and air conditioning (HVAC) systems, installing on-site renewable energy generation and other technological solutions. Additionally, minimising energy consumption of buildings can also be achieved through monitoring, energy management and fostering of behavioural change, as described also in a specific BEMP (see Section 3.2.5). The present BEMP focuses instead on the role of energy management itself, specifically for Public Administration offices.

Energy management, often together with carbon management, is an important element within environmental management. Energy management comprises a systematic approach to managing energy consumption including energy efficiency (reducing the amount of energy used) and renewable energy (switching to a low or zero carbon energy source). Good energy management should be integrated into wider management systems and have support at the top level of management and a dedicated staff resource. It must include a policy (action plan and regular reviews) and performance measurement. It must be embedded at all levels through internal and external communication plus staff training.

This BEMP explains how energy management can be implemented in practice and applies at the building level. It follows the principles of PDCA (Plan, Do, Check, Act) (IEMA, 2014) as per leading environmental management systems e.g. EMAS and ISO 14001. This is an iterative sequence which facilitates continuous improvement and allows those responsible to be proactive. This BEMP focuses on implementing parts of the PDCA cycle which are specific to energy management:

- Identify benchmarks
- Data collection and ongoing monitoring (in the "check" part of the cycle)
- Data analysis, target setting, establishing a strategy / action plan (in the "plan" part of the cycle)

Identify benchmarks

Benchmarks are useful for comparing actual energy use performance to standardised performance – whether that is best practice, good practice or typical performance.

PassivHaus is an example of one of the most ambitious energy performance standards on the market and represents a best practice benchmark – see Table 2-1. Energy performance for new buildings should certainly be equivalent to this. Passive House has been developed for cool temperate climates but should be applicable throughout Europe unless there are particularly extreme conditions. An example of office building complying with the PassiveHaus standard is the 4-storey, 8266 m2 Energon office in Ulm, Germany. It achieves 12 kWh per m^2 per annum for heating and primary energy use of 67kWh/ m2 per annum (EnOB, 2014).

Table 2-1: Passive House Institute criteria for non-residential buildings (PassivHaus Institut, 2013, p.1)

Heating	**Cooling**	**Primary energy**
Specific space heating demand ≤ 15 kWh/(m^2 / annum) *or alternatively:* heating load ≤ 10 W/ m^2	Specific useful cooling demand) ≤ 15 kWh/(m^2 / annum)	Total specific primary energy demand) ≤ 120 kWh/(m^2 / annum)

Schlenger (2009) analysed energy use for typical office buildings categorised into three climate zones – and then modelled energy use if the buildings were to be optimised. Colder climates did not necessarily have larger energy use, as warmer climates use cooling energy. The energy performance of the optimised buildings were:

- Oslo - 47.8 kWh/ m2/annum (of which 13.6 kWh/ m2/annum heating)
- Brussels - 33.3 kWh/ m2/annum (of which 19.3 kWh/ m2/annum heating)
- Madrid – 50.8 kWh/ m2/annum (of which 43.5 kWh/ m2/annum heating)

The UK Energy Efficiency Best Practice Program (2000) showed best practice total values ranging between 112 and 348 kWh/ m2/annum and carbon emissions from 8.3 – 36.6 CO_2e / m2/annum depending on office type (Wade et al, 2003, p.7-8).
Current average energy intensity for offices in the UK, Czech Republic, France, Finland and Belgium is in the range 200 - 320 kWh/ m2 (Economidou, M., 2011, p53).

Data collection and monitoring
Energy consumption data should be collected at building level and ideally also by building area, particularly if the building envelope has different characteristics in different zones (such as a lobby which has more air changes, or two wings built in different decades). The data should be collected by fuel type and also if possible by end use category, such as heating, catering, lighting and equipment. This should all be set up within the building management system (BMS) where available and / or possible to implement. A summary of information that could be collected is shown in Table 2-2:

Table 2-2: Types of energy, what they are used for and how they are measured

Type	**How measure**	**Used for**
Gas	Use meter readings	Boiler or other heating Domestic hot water Catering
Oil	Use gauge / tank dip or use heat submeter	Boiler or other heating Domestic hot water Catering
Coal	Measure level or use heat submeter	Boiler or other heating Domestic hot water Catering
Biomass	Measure level, use heat submeter or record delivery figures	Boiler or other heating Domestic hot water Catering
LPG	Use delivery figures or submeter	Boiler or other heating Domestic hot water Catering

Electricity	Use meter readings	Lighting IT equipment Ventilation Air conditioning Heating system pumps Catering
Purchased hot water and heat	Use heat meter readings	Heating Domestic hot water

The data collected above is expressed in terms of final energy. It is important to analyse the data and develop indicators not only for final energy but also in terms of primary energy. To do so, primary energy factors should be applied to all fuels and energy carriers (Pout, 2011). Primary energy more accurately reflects resources used. This is important when comparing the effects of a fuel switch, as the same amount of final energy for different energy carriers can correspond to very different amounts of upstream energy needed to generate them. Final energy can be more helpful for analysing the elements within the building occupants' control.

Measuring energy consumption continuously using automatic meter readings (AMR), ideally as part of a building management system / building energy management system, is usually the best possible option. However, functioning of the meters and sensors must be regularly checked. Energy consumption should be monitored half-hourly, particularly where this is dependent on external temperature and weather such as heating and cooling. This is less important where energy use is automated e.g. for ventilation which is set to a constant level during office hours. For unmetered commodities (often liquid / solid fuels), delivery notes, stock-level records and period opening and closing values can be used. Use of invoices should be avoided in case they are based on supplier estimates. All units will need to be converted into a common unit (e.g. kWh) if other units have been used e.g. for gas / LPG.
As well as the data on energy, data on other variables will need to be gathered, such as floorspace and occupancy i.e. full time equivalent staff.

Data analysis
Data must be analysed in order to detect inefficiencies and establish priorities for action. Space heating and space cooling energy use needs to be normalised for weather variations in order to allow meaningful comparison e.g. with benchmarks, targets or previous years. Regression analysis and cumulative sum of deviation (cusum) can quickly help energy managers spot wastage.

<u>Climate correction</u>
Energy use is normalised for weather using degree days to eliminate fluctuations caused by external weather changes. This allows energy figures to be meaningfully compared year to year and changes to reflect the results from actual actions taken rather than external factors such as a milder or cooler winter (International Energy Agency, 2014, Annex C).
Heating degree days are a measure of how much and for how long external air temperature fell below a certain base temperature (which should correspond to the average temperature at which the building is kept during the heating period). Number of heating degree days is directly proportional to amount of heating energy needed in order to maintain the building internal temperature. The figures vary depending on the base temperature – the external temperature above which the heating is switched on. This is always a few degrees lower than the thermostat setting for internal temperature. Eurostat (2010) defined a common European baseline figure of 15°C, based on a target internal air temperature of 18°C, with 3°C due to internal heat gain and effects of insulation. Heating degree days for local weather stations worldwide can be downloaded from various websites e.g. BiZee Degree Days (2014).

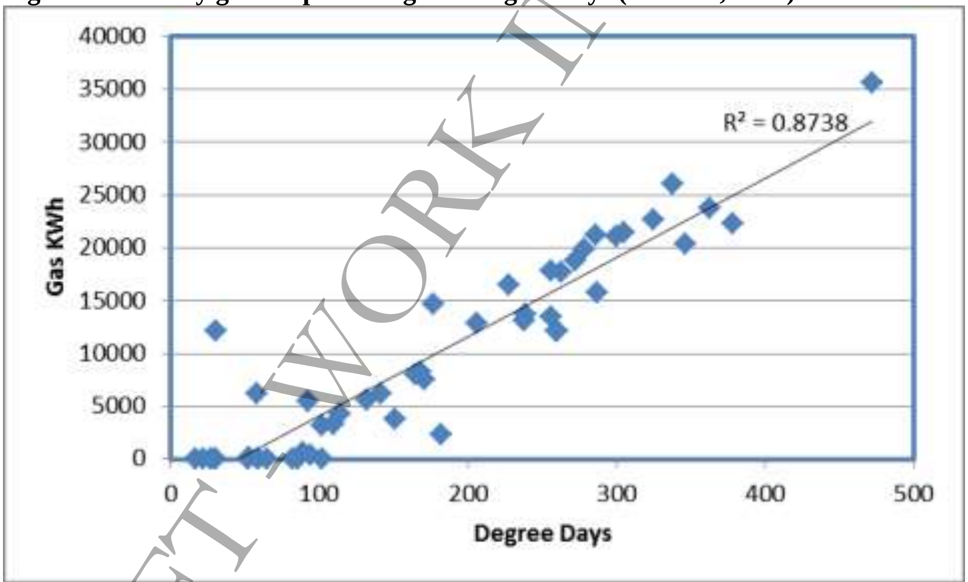
Annual reporting of heating energy used should include both actual and weather normalised figures in order to compare performance fairly from year to year (or other time period). This can be done as follows:

Annual total heating energy used/annual total degree day figure x degree days 20 year average

Conversely, cooling degree days measure how much and for how long external air temperature rose above a certain base temperature (which should correspond to the average temperature at which the building is kept during the cooling season). Number of cooling degree days therefore reflect the amount of cooling energy required to keep the building cool during warm weather in buildings which use cooling. The same methodologies can be applied as for heating degree days.

<u>Tools for analysis over time</u>
Analysis is then carried out to show differences over time e.g. a comparison with the same month in previous year. This allows the person responsible for energy management to ensure energy use is minimised and anomalies dealt with. It contributes to the “check” part of the plan-do-check-act cycle.
Regression analysis is a methodology where the energy used is plotted against degree days in order to detect anomalies. This can be done for any time period as long as the degree days for each point are for the same time period as the energy use. The example in Figure 12 shows daily gas use (kWh) plotted against degree days for a month during the heating season.

Figure 2-1 – Daily gas use plotted against degree days (Ransom, 2014)



The R^2 value describes the level of correlation between the two sets of data. The nearer to 1 the R^2 value is, the better the correlation, showing that control of the heating system is good, with proportional increases in heating use with colder weather. In the example shown in Figure 2-1, the building has a relatively good fit, improving further when the two outliers are removed (R^2 increases from 0.87 to 0.92). The particular outliers in this example were due to a temporary need to supply heating to a neighbouring building.
An R^2 value over 0.75 represents a reasonable correlation and over 0.9 represents a good correlation (Bizee Degree Days, 2014).
Where there is a wide scatter above the line, this could signal energy wastage e.g. too much heating in warm weather. Good performance for the building will be shown by the lower points under the line of best fit. However if there is an anomaly far below the line, this could signal, for example, a broken boiler on a cold day. A gradual drift of all points above the historic line of

best fit would indicate more persistent changes which have not been addressed e.g. ineffective building energy management system settings or broken equipment.

If the best fit line meets the y-axis, it can indicate the building base load. In the example above, the line of best fit meets the x-axis. This indicates that the building is possibly benefitting from internal heat gain (e.g. due to good insulation). This will not affect the R^2 analysis.

A regression line can also be used to compare expected and actual energy use from a historical best practice line. Once a degree day figure has been obtained for a certain period, expected energy use can be read off from the y-axis and compared to the actual energy use for that period and wastage calculated.

Regression analysis is a useful tool; however it can be misleading due to assumptions around base temperatures, i.e. if the building is heated or cooled at temperatures which are (very) different from the chosen base temperatures.

A "cusum" (cumulative sum) chart shows trends in deviation from the best fit line (or any target). Cusum charts show the running total of deviation and can be used for energy consumption overall or for individual metering points. A cusum chart can be drawn by entering the monthly deviances from the expected energy use into a spreadsheet, then making these cumulative and plotting on a graph. Expected energy consumption can be read off a historic best-fit line such as Figure 2-1 using the degree days derived for the month.

An example of the resulting cusum graph is shown in Figure 2-2. A horizontal cusum line reflects expected performance. Changes in the angle of the cusum line show changes in performance with a downward section indicating less energy use than expected, and an upward section indicating more energy use than expected.

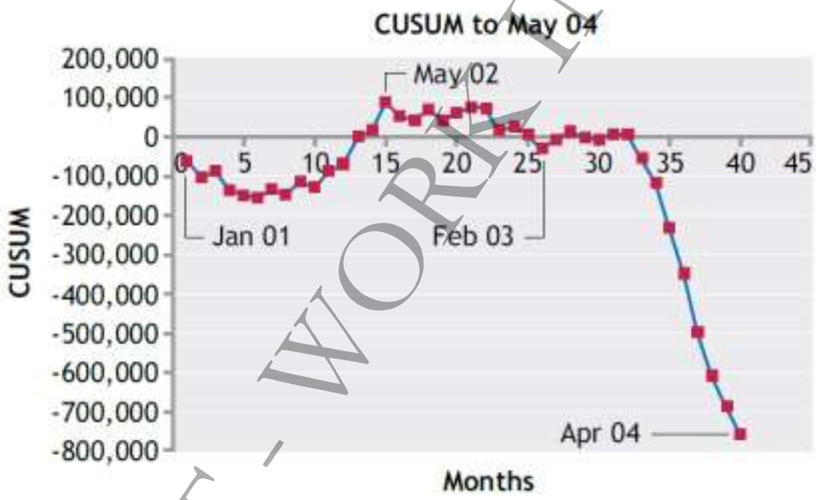


Figure 2-2: Sample cusum chart (Carbon Trust, 2012, p.18)

In the example, a sustained downward trend was due to replacement of an old boiler and controls.

The methodologies described above for analysing energy use can be performed as frequently as desired subject to availability of data and staff resources, however it is recommended they be carried out monthly as a minimum. A wider review can be done annually.

Target setting

Targets are a quantified goal to be reached within a specified timeframe. They are different to benchmarks which comprise a point of reference which could be typical, good practice or best practice and may be set by third parties. Benchmarks can also be theoretical such as 50% of a measured figure (Bosteels et al, 2010).

Whilst it is interesting to consider office energy use benchmarks and use these for aspirational wider corporate targets (e.g. 95% CO2e reduction by 2020 based on reaching best performance by then), there should be targets set at the office building level based on a bottom up approach.

This means they should reflect proven achievable performance e.g. best achieved performance to date. This will be limited to constraints of the current building envelope, HVAC systems, and occupancy requirements.

Targets should be set for energy intensity per m^2 and per employee. Sometimes an increase in intensity will be necessary if more employees begin working in a building. Equally, if a building expansion is planned, this could affect energy intensity per employee. Identifying best performance to date varies by use, so targets should be calculated that apply to individual monitored streams, which can be consolidated to form an overarching target in kWh/m^2/annum and kWh/employee/annum.

Heating targets can be set using cusum by identifying those points on low-gradient sections of the cusum chart (y axis is kWh used, x axis is month) and plotting these on a chart showing monthly kWh used against degree days for the month (making sure all seasons are covered, ideally over the course of several years). Then a best fit line can be created as mentioned above, which indicates kWh/degree day based on best previous performance.

This figure can be multiplied by 20-year average degree days for the region or country, giving a prediction of energy use based on best previous performance. The percentage improvement can be calculated based on current energy usage. A date can then be set for achieving this improvement and will depend on estimated length of time for actions to be implemented e.g. changing BMS settings or behaviour change. For each intervening year / month, figures should be calculated reflecting these expectations to ensure progressive improvement is being achieved. Targets should be updated regularly as better performance is achieved.

Establishing a strategy

An energy strategy outlines how energy is managed in a building or portfolio of buildings and actions that will be taken to reduce energy use. This involves:

- Carrying out an initial energy audit
- Carrying out an audit of the current situation, including the building systems (HVAC), building envelope characteristics and any energy management systems already in place.

Once the energy management strategy starts to be implemented, ensuing tasks will help locate and implement energy saving projects. The strategy should include who is responsible for energy management, how regulatory compliance will be ensured, what investments will be made in energy saving equipment or renewables and how procurement will be managed taking energy efficiency implications into account (Carbon Trust, 2011).

Identification of energy saving projects is key to the strategy as mentioned above. This will involve prioritisation in terms of management activities and physical upgrades. BRECSU (2001) produced a guide which includes matrices for scoring progress on three levels including overall energy management, awareness and information and technical matrices covering space heating, lighting, boilers and building fabric. The detailed matrix is reproduced in

. The levels 0 – 4 reflect scores, with 4 being the best.

Table 2-3: scoring matrix for space heating (BRECSU, 2001, p15)

Level	Time control	Boiler output controls	Heat emitters	Operation of heating systems	Heating levels and balance	Zoning
4	Space heating is controlled by a sophisticated system such as a BEMS, programmed for weekends and holidays, and with self-learning optimum start and stop functions.	Effective automatic control of boiler standing losses. Only those boilers whose output is required are hot, all others cold or cooling. Boilers and manifolds are well insulated.	Radiators have thermostatic valves, fan convectors have individual controls and different areas of the building each have internal temperature sensors or thermostats.	Rigorous checking of controls function, settings, and system balance carried out once per year. Documented procedures and comprehensive records of results.	Temperatures are even throughout the building – within the range 18°C to 20°C during the periods of occupancy, and reducing to lower temperatures outside those periods.	Objective zoning for occupancy, solar gain, equipment gain, emitters, structure, etc, where appropriate. Adequate means for controlling temperature in each zone.
3	An optimum start controller varies the start time of the heating according to outside temperatures, and an optimum stop does the equivalent at the end of the day.	Effective manual isolation of boilers to reduce standing losses when full output is not required. Boiler and manifolds are well insulated.	Radiators and fan convectors have individually operated controls. The temperature of radiator circuits is hotter in mid-winter and cooler in autumn and spring.	Full checking of controls function, controls settings, and system balance carried out once per year. Documented procedures exist for each check. Some results on record.	Temperatures are even throughout the building, but in some parts they occasionally rise over 20°C during spring or autumn. 20°C is maintained only during the hours of occupancy.	Extensive zoning, approximately reflecting occupancy time and temperature requirements. Temperature controls exist for each zone.
2	There is an optimum start controller fitted to the heating system. Holiday periods can be programmed in advance.	All boilers become hot only when boiler output is required. Boilers are cold at all other times (eg overnight).	Radiators and fan convectors have individually operated controls but water temperature to the radiators is the same all year round.	Informal checking of controls function and system balance carried out once per year. Schedule of checks exists but no proof of occupancy.	Temperatures above 20°C during spring and autumn, and the building is warm for more than an hour before or after the occupied periods.	Limited zoning, perhaps led by building expansion, but zones approximately reflect the need for separate occupancy times and temperatures.
1	The heating system has a simple timer that can be easily set. Timer settings are adjusted manually to suit seasonal heating requirements.	All boilers remain hot during pre-heat and building occupation hours during summer and winter.	Radiators and heat emitters have basic controls, and there is only one internal temperature sensor to control them.	Annual functional checks carried out although these are not well documented.	Temperatures vary and they are frequently above 20°C for long periods – including outside periods of occupancy.	Limited zoning or inappropriate zoning of circuits.
0	The timer is in a poor state of repair and cannot be easily adjusted. The controller may not recognise days of the week.	All boilers remain hot regardless of whether or not there is a demand for heating.	Radiators and heat emitters have no controls and get hot together. Radiator temperatures appear to be the same all year round.	Maintenance is on breakdown basis and controls are checked only when things go wrong.	For much of the building temperatures are frequently too hot, particularly in spring and autumn.	No zoning where zoning desirable, or inappropriate zoning.

Achieved environmental benefits

The main environmental benefits to energy management in offices, specifically strategy, measurement and implementation of performance improvements at a building level are reductions in:

- energy use and, especially, use of non-renewable fossil fuels; and consequently
- greenhouse gas emissions.

Of particular relevance to public offices, there is the secondary benefit of dissemination of good practice that can lead other organisations to also reduce their energy consumption. Information can be shared retrospectively including lessons learned and wider strategy (DECC, 2012). Energy use can be shared publicly in real time – for example see Carbon Culture.net (https://platform.carbonculture.net/landing/).

Appropriate environmental indicators

Indicators to track progress on energy consumption over time and across buildings are shown in Table 2-4 :

Table 2-4: Environmental indicators and data required for each indicator

	Indicators : **Intensity / m2**	**Indicators :** **Intensity / employee**	**Which data is required for the indicator?**
Energy consumption (in terms of final energy)	Total energy use (kWh/m2/annum), broken down into: • Space heating (kWh/m^2/annum) • Space cooling (kWh/m^2/annum) • Electricity (kWh / m^2/annum)	Total energy use (kWh/employee/annum), broken down into: • Space heating (kWh/employee/annum) • Space cooling (kWh/employee/annum) • Electricity (kWh /employee/annum)	• Energy consumption figures (e.g. from bills or meters) • Total area of internal floorspace that is heated/cooled (m^2) • Number of employees (full time equivalent)
Primary energy consumption	Total primary energy use (kWh/m^2/annum)	Total primary energy use (kWh/employee/annum)	• Total energy consumption figures broken down by fuel type. • Primary energy conversion factors specific to each country • Floorspace (m^2) and employees (FTE)
Greenhouse gas emissions	Total greenhouse gas emissions (Kg CO2e / m^2/annum)	Total greenhouse gas emissions (Kg CO2e / employee/annum)	• Total energy consumption figures broken down by fuel type. • Greenhouse gas conversion factors for each fuel/energy carrier (where applicable, e.g. for electricity, specific to each country) • Floorspace (m^2) and employees (FTE)

Primary energy is calculated by multiplying the energy consumption figure for each fuel type by a primary energy conversion factor for that fuel. For certain energy carriers, e.g. electricity, the primary energy conversion factor must be specific to the country as it depends on its specific energy mix. Greenhouse gas emissions are calculated by multiplying the energy consumption figure for each fuel type by the greenhouse gas conversion factor for that fuel. Also greenhouse gas conversion factor must be specific to the country for certain energy carriers. Greenhouse gas emissions will vary from the energy use figures depending on carbon intensity of the fuel source.

Although the indicators above are aggregated to give annual figures, the consumption itself of heating, cooling and electricity should be measured much more frequently, for example half hourly where AMR is installed and at least monthly where meter reading is manual. The indicators permit comparisons from year to year whereas the more granular measurements can be used to investigate anomalies and any specific situations as required and to take appropriate actions.

Cross-Media Effects

There are no cross-media effects from the implementation of this BEMP. The increased energy use from the implementation of AMR and IT systems to control the energy use and/or the building operations are much lower than the likely energy savings.

Operational data

This section contains case studies showing best practice in operation.

CREATE Building, Bristol Council (UK)

CREATE Centre (http://www.createbristol.org/) is one half of a re-purposed tobacco warehouse built in 1908, that now provides office space for Bristol City Council, as well as numerous organisations working in the field of sustainable development. In addition, there is event & exhibition space, a café and a demonstration ecohome. The council's Environmental Performance team is based within the building, and is part of the Bristol City Council Energy Service.

Features relating to energy include:

- The only Display Energy Certificate (DEC) "A-rated" building in the Bristol City Council estate
- Automatic meter readers for electricity and gas providing on-line half-hourly data
- Comprehensive Building Energy Management System allowing for weather compensation, zoned multiple occupancy temperatures and hours of operation
- Solar thermal panels providing hot water for the café

The building falls within the Bristol City Council EMAS system so is part of a corporate target to reduce carbon emissions by 3% year-on-year. Overall energy consumption has slightly reduced over four years – see **Table 2-5** – Energy consumption reductions at CREATE Building, 2010 – 2014

Table 2-5: Energy consumption reductions at CREATE Building, 2010 – 2014

	Electricity (kWh)	Electricity (kg CO_2e)	Gas (KWh)	Gas (kWh weather corrected)	Gas (kg CO2e)	Emissions (tonnes CO2e)
2010/11	257 852	135 215	131 606	115 606	24 377	160
2011/12	202 715	99 468	92 904	94 859	17 057	117
2012/13	218 188	108 300	145 982	110 982	27 037	135
2013/14	232 259	112 313	108 345	100 292	19 940	132

During that period there was a significant increase in the number of building tenants. Energy/ carbon intensity per tenant has nearly halved, representing a significant performance improvement – see Table **2-6**.

Table 2-6: Energy intensity reductions per full time equivalent employee at CREATE Building, 2010 - 2014

	Electricity and gas (weather corrected) (kWh)	FTE employees	Energy use per employee (kWh)	kWh/m2 (energy consumed)	Primary electricity and gas (weather corrected) (kWh)	Primary energy intensity per employee (kWh/FTE)
2010/11	373 458	129	2895	39	783 871	6 077
2011/12	297 573	162	1837	31	620 329	3 829
2012/13	329 169	160	2057	34	676 791	4 230
2013/14	332 551	207	1607	34	702 128	3 392

Energy intensity per m^2 has also improved – see Table above.

Table 2-7: Energy intensity reductions per m2 floorspace at CREATE Building, 2010 - 2014

	Electricity and gas (weather corrected) (kWh)	Floor area (m2)	kWh/m2 (energy consumed)	Primary electricity and gas (weather corrected) (kWh)	Primary energy use per m2 (kWh/m2)
2010/11	373 458	9689.6	39	783 871	81
2011/12	297 573	9689.6	31	620 329	64
2012/13	329 169	9689.6	34	676 791	70
2013/14	332 551	9689.6	34	702 128	72

Carbon emissions reductions are shown in Table 2-8.

Table 2-8: Greenhouse gas emission reductions per full time equivalent employee and m2 floorspace at CREATE Building, 2010 - 2014

	Electricity, gas and oil (CO2e)	FTE employees	Emissions per employee (kg CO2e / employee)	Floor area (m2)	CO2e/m2 (kg)
2010/11	160	129	1.237	9689.6	16
2011/12	117	162	0.719	9689.6	12
2012/13	135	160	0.846	9689.6	14
2013/14	132	207	0.639	9689.6	14

The improvement in energy use per FTE was largely due to increased occupancy. The energy intensity improvements were otherwise due to a number of factors. The AMR and BEMS data was analysed to identify hours of operation, and relate it to known occupancy in different areas of the building. Bristol was able to reduce temperature and heating hours of operation (based on occupancy) without reducing staff comfort. “Observers” were recruited from each floor of the building to report on comfort at marginal times e.g. early in the morning and late in the evening.

Also, a programme of insulation including window seals and insulation of all heating and hot water pipes, saving an estimated 15 tonnes CO_2e per annum and solar thermal and solar PV were installed.

There is more detail below which demonstrate the methodologies mentioned in the Description section. Table 2-9 shows an example primary energy and consumption energy.

Table 2-9: Energy use and primary energy use (data from CREATE Building, Bristol City Council, UK)

	Electricity (kWh)	Primary electricity factor	Primary energy electricity (kWh)	Gas (KWh)	Gas (kWh weather corrected)	Primary gas factor	Primary energy gas (kWh)
2010/11	257 852	2.58	665 259	131 606	115 606	1.026	118 612
2011/12	202 715	2.58	523 004	92 904	94 859	1.026	97 325
2012/13	218 188	2.58	562 924	145 982	110 982	1.026	113 867
2013/14	232 259	2.58	599 228	108 345	100 292	1.026	102 900

Screenshots of half-hourly electricity and gas usage from a building management system control panel are shown in Figure 2-3.

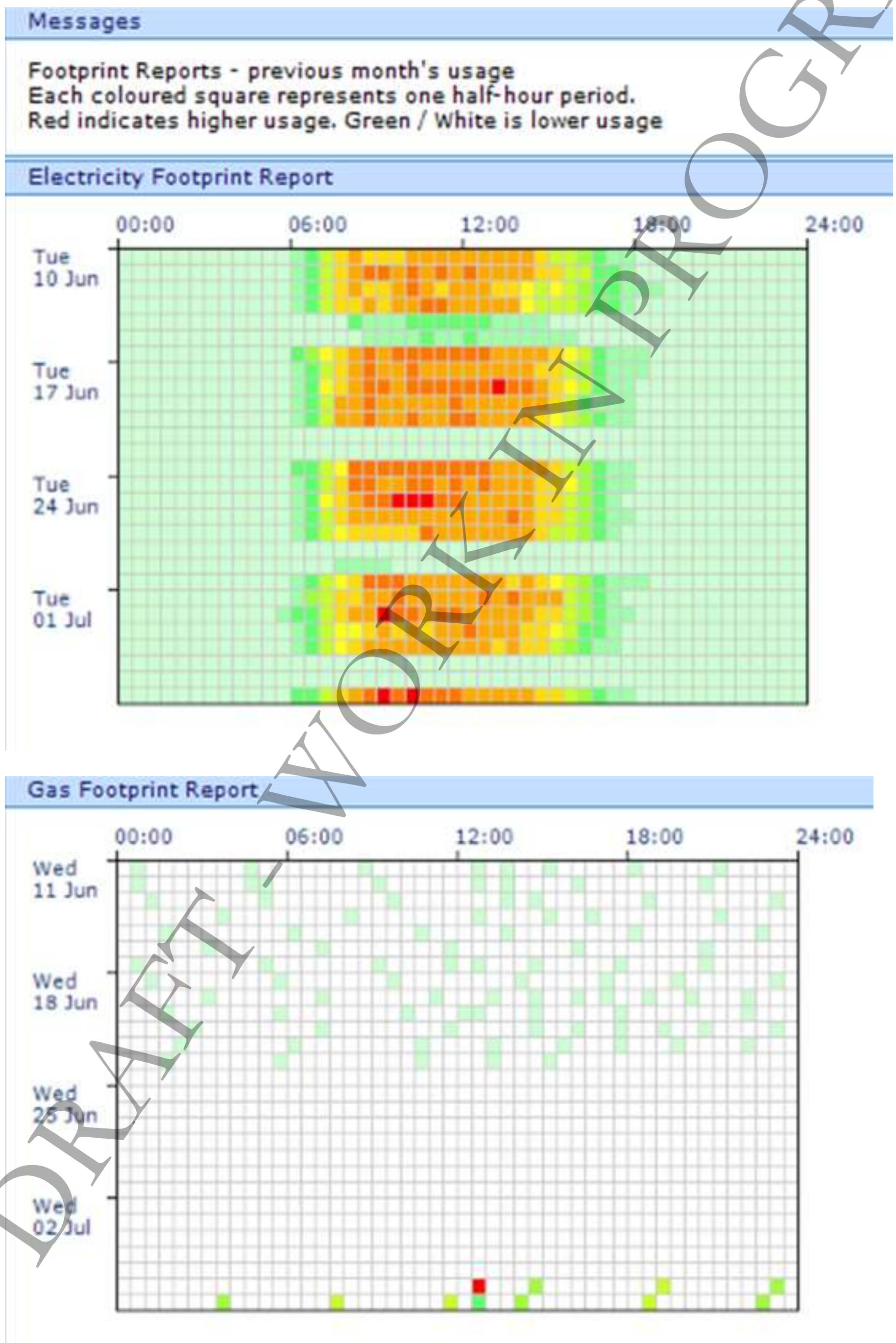


Figure 2-3: Electricity and gas footprint reports from building management system control panel, CREATE Building, Bristol City Council (Ransom, 2014).

These screenshots signal in real time when energy use is becoming high and this can then be immediately investigated.

An example of annual degree day normalisation for heating, using the equation:

Annual total heating energy used/annual total degree day figure x degree days 20 year average

is shown in Table 2-10.

Table 2-10: Gas consumption and gas consumption weather corrected at CREATE Building, Bristol City Council (Ransom, 2014).

Year	Gas (kWh)	Gas (kWh weather corrected)	Degree days
2010/11	131 606	115 606	2155
2011/12	92 904	94 859	1854
2012/13	145 982	110 982	2490
2013/14	108 345	100 292	2045
20 year average			1893

Whitehall Place, Department of Energy and Climate Change (UK)
The UK's Department of Energy and Climate Change (DECC) have been effectively managing and reducing energy use since 2009. DECC have three office buildings in their London estate and have achieved great savings since the inception of the programme. Figure 2-4 shows energy consumption 2008/09 – 2011/12 for 3 Whitehall Place. At this site DECC achieved an 87% reduction in gas consumption and a 39% reduction in electricity consumption - a total energy saving of 60%. This was despite an increase in the number of staff from 782 FTEs in March 2009 to 1108 FTEs in March 2012 – an increase of 42%. The annual office energy use per FTE was reduced from 4520kWh in 2008/09 to 1287 kWh in 2011/12.

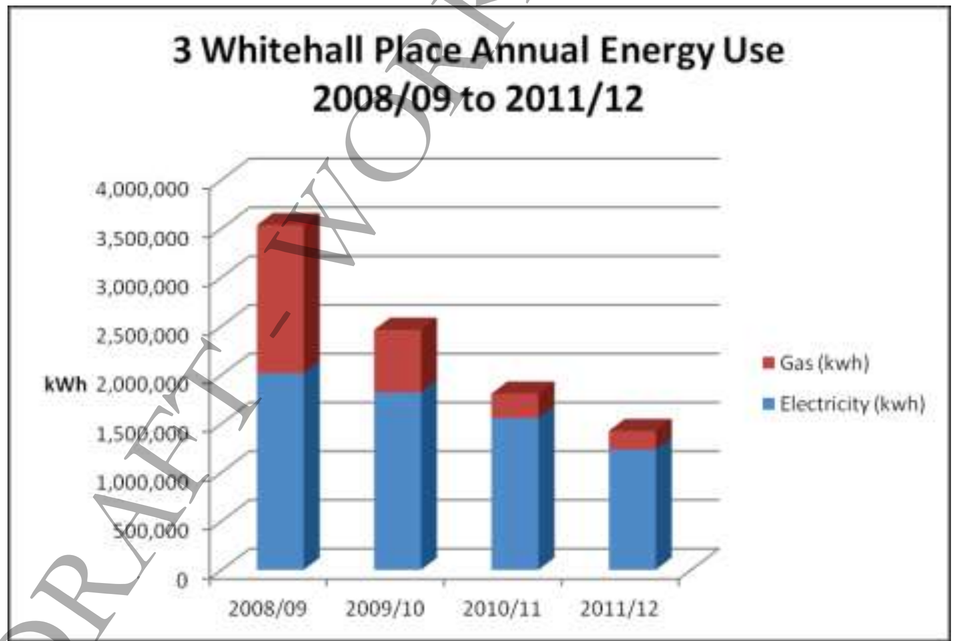


Figure 2-4: Energy use, 3 Whitehall Place, London (DECC), 2008 - 2012

These impressive cuts have been achieved by a variety of actions many of them focused on active management using the Building Energy Management system. These include:

- A large number of electricity sub-meters monitoring high consuming areas or equipment

- Floor by floor automated temperature settings (air conditioning switches on where the temperature reaches higher than 24°C, heating switches on when temperatures dip below 20°C.
- Server room cooling kicks in at 25 – 27°C – previously they had been cooled to 19°C.
- The Energy and Carbon Manager monitors the building parameters and adjusts the BMS controls on an ongoing basis to ensure both energy efficiency and occupant comfort. These adjustments are being automated in order that the level of energy savings is maintained
- The Building Energy Management System was programmed in Summer to pre-cool the building at no cost in the mornings using relatively cool ambient air.
- Grills were installed between colder rooms on the corners of the building and the generally warmer office areas to reduce heating requirement in Winter (DECC, 2012).

In terms of cost savings, DECC spent around £500,000 on energy efficiency projects between October 2008 and March 2012, and estimate they saved around £156,000 in 2011/12 on their energy bills as a result.

Frankfurt-am-Main

Frankfurt-am-Main has been exemplary in long standing energy management activities for municipal buildings. They are exemplary in their metering and monitoring of energy use throughout their building portfolio.

Automatic meter reading has been installed at 330 buildings, involving the installation of over 1000 data loggers for heat, electricity and water. Energy use profiles are stored by the data loggers and downloaded centrally once per day. This allows tight monitoring of energy use, the checking of settings (e.g. switch off during night / weekends) and the detection of losses. Figure 2-5 shows an example of the previous day's energy use for one of the buildings.

Figure 2-5: Screenshot showing kWh per hour, up to the previous day, for a selected building (Buergeramt) (Stadt Frankfurt-am-Main, 2014).

Historical data is also available alongside previous years' energy use – see Figure 2-6.

Figure 2-6: Historical energy use shown for selected building (Verkehrsamt) updated to 3 months previously

Display Energy Certificates, guidance for facilities managers, staff training is also publicly available.

Another section shows performance of energy saving measures that are being implemented or trialled (Stadt Frankfurt-am-Main, 2014). It is even possible to download bonuses paid (to buildings energy managers) for energy cost savings since 1998.

Forty one buildings have received thermal imaging reports which enables identification of where heat is being lost in a building. Some sample images of The Romer Rathaus (town hall) are shown in Figure 2-7.

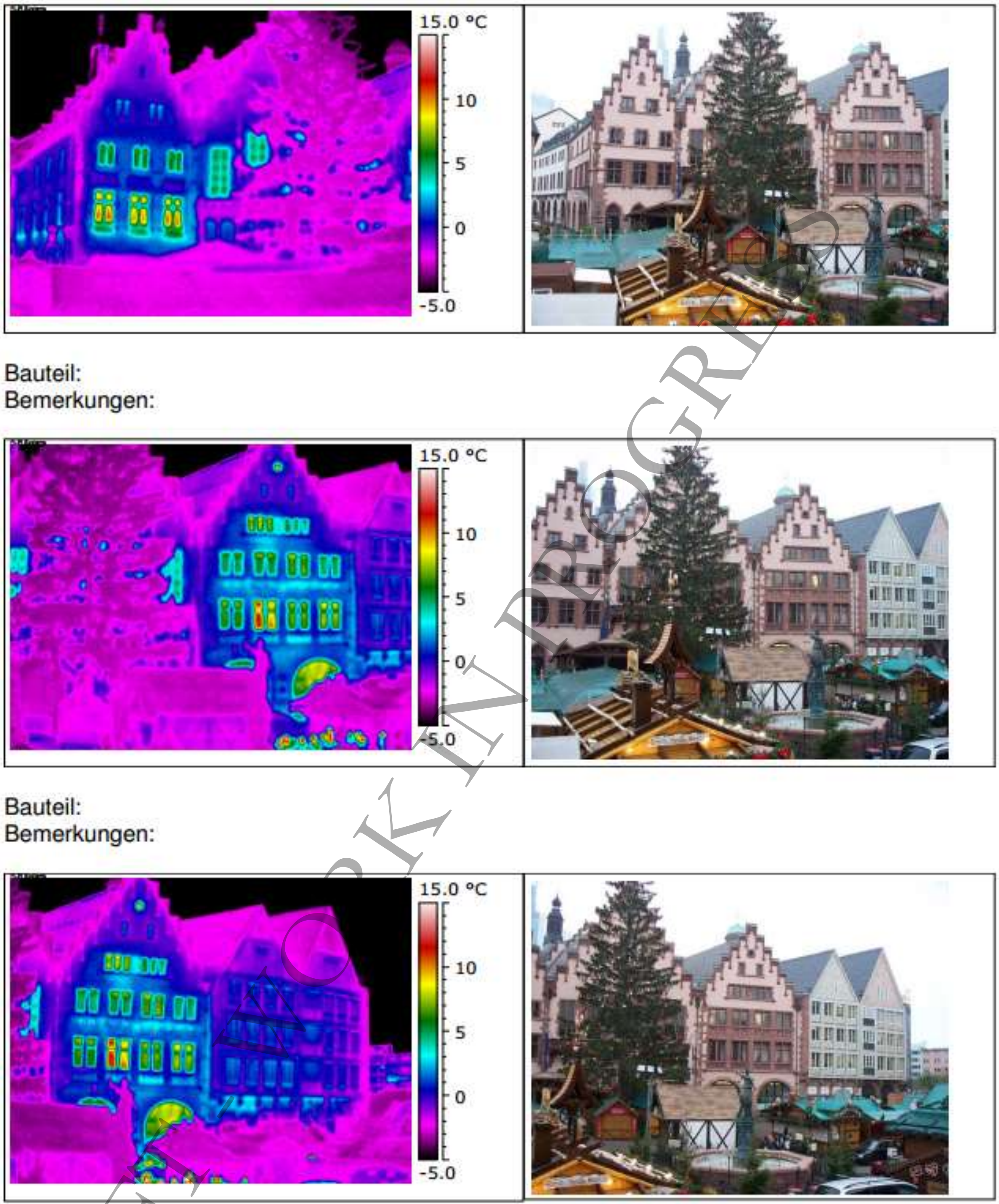


Figure 2-7: Part of the Romer Rathaus thermal imaging report, 2008 (Stadt Frankfurt am Main, 2014)

As a result of the many activities, energy use – heating in particular has reduced by over a third – see Figure 2-8.

Consumption	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013		2013/1990	
Electricity	67	70	64	63	63	62	64	71	61	62	66	69	53	64	68	62	59	67	69	64	64	70	68	62	GWh	-8	%
Natural gas	177	171	215	227	217	202	181	167	193	208	184	152	189	185	210	198	181	191	157	165	135	164	133	128	GWh	-28	%
District heating	49	47	46	40	51	38	41	46	46	49	51	48	36	52	57	58	59	56	63	63	55	67	62	62	GWh	26	%
Fuel oil	87	80	71	53	61	47	30	33	28	27	28	22	20	18	11	11	10	7	6	9	4	4	5	4	GWh	-96	%
Heating	313	298	332	321	329	287	252	246	267	283	263	221	246	254	278	267	250	253	225	236	194	235	200	193	GWh	-38	%
Water	3,18	3,05	3,08	2,71	2,32	2,37	2,13	1,97	2,25	1,84	1,63	1,53	1,28	1,93	2,00	1,50	1,57	1,74	1,48	1,42	1,42	1,44	1,07	1,13	Mio. m³	-64	%

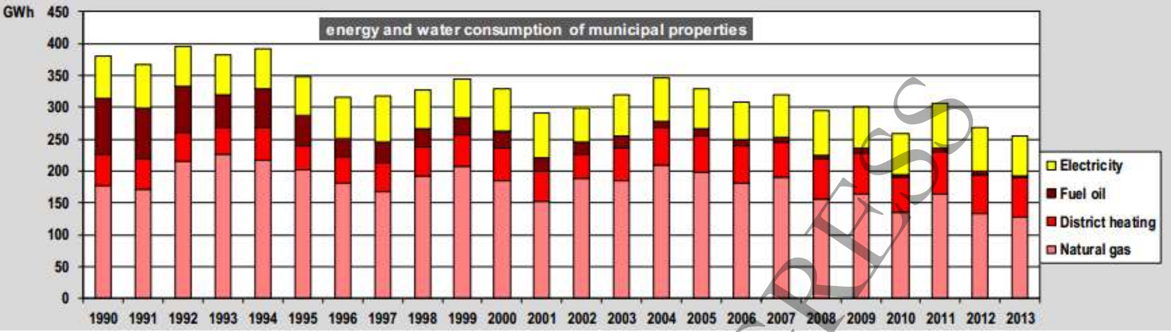


Figure 2-8: Energy use shown 2009 – 2013 (Stadt Frankfurt-am-Main, 2014)

Applicability

This BEMP relates to public administration offices and is applicable across the whole of Europe. Though most of the principles are widely applicable, this BEMP is specific to office buildings and not other buildings that may be owned by public administrations but used for other uses. Indeed, aspects of energy management that apply specifically to other functions such as industrial process energy management have not been covered. This BEMP has environmental and economic benefits whether the building is rented or owned even though actions may be more restricted in rented buildings.

Economics

Public administrations can save 20% of their energy costs by implementing energy management in their office buildings. Savings range from 5 – 25% with payback typically two years or less. Even with minimal capital expenditure, savings of 5 – 10% can be made. UK Carbon Trust research has identified that the investments required to save 15% of energy bills have an average Internal Rate of Return (IRR) of 48%, well above the minimum requirement set by businesses, which averages 11.5% (Carbon Trust, 2013, p.7).

Driving force for implementation

Public Administrations are implementing energy management to help reduce energy costs and, if applicable, carbon taxes payable, comply with legislation, help ensure business continuity (security of supply), enhance reputation and contribute to comfort and wellbeing of the building's users. The implementation of energy management can also be dictated by environmental consciousness and/or the need to deliver carbon and resource savings to reach high-level political targets. When an effective energy management system is implemented specifically for Public Administration offices, it can play the additional role of leading by example. For example the energy policy, energy data, KPIs and actions can be made public.

Often implementing energy management has been part of a broader sustainability agenda, sometimes first considered under Agenda21. Bristol City Council has a Climate Change and Energy Security Framework, which aims to reduce carbon emissions by 40% by 2020 from a 2005 baseline. For DECC energy management was an important part of their own carbon management. As well as having a 10% central government carbon reduction target, they consider it crucial to lead by example (DECC, 2011). For the City of Frankfurt, internal energy management has its own department as an integral part of the broader management of municipal buildings. They have been keeping records of gas, oil, electricity, water use, etc. since 1990.

Reference organisation

Bristol City Council (UK)

In Bristol Council's Create Building effective energy management has halved energy and carbon intensity per building occupant. This is as a result of increased occupancy as well as updating settings, fitting insulation and introducing renewables.

Department of Energy and Climate Change, London (UK)

Whitehall Place has reduced energy use by around 60% between 2008 and 2012 thanks to proactive energy management, including fine-tuning building management system settings.

Stadt Frankfurt am Main (Germany)

Stadt Frankfurt am Main has a comprehensive metering and monitoring system for its buildings as well as a programme of thermal imaging reporting.

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2.2 Managing and minimising water consumption

Description

There are two key mechanisms for reducing potable water use in offices – becoming more efficient (reducing consumption) and supplementing mains water with harvested rainwater and/or recycled greywater. Reductions in office water use can be mainly achieved through the following activities:

- Technical solutions (e.g. low flow taps, rainwater harvesting)
- Measurement and monitoring of water use
- Occupant behaviour change

The above should be implemented by means of a water management approach following the principles of PDCA (Plan, Do, Check, Act) (IEMA, 2014), as do environmental management systems more broadly e.g. EMAS and ISO 14001. This sequence facilitates continuous improvement and allows those responsible to be proactive.
The rest of this section sets out methodologies for setting water use targets and strategy, based on water monitoring, as well as practical guidance on technical and behavioural solutions to save water.

<u>Management aspects and setting targets</u>
An effective management approach is essential for effectively minimising water consumption. There should be a nominated person who has responsibility for managing water consumption, such as a facilities manager, building manager or sustainability manager.
Water management involves a cycle of monitoring and measuring consumption, comparing with expected consumption, setting targets and creating strategies for reduction in consumption.
In order to help set targets, many data are available in literature. Some of these are presented in Table 2-11.

Table 2-11: Examples of benchmarks for office water use. Note that the daily figures in this case assume 253 days per business year

Note	m3/ employee/ year	m3/m2 internal floorspace	Litres/employee/day	Litres/m2/day	Notes	Source
Office	4	0.6	15.8	2.4	Total employee numbers rather than full time equivalents are required	Waggett & Arotsky, 2006, 2006, p14
Office	9.3					Environment Agency, UK, 2013
Office	1.5					Friends of the Earth Scotland, 2013
Office	2	0.4	7.9	1.6	Total employee numbers rather than full time equivalents are required	Waggett & Arotsky, 2006, p14
Office	6.4					Environment Agency, UK, 2013
Small office	4.4				Small office defined as less than 1000m2	Friends of the Earth Scotland, 2013
Small office with catering	5.9				Small office defined as less than 1000m2	Friends of the Earth Scotland, 2013
Larger offices	6.8				Larger office defined as over 1000m2	Friends of the Earth Scotland, 2013
Larger offices with catering	8.3				Larger office defined as over 1000m2	Friends of the Earth Scotland, 2013

Targets for total water consumption can be established by multiplying values achieved by frontrunners by the number of employees to give a total best practice figure:

Water use if best practice achieved (m^3/year) = best practice benchmark (m^3 / employee / year) x number of employees

Water use per person in litres per day is also a useful metric that is easily grasped by building occupants. It can be calculated as follows:

$$\textbf{Water use(litres/employee/day)} = \frac{\textbf{water use (m}^3\textbf{) / number of working days per year}}{\textbf{number of employees}} \times \textbf{1000}$$

The number of working days per year varies in different European countries – with annual leave and bank holidays ranging from 27 to 40 days per annum (Eiroline, 2011).

Potential savings can be calculated as follows:

Possible savings (m^3/year) = current annual water use (m^3/year)–water use if best practice achieved (m^3/year)

The resulting figure will enable an estimate of financial savings based on the cost of water per m^3. This can help estimate payback times for any capital investments or behaviour change campaigns.

<u>Data collection and analysis</u>

Once targets have been set, meter readings and inventories of water using devices can be used to determine priorities for action. This should be based on areas where the maximum impact can be made and return on investment is best.

Automatic meter reading (AMR) should be installed, ideally linked to the Building Management System. Automatic reading could be set at frequent intervals such as half hourly. There should be submetering points for major water using areas e.g. bathrooms, kitchens, outdoor areas etc.

Where AMR is not present, it is recommended that meters be read weekly but also between times when the building is empty (at night or during weekends) to check for leakages.

<u>Setting a strategy and developing an action plan</u>

The data above combined with information on water using devices and activities will allow breaking down water uses – Table 2-12. It will help clarify where there is most capacity for improvement based on amount of water consumed, potential for reduction etc.

Table 2-12: Sample breakdown of water use (EPBV, 2009)

Total annual water use	**Area**	**Volume used (m3)**	**Description**	**Intensity of use**	**Potential for improvement**
980 m^3 / year	Bathrooms	898 m^3/ year estimated	8 WCs (dual flush, 4 litres average flush volume) 4 wash basins. Taps have flow limiters but no aeration	Intensive	Adaptations have already been made except for the mixer shower

			Mixer shower		
	Internal cleaning	8 litres x 6 x 50 weeks = $2.4 m^3$/year	Mopping indoor areas	Not significant	Potential for improvement
	External cleaning	20 litres / minute x 30 minutes x 50 weeks = 30 m^3/year	Pressure cleaning, 20 litres / minute	Equivalent to 5 buckets of water twice a week	Efficient
	Irrigation of outdoor areas	10 litres / m^2 / hour x 20 minutes x 100m2 x 150 days = 50 m^2 / year	100m^2 shrubs being watered by sprinkler, 10mm / hour	Every week for 30 minutes.	This source of water consumption could be avoided altogether
	Leaks	0 m^3/ year	Two readings taken per day during test phase	Test carried out for 20 minutes per day, May to September	Automatic meter readings preferable.

Minimising water consumption should follow the lines of the waste hierarchy applied to water as illustrated in Figure 2-9 (WRAP, 2013)

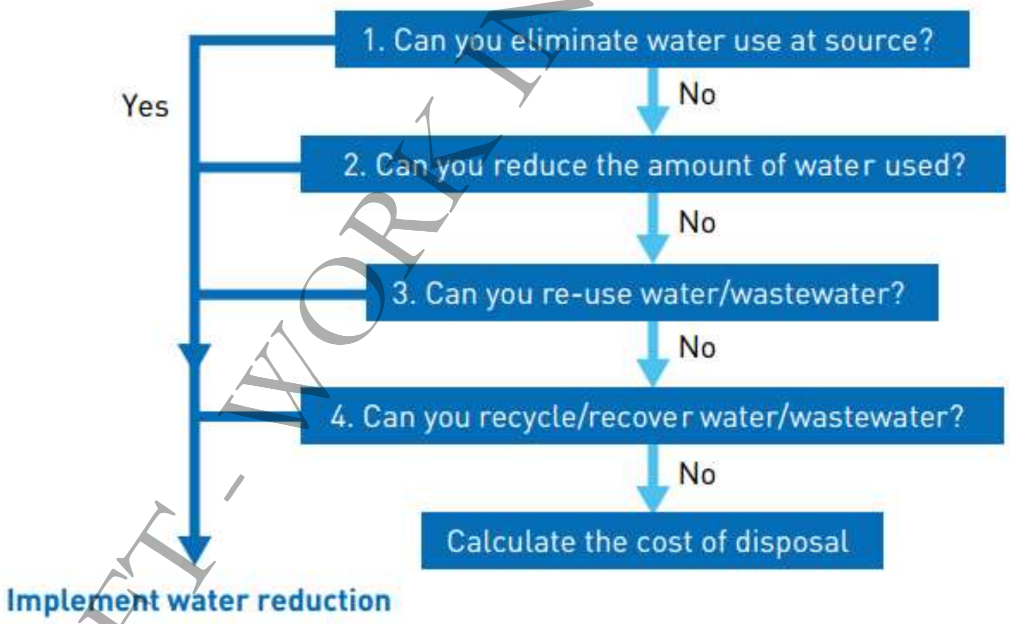

Figure 2-9: Waste hierarchy applied to water

<u>Technical solutions</u>

Water efficient taps, WCs and showers

Low flow taps and showers can enable significant water consumption reductions. Savings will depend on existing fittings (if retrofitting) and water pressures in the area if flow rates are not capped by the device.

Dual/variable flush or siphon mechanisms for WCs can save 4 litres per flush (WRAP 2013).

For individual water using devices such as taps, showers and WCs, the performance of products bearing the EU Ecolabel[3] can be considered best practice. In terms of maximum available water

[3] Further information on the EU Ecolabels for sanitary tapware and flushing toilets and urinals is available at: http://ec.europa.eu/environment/ecolabel/products-groups-and-criteria.html

flow rates, the criteria that EU Ecolabelled tapware products must fulfil are (European Commission, 2014a):

- Kitchen taps (without flow limiting device) shall not exceed 6,0 l/min, with flow limiting device[1] shall not exceed 8,0 l/min
- Basin taps (without flow limiting device) shall not exceed 6,0 l/min, with flow limiting device[1] shall not exceed 8,0 l/min
- Showerheads and showers – shall not exceed 8,0 l/min. Showerheads and showers with more than one spray pattern shall fulfill the requirement for the setting with the highest water flow.

[1]The flow limiting device must allow for setting the default water flow rate (water-saving setting) at the value of max of 6 l/min. The maximum available water flow rate shall not exceed 8 l/min.

As for flushing toilets and urinals, EU Ecolabelled products must respect the following (European Commission, 2014b):

- The full flush volume shall not exceed 6 l/flush for flushing toilet equipment or 1 l/flush for flushing urinal equipment.
- A water saving device should be added to toilet suites with a full flush volume of more than 4,0 litres and to toilet flushing systems. When placed on the market, the reduced flush volume shall not exceed 3,0 l/flush.

Another source of information on water efficiency of taps, showers and WCs is the Water Label European Industry Scheme, which provides a water efficiency grading system. A best practice benchmark for water using devices could be taken as the most efficient band within this system:

- Taps and showers – maximum flow rate of 6 litres per minute or less (tested at a pressure of 3 bar)[4]
- Dual flush WCs – average flush volume[5] of 3.5 litres or less

The best practice in BREEAM[6] sustainable building standard are lower, as follows:

- Taps – maximum flow rate of 3 litres per minute.
- Showers – 3.5 litres per minute.
- Urinals – waterless urinals
- WCs – average flush volume of 3.5 litres or less (BRE, 2012,p241)).

There are additional technical "hardware" solutions, for example (WRAP, 2013):

- Installing push button showers or ball valves
- Fitting older 9 litre cisterns with Hippos / Save-A-Flushes (these devices reduce the flush volume by up to 3 litres by displacing this with their own volume)
- Fitting electronic taps with infrared hand sensors or self-closing taps.

Once water efficient devices have been installed, it is also important to maintain them regularly. Limescale and soap can cause jamming of mechanisms leading to dripping (WRAP 2013).

Pressure reducing valves

Pressure reducing valves (PRVs) may be necessary if mains pressure is causing excessive flows at taps. For example, tap flow rates of 60 litres per minute can occur if there is a gravity fed system in a 14 storey building. PRVs can be located in various locations e.g. at the incoming mains, or at each floor (WRAP, 2013 b).

[4] It should be noted that electric showers can be relatively carbon intense despite low flow rates depending on the energy mix of the country-specific national grid, hence these would not necessarily be recommended.

[5] The average flush volume for dual flush WC Suites and Cisterns is calculated as (A + (3 × B)) ÷ 4, where A is the full flush value and B is the low flush value.

[6] BREEAM (Building Research Establishment Environmental Assessment Methodology) was first published by the Building Research Establishment (BRE - UK) in 1990. Globally, it is the most widely used method of assessing, rating, and certifying the sustainability of buildings.

Rainwater harvesting systems
Rainwater collection capacity can broadly be calculated using the following equation:

Rainfall harvest (litres) = rainfall (mm/annum) x area (m^2) x runoff coefficient

The runoff coefficient takes account of the fact that not all water reaches the collection tank – some may evaporate once it stops raining. The runoff coefficient is typically 0.8 but varies depending on the roof surface, e.g. (Khoury-Nolde, no date; p. 5):

- Plastic / metal surfaces - 0.8 – 0.9
- Cement – 0.75
- Clay tiles – 0.5

Table 2-13: Typical volumes of rainwater collected for different roof sizes and rainfall (Envirowise, 2008)

Y (m^3)	Rainfall (metres/year)					
Surface area (m^2)	0.4	0.6	0.8	1.0	1.5	2.5
100	32	48	64	80	120	200
200	64	96	128	160	180	400
300	96	144	192	240	360	600
500	160	240	320	400	600	1000
800	256	384	512	640	960	1600
1200	384	576	768	960	1440	2400

<u>Identifying leaks</u>
There should be regular monitoring of the building when vacant. If meters are showing water use above zero, this highlights a leak somewhere in the building.

<u>Occupant behaviour</u>
One of the easiest and cheapest ways of reducing water consumption is through encouraging behaviour change. All staff should be aware that the organisation is working to save water and that they are a crucial part of this effort. Campaigns can be run that include:

- Posters / stickers next to water using devices in bathrooms / kitchens
- Accessible information on how to report dripping taps and other water issues
- A water champion who can be a point of call and help promote water awareness and saving

<u>Outdoor areas</u>
Outdoor areas should be designed to require minimal / no irrigation. This can be achieved by choosing drought-resistant plants and trying to conserve water in the soil e.g. by using mulches.

Examples of drought tolerant plants can be found using online directories, for example *Drought Resistant Plants* (Royal Horticultural Society, 2014) or *Repertoire des Plantes a ne Jamais Arroser* (Saint Jean, 2014). Drought tolerant plant lists must be regionally relevant as clearly suitable plants vary with climate.

Achieved environmental benefits

The main environmental benefit to implementing this BEMP is saving potable water, a very valuable resource. This is particularly true taking into account the high environmental burden of transporting from far away and/or treating the water to reach the quality needed for drinking and treating the waste water (grey and black water) before these are being returned to the natural water cycle, which is energy and carbon intensive. For instance, the embodied carbon of a litre of potable tap water in the UK is 0.79 gCO_2/litre (Water UK, 2011, quoted in Bull, 2014). Reductions in hot water use will also save energy, again leading to reduced carbon emissions.

Appropriate environmental indicators

- Water consumption (m3 /full time equivalent person / year) or
- Water consumption (m3/m2 internal floorspace/year)

  Of which (if relevant):
  - Mains water consumed (m3 / full time equivalent person / year) or
  - Mains water consumed (m3/m2 internal floorspace/year)

  - Harvested rainwater consumed (m3 / full time equivalent person / year) or
  - Harvested rainwater consumed (m3/m2 internal floorspace / year)

  - Recycled greywater consumed (m3 / full time equivalent person / year) or
  - Recycled greywater consumed (m3/m2 internal floorspace/year)

Generally it is more useful to use the per person indices as these take the main variable into account.
Additionally it is useful to state the same data in litres per full time equivalent person per day (using business year of 253 days per year) (Waggett & Arotsky, 2006).

Cross-media Effects

There are no cross media effects from the implementation of this BEMP.

Operational data

This section sets out case study examples of different size, which demonstrate some of the methodologies outlined above and represent best practice.

<u>*Case study: Libourne Town Hall, France*</u>
Libourne Town Hall, France, installed flow regulators on 42 taps at its town hall. The capital cost was 650 euros and they have been able to save 1,350 m3 / year, with a payback time of 8 months (EPBV, 2009).

<u>*Landeshauptstadt Hannover*</u>
The city council of Hannover began an internal energy and water saving programme for its offices in the year 2000. This is an incentive scheme for staff within office buildings. Taking part is on a voluntary basis but there are financial benefits. Saved costs are returned for the benefit of the building – 30% of savings are ringfenced for improvements in the working environment and 40% of savings for energy saving capital equipment. In terms of water costs, it was found that an average of 8.5% were saved (Hannover, n.d.).
Once human resources have agreed a project, an "Oekoteam" (eco team) is formed who are trained by external experts in energy and water saving. In situ, the experts and eco team together develop a series of measures for the building, which are then implemented by the team and other colleagues internally as necessary, as well as suppliers such as cleaning contractors. Any retrofitting e.g. switching to low flow taps is also carried out by contractors as necessary. Once the measures have been implemented, results are presented and publicised and premiums paid.
One building where the project was implemented was Hannover Town Hall. Here water is used for catering, public and staff WCs, wash hand basins in the public toilets, staff tea and coffee-

making facilities, wash hand basins in the offices, showers and in the kindergarten. Total average annual consumption is almost 9 million litres costing 30,000 euros.
Initially, an audit was completed at the public and staff toilets and washing facilities. Flow rates were measured at each basin. WC cisterns, their flush volumes and any water saving functions were inventoried.
This was followed with retrofitting of water efficient devices. Hand basins in the offices were fitted with aerators at a cost of 1.50 euros each and flow rate was capped to 6 litres per minute at the angle valve. Washbasins in the toilets were fitted with aerators that cut the flow rate to 1.7 litres / minute (most taps had previously been set to 14 litres / minute). Push button taps that were unsuitable for aerators had their operation time regulated for 10 to 15 seconds instead of 7 to 37 seconds as had been the case previously. For the older toilet cisterns, weights were fitted to counterbalance the lever action, so that the the WC only flushed whilst the handle was being pressed. Stickers explaining this were placed on the cisterns.
Furthermore Ecoteam members were responsible for explaining the new water saving measures at routine staff meetings. Water consumption was monitored weekly at the building's three water meters.

After the implementation of the measures above in October 2002, water consumption decreased from $25m^3$ to just over $22m^3$ a day, and these savings have been sustained. This remained the case despite several major events being held at the Town Hall (Display-Campaign, 2014).

Case Study – UN City complex

Officially opened in July 2013, this building is the location for eight UN organisations located in Copenhagen on an artificial island by the North Harbour district.

UN City captures nearly three million litres of rainwater per annum. This enables WCs to be flushed on average 5,300 times per day throughout the year, almost all the water needed for WC flushing in the building. Additionally, there are efficient water using devices installed. There are low flow taps fitted with aerators, low flow showers and low flush toilets. Together, these features have resulted in more than 60% reduction of total water use in the building's WCs, showers and kitchens (Reyes, 2013 / Official Website of Denmark, no date).

Bristol City Council

Bristol City Council's target is to reduce water consumption by 3% year on year and has managed to achieve a reduction of around 37% since 2009 (Figure 2-10). In the last two years there has been the additional positive benefit of a carbon saving of 23 tonnes CO2 (using UK government carbon factors for mains supply and sewerage) and a financial saving. Other indirect benefits include reduced sewerage loads, reduced demands on mains drainage and reduced demand for chemical treatment of supplied water.

In terms of office buildings, in 2012/13, water consumption was equivalent to 5.7m3/employee compared to 6.02m3/employee in 2011/12 (Bristol City Council, 2014).

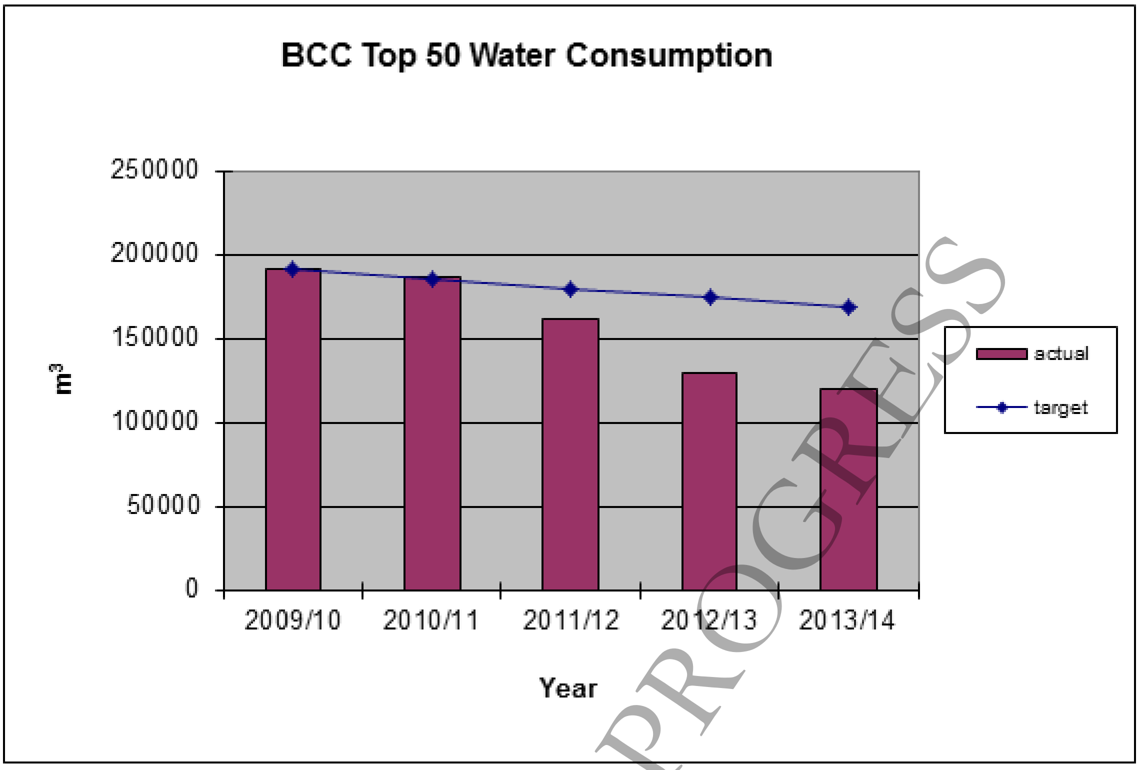

Figure 2-10: Water consumption of top 50 sites, Bristol City Council (Ransom, 2014)

Bristol Council, working closely in partnership with Bristol Water, monitors all high consuming sites for water consumption to provide accurate data analysis and identify trends and leaks for further work or resolution. Leaks have been dealt with and the highest consuming sites have been identified and as a result a number of initiatives to reduce its water consumption have been undertaken.
This includes:

- Installing waterless urinals at the larger offices
- Installation of rainwater harvesting at key sites including the City Hall and the Create Centre.
- 100 Save-A-Flush devices installed in older council buildings

Bristol City Council has also managed to reduce water use in outdoor areas. Water used in horticultural operations was minimised by selecting drought tolerant flowers and replacing annual plants with perennials that are less water intense. There is a plan to replace water thirsty trees with those which only require watering in a very dry summer, instead of weekly, thus making further water savings.
Additionally, new horticultural features have been planted close to newly planted trees to benefit from shared resources, promoting better germination and establishment with less watering. The Council has also fitted drainage reservoirs in hanging baskets which better retain the water and again reduce the level of watering requirement (Ransom, 2012).

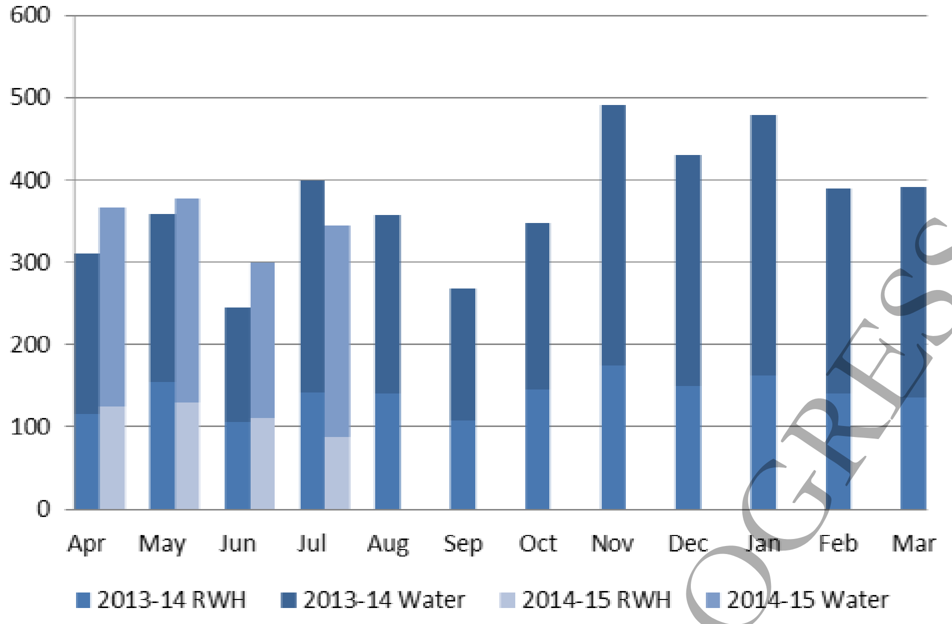

Figure 2-11: Mains and rainwater use (m3 per month)(Worsfold, 2014, pers.comm., 14 August)

Rainwater harvesting from a large roof feeds a 70m3 underground storage facility. Rather than a conventional storage tank, a system of 1350mm diameter pipes was used, which avoids the need for deep excavations. Combined with water saving appliances, potable water consumption has been reduced by 40%[7].
The water using devices include push button taps, dual flush WCs and low flow showers.

Applicability

The technique described in this BEMP is applicable to all office buildings. It has environmental and economic benefits whether the building is rented or owned even though there may be more restricted actions possible in rented buildings.

This BEMP is particularly relevant to areas prone to water stress due to their geographical location e.g. Southern Europe. **Figure 2-12** comprises a water stress map of Europe showing regions with low, medium and severe water stress. However, even in an area of apparent low water stress, this BEMP applies as it can be a function of the geology and climate of an individual river catchment, as well as the varying weather patterns. Also, there is always an environmental benefit with saving water because of the avoided energy / carbon / environmental cost to supplying potable water and treating waste water.

[7] Sometimes large volumes of harvested water are also used for the washing on site of archaeological finds.

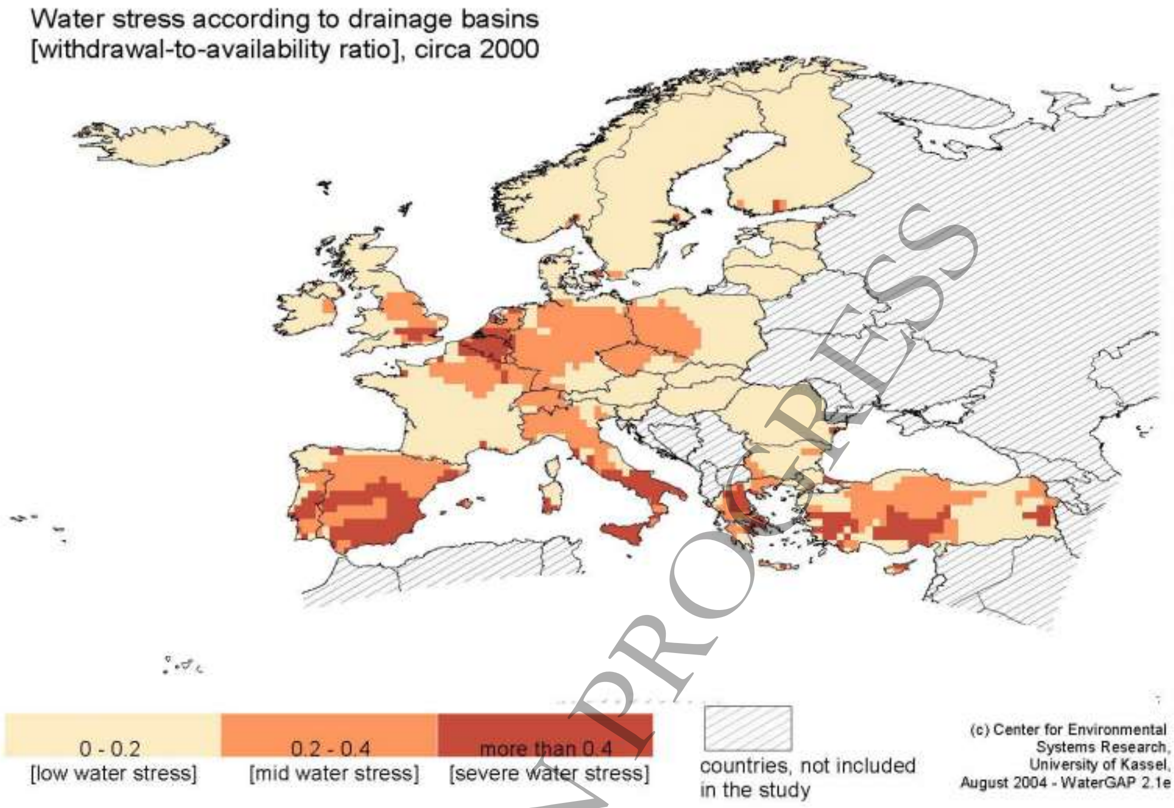

Figure 2-12: Water stress in Europe (Floerke and Alcamo, 2004, p50)

Economics

Minimising water consumption in offices can deliver financial savings equivalent to an estimated 30% of reduced water bills (figure applies to businesses, WRAP, 2011). In Europe, water costs on average €3.25 per m3 (EPBV, 2009). A 5mm stream of water flowing from a tap can use 528,000 litres (528m^3) of water/annum, costing about €1,300 for cold water, but up to €5,100 if the water has been heated. A dripping tap wastes at least 5,500 litres of water / annum (WRAP UK, 2013). Below are some examples of possible savings through water management and investments:

- Tap aerators and flow restrictors are low-cost solutions which can reduce water use of basin taps by up to 70% (WRAP, 2013).
- Replacement of an 11 litre single flush WC with a low flush 4 litre or 4.5/3 litre dual flush WC, water savings of 170 litres per day can be achieved (assumes relatively high utilisation rate of 50 flushes per day). It is usually expensive to replace old WCs, except as part of a whole building upgrade / major refurbishment, due to the low cost of water (WRAP, 2013).
- There is an estimated 10-20 year payback on rainwater harvesting system installations. Variables affecting payback include climate and building characteristics (Khoury-Nolde, no date).

As well as saving directly on water and effluent charges, there are possibilities for savings elsewhere in the value chain, including cost of energy to heat water and cost of wasted energy (e.g. heating system pumps).

Driving forces for implementation

Public Administrations are implementing water savings measures to reduce water costs as well as energy costs and carbon taxes payable, if applicable. They help ensure business continuity (security of supply) and enhance reputation. The implementation of energy management can also be dictated by environmental consciousness and/or the need to deliver water resource and carbon savings according to political targets. When an effective water management system is implemented specifically for public administration offices, it can play the additional role of demonstrating best practice. For example the water policy, water consumption data, key performance indicators and actions can be made public.

Reference organisations

Liborne Town Hall, France
Cost benefits of installing flow regulators at town hall taps

UN City Complex, Copenhagen, Denmark
Demonstrates rainwater harvesting and water management at state of the art UN Building

The Hive, Worcestershire Council, UK
Demonstrates water management at the building level, including rainwater and mains water.

Bristol City Council, UK
Demonstrates reductions in water use through water management and reducing water demand in outdoor areas.

Hannover City Council, Germany
Outlines an incentive scheme for reducing energy and water use in Hannover's municipal office buildings, with a case study of Hannover Town Hall and water efficiency retrofits implemented.

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2.3 Managing and minimising waste production

Description

This BEMP covers the managing and minimising of waste production for public administration offices. Office waste typically comprises:

- Paper (white paper, printed matter e.g. magazines)
- Packaging including envelopes
- Other non-hazardous waste (e.g. office consumables, office furniture, disposable cups)
- Waste electric and electronic equipment e.g. lighting, computing equipment
- Hazardous waste e.g. printing toners. Computing equipment can contain pollutants such as arsenic in diodes, flame retardants in screens, heavy metals in circuit boards, but also recyclable materials such as metals (ADEME, 2012).

Offices may typically produce less waste than other sectors (e.g. domestic / manufacturing), however a typical worker in the service sector can produce 120 – 140kg waste per year (ADEME, 2012). There is potential for reducing this significantly and achieving recycling rates of over 70%.

Waste management at all levels should follow the so-called waste hierarchy[8] where first waste should be prevented, followed by reuse (with no / minimal processing), recycling (reuse of the material after processing), then energy recovery, with disposal to landfill as a last resort – see Figure 2-13.

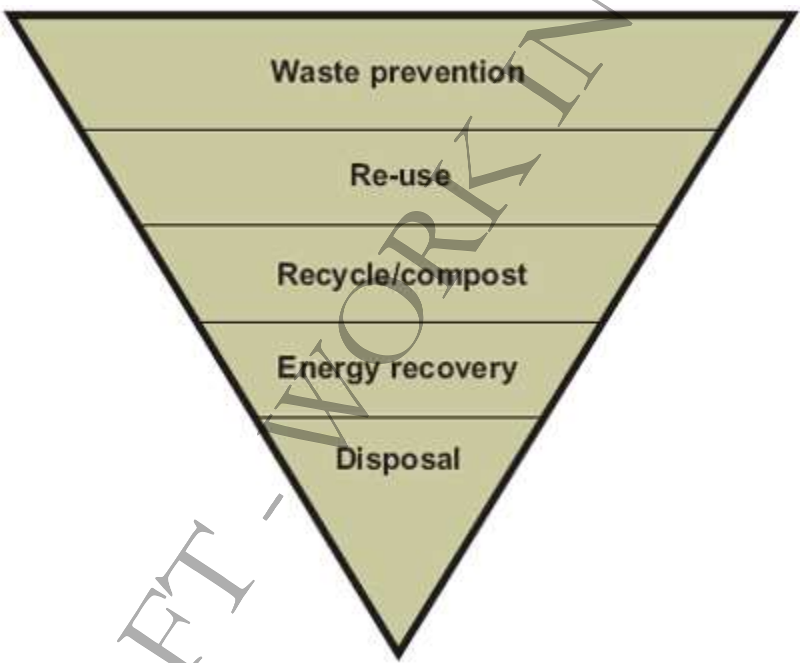

Figure 2-13: Diagram depicting the waste hierarchy (Defra, 2010). The most preferred option is at the top and the least preferred option is at the bottom of the hierarchy. Disposal refers to landfill.

A strategy for an office building based on the waste hierarchy would broadly comprise:

- Prevention
- Promoting reuse
- Establishing infrastructure that enables segregation for recycling
- Monitoring and reducing residual waste

The above should be implemented by means of a waste management approach following the principles of PDCA - Plan, Do, Check, Act , as per environmental management systems such as

[8] The concept of waste hierarchy is laid out in the European Waste Framework Directive (Directive 2008/98/EC).

EMAS and ISO 14001. This sequence facilitates continuous improvement and allows those responsible to be proactive (IEMA, n.d.).

For management of waste produced from office canteens and coffee bars see also Section 2.6 and for waste generated by events see Section 2.7.
Effective waste management is a comprehensive approach that requires buy in from management, building managers, contractors and building occupants.

Waste prevention and reuse
The initial approach should always be to avoid waste. There are some suggestions below for how this can be implemented:

- Paperless procedures/archives
- Employees can have their own cups and pens, which are refilled rather than using disposables.
- Systems can be created to enable reuse such as for office furniture or IT equipment. This will probably involve a well organised physical storage space coupled with an online inventory. Where there is no need for the items, administrations could resell these. They could be offered to staff in the first instance and then offered to third party organisations such as community groups.
- Equipment could be leased rather than purchased (e.g. printers) as then service providers are incentivised to use durable equipment, thus steering away from buying products that are built for obsolescence. When it is preferable to buy equipment, appropriate durability criteria should be included in the technical specifications.
- Green procurement policies should ensure that the whole product lifecycle is being considered rather than just price – this could involve purchasing more durable products, which in some cases may cost more. Minimal packaging should also be considered in any criteria. Detailed criteria for Green Public Procurement (GPP) are available for various products including cleaning products and services, furniture, etc. (European Commission, 2014). See also Chapter 12 on green public procurement**.**
- Reuse should be promoted with employees and awareness raised. There may be added social benefits such as helping charities e.g. donating computers which are no longer needed. Reuse facilities could be extended to items staff can bring from home, including IT equipment, batteries, textiles, etc., and reported separately.

Increasing recycling rates
Robust infrastructure for segregated waste collection should be made available throughout the offices and this must be integrated with the waste streams that can be recycled by the contracted waste management company. Staff should be trained in the importance of waste segregation. This includes cleaning staff, who are often in charge of emptying the different bins into larger containers.
The design and signage of waste bins is important – signs hung above waste bins can flag their location from a distance and bins should be colour-coded and labelled with wording and images to demonstrate types of waste suitable for each bin. For major waste fractions (such as paper), it is best practice to make bins available wherever there is a residual waste bin so that the option to recycle is facilitated.

Management aspects
As with environmental management more broadly, measurement and monitoring is necessary. This will record the disposal routes (e.g. recycled, composted or landfilled) and progress made towards targets. Regular waste audits are necessary to ensure that there is minimal contamination and to highlight any additional waste streams which do not yet have a reuse or recycling route.
In some cases on-site balers for paper / cardboard may be cost effective. This equipment compress the waste on site reducing storage space required and can enable a return-on-investment, depending on the amount of waste produced, by reducing how often this waste fraction needs to be collected from the office building.

Part of the management role is for all staff to be made aware of the issues. Awareness campaigns could be run, making use of posters, signs and educational guides distributed to staff. There could be a central sustainability hub where information on waste segregation and advice is provided. Alternatively, a nominated waste officer could carry out training in situ, for example around employees desks and ensure that every employee understood the aspirations and nature of each waste stream.
Checks and sanctions could be put in place. This could include regular monitoring of waste with results possibly displayed. There could be inter-departmental competitions set up, departments with the least waste and wrong segregations receiving prizes.

Setting targets
Targets can be set on the basis of available benchmarks but will depend on size of the office and facilities e.g. whether it has a canteen or not. However, this can be helped by normalising performance figures per employee.

Leeds City Council has a target recycling rate of 50% by 2020. The Council measures total waste (tonnes), recycling rate (%), waste to landfill (%) and hazardous waste. Targets are to increase recycling year on year, reduce waste at source and reduce waste to landfill (Leeds City Council, 2013).

Achieved environmental benefits

Minimising the amount of waste generated and maximising re-use and recycling rates have the following environmental benefits:
- Save virgin resources
- Reduce processing energy – recycling materials uses less than extracting and processing virgin materials
- Save on lifecycle energy and carbon involved in producing products and transporting them to the end user.

Appropriate environmental indicators

The most common indicators are shown in **Table 2-14** alongside their rationale:

Table 2-14: Suggested waste management / minimisation indicators alongside their rationale. Separate collection rates should be further broken-down by waste stream, e.g. white paper, glass, plastics, other recycling, WEEE.

Indicator	Rationale
Tonnes office waste per full time equivalent employee per year (tonnes/employee/year)	This shows the effectiveness of the waste prevention measures.
Total office waste reused as a % of total waste by weight (%)[9]	This shows the effectiveness of the waste prevention measures.
Total office waste recycled as % of total waste by weight (%)	This shows whether the infrastructure for segregated collection is fit for purpose and reflects employee behaviour.
Total residual office waste as % of total waste by weight (%)	This shows whether the infrastructure for segregated collection is fit for purpose and reflects employee behaviour.

[9] Reuse is difficult to quantify but worth measuring, monitoring and incentivising. Depending on reuse systems implemented, there could be a database with weights assigned which is used every time an item is sold or donated. Alternatively, any decreases in purchasing of certain equipment could be monitored following actions such as introducing a central stationary cupboard.

Cross-media effects

There are no cross media effects with the implementation of this BEMP.

Operational data

This section sets out case studies that demonstrate some of the methodologies outlined above and represent best practice.

BARCELONA CITY COUNCIL, Spain

Barcelona City Council has long been committed to sustainability since the 1990s. They introduced a Sustainable City Council (SCC) programme in 2009 as part of their Agenda 21. As well as making the city more sustainable, this included reducing their own social and environmental impact and publicising information that will help others to do the same.

They established a Green Office Programme which included a variety of activities. Many of these were focussed on reducing the use of paper, estimated in 2006 to be about 60% of the waste generated. This included switching to electronic systems for note-taking, reports and Christmas cards and promoting double sided printing using stickers on photocopiers (Ajuntament de Barcelona, 2006). Further information focussed specifically on paper is available in Section 2.4.

A robust recycling infrastructure has been introduced including paper, packaging, glass and residual waste streams as well as toner cartridges. Appropriate bins are placed strategically e.g. next to coffee machines. Specially designed boxes were made available for individual workstations to collect waste paper for reuse. A toner recycling service is available, which also allows staff to recycle toners brought in from home. Computers, photocopies and other office machines that are no longer required but still usable are donated to charity. In the year 2000, 407 computers were donated to NGOs (Ajuntament de Barcelona, 2000).

Dissemination of information to council staff is assured by educational guides, posters throughout the offices e.g. promoting the use of recycling bins, and face to face. The latter includes training tailored to the specific audience and information desks at building entries publicising information, advice, forthcoming activities and other news around the Green Office Programme – for example at the Coll Civic Centre (Ajuntament de Barcelona, 2006).

An appealing Green Office Guide designed specifically for the staff at the Council was produced in 2000 and distributed to 12,000 staff. It provides advice on a variety of sustainability themes including waste minimisation. It recommends actions including:

- Placing a box next to each workstation to collect paper for reuse (i.e. with a blank side)
- Avoiding products made of mixed materials e.g. plastic covering on paper file, to facilitate segregation at end of life
- Avoiding individually packaged products
- Where possible, avoiding procurement of supplies which contain toxic substances (e.g. solvent based glues)
- Choosing refillable products
- Choosing quality non-consumable products (e.g. pencil sharpeners, scissors, trays) which will therefore have an extended life
- New toners and ink cartridges can only be obtained by handing in an old one

Recycling figures for Barcelona council offices are shown in **Table 2-15**.

Table 2-15: Recycling figures for council offices (Ajuntament de Barcelona, nd)

Waste stream	2004	2008	2012
Paper	74%	73%	73%
Glass	18%	54%	82%
Light packaging	12%	20%	42%
Organic matter	-	-	25%
Toners	-	-	61%

<u>*LONDON SCHOOL OF ECONOMICS (LSE), UK*</u>

LSE first published its Environmental Policy in 2005, gaining ISO 14001 certification in 2012. Having the right management and governance structure has strongly influenced how well their environment and sustainability targets have been received and delivered. The School has a zero waste to landfill policy which was achieved last year and continued this year.

LSE participates in an environmental awareness scheme called Green Impact which includes waste training for office staff provided by a dedicated Sustainability Officer dealing with waste and procurement. The training includes 15 minutes covering how to avoid producing waste and a question and answer session on what goes in each bin. The training sessions are carried out during lunch time or as part of other regular meetings. It offers the opportunity for the Sustainability Officer to visit staff in their working environment and get a feel for how they use their space and what sort of waste they have. The Sustainability Officer, found that she gets a lot of questions about what to do with odd items and especially about what happens once the items are collected.

Most office spaces have access to teapoints / kitchenettes which use tableware (i.e. non-disposable cups / cutlery). The catering team sells LSE branded durable drinks holders and are planning to introduce reusable water bottles too.

LSE prioritises reuse - in 2013/14, 52% of internal requests for furniture items were met through reuse of internal furniture. LES also runs a small scheme for reuse of office stationary, and recently installed a textile recycling bin on campus for staff and students. In 2014, LSE also sent 3,000 books to be reused by libraries.

LSE has invested heavily in internal infrastructure. They implemented a four bin model:

- paper and cardboard
- mixed recyclables
- compostable waste
- residual waste

There are also special recycling points in office reception areas for batteries, phones, CDs and toner cartridges.

The branding and signage are really important, as they prompt staff to act as well as by clarifying which is the correct bin for which type of waste – see **Figure 2-14** and **Figure 2-15**.

Figure 2-14: Bins in kitchen area, including facilities for CDs, mobiles, batteries etc (Rivilla Lutterkort, 2014 (b)).

Figure 2-15: Bins in general office area – specific paper recycling bin is available. Recycling bins are being slowly substituted for larger bins / bins with larger apertures (Rivilla Lutterkort, 2014b).

Staff know that for anything else they can contact the helpdesk which will then direct all enquiries appropriately.
As part of the environmental management system (ISO 14001), monitoring is considered key. This is particularly the case for waste, where duty of care also comes into play. The Sustainability Officer works with contractors and cleaners to produce comprehensive annual waste data and ensure targets are being met. There are two main aims:

- Zero waste sent to landfill
- Push materials up the waste hierarchy, i.e. preferring reuse to recycling, and recycling to energy from waste.

In terms of data collection, LSE obtains monthly information for “normal” waste (paper, card, general waste, glass, composting, mixed recyclables). The contractor carried out sample weighing and then when they collect they note containers fullness (100%, 75%, 50%, 25%). This is used to derive a calculated weight:

% fullness x average weight of material in that container size x collections made in month

For other wastes (wood, metal, batteries, WEEE, furniture, construction & maintenance waste), data is collected in a more ad hoc manner. For furniture they keep track of item numbers and type and associate them with an average weight at the end of the year.

LSE are developing data collection processes and have just started an exercise to weigh waste and draw information out about types of waste by floors/departments.

Reporting is carried out annually with roughly a 6 month lag from the year end (Rivilla Lutterkort, 2014 (b).

Figure 2-16: shows percentage of total waste that has been going to landfill since 2009.

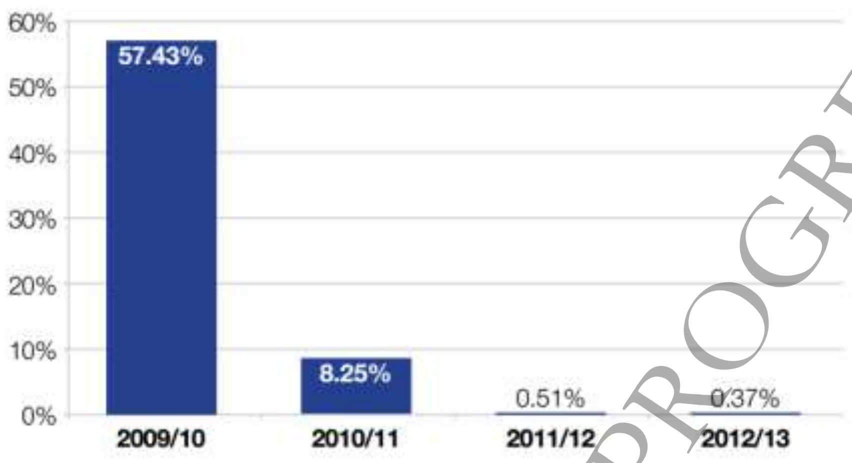

Figure 2-16: LSE Percentage of waste sent to landfill (LSE, 2013, p6)

Figure 2-17 shows the end destination of waste produced by LSE in 2012/13. A total of 55% was reused or recycled.

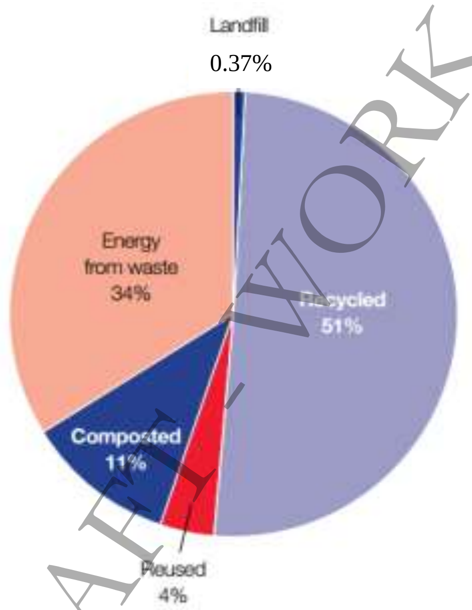

Figure 2-17: End destination of waste produced by LSE in 2012 / 13 (LSE, 2013, p6).

TARBES, FRANCE

In 2008, the city of Tarbes launched a sustainability initiative for its internal operations, called "Mairie Eco-Responsable". Waste management is one of the main strands of the initiative alongside responsible procurement, energy and transport.

Tarbes offices have enabled recycling of paper, batteries and pens (metal / plastic). A system has been set up for reusing office furniture internally. Where there is not a requirement for the piece of furniture, it is offered for reuse outside of the council (Tarbes, 2014).

SUNDERLAND CITY COUNCIL, UK

Sunderland City Council launched a furniture reuse scheme in 2011, run by WARPit (the Waste Action Reuse Portal). The scheme was established following the closure of several buildings in 2010 following restructuring. This meant there were significant amounts of waste furniture. Rather than disposing of these, an online inventory of available furniture, stationary and other supplies was established. When a member of staff requires any items, they see whether the item is available online and then arrange for it to be collected from the original department via a central storage facility.

It is easy to enter new items onto the system. Where items are not picked up within a few days, they can either be sent to the central storage facility or donated by "friending" other organisations on the WARPit website.

There are disclaimers in place for electric items saying that the beneficiary will test appliances in compliance with regulations.

As a result of this initiative, Sunderland Council saved over £400,000 in 2.5 years following an investment of only £6,000, through reduced procurement of new goods and waste management costs. An estimated 50 tonnes of waste have been saved and over 1000 staff have used the system (WARPit, 2014).

ABERDEENSHIRE COUNCIL, UK

Over the last 7 years, various ongoing initiatives in council premises have seen a 21% increase in the amount of waste collected for recycling and a 13% decrease in the amount of residual waste sent to landfill by March 2013. This has been enabled by recycling bins that were provided to all Council buildings. There was a roll-out of new recycling bins for additional waste streams during 2014 including food waste.

Other initiatives include regular WEEE and battery collections as well as free toner and cartridge collections, and an online internal furniture and resource reuse scheme, Requip. This enables internal sites to share assets and avoid purchasing new items and reuse existing resources. The internal website is used to publicise new initiatives and service updates with staff, as well as promoting ongoing waste management practices (e.g. avoiding unnecessary printing, avoid using paper cups, reuse and recycle resources). Good practice has been disseminated by getting articles featured in local press and recycling company newsletters.

Aberdeenshire manages internal waste minimisation by means of a dedicated Waste Minimisation Officer, for which a role was created in 2008 (Remade Scotland, 2009).

Applicability

This BEMP is applicable for all public administrations throughout Europe. However, the different fractions in which waste is segregated should reflect the local availability of recycling services for particular waste types and costs in different countries. Certain practices may be more appropriate for larger offices and some for smaller. For example, a formal on and offline system for furniture reuse would only make sense for larger organisations or for a number of smaller organisations running a common scheme.

Economics

An effective waste management strategy (with a good focus on prevention) can enable significant reductions in purchases. For example spend on disposable cups can be entirely avoided, and refills are generally much cheaper than new disposable items. As for more durable equipment, although the purchasing cost may be higher, significant reductions in life-cycle cost[10] can be achieved.

Markets for recycled goods are global and heavily fluctuate hence costs of recycling can vary to a large extent. However as a general rule, recycling can be cost effective and sometimes cost recovery is available e.g. for baled cardboard. Table 2-16 shows some sample prices for different disposal routes for waste in the UK. Although these prices are for waste management companies, they will be reflected to some extent by end costs paid by the waste producers.

Table 2-16: UK gate fees report 2012 - costs in £ per tonne (WRAP, 2012)

Treatment	Grade / material / type of facility	Median	Range
MRF	All	£9	-£66 to £73
	Contracts starting in 2011 or later	-£26	-£55 to £4
Organics	Open-air windrow (OAW)	£25	£15 to £53
	In-vessel composting (IVC)	£44	£28 to £60
	Anaerobic digestion (AD)	£41	£35 to £60
Wood Waste	All grades/types collected from HWRCs	£26	£0 to £70
	Gate Fees for end use markets:		
	Animal bedding	-£44	-£130 to -£12
	Panelboard	-£22	-£36 to -£12
	Biomass	-£21	-£38 to £25
MBT		£79	£65 to £84
EfW[7]	Pre-2000 facilities	£64	£32 to £75
	Post-2000 facilities	£82	£44 to £101
	Defra Gate fee data		
	<200kt	£90	£79 to £131
	200kt to 300kt	£76	£56 to £102
	350kt to 450kt	£68	£57 to £78
Landfill	Non hazardous waste gate fee only	£21	£9 to £63
	Non hazardous waste gate fee plus Landfill Tax	£85	£73 to £127
	Hazardous waste gate fee (code 17 05 03)	£29	£23 to £50
	Hazardous waste gate fee (code 17 06 01)	£85	£40 to £95
	Hazardous waste gate fee (code 17 06 05)	£40	£30 to £60

Recycling has been incentivised by landfill taxes in Europe. The tax now exists in 20 European countries and rates are on the increase (Fischer et al, 2012).

Driving force for implementation

Drivers for managing and minimising waste consumption in public sector offices are environmental, financial and social.

Avoiding purchases clearly lower procurement costs for supplies required by offices, and recycling often costs less than landfilling residual waste. It is estimated that local authorities can spend millions unnecessarily on landfill taxes (Shankleman, 2013).

There may be social drivers such as helping charities benefitting from reuse opportunities e.g. reuse of computers.

Implementing the BEMP is also likely to reduce risk of non-compliance with legislation, help ensure business continuity (security of supply) and enhance reputation.

When an effective waste management system is implemented specifically for public administration offices, it can play the additional role of demonstrating best practice. For example the landfill diversion figures, recycling rates and actions can be made public.

Reference organisations

Barcelona City Council (Spain)

Barcelona has run a long term and pioneering Green Office Programme incorporating actions on waste reduction and increasing recycling.

[10] Lifecycle costing is a technique for estimating the total cost of ownership. It allows costs between different options to be compared over a set timeframe, taking initial capital costs and future operational and asset replacement costs into account (European Commission, 2014).

London School of Economics (UK)
Recycling activities, waste streams and embedding processes with staff. Success demonstrated by reduction in waste to landfill.

Tarbes (France)
Recycling offered for various waste streams, internal furniture reuse scheme.

Sunderland City Council (UK)
A successful furniture reuse scheme.

Aberdeenshire Council (Scotland, UK)
Increase in recycling and reductions in waste to landfill, employment of a dedicated officer.

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2.4 Minimising consumption of paper and consumables

Description

This BEMP is about managing the consumption of paper and consumables in public administration offices. Consumables - often referred to as office supplies in the context of office procurement - are goods used by individuals and businesses that must regularly be replaced as they wear out or are used up. Consumables are in contrast to durable or long-lasting office goods such as computers, printers and furniture. They include:

- Paper
- Writing and stationary supplies, including pens, file folders, adhesives
- Mailing supplies, including envelopes, shipping boxes, plastic wrapping.
- Toner or ink cartridges
- Cleaning supplies
- Commercial bathroom supplies, including soaps, hand towels and tissues

Paper, in particular white A4 copier paper, is often one of the most significant consumables within an office environment. Around 80kg of paper is used per employee per annum – equivalent to 30 reams and typically constituting three quarters of office waste produced (ADEME, 2012). Elsewhere it is estimated that the average office worker uses 45 sheets of paper a day, though this could be reduced to 16 (WRAP, 2013).

Managing consumption of paper and consumables includes:

- Implementing and promoting internal procedures that help employees and other building occupants
  - avoid the use of products and materials
  - reuse products and materials, thereby reducing demand
- Using procurement to drive lower impact choices e.g. longer lasting, refillable products and low environmental impact / low toxicity alternatives.

This BEMP includes best practice around reuse of paper and consumables. Best practices for recycling at end of life are covered under Section 2.3 *'Managing and minimising waste production'*. Catering supplies are covered under Section 2.6 '*Minimising the environmental impact of canteens and coffee bars'*.

Managing and minimising consumption of paper and card

There are some easy practical actions that can be taken to avoid consumption of paper:

- Where possible, printing should be avoided. Where printing is necessary, printers can be set to print double-sided, two pages to a page of A4. E-mail footers can include a note reminding recipients to "Think before you print".
- The number of printers can be reduced to a smaller number of centralised printers.
- Employees can be given access codes so printing levels by employee can be monitored.
- A printer can be designated for draft printing, which is permanently loaded with scrap paper (WWF, n.d.)
- Paper with a maximum thickness of 80gsm should be used. It is also possible to use thinner paper e.g. 50 – 70gsm (WWF, n.d.)
- Databases and distribution lists should be kept up to date to ensure no excess correspondence and materials are distributed.
- Scrap paper with a blank side can be reused internally, as can envelopes and files.
- Subscriptions to publications that are no longer required can be cancelled (WRAP, 2013; Ajuntamento de Barcelona, 2006).

In terms of type of paper being purchased, the pulp should be unbleached (TCF) and from 100% post consumer recycled paper. Where recycled paper or paper products are using a proportion of virgin pulp, it should be certified as being from a sustainable source (Siegle, 2013). As a minimum all paper for internal use (e.g. notepads) should be unbleached. Criteria for eco labels used on paper products are shown in **Table 2-17**.

Table 2-17: Raw materials criteria for eco labels used on paper products (WRAP, 2013)

Name of label	Symbol	What the label means
NAPM Approved Recycled		The National Association of Paper Merchants awards the NAPM Recycled Paper Mark to all branded papers and boards containing a minimum 75% genuine paper and board waste, no part of which must contain mill-produced waste.
Blue Angel		Label awarded to paper and board products containing 100% waste paper (minimum 51% post-consumer waste).
Mobius Loop		There are two versions of the Mobius Loop – one denotes whether the product can be recycled, the other its recycled content. When using the latter, the percentage of recycled fibre used appears in the centre of the loop. Where the product comprises entirely recycled fibre, there is no figure. These symbols are often used without authority and in a misleading manner. Always check the basis for using these labels with your supplier.
ECF, TCF and chlorine free		**Elemental chlorine free** (ECF), chlorine gas has not been used to bleach the pulp during the pulping process. **Totally chlorine free** (TCF), no chlorine compounds have been used during the pulping or papermaking process. **Chlorine free** is often used to mean either of the above; ask for clarification from the paper supplier.
EU Eco-label		Specifies maximum limits for discharges to water, emissions to air and energy consumption as well as requiring sustainable forestry management for virgin fibre.
Nordic Swan		Awarded to paper mills meeting minimum environmental performance standards.

Standards for procurement of recycled paper

Green Public Procurement (GPP) is a voluntary instrument for public authorities in European Member states which provides processes for sustainable procurement. There are detailed criteria available for copying and graphic paper, cleaning products and services, furniture etc (European Commission, 2014). Further information on green procurement is available in Section 12.1.

Managing consumption of consumables

A culture of reducing consumption can be encouraged. One approach is to give employees their own refillable stationary e.g. their own named pens and highlighters (this is recommended by Barcelona City Council in their Green Office Guide, Ajuntament de Barcelona, 2000).

Purchases of products containing PVC such as files should be replaced, for example, with products made of renewable or 100% recycled plastics e.g. polypropylene (PP) or polyethylene (PE). Consumables should be low VOC (Volatile Organic Compounds) or VOC free (including inks, toner, adhesives, cleaning products etc). Low VOC is defined as containing less than 0 – 0.29 VOC per litre.

Where possible, consumables should be accredited by a reputable eco label.

Reuse

A central stationary cupboard could be implemented, even for large buildings. Often unused items are left in one department or desk, when someone elsewhere in the building could be using these and displacing the need for a new order of that product.

Building occupant behaviour

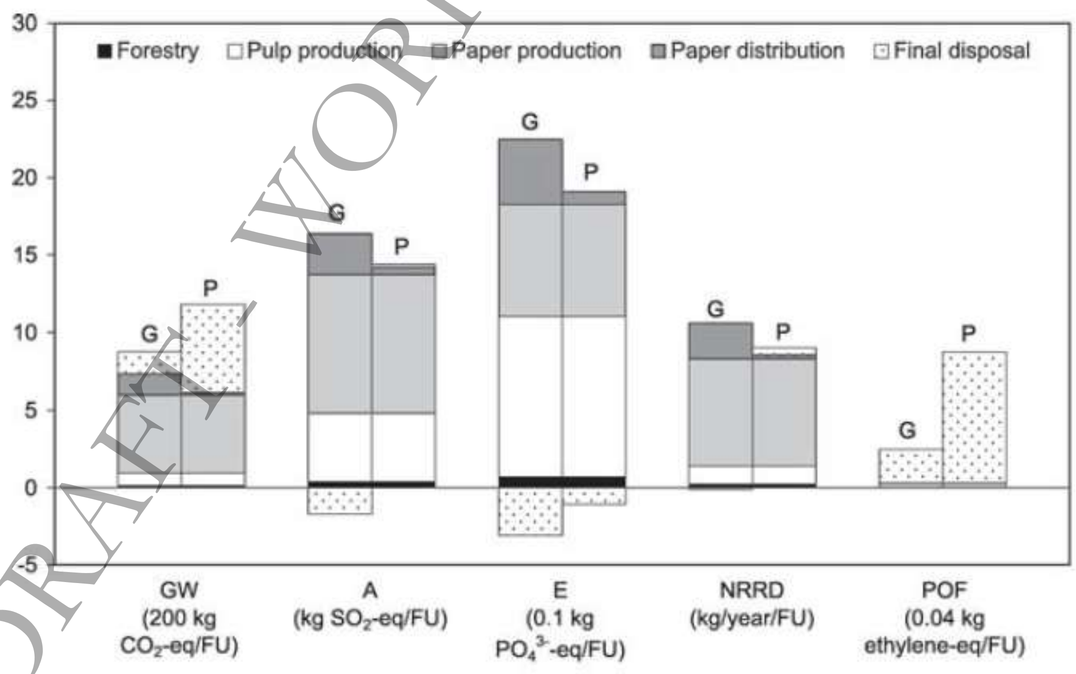
Employees can play a role in minimising the consumption of paper and consumables. Comprehensive guides can be produced for employees to ensure they are choosing the right products (if they are ordering products like stationary) and using these efficiently. Training might be required such as setting computers to print double sided perhaps two sheets to a page. There could be a hub for disseminating information, e.g. at the entrance to a building where these topics are promoted and questions can be answered.

Achieved environmental benefits

There are many environmental benefits to reducing the consumption of paper and consumables. The product lifecycle includes extraction of raw materials, manufacture, distribution and transport, use and disposal at end of life. In most cases there will also be impacts from packaging. The lifecycle impacts are particularly important for paper and consumables as the use phase of the product is relatively short.

Particular problems in relation to non-recycled paper include high consumption of natural resources (timber), water and energy, alongside water contamination and emissions to air (such as organochloride products and sulphur compounds). Emissions produced by bleaching paper are particularly harmful.

Figure 2-18 shows impact assessments carried out for paper produced in Portugal for Portuguese and German markets. The pulp production phase is particularly harmful in terms of acidification and eutrophication, with the production phase having a major impact in terms of global warming, acidification, eutrophication and resource depletion. Variations by country largely occur at the distribution and disposal phase.



- GW – Global warming indicator
- A – Acidification
- E – Eutrophication
- NRRD – Non-renewable resource depletion
- POF – Photochemical oxidant formation

Figure 2-18: Impact assessment results. G = German market, P= Portuguese market (Dias et al, 2007, p526)

Implementing actions mentioned in this BEMP will help to reduce impacts to a minimum across the product lifecycle.

Appropriate environmental indicators

Appropriate environmental indicators applicable in an EU-wide context are shown in **Table 2-18**, alongside their rationale:

Table 2-18: Environmental indicators for the BEMP on minimising consumption of paper and consumables

Indicator	**Rationale**
Paper used per full time equivalent employee (kilograms / employee / annum	A basic indicator which can easily be compared across different countries / regions. Weight of paper is easily calculated from the number of reams purchased and gsm (grammes per square metre) value.
Sheets of paper/employee/working day	A basic indicator which can easily be compared across different countries / regions. This indicator is particularly useful for people to relate to and thus more effective in communication / awareness raising campaigns.
Recycled paper/paper products made of 100% post consumer waste as % of total procured (%)	Ideally public administrations would procure 100% recycled paper; however this indicator is required where this is not yet the case to ensure steady progress towards this.
Environmental-friendly certified paper/paper products as % of total procured paper/paper products (%)	This indicator is necessary for any procurement of virgin paper (i.e. not recycled).
Cost of office consumables used per full time equivalent employee (€ / employee / year)	Cost of consumables is a convenient way of monitoring the relative amount of resource usage from procurement of non-paper consumables. Weight would prove too difficult to measure. Monitoring by weight of items over a quarter could be used to derive a factor for weight of consumables (kg) relative to cost.
Cost of consumables (other than paper) containing over 50% recycled materials as a % of total cost of non-paper consumables (%)	As above. It is also relatively easy to determine recycled content of any goods purchased. These can also usually be checked in retrospect (e.g. in stationary catalogue)

Cross-media effect

A reduction in paper files can in some cases result in an increase in digital files and corresponding increase in energy use from server space and screen use. Aside from this, there are no negative cross media effects.

Operational data

This section sets out case study examples which demonstrate some of the methodologies outlined above and represent best practice.

BARCELONA CITY COUNCIL, SPAIN

As part of Barcelona City Council's commitment to Agenda 21, a Green Office Guide designed specifically for the staff at the Council was produced in 2000 and distributed to 12,000 staff, and another more general educational guide for employees - the Sustainable City Council – was released in 2006. Recommended actions from these publications in relation to better management of paper and consumables include:

- Choosing recycled paper with an accredited ecolabel such as the EU Ecolabel, the White Swan, the Blue Angel or Catalunya's Environmental Quality Guarantee Mark
- Where possible, avoiding procurement of supplies which contain toxic substances (e.g. solvent based glues)
- Choosing quality non-consumable products which will therefore have an extended life(e.g. pencil sharpeners, scissors, trays)
- Choosing refillable products
- Choosing pens, pencils and highlighters that use water based inks, with metal, wood or non-PVC casing
- Choosing adhesive tape made of polypropylene or cellulose acetate rather than PVC
- Cleaning products consumption can be controlled by using dose dispenser systems and where possible, lower impact alternatives should be used e.g. acetic acid instead of bleach for toilet cleaning.

Around the millennium Barcelona City Council found that 90% of their waste was comprised of used paper and cardboard (Ajuntament de Barcelona, 2000). Many actions were implemented to reduce this.

Specially designed boxes were placed next to each workstation as well as photocopiers and printers to collect paper with an unprinted blank side remaining. This paper could either be reused directly or turned into notepads by the Document Reproduction Centre.

Old printers were replaced with new ones that could print on both sides of the paper, alongside staff training on how to use the new machines. Stickers were located next to photocopiers to encourage double-sided copying.

Diaries and desktop notepads were replaced with digital systems, leading to a 40% reduction in paper use in first year. Reports and publications were replaced with electronic versions. For example, the annual Parks and Gardens report, normally with a print run of 1500, was replaced with an electronic version saving a tonne of paper (720g paper per edition). Other publications were printed on recycled paper including the magazine La Municipal.

The new staff behaviours were embedded by having Green Office Information Desks set up at building entries e.g. at the Gracia Personnel Services Building. Here employees were also encouraged to suggest ideas, discuss issues and be shown how to set up printers to print double sided etc. A training workshop was also made available online explaining the environmental impact of paper.

Barcelona City Council also switched from virgin white paper to recycled. This is estimated to have had the following benefits between 1999 and 2005:

- Water savings of 40 million litres
- 1.4 million kWh energy saved
- Saved 7000 trees being felled

(Ajuntament de Barcelona, 2006).

<u>GLOUCESTERSHIRE COUNTY COUNCIL, UK</u>

Gloucestershire County Council decided to take part in the UK's Government Office Supplies Contract (GOSC) which began in 2012 – the required purchasing framework for all central government offices.

The Council prepared for this by organising a month long ban on stationary purchasing. Staff were asked to place all unused items in a central stationary cupboard so other employees could use them during the ban. This system has continued ever since. Stationary is either exchanged via the central stationary cupboard or via an intranet page.

This initiative arose from a meeting of council leaders, where staff views were sought from to gather grass roots ideas for more efficient working.

Specifications of the office supplies contract included the following:

- Provision of a closed loop service for white paper (waste will be shredded and recycled)
- Copier paper will be 100% recycled
- Envelopes for general use will be 100% recycled
- Envelopes for internal mailing systems will be at least 60% recycled, with the rest from 100% certified sustainable sources
- Pencils will be free of varnish, inks will be free of VOCs and adhesive tapes will be free of PVC
- Adhesives on self-seal envelopes will be water / vegetable based
- Single use batteries will be mercury and cadmium free

(GPP, n.d. c)

PAPER PROCUREMENT CRITERIA – VARIOUS EXAMPLES

Every year, Dutch public authorities (national government, provincial authorities, municipal authorities and water boards) spend more than €50 billion on goods, projects and services (Netherlands Enterprise Agency, 2014). The national government of the Netherlands, together with regional and local authorities are aiming to stimulate the market for sustainable products through purchasing sustainable goods and services. All public authorities involved have committed themselves to 100% sustainable procurement in 2015, through the use of core sustainability criteria in all its tendering and procurement processes.

The Dutch government has produced guidance for paper procurement. This includes recommendations for reducing the quantity of paper used, choosing 70gsm paper as standard and setting maximum emissions to water and air from production in line with European Ecolabel requirements (Dutch Ministry of Infrastructure and the Environment, 2013).

The Bulgarian Environment Ministry's 2009 paper procurement tender required that all paper should be 100% recycled from post consumer waste, elemental chlorine free (ECF) or total chlorine free (TCF) and accredited with either the Nordic Swan or Blue Angel ecolabel (European Commission, 2014, b).

Public bodies in Lombardy (Italy) have a framework agreement for paper purchase. This specifies that all paper must be at least 85% recycled from post consumer waste, with maximum 15% virgin fibres that must originate from a certified sustainable source. Again paper must be ECF or TCF. Additionally they ask for packaging to be 100% recycled and paper weight should be 75gsm rather than the usual 80gsm (European Commission, 2014, b).
The Danish Central government has set a requirement for 100% sustainably sourced paper (PEFC, 2014).

BRISTOL CITY COUNCIL, UK

Bristol City Council measure the percentage of environmentally friendly stationary purchased, defined as products containing recycled material. Performance is shown in **Figure 2-19**.

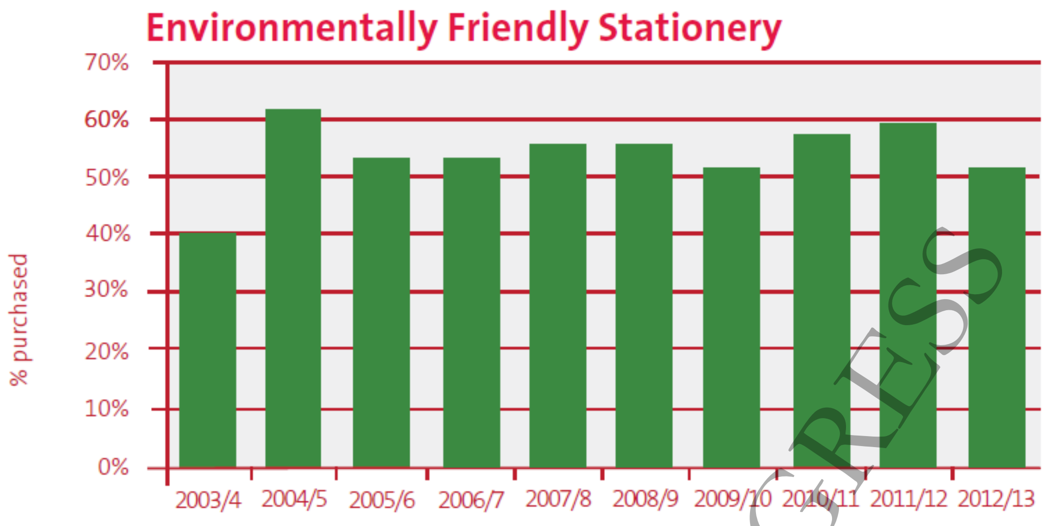


Figure 2-19: Percentage of environmentally friendly stationary purchased by Bristol City Council (Bristol City Council, 2013)[11]

Applicability

This BEMP is applicable across all typologies and scales of Public Administration offices across Europe.

Economics

Good management systems for reducing the use of materials help reduce costs. Savings come from avoided purchases and refuse collection costs. Reusing stationary, including paper, and minimising printing can have significant economic benefit. For example, Gloucestershire County Council saved around £29,000 (34,000 euros) by effective demand management of stationary (GPP, n.d. c - see Operational Data section).

Driving force for implementation

Aside from cost savings, public administrations become more efficient in the use of materials to help ensure business continuity (security of supply) and enhance reputation.

When public administration offices effectively manage their use of materials and consumables, it can play the additional role of demonstrating best practice, for example, visibility that the administration is using sustainable paper for external correspondence. The procurement policy, internal procedures, performance and cost savings can also be made public.

Reference organisations

Barcelona City Council, Spain
Green Office Guide – internal publications which cover reducing impact of paper and consumables, as well as actions which have been taken in the past decade.

Gloucestershire County Council, UK
Initiative to reduce use of paper and consumables, as well as procurement of more sustainable products.

[11] The fall in percentage of environmentally friendly stationary purchased was in part due to an overall reduction in the total quantity of stationary purchased.

Dutch Ministry of Infrastructure and Environment (Holland)
Example of detailed procurement guidelines on paper

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2.5 Minimising the environmental impact of commuting and business travel

Description

This BEMP covers all work-related transport; including everyday travel to/from a main office base, along with any travel undertaken for work-related meetings or events. This may include local and/or international travel. For further reference on general mobility issues (e.g. the provision of public transport services, the promotion of sustainable modes of transport… by local authorities in their territory) please see Chapter 4.

While individual public administration offices have little influence over wider transport and infrastructure issues, they can encourage sustainable transport within their employees through internal initiatives such as staff travel plans, behaviour change and engagement, sustainable procurement and agile working. They may also engage with local transport providers to improve links. A selection of best practice approaches to minimising the impact of commuting and business travel are outlined below.

Engagement and behaviour change

Staff engagement is an easily achievable and low cost option for reducing the impact of business travel by Public Administration bodies. Staff engagement and behaviour change campaigns can result in significant reductions in inefficient modes of transport, frequency of travel and commuter miles and may not require any initial capital outlay. Campaigns driven through digital tools such as online platforms and social networks, have a near zero cost of scale, and can be delivered to thousands of staff at little additional cost than engaging a nominal number, allowing for acceleration of impact and savings. This is particularly appealing to Public Administration bodies that have a large outreach, but potentially limited funding for direct engagement.

Routine behaviour change has the potential to be a powerful instrument for carbon saving. While changing the mode of a transport for one single journey may not have a significant impact in itself, altering the behaviour of groups can have a large cumulative impact. At the same time, creating a culture of change across a whole office can multiply the effect, making unconventional behaviours common place and habitual.

Public administrations can also employ gamification tactics and incentivisations to engage staff and encourage behaviour change towards sustainable transport. Examples include team/individual cycle challenges, cycle to work days, provision of cycle facilities (showers, parking, lockers etc.), walking challenges, greater mileage payments for sustainable modes and subsidised season tickets.

Staff Travel Plans

Staff Travel Plans are organisational wide plans or policies which offer support and incentives to encourage sustainable modes of commuting and business travel amongst staff. These plans help to reduce Scope 3 carbon emissions within an organisation while also helping to reduce local traffic congestion and air pollution. They also provide benefits to both the employer and employee.

Benefits to the employer/public administration office include:

- Reduced environmental impacts through encouraging alternative modes of transport and agile and home working
- Reduction in travel costs
- Reduction in the amount of land and maintenance required for car parking provision
- Better staff recruitment and retention and reduced absenteeism

Benefits to the employee include:

- Save money through season ticket loans, cycle loans or car sharing

- Help achieve work life balance through agile working and homeworking
- Improved health and fitness by incorporating exercise into daily routines

Public administrations may also wish to implement a carbon budget for business-related travel – this budget will place a cap on the amount of carbon to be expended on business travel in any given year. The budget cannot be exceeded, with carbon emissions for each trip calculated and deducted from the budget; this encourages staff to choose low carbon transport options.

Procurement policies

Sustainable transport procurement policies should in the first place deem whether the transport is actually necessary or, in the case of a meeting or an event, whether it could be attended remotely. Where transport is necessary, core criteria should stipulate that the most sustainable mode of transport is taken where applicable (i.e. a train journey within the EU, rather than a flight). Sustainability criteria should be stringent, however should also ensure there is sufficient market supply and not substantially increase total lifetime costs.

For domestic travel, sustainable public transport options should be sought (i.e. train and/or bus). For international travel it is recommended that any journey, of which the one-way journey (by train) from workplace station to destination address station lasts 6 hours or less according to the fastest connection schedule, should be taken by train. Flights should be avoided; in some cases ferries may provide a viable alternative. However overseas flights are necessary (i.e. the journey is over 6 hours, or no viable alternative is available) direct flights should be preferenced; where this is not possible, connecting journeys should be undertaken by a sustainable transport mode (i.e. train, bus, ferry + flight rather than two flights). Public administration procurement policies can also stimulate the market for sustainable products on a wider regional scale and encourage frontrunner suppliers and/or progressive public purchasers through making sustainability criteria business-as-usual within the tendering process.

Encouraging efficient car use

In some situations, car use is unavoidable (e.g. rural locations, long distance commutes, poor public transport connections); in these cases efficient car use should be encouraged. Car-pooling, car-sharing, car hire schemes, along with efficient driving training should be initiated where car use is unavoidable. Significant individual CO_2 and monetary savings can be achieved through operating a car at full occupancy – for example a medium size petrol car (1.4 – 2 litres) commuting 20 miles with four occupants could reduce an individual's carbon footprint by 2.4 tonnes CO2 and save over £2,000 annually compared to occupying the car alone (**Figure 2-23**).

Where cars are used for business transport, the following average efficiency standards can be met across the fleet; average and minimum standards have also been included for reference (Table 2-19). A number of public administrations have introduced electric vehicles to their municipal fleet – for example 10% of the municipality fleet in Palma de Mallorca consists of electric vehicles (Civitas, 2013d).

Table 2-19: EU vehicle efficiency standards (gCO_2/km)

Best practice	Grams CO_2 per kilometre (g/km)	Source
Electric vehicles (EVs)	0g/km	Vehicle Certification Agency (VCA) (2014)
Other vehicles	≤75g/km	VCA(2014)[12]
Average and minimum industry standards (for reference)		

[12] 75 g/km is the next band level for company cars following 0g/km electric vehicles in the UK carbon tax.

EU average (2012)	132.2g/km	SMMT (2014)
EU maximum cap for new cars (2015)	130 g/km	EU Commission (2014)

Technologies to enable agile working

One of the quickest ways to achieve a reduction in the environmental impact of commuting and business travel is to introduce an agile working programme (this could include flexible hours, hot desking or remote and home working). Virtual meeting facilities, including video and phone conferencing and cloud-based office systems can all help to facilitate agile working practices. While this may require some significant upfront investment to upgrade office technologies and cloud-based systems, an agile working programme can deliver relatively short pay back through a reduction in business expenses, office energy use and capital expenditure through office rationalisation. There are also a number of indirect benefits such as increased employee satisfaction and productivity, and a reduction in absenteeism.

Achieved environmental benefits

The chief environmental benefits of minimising commuting and business travel, both to the individual public body in question and the wider area in which they operate, include:

- Reduced fuel consumption and CO_2 emissions
- Reduced congestion
- Reduced air pollution

Dissemination of best environmental practice to other councils, business and individuals can multiply the impact of these environmental benefits (for example CarbonCulture, Perugia Home-Work Plan and Rome car-pooling initiatives have all been adopted by additional public bodies and private sector actors through dissemination).
Benefits to the individual employee are also significant; for instance, according to the UK Carbon Trust, the average UK employee can save 390 kg CO_2e, 50 hours commuting time and £450 including travel costs, by working from home two days a week for a year (Carbon Trust, 2014).

Appropriate environmental indicators

Key environmental indicators, applicable in an EU-wide context, include:

- Total CO_2e emissions from local business travel (kg CO_2e)
- Total CO_2e emissions from long-distance business travel (kg CO_2e)
- Carbon intensity of business fleet/vehicles (g CO_2e /km)
- % staff commuting by sustainable transport modes > 3 times per week (% sustainable modes/total) where sustainable transport modes refer to walking, cycling and public transport.

Additional appropriate environmental indicators, applicable in an EU-wide context, include:

- Total CO_2e emissions from local business travel per full time equivalent (FTE) employee (kg CO_2e /FTE)
- Total CO_2e emissions from long-distance business travel per full time equivalent (FTE) employee (kg CO_2e/FTE)
- Average fuel consumption of business fleet/vehicles (litres/km)
- Average vehicle occupancy (% or persons/car)
- % of total km travelled by sustainable transport modes (km sustainable modes/total km)
- Total km per full time equivalent (FTE) employee (km/total FTE)
- Total full time equivalent employees engaged in internal initiatives to promote sustainable transport (total FTE)

- % FTEs with access to sustainable transport initiatives (e.g. season ticket loans, pool bikes) (%/total FTEs)
- Uptake of sustainable transport initiatives (e.g. % FTEs with season ticket loans, hours of pool bike use/FTE)
- % FTEs with access to virtual meeting or agile working facilities (%/total FTEs)
- Total hours 'virtual meetings' per annum per FTE (total hours/FTE/year)
- % of total meetings which are carried out remotely (virtually)

Cross-media effects

Agile working may lead to rebound effects that result in increased carbon emissions, particularly regarding home energy consumption; e.g. the impact of heating numerous individual homes compared to heating one office, especially in geographical areas with an inefficient housing stock. However, there are examples of companies including Accenture, EDF Energy, Aviva and HSBC in the UK (in association with DECC), who have piloted schemes, which are replicable in the public sector, to encourage employees to increase home insulation (Carbon Trust, 2014). There may also be inefficiencies within the office building, for example if the entire building is powered but not fully occupied.

However, along with significantly reducing the CO_2e emissions associated with employee travel, if office space is appropriately rationalised, agile or home working can significantly reduce office energy consumption and rental costs. The average CO_2e and monetary savings incurred through the reduction in employee commuting generally outweigh increases in home energy consumption (Carbon Trust, 2014).

Investment in new technologies, and staff IT training, may compete with investment in energy efficiency, however the entry cost point for agile working technologies has reduced significantly over the preceding years.

Operational data

Case Study 1: Carbon Culture at DECC

The CarbonCulture Platform was introduced to UK Department of Energy and Climate Change (DECC) head office at Whitehall to provide a number of user engagement tools which encourage sustainable behaviours amongst its 1,000 staff. The platform provides a user-facing communications channel, incentive mechanisms and practical examples of individual interventions.

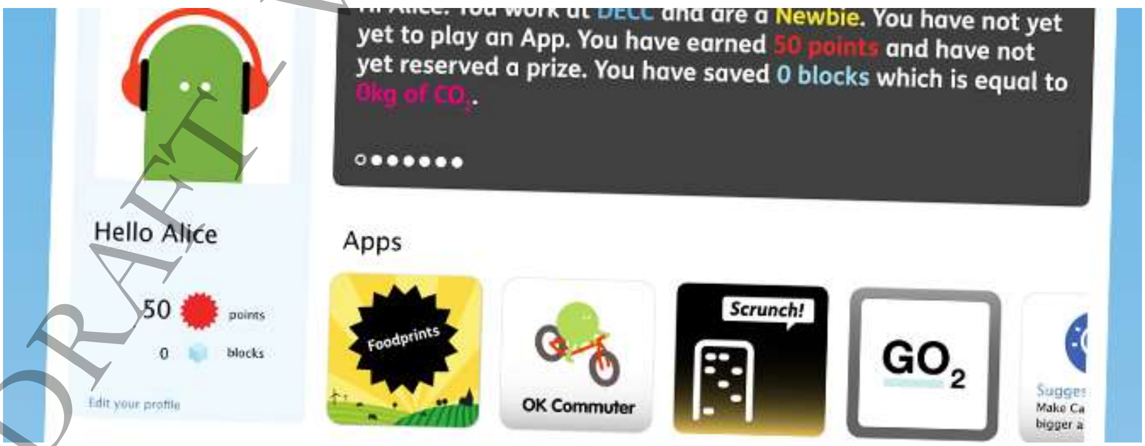

Figure 2-20: CarbonCulture dashboard (CarbonCulture, 2012)

The 'OK Commuter' application focusses on employee commuting; allowing users to record what transport type they took to work, through creative description. The outcome is a calendar entry and a notification on the activity feed (**Figure 2-21**). It is designed to be fun and simple to use — the journey 'narrative' is limited to 42 characters, and is intended to add a sense of community, with individual staff members able to view how their colleagues described their commute, and view statistics for how many journeys by each mode of transport were made. Presenting the information in this format humanises what can be a technical and intangible concept (i.e. transport-related CO_2 emissions) and facilitates a better understanding of the issue.

Figure 2-21: OK Commuter dashboard (CarbonCulture, 2012)

While the application allows an engaging method to address CO_2 emissions from business commuting and travel, the location and infrastructure in which it is implemented will impact upon the potential and/or level of change which can be expected. For example, the DECC pilot was focussed on a London city-centre office where many staff are only able to travel by public transport due to the distance from home, and few people drive due to external factors such as congestion and parking costs.

However, benefits were still observed from the tool in this setting. The action of recording the journey each morning, and the visualisation of the past four weeks' travel can prompt different decisions and behaviour change in commuting and wider personal travel decisions. For example, if an individual has a few options to choose from with one of them being healthier, cheaper or more environmentally preferable e.g. taking a tube or bus for a short journey or walking instead.

In addition to these influences on the decision making process, ego plays a role as a behaviour influence in a public facing platform such as CarbonCulture. Individuals may feel a sense of personal pride when logging a 'sustainable journey', particularly in difficult weather conditions (e.g. if they walk or cycle in rain or the snow) and this has the potential to drive competition between staff.

The pilot period of CarbonCulture achieved high levels of engagement when compared to existing sustainability engagement programmes, wider generic user engagement programmes, or general-purpose web based applications. Over 40% of staff voluntarily used the platform, with 2229 journeys logged within the OK Commuter app alone; averaging over 240 individual uses per week over the pilot period (CarbonCulture, 2012). An average of 48 users logged journeys each day. Qualitative data was also gathered, with a selection of feedback quotes captured in **Figure 2-22**:

Figure 2-22: Collection of quotes adapted from (CarbonCulture, 2012)

The initial version of OK Commuter focused on establishing DECC's baseline commuting behaviours; however it is under further development to add a mechanism for capturing carbon savings. Additional concerns such as health and safety will also be considered in future versions with features such as 'safe' cycle routes and group cycle events.

The CarbonCulture feasibility study created opportunities to share learning with wider audiences; a number of collaborative projects and further development of tool are already underway. The platform has been deployed across eight Whitehall departments including Number 10 Downing Street, and is now being made available to other office environments.

Case Study 2: Rome car-pooling scheme

Rome has one of the highest rates of car ownership in the world, with 76 cars to every 100 inhabitants (CIVITAS, 2013a). During peak hours, many of the cars circulating in the centre of Rome have a single occupant travelling to work. In order to reduce city-centre congestion, home-to-work trip plans, with a focus on car-pooling, were developed to change commuters' travel habits.

A comprehensive survey, comprising over 100,000 interviews, was carried out to analyse current travel behaviour. A simulation model was then designed to manage car-pooling services, using origin and destination data, and incorporating revealed preferences about trip characteristics and scheduling. This was implemented by the Sustainable Mobility Department of the public transport operator ATAC, who also provided technical support through computer-based tools. This led to the design of several home-to-work plans and car-pooling schemes and agreements with local parking lots to provide facilities at special rates.

A total of 1,180 employees participated in the trial; with 383 car pools and a vehicle occupancy rate of 75% (CIVITAS, 2013b). The scheme engaged 480 employees at the municipality's offices, with 160 car pools formed; 600 employees at the Policlinico Umberto I hospital forming 200 car pools; and 100 employees and 23 car pools at the Ministry of Public Health. Carbon savings were captured as part of the wider CIVITAS-led MIRACLES (Multi-Initiative for Rationalised Accessibility and Clean Liveable Environments) project; results of which can be reviewed at http://www.civitas.eu/sites/default/files/d2_2_annex1_rome_v_6_0.pdf **Table 2-20** (MIRACLES, 2006).

Table 2-20: Ex-ante and ex-post measure indicators (MIRACLES, 2006)

Planned quantifiable objectives	Actual achieved results	Notes	Achievement rate
1) Increase collective vehicles occupancy by 20%	Occupancy rate of vehicles during the trial: 75%	The large scale implementation of this measure consists in the control and verification on the proper use of parking areas that are free for car poolers.	
2) Broaden up to 1,000 citizens the car pooling group in the Demonstration Area	Car-poolers addressed during the trial have been 1180		

Caption
achieved far beyond forecasts; not fully achieved but still satisfactory outcome; achieved at a minor level
difficult to assess not achieved

Case Study 3: Perugia Municipality Home-Work Journey Plan

Perugia Municipality created the Home-Work Journey Plan to change the travel habits of its employees and reduce private car use for commuting. Perugia Municipality's (MUPER) head office employs almost 600 staff and is based in the city centre. The offices have generated a significant car commuting problem, with a lack of parking facilities also an issue, leading to congestion within the city centre. The Home-Work Journey Plan raises awareness amongst employees and encourages the use of sustainable modes of transport.

An initial survey and analysis of staff commuting behaviours was carried out to establish a baseline scenario – data was gathered from questionnaires which were distributed to MUPER employees. Additional research was carried out to determine how other best practice municipal bodies supported sustainable transport. Restrictive and permissive actions were also explored, and stakeholders engaged where adjustments were needed to local transport networks. For instance, some adjustments to bus routes and timetables were required to make bus transport a realistic option for employees.
Following this initial feasibility phase a selection of sustainable transport initiatives were launched under the plan including promoting public transport, car-pooling, and car-sharing. A follow-up survey was also carried out to evaluate the success of the measures employed. A communications plan was also launched to disseminate the Plan and engage employees, with an internal brochure, information campaigns, and website and Metropolitan TV advertisements.
A wider dissemination programme was employed to share the Municipalities learning and to raise awareness amongst other public bodies and the private sector companies operating within the city. It was also observed through the follow-up survey that the Plan helped to reduce the overall presence of cars within the city centre during peak times, while improving parking availability for other groups of car users.
The outcome of the Plan has seen a positive change in employees' commuting travel patterns and a greater satisfaction among employees with their journeys. Perugia are currently working to increase the proportion of employees adopting the travel Plan; and in the longer term plans to facilitate home or remote working.

Case Study 4: Staff Travel Plans (Brighton & Hove City Council, Surrey County Council, Wandsworth London Borough Council)

A number of local authorities in the UK, including Brighton & Hove City Council, Surrey Council and Wandsworth London Borough Council, have implemented Staff Travel Plans which offer support and incentives to encourage sustainable modes of commuting and business travel amongst their staff. These plans also help to reduce local traffic congestion and pollution and contribute to reducing carbon emissions.
Common features of the travel plans include:

- Safe cycle parking and mileage rates for cyclists
- Showers and storage lockers

- Pool bicycles
- Season ticket loan schemes
- Car sharing
- Car club membership
- Changes to working arrangements, such as home working and video conferencing
- Flexible working hours to reduce peak travel
- Providing alternatively fuelled vehicles
- Provision of public transport information

Brighton & Hove City Council Travel Plan communicates the benefits of transport modes, along with common barriers to implementation, and has made the plan publically available to encourage dissemination to other organisations within the city (BHCC, 2004). The Travel Plan also uses financial incentives to sustainable transport such as cycle mileage rates and improved mileage rates for more efficient vehicles where car transport is necessary. The Travel Plan is shared in staff inductions to make all new members aware of the options available to them.
Through the ‘Travel Smart’ website, Surrey County Council shares best practice learning on sustainable travel and provides information on public transport, cycling, walking and smarter driving to staff and the wider public (Travel Smart, 2014). The Council also has its own internal lift share website which allows employees to find someone to share a car with for business or private transport (Surrey Lift Share, 2014) – it also allows non-drivers to register for a ‘passenger only’ place and provides details on the CO_2 and cost savings from car-sharing (**Figure 2-23**).

Figure 2-23: Surrey lift share savings calculator (Surrey Lift Share, 2014)

Wandsworth London Borough Council was an early adopter of a Staff Travel Plan in 1999, which has successfully reduced the proportion of council staff driving to work from 58% in 1999 to 32% when last surveyed in 2010 (Wandsworth, 2014).

Case Study 5: Worksmart at Aberdeenshire Council

The Aberdeenshire Worksmart programme includes four working profiles: Fixed, Flexible, Mobile and Home, with eight different patterns of working time: Annualised Hours, Compressed Hours, Day and Time of Day changes, Flexitime, Part-time working, Self Rostering, Shift Swapping and Term-time working (more information on these work profiles can be found in Aberdeenshire, 2014). Aberdeenshire Council faced additional challenges in adopting a flexible working programme, given their rural location and unreliable 3G and mobile phone coverage. However, the programme was successfully introduced, one team at a time, with each of the early adopters consulted on an ongoing basis to highlight and counteract any initial difficulties associated with agile and homeworking.

The programme has exceeded expectations with a 10-15% reduction in employee commuting and business mileage, and significant reductions in associated CO_2e emissions (Carbon Trust, 2014). Between 2010 and 2011, figures from 230 officers who recorded their commuting mileage (out of 1200 who went through the Worksmart programme) showed a 69% reduction in CO_2 emissions over the previous year from 104,593kg of CO_2 to 51,116kg CO_2 through working from home or at a location closer to home (Flexibility, 2012).

The council has also achieved a minimum of 1.4 employees per desk across all teams, releasing fourteen offices and achieving annual savings of around £270,000 and a capital receipt of £200,000 (Carbon Trust, 2014). Employee productivity has also increased according to 61% of managers, with only 2% feeling that productivity had decreased.

Case Study 6: Smart Working at Wokingham Borough Council

Wokingham Borough Council introduced a homeworking policy in order to rationalise office space and reduce rental costs. Early data gathering identified roles which would be suitable for homeworking, while a Smart Working Project Manager was put in place to address personal concerns employees had about moving from static office based work to agile and homeworking. Smart working champions, early adopters of homeworking, were recruited to address staff concerns on the basis of their own personal experience.

Over the first two years the initiative has achieved a staff to desk ratio of approximately 1.6, with 600 staff working from home at least part of the week. The initiative delivers annual savings of approximately £50,000, and 80% of staff working from home feel they are more productive than they were (Carbon Trust, 2014). Employee satisfaction has also improved with staff members reporting that team meetings have become more focused and build on team spirit and motivation; while sickness absence is down from 5.43 FTE days per person to 3.54 FTE days per person in areas with Smart Working (Flexibility, 2013).

Case Study 7: South Tyneside Virtual Meeting facilities

South Tyneside Council has installed 'virtual meeting' facilities at their main site to reduce unnecessary business travel. Video and data conferencing facilities allow meetings to take place with colleagues at other sites as if they were in the same room. A number of video 'kiosks' have also been installed (see **Figure 2-24**) after a successful pilot study which saw a kiosk was installed in a customer service centre and provided the public with a high quality video call to the relevant council department through the touch of a button (JKC, 2014).

Figure 2-24: South Tyneside video kiosks (JKC, 2014).

<u>*Case Study 8: Netherlands International Business Travel Procurement criteria*</u>

The national government of the Netherlands, together with regional and local authorities are aiming to stimulate the market for sustainable products through purchasing sustainable goods and services. All public authorities involved have committed themselves to 100% sustainable procurement in 2015, through the use of core sustainability criteria in all its tendering and procurement processes.

The Netherlands Enterprise Agency commissioned by The Ministry of Infrastructure and the Environment has developed sustainability criteria for various product/service groups procured by public authorities, including international business travel. Prior to the launch of the Criteria document, a Dutch news investigation revealed that the State government had made over 24,000 air trips in 2007 alone – with around 15,000 of these made within Europe (Netherlands Enterprise Agency, 2011); suggesting significant potential to reduce air travel and CO_2 emissions from government business travel.

The core criteria for international business travel procurement consist of minimum specifications (product), selection criteria (supplier) and standard contract clauses. Additional discretionary award criteria encourage frontrunner suppliers and/or progressive public purchasers. Criteria are developed so that total lifecycle costs do not increase substantially and there is sufficient market supply to meet the core criteria; and are assessed by legal experts to guarantee they fulfil the European tendering procedures.

The criteria covers both the pre- and post-procurement stages and focusses primarily on procurement from travel agents, as this is the most common method of booking international transport; however some of the core criteria is equally applicable to transport booked independently via online booking systems. As a first step the criteria stipulates that government bodies investigate if the travel is necessary, and explore alternative options to reduce the need for international transport e.g. through videoconferencing or reducing the number of staff required to travel. This process is supported by use of the ‘Entscheidungshilfe für Klimafreundliche Geschäftsreisen’ (roughly translated as ‘decision support for climate friendly business travel) tool developed by Germanwatch and the European Business Council for Sustainable Energy (Germanwatch, 2004) which allows the comparison of costs lost working time and CO_2 emissions of various transport alternatives (see Figure 2-25).

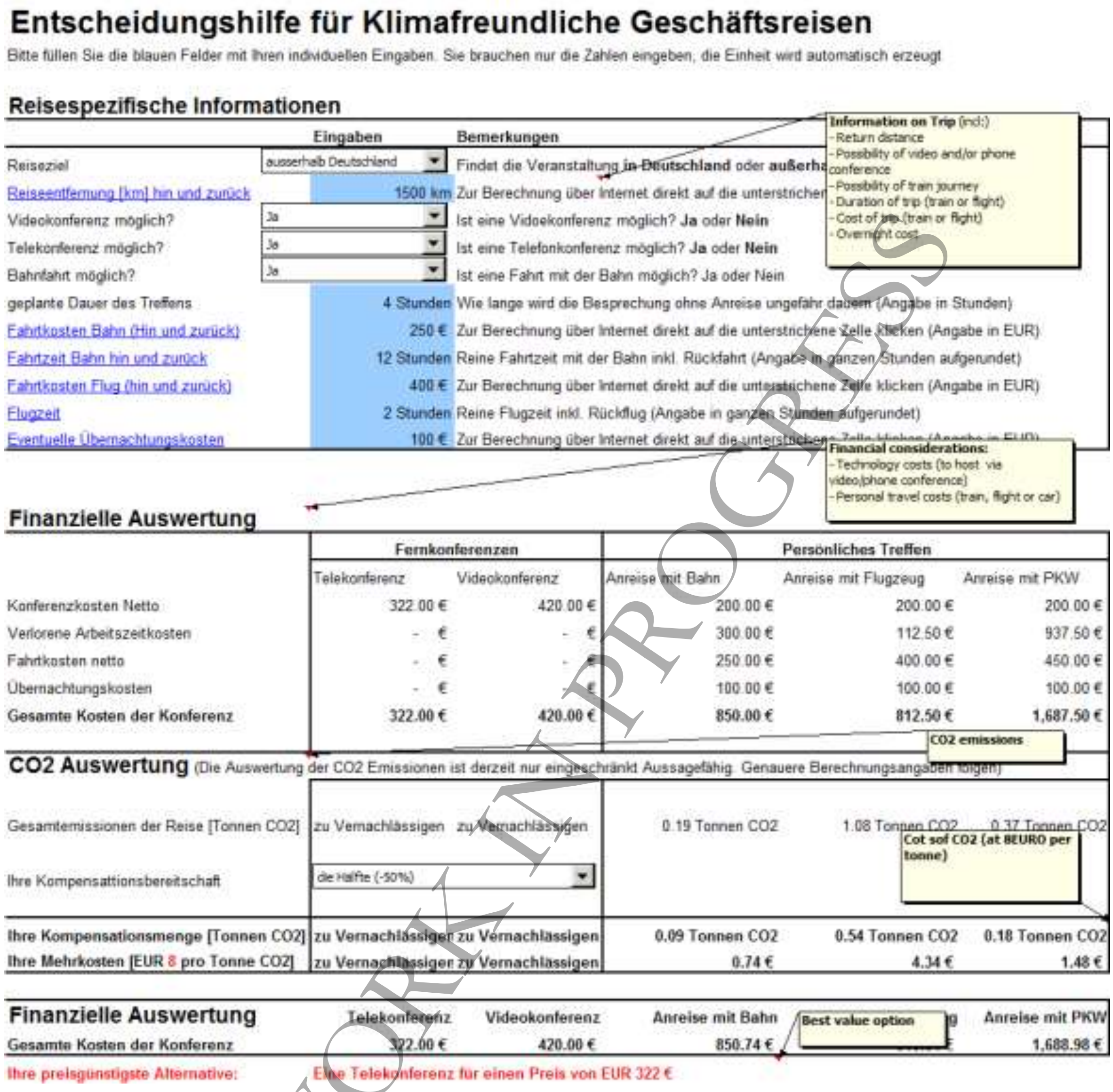

Figure 2-25 - Entscheidungshilfe für Klimafreundliche Geschäftsreisen tool (Germanwatch, 2004)

Where international travel is deemed necessary, journeys with a duration of less than six hours each way are only to be provided by train (unless there are mitigating circumstances). Where the journey duration is above 6 hours each way, viable alternative modes of transport (to air transport) are offered to employees. The criteria also demand that 100% of greenhouse gas emissions associated with international business travel is offset – either through planting trees or investing in sustainable energy and/or energy saving initiatives. This is done on an annual basis, having collated travel data and associated CO_2 for the previous calendar year – data should be collated and reported by the tenderer as part of their contract.

The award criteria specifies maximum CO_2 emissions (grams/km) and maximum fuel consumption (litres/100 km) permitted for hire cars; the criteria is based upon the upper B-rating limit of the voluntary Dutch energy label for cars and is reviewed on an annual basis (see

Table 2-21 for original criteria based on the 2009 energy label).

Table 2-21: Hire car efficiency criteria (Netherlands Enterprise Agency, 2011)

Petrol	Maximum CO_2 emission (grams/kilometre)
Mini	125.0
Compact	135.0
Small medium class	153.0
Large medium class	179.0
Large cars	212.0
Diesel	
Mini	107.0
Compact	116.0
Small medium class	131.0
Large medium class	152.0
Large cars	179.0

Petrol	Maximum fuel consumption (litres/100 kilometres)
Mini	5.2
Compact	5.6
Small medium class	6.4
Large medium class	7.4
Large cars	8.8
Diesel	
Mini	4.0
Compact	4.3
Small medium class	4.9
Large medium class	5.7
Large cars	6.7

Case study 9: Belgium Bike to Work schemes

A number of public administration bodies in Belgium have signed up to the national Bike to Work scheme. Under this incentive scheme, employees of participating organisations collect 'bike points' for every bike commute logged online; these points can then be exchanged for vouchers for a number benefits, such as discount vouchers for high street stores. Participating organisations include (Bike to Work, 2014):

- Administration communale de Molenbeek-Saint-Jean
- Bruxelles Environnement – IBGE
- European Commission
- Executive Agency for Small and Medium Size Enterprises (EASME)
- Stad Aalst
- Stad Damme
- Stad Diest
- Stad Lier
- Stad Mechelen
- Stad ninove
- stad Sint-Truiden
- STAD TORHOUT - MILIEUDIENST
- Stadsbestuur Geraardsbergen
- Stadsbestuur Sint-Niklaas

There is also a wider Cycle to Work scheme in Belgium which provides a tax-free mileage allowance for bike commuters. Under the scheme, public administration bodies and organisations are entitled to pay their employees a tax-free allowance up to € 0.21 / km cycled / day (a total of up to 15 km / day or €3.15/a day) on their salaries. The incentive is limited to € 664.65 per person per year (for a person commuting the maximum 15km/day for an average of 211 working days within the year) (ECF, 2012a). Employers are then compensated for the wage supplement through a tax refund.

In 2010, the cycle to work mileage allowances paid in Belgium totalled € 43.4 million – 270,728 participants cycled the equivalent of over 206 million km by bike that year, **Table 2-22** (ECF, 2012a).

On this basis, the average incentive was € 160.3 a year per participating employee, with each employee cycling and average of 763.3 kilometres per year.

Table 2-22: Development of commuter cycling tax incentive in Belgium from 2006 -2010 (ECF, 2012a)

Fiscal year	Beneficiaries	Total incentives
2006	140 636	€ 21 683 357
2007	162 203	€ 24 937 523
2008	208 750	€ 31 501 080
2009	241 242	€ 36 212 808
2010	270 728	€ 43 407 528

A similar scheme has also been introduced in the Netherlands where employers can pay a tax-free mileage allowance for bike commuters of up to € 0.15 / km cycled / day (Bike to Work, 2012b).

Applicability

This BEMP is potentially applicable across all typology and scale of Public Administration organisations across Europe. However perceived benefits may vary depending on external situations, such as geographical setting and availability of public transport. In remote areas without access to public transport, agile working may be considered the most viable option.

Economics

While some upfront investment may be required to provide virtual meeting and agile working facilities, this can have a relatively short payback through savings in business expenses and staff time due to travel.
Similarly, internal sustainable transport initiatives, such as pool bikes or cycling facilities, will require some upfront investment but can also payback through reduced business expenses. If the number of staff travelling by car is reduced, financial savings can also be achieved through reduced parking costs and/or savings in land required for parking spaces. Season ticket loans are an initial upfront expense but are recouped over the space of the financial year, and can aid in staff wellbeing and retention, which bring about indirect economic benefits. Agile working and reduced commuting can also improve productivity and retention which can also produce economic benefits (Carbon Trust, 2014).
There are also economic benefits to individual employees; for example an individual commuting 20 miles to work five days a week, could save around £2,000 annually, sharing a medium-sized petrol car with three others (and splitting the cost of petrol) compared to driving alone (**Figure 2-23**). Similarly season ticket loan schemes allow employees to take advantage of economies of scale through purchasing annual tickets, while pool bikes also offer savings on business travel.

Driving force for implementation

Business travel and employee commuting can account for a significant proportion of indirect emissions of public administrations. The support and provision of sustainable transport options and/or resources which reduce the need for travel reduce the associated carbon emissions, while also reducing costs (e.g. fuel bought).
There are also a number of additional 'soft' benefits to implementing a sustainable transport policy including: enhancing reputation, business continuity, improved employee satisfaction, productivity and retention (for example Aberdeenshire and Wokingham smarter working

programmes), reduced business expenses and lost work time (i.e. where virtual meetings and agile working are encouraged).
Access to virtual meeting and agile working resources reduce employee commuting and travel time and improve productivity.

Reference organisations

Aberdeenshire Council, UK
Aberdeenshire Council were a frontrunner local authority in adopting a Smart Working policy, with a focus on flexible working profiles and working time patterns.

Brighton & Hove City Council, UK
Brighton & Hove City Council's Staff Travel Plan is designed to support staff in choosing more sustainable and healthy ways of travelling, both to and from work and within the working day.

City of Palma, Spain
In 2011, Palma procured a number of electric vehicles to their municipal feet, equating to 10% of the total municipal fleet. Public tender guidelines were also launched which demand 10% of subcontractors vehicles to be electric.

Department of Energy & Climate Change, UK
The CarbonCulture Platform provides a user-facing communications channel, incentivisation mechanisms and practical examples of individual interventions to encourage sustainable behaviour.

European Commission
The European Commission is one of a number of public bodies based in Belgium which participate in the Bike to Work scheme. Under this incentive scheme, employees of participating organisations collect 'bike points' for every bike commute logged online; these points can then be exchanged for vouchers for a number benefits, such as discount vouchers for high street stores.

Ministry of Finance, Belgium
The Ministry of Finance supports the national Cycle to Work scheme, under which, public administration bodies and organisations are entitled to pay their employees a tax-free allowance up to € 0.21 / km cycled / day (a total of up to 15 km / day or €3.15/a day) on their salaries.

Municipality of Perugia, Italy
Perugia Municipality created the Home-Work Journey Plan to change the travel habits of its employees and reduce the dependence on private car use for commuting.

Municipality of Rome, Italy
Rome Municipality introduced a car-pooling scheme as part of their home-to-work plans which were developed to reduce city-centre congestion and to change commuters' travel habits.

Netherlands Enterprise Agency / Ministry of Infrastructure and the Environment, Netherlands
The Netherlands Enterprise Agency commissioned by The Ministry of Infrastructure and the Environment has developed sustainability criteria for various product/service groups procured by public authorities, including international business travel.

South Tyneside Council, UK
South Tyneside Council has installed 'virtual meeting' facilities, including video and data conferencing facilities and video kiosks, at their main site to reduce unnecessary business travel.

Surrey County Council, UK
Through the 'Travel Smart' website Surrey County Council shares best practice on sustainable travel and information on public transport, cycling, walking and smarter driving.

Wandsworth London Borough Council, UK
Wandsworth London Borough Council was an early adopter of a Staff Travel Plan in 1999, which has successfully reduced the proportion of council staff driving to work.

Wokingham Borough Council, UK
Wokingham Borough Council introduced a homeworking policy in order to rationalise office space and reduce rental costs.

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2.6 Minimising the environmental impact of canteens and coffee bars

Description

This BEMP covers food procurement, catering-related consumables, energy and water consumption, and waste production relating to canteens and coffee bars. More general aspects of managing and minimising energy and water consumption, and waste minimisation and segregation, are covered in previous areas of this report (Section 2.1 and Section 2.3). Similarly, use of catering agencies for external events will be covered within the next Section 2.7. This report focuses on environmental impacts, and will therefore not cover social aspects such as provision of healthy food options and catering to varied dietary requirements, unless covered under a more general sustainable food initiative.

While public administration offices will have significant control over procurement and waste production, they have little influence over national waste infrastructure or availability of technologies such as anaerobic digestion. Best practice in minimising the environmental impact of canteens and coffee bars may be most effectively administered through a multilateral approach of engagement, behaviour interventions and the formalisation of minimum standards.

Engagement campaigns

Staff engagement is an easily achievable and low cost option for reducing the impact of canteens and coffee bars. Staff engagement and behaviour change campaigns have a near zero cost of scale and may not require any initial capital outlay; allowing for acceleration of impact and savings. On the simplest level, an engagement campaign may consist of posters or leaflets within the office encouraging sustainable food choices. The introduction of 'game' elements or incentives can further multiply the impacts and maintain individual interest (for example DECC's Foodprints initiative, or Halmstad schools competition). Altering the routine behaviour of groups can have a large cumulative impact; while creating a culture of change across a whole office can multiply the effect, making unconventional behaviours common place and habitual.

'Nudge' behaviour interventions

Dietary decisions can be habitual, personal and 'locked in' actions – in some cases it may be preferable to utilise behavioural interventions, particularly 'nudge' approaches. 'Nudge' interventions aim to discreetly change behaviour through choice architecture (i.e. changing how options are presented which can make a particular choice the natural or default preference) (House of Lords Science and Technology Select Committee, 2011). This can be achieved, for example, through introducing more vegetable and low meat options without advertising them as specifically 'vegetarian'. Pricing policies which encourage healthier, more sustainable choices may also be adopted as a 'nudge' tactic, whereby staff making sustainable choices (e.g. vegetarian meal, using own reusable mug) pay less.

Setting minimum standards

It may be preferable to introduce minimum standards, alongside behavioural interventions, to achieve the greatest impact. While individuals can be influenced through engagement, sustainable procurement and minimum buying standards for catering contracts and equipment can achieve 'economies of scale' in directly influencing suppliers, having an impact across the supply chain, rather than just at an individual level. Public administration procurement policies can also stimulate the market for sustainable products on a wider regional scale and encourage frontrunner suppliers and/or progressive public purchasers through making sustainability criteria business-as-usual within the tendering process. Minimum buying standards should preference local, low-meat, fresh and sustainable food choices and may be included as part of the tendering process; whereby only suppliers meeting those standards or better will by procured by the public administration body.

Minimum buying standards for catering equipment may also be employed to procure the most energy and water efficient equipment – within the EU, the highest level of EU energy rating for appliances may be used as a guide.

Reducing food waste
Minimum standards should also be set for food waste, this may be done by measuring average food waste across a set period (e.g. a day, week, month) and a target reduction set. Reducing food portions, offering different sized portions, careful forward planning of menus can all help to reduce food waste on-site. Where anaerobic digestion facilities are available in the locality, these may be used for any residual food waste.

Achieved environmental benefits

Low impact diet options can significantly reduce the greenhouse gas (GHG) emissions (particularly carbon dioxide, methane, and nitrous oxide) associated with food production and distribution. The impact of food on an individual's ecological footprint could be reduced by over 50% through switching to a low meat, locally sourced, organic and waste free diet (BioRegional, 2005). Sustainable agriculture practices also protect land, soil fertility, ground water and air quality through the reduction of overgrazing and synthetic chemical use. Efficient catering equipment can also save energy and water.
There are significant environmental benefits to minimising food waste – a 30% reduction in food-related waste could achieve a 30% reduction in an individual's ecological footprint (BioRegional, 2005). Zero food waste in the UK alone could prevent 27million (m) tonnes GHG a year from entering the atmosphere, return over 1.3m tonnes a year of valuable nutrients to the soil, and generate over 1 terrawatt-hour (Twh) electricity a year (Vision 2020, 2013). Similarly a reduction in catering related packaging and consumables such as disposable cutlery and single-use containers can reduce waste even further.
Finally, minimising the environmental impact of canteens and coffee bars may have a ripple effect on minimising energy, water and waste levels across the office as a whole.

Appropriate environmental indicators

Key environmental indicators, applicable in an EU-wide context, include:

- % of low impact food options (e.g. locally-sourced, low-meat, seasonal, organic) (% low impact/total purchase volume)
- % of food waste sent for anaerobic digestion (% sent for AD/total tonnes food waste)
- % total tonnes food waste landfilled (% landfilled/total tonnes food waste)
- amount of food waste generated per meal served (g/meal)
- % caterers with recognised environmental management system (e.g. EMAS, ISO14001, ISO20121) (%/ total purchase volume)

Additional environmental indicators, applicable in an EU-wide context, include

- % plant-based products grown without chemically synthetic substances (%/ total purchase volume of plant-based products)
- % animal products which are sustainably farmed (e.g. free-range, organic) (%/total purchase volume of animal products)
- % sustainably certified fish (% certified fish/total purchase volume of fish)
- % total purchase volume covered by a recognised eco label (e.g. MSC, Organic, Fairtrade) (%/total purchase volume)
- % total tonnes food waste (% food waste/total tonnes procured)
- Total energy consumption of catering/kitchen equipment (total kWh)
- Total energy consumption of catering /kitchen equipment per full time employee (total kWh/ total FTE)
- Carbon emissions of catering/kitchen equipment (total kg CO_2)
- Total water consumption of catering/kitchen equipment (total litres)
- Total water consumption per full time equivalent employee (total litres/total FTE)
- % crockery and cutlery which is reusable or biodegradable (%/total purchase volume)

- Total full time equivalent employees engaged in internal initiatives to promote sustainable food and/or reduce food waste (total FTE)
- Presence of a sustainable procurement policy in place which covers all catering related procurement contracts (e.g. food, consumables, and equipment).

Cross –media effect

There are no obvious cross-media effects associated with minimising the impact of canteens and coffee bars. However it may be noted that the introduction of on-site catering can increase overall energy, water and waste figures within an office environment.

Operational data

<u>*Case Study 1: Foodprints at Department of Energy and Climate Change (UK)*</u>

The CarbonCulture Platform was introduced to the UK Department of Energy and Climate Change (DECC) head office at Whitehall to provide a number of user engagement tools which encourage sustainable behaviours amongst its 1,000 staff. The platform provides a user-facing communications channel, incentivisation mechanisms and practical examples of individual interventions.

The 'Foodprints' application focusses on sustainable food and encourages staff to "get into the habit of eating healthier lunches, and save carbon at the same time" through a recording tool and pledge card system (CarbonCulture, 2012). Foodprints operates on the assumption that moving from a typical UK diet to a low meat diet can reduce a personal ecological footprint attributed to diet by ca. 27%; with food accounting for 20% of personal ecological footprint, a reduction in the consumption of animal products has the potential to significantly reduce an individual's impact (Bioregional, 2005). CarbonCulture identified a baseline intervention applicable to all DECC staff, which would provide verifiable data recording through the internal canteen at 3-8 Whitehall Place.

Foodprints provided incentives for users to record their lunch choices in an easy to use process through awarding fixed points each time a user logged their lunch, regardless of their meal choice. The application included additional 'game' elements and added incentives to engage staff and maintain interest (**Figure 2-26**); including:

- 'Hidden Treasure' – extra points were hidden within the tool to encourage regular use and exploration
- '5 in a row' – extra points were awarded for recording a full week of lunch choices

Figure 2-26: Foodprints dashboard on the CarbonCulture platform (CarbonCulture, 2012)

The self-awareness created through recording food choices helps redress the influence of competing factors (e.g. 'peer' choices, low glucose levels) on rational decision making in choosing a meal option which is both healthy and environmentally preferable. While the public declaration of diet choice encourages users to make choices which are healthier or more sustainable, the online platform does not directly incentivise low meat choices as the information gathered cannot be verified and there is a risk of false data recording if low meat options were rewarded.

However, 'Canteen Days' pledge cards were used in parallel which provided the opportunity for verifiable data collection, as canteen staff were asked to confirm that purchased lunch choices matched those 'pledged' each day. The cards were then returned and extra points allocated for low meat and vegetarian meal choices, with 'double points' weeks which offered to double individual points if a full card was completed within the week.

The pledge cards allowed staff who used the internal canteen to select one of three levels of commitment based upon the number of carbon intensive meals included on a 5-day card. This made the initiative accessible to all staff as it allowed users to start at any level, encouraging participation through low barriers to entry. The independent selection of entry level also made participants more inclined to complete the card as it was a personal commitment.

The tool received high levels of engagement and was the most popular of the CarbonCulture tools, with over 40 users a day on average during the trial period (**Figure 2-27**). In total 2747 lunches were logged and 112 cards registered (87 completed), representing ca. 27% and ca. 11% (ca. 9%) of staff respectively (CarbonCulture, 2012).

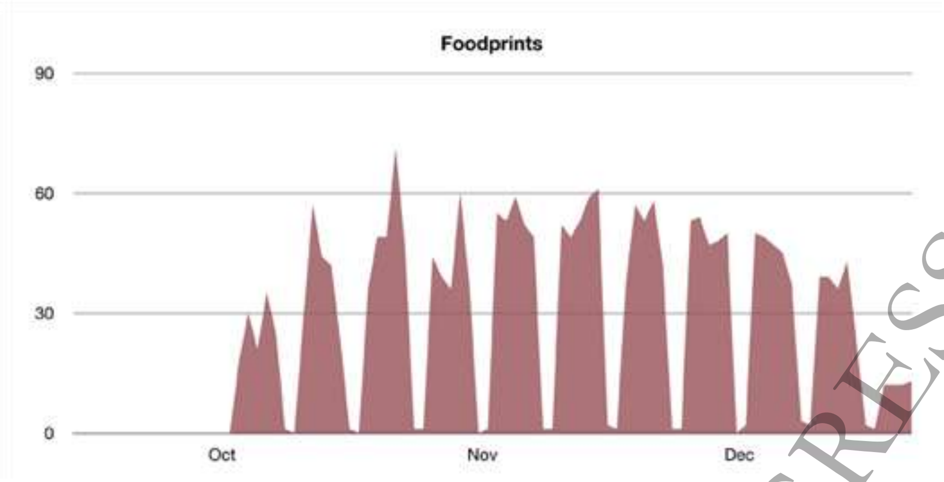

Figure 2-27: User data for Foodprints trial period (CarbonCulture, 2012)

Qualitative data was also gathered which indicated that the application and pledge cards had a positive influence on the selection of sustainable food choice (CarbonCulture, 2012):

- *"I've been watching what I've been eating – it's been helpful"*
- *"I definitely eat less meat now"*

The CarbonCulture feasibility study created opportunities to share learning with wider audiences; a number of collaborative projects and further development of the tool are currently underway. The platform has been deployed across eight Whitehall departments including Number 10 Downing Street, and is now being made available to other office environments.

Case Study 2: Brighton & Hove City Council Food strategy

Brighton & Hove was one of the first cities in the UK to take a citywide, strategic approach to food issues when it launched 'Spade to Spoon: Digging Deeper' - Brighton & Hove's strategy for a local food system which is healthy, sustainable and fair. It provides a set of nine aims that the city's food strategy will work towards and outlines a five year action plan for partners (2012-2017). Aim 4 of the strategy focuses directly upon sustainable food procurement by public bodies in the city, and is further broken down with three objectives (BH Food Partnership, 2012):

Aim 4: Public organisations have healthy, ethical and environmentally responsible food procurement policies and practices

4.1 Increase the number of public institutions serving healthy food

4.2 Set up a working group to look at purchasing and procurement issues, learning from good practice within the city and elsewhere in the country

4.3 Public organisations introduce purchasing policies that encourage environmental sustainability, local sourcing, animal welfare, healthy eating and fair trade

Under this aim Brighton & Hove City Council (BHCC) recently approved pioneering Minimum Buying Standards for public catering contracts which specify that contracts over £75,000 per year are delivered to Bronze Food for Life (FFL) Standards (Soil Association, 2014) as a minimum and contracts under £75,000 be delivered to the Minimum Buying Standards requirements equivalent to Bronze FFL, though certification is not a requirement (BHCC, 2014).

A number of canteens under BHCC's operation have already achieved the Bronze FFL standard, including the Councils School Meals Service which serves 7,000 meals a day across sixty-four canteens and the Brighton Centre, in collaboration with Kudos (which holds the on-site catering contract), which hosts 250,000 visitors a year and is working towards Silver FFL standard (BH Food Partnership, 2014).

"All 7,000 meals served at primary and special schools across Brighton & Hove feature local, free-range eggs; all meat is British and all fish carries the MSC certification. A seasonal

vegetables slot on the menu every Wednesday gives us the flexibility to use the best produce available. Global produce such as bananas and fruit juice are Fair Trade. We are on a continuous journey to make improvements to the food we serve and to ensure that the dining experience is positive for all children across the city" Susie Haworth, School Meals Team Manager at Brighton & Hove City Council (BH Food Partnership, 2013)

Case Study 3: Halmstad food waste reduction in school canteens

Lunch for nursery, primary school (age 7-15) and secondary school (age 15-18) children was introduced as a municipal responsibility in Sweden in the 1940s. In 2011 the law was amended to state that lunch must not only be free, but also nutritious (Prewaste, 2012). However, municipalities have autonomous control over fiscal spend and the extent of vegetarian or healthy meals offered.

Halmstad municipality, on the Swedish West Coast, south of Gothenburg, has a population of ca. 90,000, with 14 schools that supply approximately 6,850 students with daily meals (FAO, 2014). Halmstad Servicekontoret (Service office), who have operational responsibility for school meals and waste collection, ran a long term food waste reduction information campaign from 2008 to spring 2011, targeted at the middle and high schools.

Significant and unnecessary food wastage was detected by the Municipal Meal Manager, who suggested targeting an information campaign directly at the pupils. The campaign was designed as a contest between the schools where the canteen throwing away the least food waste at each weighing won. The behaviour change campaign had the additional targets of decreasing CO_2 emissions, decreasing meat consumption, increasing vegetarian and locally produced food, and saving money through less food waste.

A baseline waste value was established through weighing the food waste from the school canteens three weeks prior to the campaign launch; with 44.7 grams of waste per meal and pupil (Prewaste, 2012). A working committee was established with representatives from the municipality, the schools and the canteens; and workshops were held with the 14 different schools to adapt the campaign to individual conditions and coach key personnel. Teachers were also consulted in order to convince them to include the campaign objectives in their teaching for wider buy-in.

Pupils were then addressed directly in their school canteen by a locally famous footballer, to promote the importance of proper food and nutrition, and provided with information material. To track the impact of the campaign food waste was weighed on a daily basis for three weeks at four occasions at each school (January, May and October 2009 and in November 2010) and compared to the baseline value. The daily results for each school were made publically available to encourage competition amongst the pupils of the participating schools during the weigh-in periods. The school which wasted the least food over the period was rewarded with a special lunch including live music and entertainment.

Summery of food wastege campaign 2009

School	Quant. eating	Waste KG after	Grams/portion Before	Grams/portion After	Change percentage
Österled	6,370	154	32.2	24.0820	-25%
Fyllinge	6,074	147	30.4	24.218	-20%
Getinge	8,217	210	28.1	25.5081	-9%
Gullbrandstorp	5,270	139	27.7	26.2808	-5%
Brunnsåker	7,337	207	28	28.2132	1%
Trönninge	5,401	177	23.3	32.8087	41%
Furulund	6,025	200	35.6	33.1067	-7%
Östergård	7,791	276	35.90	35.4396	-1%
Hallägra	5,325	224	51.8	42.1033	-19%
Stenstorp	2,548	118	50	46.1146	-8%
Sture	9,493	497	56	52.3544	-7%
Sannarp	6,885	373	59.7	54.1031	-9%
Kattegatt	12,133	725	86.7	59.7544	-31%
Totalt	88,877	3,445		38.8	-13%

Measurement the autumn of 2008 (pre-campaign) showed that pupils on avarege threw away 44,7 gr./meal
The autumn 2009, after the campaign, the avarage decreased to 38,8 gr./meal or 13%

Figure 2-28: Summary of Halmstad food waste campaign 2009 ***(Prewaste, 2012)***

Over the course of the campaign the food waste per portion reduced by 5.8g (13 %), from 44.7g/serving to 38.8 g/serving (Figure 2-28). The sample group consisted of 6,850 pupils over a full school year consists of 173 days. This equated to 1,185,050 servings annually and the avoidance of 6,783 kg of food wastage or 17,180 portions. The cost per portion is approximately 1 Euro, so approximately 17,180 Euro was saved annually (Prewaste, 2012). Informal measurements taken months after each campaign suggested that the wastage decrease remained, indicating a successful change. The campaign also had a wider political impact on with a municipal decree to weigh the food waste in all schools twice per year; with 21 additional municipalities expressing direct interest in the campaign.

<u>*Case Study 4: Brussels Sustainable Canteens project*</u>

Following engagement with sustainable food research and action for several years, “Sustainable Food” was explicitly established as a strategic political priority by the Regional Ministers of Brussels for the years 2009-2014 (Knops, 2013). The food industry represents 10% of industrial employment in Brussels and is the third largest industrial sector in the Region. Many companies were already engaged with Sustainable Food, with ca. 1,500 persons in the Brussels Capital Region employed in sustainable catering and processing (Sustainable Everyday Project, 2012).
One of the most successful campaigns to date is the “Sustainable Canteens” project coordinated by Brussels Environment Ministry, which supports public canteens (e.g. in schools, care homes, administrations) that want to transition to sustainable food. Every day 270,000 meals are served in canteens across Brussels, with 40% of meals taken outside of the home. Theoretical and practical training is provided to kitchen staff in participating canteens – to date 94 canteens, including 40 within the public sector, have been involved, representing almost 85,000 meals a day (Sustainable Everyday Project, 2012). This included 15 schools and two providers of school meals, accounting for 30,000 meals per day. Around 6,000 new students were engaged in the project each year, leading to the development of independent school-led sustainable food projects across 16 schools.

The Sustainable Canteens project encourages the gradual introduction of more fruits and vegetables (preferably of local origin), the use of organic produce, and the reduction of food wastage. Specifications are developed to help organisations integrate sustainability criteria into their procurement. The region has set a target of 125,000 ‘sustainable’ meals per day in 2015; with the ultimate goal for all public canteens to offer sustainable meals (Brussels Sustainable City, 2014).

"*The training confirmed our instincts about quality food, and enabled us to establish contact with other actors and share recipes and ideas for implementation. It caught our imagination, because the method allows you to move forward step by step. Preparing tasty and high quality food is very rewarding for both staff and customers, including those in short trousers. Sustainable food is a never-ending source of pleasure. Sustainable eating is not just for the rich, it's simply another way of eating*." Jeanne Collard, TCO Service (which serve 7,000 meals a day in schools) (Brussels Sustainable City, 2014).

Case Study 5: Netherlands catering equipment procurement criteria

The national government of the Netherlands, together with regional and local authorities are aiming to stimulate the market for sustainable products through purchasing sustainable goods and services. All public authorities involved have committed themselves to 100% sustainable procurement in 2015, through the use of core sustainability criteria in all its tendering and procurement processes.

The Netherlands Enterprise Agency (commissioned by) The Ministry of Infrastructure and the Environment has developed sustainability criteria for various product/service groups procured by public authorities, including catering and canteen equipment. The criteria document applies to professional equipment exclusively and not to consumer products such as toasters, kettles, or coffee-makers, or to beverage vending machines. The catering equipment covered in the document breaks down into the following subsets:

- Refrigeration and freezing equipment - cold display counters, fridges, freezers, and deep-freeze units.
- Cooking equipment - stoves, hot plates, steamers, ovens and deep fryers.
- Dishwashers - conveyor and basket-type dishwashers, front loaders, pass-through dishwashers and glass washer machines.

The document takes sustainability into consideration across all stages of procurement, from tender to operational recommendations. During the tender preparation stage the following key considerations should be incorporated into any procurement decision:

- Total Cost of Ownership (TCO) calculation that includes details of not only the purchase price, but also the energy consumption and life span of the appliance.
- Prevent unnecessary energy consumption; make a critical assessment of the actual capacity required from the catering equipment.
- Consider whether it would be possible to realise production resource savings by having existing equipment repaired or by purchasing refurbished appliances.

There are also a number of recommendations and requirements for specific items of equipment, including soup kettles, double boilers, hot counters, heating equipment and consumables (Netherlands Enterprise Agency, 2011).

There are thirteen core minimum purchasing requirements; along with six award criteria, intended to encourage frontrunner suppliers and/or progressive public purchasers. Criteria are developed so that total lifecycle costs do not increase substantially and there is sufficient market supply to meet the core criteria; and are assessed by legal experts to guarantee they fulfil the European tendering procedures.

A selection of core criteria requirements for the three main product subsets is as follows (a full list of requirements can be found in: Netherlands Enterprise Agency, 2011):

- Refrigeration and freezing equipment – energy consumptions should not exceed:
  1. Refrigeration equipment: 15 kWh per m^3 net volume during 48 hours.
  2. Freezer equipment: 40 kWh per m^3 net volume during 48 hours.

- Cooking equipment
    - Gas powered fryers should be preferenced and must comply with the following:
      1. The thermal performance must be at least 83% LHV (lower heating value).
      2. The annual NOx emission may not exceed:
         a. 40 ppm for appliances up to 36 kW LHV, or
         b. 1.11 ppm per kW load for appliances not exceeding 36 kW LHV and 54 kW LHV, or
         c. 60 ppm for appliances exceeding 54 kW LHV; annual CO_2 emission does not exceed 100 ppm.
    - Gas-powered steam or convection ovens should be preferenced and must comply with the following:
      1. Indirect performance must be at least 80% LHV.
      2. The annual NOx emission value of 83.6 ppm may not be exceeded.
      3. The annual CO emission value of 100 ppm may not be exceeded.

- Dishwashers – conveyor dishwashers must meet the following requirements:
    1. Maximum energy consumption per metre: 0.10 kWh
    2. Maximum output of drying zone: 9 kW
    3. Maximum water consumption per metre: 2.2 L
    4. Maximum specific water consumption per load: 300 L • min/m

- Basket-type dishwashers must meet the following requirements:
    1. Maximum energy consumption per basket: 0.10 kWh
    2. Maximum output of drying zone: 6 kW
    3. Maximum water consumption per basket (rinsing water): 2.2 L
    4. Maximum specific water consumption per load: 1.9 L • h / basket

- Glass washers must meet the following requirements:
    1. Energy consumption per basket: 0.20 kWh
    2. Water consumption per basket: 2.5 L
    3. Water consumption per load: 12 L

Case Study 6: Vienna 'naturally good' school meals

Food is responsible for ca. 20% of greenhouse gas (GHG) emissions in Austria; with edible food waste accounting for 14.7% of residual waste in Vienna (Stocker, 2013). Public canteens register particularly high levels of food waste with 385 tonnes (t) food/year discarded at schools and 240 t food/year at kindergartens (Österreichisches Ökologie-Institut, 2010)

ÖkoKauf Wien or 'EcoBuy Vienna' (Wien, 2014) is the sustainable public procurement programme of the Vienna City Administration, under which goods and services are bought according to environmental considerations, defined in legally binding eco-criteria and guidelines. These criteria are applicable to all departments and offices of the administration, along with public services under their operational control such as municipal hospitals and retirement homes.

Natürlich gut Teller or 'Naturally Good Plates' is the leading sustainable food programme of ÖkoKauf Wien. Natürlich gut Teller aims to reduce the negative impact of the food & drink industry, reduce consumption and improve health. CO_2e emission levels vary greatly across canteens, depending on food production methods and seasonality and origin of food. Through the use of organic-food labels, regional products and reduction of meat and fish, GHG emissions levels from field to plate can be significantly reduced.

The natürlich gut Teller criteria document has four essential requirements (ÖkoKauf Wien, 2012):

1. At least one organic component per meal
2. Seasonal fruit and vegetables must be used

3. Less meat; ethically sourced with a maximum of 90g per meal portion (down from an average of 200-250g)
4. Fish must be organic or sustainable; and from an approved fish list (such as: WWF, 2014)

There are six additional discretionary criteria, two of which should be implemented in each meal:

5. Two-thirds of the meal should consist of vegetable components
6. One third of ingredients should be local (regional)
7. At least one fair trade component
8. No convenience foods permitted, e.g. frozen vegetables and seasoned meats
9. Minimal packaging and no single-portion consumables (e.g. milk, juice, yoghurt)
10. Innovative non-traditional cooking, such as vegetarian or foreign cuisines

The programme has proved particularly successful in moving school canteens towards organic produce without causing additional expense for the customer/parent. Every day 30,000lunches containing 50% organic produce are eaten across 361 municipal childcare facilities; with an additional 18,000 students from 90 schools eating a daily lunch with 30% organically grown foods (Natürlich weniger Mist, 2014). Every retirement home in Vienna also offers a compliant dish at least 3-4 times a week. Staff were trained in the guidelines and chefs were consulted and engaged; communication, particularly to older people in retirements homes, was also a significant component of the campaign.

Applicability

This BEMP is potentially applicable across all typology and scale of Public Administration offices across Europe (provided they have internal canteen or coffee bar facilities).

Economics

Minimising the environmental impact of canteens and coffee bars should require minimal upfront investment and is mainly dependent upon the development of sustainable procurement policies. Some small investment may be required to upgrade to efficient catering equipment, however investment should only be made when current equipment has reached its end of life. Any investment made in highly efficient equipment should have a relatively short pay back through savings made due to lower energy and water consumption.
The most significant savings may be made through the reduction of waste. For example in the UK, landfill tax currently stands at £80/tonne and is increasing by £8/tonne every year (HMRC, 2014); while landfill tax in other EU countries range from an average of €30 up to €107.49/tonne in the Netherlands (ETC/SCP, 2012). Less food waste also reduces food procurement, for example Halmstad saved €17,180 annually through a reduction in portions required (Prewaste, 2012). Some empirical evidence also suggests indirect economic gains may be made through a reduction in absenteeism and improved productivity amongst employees with healthy diets (Dursi, 2008).

Driving force for implementation

The driving forces behind minimising the environmental impact of canteens and coffee bars are primarily a reduction in greenhouse gas emissions and monetary savings associated with reduced waste, energy and water consumption. Initiatives may also be motivated by a desire to drive wider sustainable procurement programmes within areas under the public administrations control (Netherlands Enterprise Agency, 2011).
Public bodies may be driven by an ambition to provide healthy and nutritious food, either voluntarily (BHCC, 2012) or legislatively (Prewaste, 2012). There is also some empirical evidence to suggest that healthy eating options (as part of a wider ‘healthy workplace’ programme) can reduce absenteeism and improve retention, engagement and productivity (Dursi, 2008).

Reference organisations

Brighton & Hove City Council, UK
Brighton & Hove was the first city in the UK to write a food strategy back in 2006; aim four of the strategy focuses specifically on sustainable food procurement by public bodies in the city. They have also recently approved pioneering Minimum Buying Standards for public catering contracts

Brussels Environment, Belgium
The Sustainable Canteens project, coordinated by Brussels Environment, aims to support public administration canteens which wish to make the transition to sustainable food.

Department of Energy & Climate Change, UK
The CarbonCulture Platform provides a user-facing communications channel, incentivisation mechanisms and practical examples of individual interventions to encourage sustainable behaviour.

Halmstad Municipality, Sweden
Halmstad Municipality ran a behaviour change competition between schools to decrease food wastage and reduce associated CO_2e emissions in school canteens.

Netherlands Enterprise Agency / Ministry of Infrastructure and the Environment, Netherlands
The Netherlands Enterprise Agency commissioned by the Ministry of Infrastructure and the Environment has developed sustainability criteria for various product/service groups procured by public authorities, including catering and canteen equipment.

Vienna City Administration, Austria
Natürlich gut Teller or 'Naturally Good Plates' is the leading sustainable food programme of the Vienna City Administration; it aims to reduce the negative impact of the food & drink industry and sets minimum sustainability standards for catered dishes.

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2.7 Minimising the environmental impact of meetings and events organisation

Description

This section incorporates all business-related meetings or events, including both indoor and outdoor events which are organised or hosted by the public administration body. Meetings or events may take place on-site, or be hosted by the public administration body off-site. Events or meetings *attended by*, but not directly organised by, the public administration body are not included in the scope of this section.

Public administration bodies can influence external venue hosts or catering companies by choosing to only work with those who are already working to minimise their environmental impact. Similarly, while they do not have direct control over access and availability of wider sustainable travel networks, they can host events with good transport links, or provide sustainable options to attendees.

Venue choice is the most prominent method by influencing the environmental impact of meetings and events – venues with strong environmental performance (e.g. low energy, water efficient, sustainable facilities etc.) and venues locations which minimise transport should be preferred. Similarly, where meetings/events can be held via video and/or phone conference, this should be chosen as the premier option.

Venues with strong energy, water, and waste performance should be chosen; the general management and minimisation of on-site energy consumption, water consumption, and waste production (including that associated with meetings and events) is covered under previous sections of this report and may also be applicable to external event venues. Business travel associated with events and meetings is presented under Section 2.5, while catering services are presented under Section 2.6.

Key considerations when hosting an event are outlined below (suggestions adapted from the Brussels Sustainable Meetings & Events Guide (BELO & ICLEI, 2011)):

- Host a virtual meeting/event as an alternative
- If a physical event is held, ensure the venue and accommodation are accessible by public transport
- Events, venues and/or contractors should be covered by a relevant certification scheme (e.g. EMAS, ISO20121, ISO 14001, Green Key, etc.)
- Sustainable catering options should be provided (e.g. low meat, local, seasonal, fresh etc.)
- Sustainable transport options should be promoted to attendees (e.g. shuttle bus service, public transport travel passes)
- Conference materials/handouts/consumables/giveaways should be avoided; where items are given away they should have a dual purpose, be reusable after the conference, and ultimately be recyclable.
- Segregated waste streams should be provided and clearly signposted
- Sustainability information and engagement materials should be shared with attendees and stakeholders
- Best practice guides and sustainable procurement guides should be produced to disseminate best practice knowledge to other organisations in the jurisdiction

Best practice in minimising the environmental impact of meetings and event organisation may be most effectively administered through the introduction of a sustainable event management system (e.g. ISO20121) and/or through stakeholder engagement and dissemination of best practice learning.

<u>*Sustainable Event Management System*</u>

The introduction of a sustainable event management system represents best practice in minimising the environmental impact of meetings and/or events. Depending on individual organisational needs, the management system may be implemented by the public administration body themselves, or alternatively contractors/suppliers should be sought who have a management system in place (i.e. for a smaller organisation hosting a minimal number of events per annum, it may be more efficient to source contractors implementing the system). ISO 20121 is the international event management standard and is suitable for organisations and events of all sizes. It is designed to help organisations in the events industry, such as caterers, security companies, stage builders, venues, and independent event organisers, to improve the sustainability of their event-related activities, products, and services. It should be used to support and structure sustainability initiatives, with third party certification for an organisation or individual event representing a benchmark of excellence.

Suppliers, hotels and venues may also be covered by EMAS or ISO14001, which are the leading international environmental management systems standards; or by other recognised international schemes such as the EU Ecolabel, Green Tourism Business Scheme or The Green Key.

Stakeholder engagement

In order to minimise the environmental impact of meetings and event organisation it is essential to engage with all interested stakeholders, from suppliers, to delegates and the wider community. Events are delivered by a collective of interested parties, from organisers, to venue owners, to caterers and the wider supply chain. It is therefore essential that each of these parties knows the role they play in the value chain of delivering a sustainable event. While a sustainable events management system can put a number of concrete measures and policies into place (e.g. recycling points, energy efficient equipment) much of the outcomes will also depend on user behaviour (e.g. using recycling points, efficient operation of equipment); it is therefore essential to clearly communicate and engage with those involved with and attending an event on simple measures they can undertake to reduce the environmental impact of attending the event (e.g. using correct segregated bins, choosing tap water and reusable water bottles, etc.). Stakeholders may also be engaged through pledge cards/online pledge boards, whereby stakeholders such as suppliers, delegates and local groups can 'pledge' to undertake a sustainable action. Organisations may also wish to promote sustainable modes of transport – this can be achieved through partnering with hotels within walking distance of the venue, arranging complementary shuttle bus services, or providing public transport travel passes.

This may be achieved through the provision of best practice guidelines and sustainable supplier lists; along with dialogue and surveying of interested parties to determine their needs/wants. Stakeholder engagement can significantly support the delivery of sustainable events and may be achieved through a near zero cost of scale following the initial production of a resource guide/information leaflet, particularly where these are hosted online. This is particularly appealing to Public Administration bodies that have a large outreach, but potentially limited funding for direct engagement.

Dissemination of best practice learning

Public administration bodies should use their unique position to disseminate best practice learning and encourage the development of a wider sustainable events industry and culture.

The purchasing power of public administration bodies also places them in a strong position to influence the local supply chain and to stimulate the market for sustainable goods and services.

They can also demonstrate leadership and commitment through sharing and communicating the benefits (both resource efficiency and cost savings) of delivering sustainable meetings and events. This can create a culture of change across their sphere of influence and multiply the effect of their own internal sustainability actions, making unconventional behaviours common place and habitual.

Achieved environmental benefits

The chief environmental benefits of minimising the environmental impact of meetings and event organisation include:

- Reduced CO_2e emissions
- Reduced energy and water consumption
- Minimal waste production and higher recycling rates

- Reduced materials/resource consumption

The unique position and influence of public administration organisations perfectly locates them to push wider standards and help mainstream sustainability through their everyday activities. Dissemination of best environmental practice to other councils, business and individuals can multiply the impact; each of the frontrunners presented in the Operational Data Section features a focus on sharing best practice and/or encouraging the development of a wider sustainable events industry and culture. Sustainable event organisation also provides an opportunity to engage directly with a number of stakeholders including delegates, suppliers and venues on sustainability issues.

Appropriate environmental indicators

Key environmental indicators, applicable in an EU-wide context, include:

- Suppliers with recognised events management system (e.g. ISO20121) (%/total contract value)
- % accommodation with a recognised sustainable certification scheme (e.g. EMAS, EU Ecolabel, Green Tourism, Business Scheme, ISO20121) (%/total hotel nights)

Additional environmental indicators, applicable in an EU-wide context, include:

- % delegates arriving by sustainable transport modes (%/total delegates)
- Total hours of video and/or teleconferencing facilities used per year and per employee
- % staff with access to video and/or teleconferencing facilities (%/total staff)
- Total waste production for off-site events (total tonnes)
- Total waste recycled, reused, composted for off-site events (total tonnes)
- Total energy consumption for off-site event (kWh)
- Total greenhouse gas emissions associated with off-site event (incl. Scope 1-3 emissions) ($kgCO_2e$)
- Total water consumption for off-site event (total litres)
- % total number of delegates engaged with sustainability initiatives (% engaged/total delegates)
- total number of other organisations using best practice guides and/or engaging with sustainability initiatives (total number of online downloads/pledges made)
- % delegate accommodation accessible by sustainable modes of transport (%/total hotel nights)
- Total consumables provided for events (e.g. delegate bags, gifts, brochures etc.) (total purchase volume (kgs))
- % of display materials which are reused and/or reusable (%/total weight)

Organisations may wish to consider implementing and certifying their organisation and/or individual events to ISO20121 standard, the international standard for sustainable events management, which should incorporate the majority of indicators listed above, along with community, governance and legacy issues.

Cross-media effects

Promoting the use of public transport where large events are taking place, may place significant pressure on public transport systems and traffic control. In cases such as these, public transport network operatives should be consulted in advance of the event to ensure alteration of services where necessary. More information on logistics and multimodality is covered in Chapter 4.

Engagement materials which generate waste (i.e. flyers, handouts, consumables) should be avoided to prevent having a negative impact on waste production.

While video conferencing facilities may reduce the number of physical events to be hosted, such facilities will increase energy consumption at the administration office hosting events virtually.

Operational data

Case study 1: Barcelona sustainable events educational guide

In 2006, Barcelona City Council released 'Sustainable City Council', an educational guide to promote sustainability internally as part of the city's commitment to Agenda 21 (Sostenibilitat Barcelona, 2014). The aim of the guide is to reduce the environmental impact caused by public activity, reduce resource consumption, improve social justice, and provide an incentive for sustainable production through the purchasing power of the public body. Section XIII of the report focusses specifically on the 'Organisation of Public Events' by public bodies and provides details of best practice events within the city (Ajuntament de Barcelona, 2006).

More specific details on the actions that can be taken to create sustainable events are contained within the 'Les Festes més sostenibles' ('More sustainable celebrations') educational guide (Ajuntament de Barcelona, 2004). This guide is used for the councils own events as well as publically available for any stakeholder hosting a public event, from small parties to large festivals. The guide features resources and skills needed to host sustainable events, along with contact details of suppliers of products and cultural services companies that incorporate environmental criteria into their supply chain.

The guide features nine guiding principles of hosting sustainable events and features a checklist of how to achieve these;

1) Reduce the use of non-recyclable containers.
2) Re-use and recycle the different types of waste generated.
3) Save energy.
4) Reduce water consumption and pollution.
5) Minimise noise pollution.
6) Encourage environmental education.
7) Avoid the risk of accidents.
8) Provide for entry and exit routes at the festival.
9) Encourage the use of public transport for going to and from the festival;

The guide is colour coded for simplicity, with a specific focus on the following three areas of impact:

- **Green** provides advice on how to reduce the amount of waste generated at celebrations and how to minimise energy consumption.
- **Orange** is used to encourage sustainable mobility and transport and guarantee the safety and wellbeing of the persons attending.
- **Purple** is associated with environmental communication and education activities.

Case study 2: Brighton & Hove City Council Sustainable Events Programme

Brighton & Hove City Council (BHCC) has developed a Sustainable Events Programme as part of its Environmental Management System (EMS); covering two internationally recognised standards for Environmental Management and Sustainable Events - ISO 14001 and ISO 20121. The programme covers all outdoor events on council land, indoor events at the Brighton Centre, Hove Centre, Hove Town Hall and the Royal Pavilion and museums (BHCC, 2014a). It focusses on the main areas of impact associated with events – energy, water, waste, food, and transport.

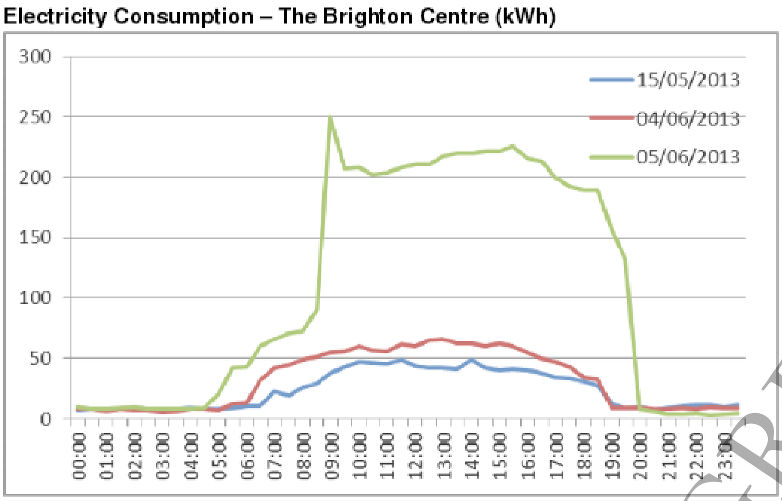
As part of its Sustainable Events programme, BHCC have implemented a number of practical measures to reduce energy, water and waste at its venues. The Brighton Centre purchases 100% renewable electricity and has installed LED lighting, timers and motion sensors to further reduce energy demand (BHCC, 2013). Comprehensive recycling facilities have been installed, including a baling machine for recycling cardboard. Catering options are locally sourced and no parking options are offered to delegates to reduce the impact of food and transport.

The council provide an Events Suppliers list of sustainable supply companies, events management companies, hotels, external catering and transport companies, which can help event organisers to contribute to and achieve ISO20121 standard for their event (BHCC, 2014b). The council have also produced a Sustainable Events Guide for Exhibitors which provides advice on how to make an exhibition space more sustainable. The guide covers four

main activities and includes tips on how to reduce your environmental impact: Your Visit to Brighton & Hove, Your Stand, Your Suppliers and Your Waste (BHCC, 2014c).
BHCC have produced Sustainable Event Commitments for indoor and outdoor events which identify activities that can make a positive contribution to the environment, society and the local economy. The Commitment for Conferences covers indoor events of all sizes, from small meetings to large conferences (BHCC, 2014d), while the Commitment for Outdoor Events is tailored to those external events taking place on council land across the city (BHCC, 2014e). Event organisers that commit to take actions that improve sustainability can use the 'approved sustainable event' logo on event marketing materials before the event (**Figure 2-29**), and if the aims have been achieved during/after the event, BHCC will award a certificate to the organiser. In order to achieve this, organisers must implement ten or more actions (out of 26-28 suggestions) across any sections of the commitment: Energy & Water, Travel & Transport, Waste & Recycling, Food & Beverage, Suppliers & Products and Community, Health & Culture.

Figure 2-29: BHCC Approved Sustainable Event logo (BHCC, 2014c)

As part of the Brighton Centre's Sustainable Events Programme, the environmental footprint of each event hosted is measured using relevant Key Performance Indicators (KPIs) agreed during the planning stage of the event. In the case of repeat events, these KPIs are reused to compare progress. A report is produced containing information on KPIs and on any sustainability initiatives which occurred as part of the event. This report is sent to the event organiser and is confidential, however some organisers make the information publically available (**Figure 2-30**).



Electricity Consumption

Date	kWh
15/05/2013	43646
04/06/2013	44437
05/06/2013	55590

The Key Performance Indicator for energy at this event was the amount of electricity consumed during a 24 hour period compared to a similar day when no event was taking place. It was **11945 kWh**. Because this is the first time we have run this event, we aren't able to compare this figure to other events, but will be monitoring future events to be able to benchmark and set targets. Gas was not measured as the room was not being heated for the event.

Figure 2-30: Extract from Sustainable Event Report at the Brighton Centre (BHCC, 2013)

Case study 3: Brussels sustainable meetings & events guide

Developed by The Brussels-Europe Liaison Office (BELO) and International Council for Local Environmental Initiatives (ICLEI), 'How to organise sustainable meetings & events in Brussels' is a practical guide to provide organisers and hosts of meetings and events from 10 to 100 participants with practical information and recommendations on how to manage their events more sustainably (BELO & ICLEI, 2011).
Brussels has around 66,000 registered meetings per year; when the consumption of drinks, food, travel, paper, water and waste per person is included, this represents a significant impact on the environment. The sustainable meetings and event guide was developed to highlight best practice in the organisation of sustainable meetings & events across the city.
The guide covers the main areas of environmental impact including: Venue; Promotion; Food; Waste; Accommodation; and Transport. It features best practice case studies, recommended suppliers, and key points to consider in order to reduce environmental impact across the six areas of activity while preparing and implementing the meeting. The guide also contains a number of general tips on planning and hosting sustainable meetings and events, including 'five top tips':

1. Do you really need a meeting? Is a virtual event an option (e.g. Teleconference)? (No meeting = most sustainable meeting)
2. Try to use this guide for your next meeting in Brussels
3. Choose one topic/recommendation at a time (step-by-step strategy starting e.g. with 'food' first)
4. Time is key! The earlier you start, the more you save.
5. Lead by example

The guide contains a checklist of practical tips on implementing a sustainable meeting or event (**Figure 2-31**). The checklist also assists event organisers in understanding and monitoring what aspects are missing and what aspects can be improved for future events.

USEFUL QUESTIONS	Y/N / notes
Venue	
Is a virtual meeting (video or tele-conferencing) an option?	
Is the venue close to transport nodes and to accommodation selected?	
Are any sustainability policies applied? (Eco-efficiency, EMAS, CSR)?	
Does the room have natural light?	
Is there a system of separated waste collection/recycling?	
Is it possible to have bio/local/Fair Trade catering?	
Any green procurement policies and eco-friendly cleaning practices?	
Invitation & Conference material	
Are all documents (invitation, agenda etc.) available online?	
Is the meeting material printed double-sided and on recycled paper?	
Are low-emission transport and mobility schemes suggested to participants?	
Are gadgets really useful and/or made of organic/recycled materials?	
Food	
Are the products "sustainable"? (e.g. local, seasonal, organic, Fair Trade)?	
Are carafes and glass containers preferred to plastic bottles?	
Does the ordered food correspond to n° of participants?	
Are disposable items recyclable, biodegradable and/or re-usable?	
Does the caterer apply any sustainability policy (CSR, green purchasing)?	
Waste	
Is packaging minimised and the use of plastic reduced?	
Is there an appropriate system of waste collection and disposal?	
Can organic waste be composted?	
Can excess food be collected by charitable associations?	
Accommodation	
Is the hotel close to the venue and/or well connected by public transport?	
Any sustainability policies in place (Eco-label, EMAS, CSR etc.)?	
Do they serve local, organic and/or Fair Trade food?	
Are other "green" measures (separated waste system, green cleaning etc.) in place?	
Transport & Mobility	
Are the main meeting locations well connected to public transport?	
Can participants access fast and easily thanks to the information provided?	
Are sustainable mobility options available? (bike, car sharing, mobility pass)	
Is there any possibility of bike renting and bike storage?	

Figure 2-31: Brussels Sustainable Meeting Checklist (BELO & ICLEI, 2011)

<u>Case study 4: Danish EU presidency ISO20121 certification</u>

The Danish EU Presidency ran from January to June 2012. The chief goals of the Presidency were to reduce the cost and direct environmental impact of the meeting and events, to share best practice and to promote the business benefits of making the Presidency more sustainable. In order to achieve this, the Danish Government and leaders from the Danish meetings industry formed the 'Danish Sustainable Events Initiative' (DSEI) consortium to improve the environmental, social and economic sustainability of the Presidency and the Danish meetings industry in general (Danish Sustainable Events Initiative, 2013).

The Danish government, supported by the DSEI, committed to delivering all Presidency meetings and events to ISO20121 standard (State of Green, 2012b). Over six months the Danish Ministry of Foreign Affairs organised over 100 meetings, including 10 high level meetings with ministers and other VIPs and up to 90 meetings on the expert/civil servant level. The Presidency attracted more than 15,000 participants (including 400 ministers and 2000 press) to Copenhagen and the city of Horsens in central Jutland (State of Green, 2012a). The meetings ranged from large conferences to small workshops; the minimum attendance at any event was 60 participants and the largest was 900 (Danish Sustainable Events Initiative, 2013).

Sustainability was an integral part of the logistical planning and execution of the Presidency, which was delivered at a fraction of the total cost of past EU Presidencies, saving €40million through the integration of the sustainable event management system (while the cost of hosting the Presidency varies depending on the host nation, previous hosts have spent up to €110million (EurActiv, 2011) (Danish Sustainable Events Initiative, 2013). This was achieved through collaborating with suppliers, entering into sponsorships with clean-tech companies (such as the Danish Wind Industry) and limiting free delegate merchandise and 'gifts'.

"The Danish Government has been dedicated to organize a sustainable Presidency. We are the first presidency, which is planned and carried out sustainably… By rethinking all the processes and by constantly focusing on doing things smarter, we have reached our goal of being certified. An important lesson we have learnt is that you can get very far by demanding more of your suppliers, but even more important close cooperation with suppliers is a prerequisite for success. Many of our suppliers have launched sustainability initiatives in connection with the Presidency, and it is precisely this ability to collaborate and innovate, that makes it possible for Denmark to organize such a big event in a sustainable way" Minister for European Affairs Nicolai Wammen (Sustainable Events Denmark, 2012a).

A number of sustainable initiatives and KPIs were established to achieve the ISO20121 standard for the Presidency, the most high profile being the substitution of bottled water for tap water at all meetings and events which led to it being referred to as the 'Tap Water Presidency' (State of Green, 2012b). Other initiatives undertaken during the Presidency include (Sustainable Events Denmark, 2012a):

- Environmental Certification of conference facilities
- All guests stayed at hotels covered by eco-labels
- Use of public transport where possible
- Limited gift policy
- Sustainable meals
- Sustainable office consumables
- Carpets made from corn sugar polymers
- PVC-free cables
- Reuse of admission cards and lanyards
- Free bicycles for all delegates in Horsens and at selected hotels in Copenhagen
- Optimisation of motorcade driving - fewer cars were sent on the road
- CO_2 compensation of flights with SAS, Wideroe and Blue1 and green take-offs and landings in Copenhagen (Sustainable Events Denmark, 2012b)

In June 2012 the Danish Ministry of Foreign Affairs became the first organisation in the world to achieve externally verified certification to ISO20121 sustainability standard (Sustainable Events Denmark, 2012a). Following the Presidency, a report detailing learning and best practice from the event was released. 'Driving Change Through Collaboration' is written in parallel to the ISO20121 standard, detailing how each stage of the standard was carried out to achieve certification, and containing a full appendix of 'Performance against Objectives' (Danish Sustainable Events Initiative, 2013).

The EU2012 Logistics Team and its DSEI partners collected the IMEX Green Meetings Award 2013, the chief international award recognising environmental awareness amongst meeting organisers, in recognition of the sustainability outcomes of the Presidency. The DSEI has also launched an English-language web portal providing best practice case studies and resources to integrate sustainable event standards, even on a tight budget, for the Danish national and international events industries (Danish Sustainable Events Initiative, 2014).

Case study 5: Scandinavian Sustainable Meetings Accord (23 Scandinavian cities involved including: City of Copenhagen; City of Göteborg; City of Helsinki; City of Reykjavik; City of Trondheim)

The Scandinavian Sustainable Meetings Accord was developed in 2010. As of August 2014, there are 23 cities involved in the project across Denmark, Finland, Iceland, Norway, and Sweden (MCI, 2014). Each city council that has signed the Accord agrees to enable and support sustainable events within their jurisdiction and collaborates with external organisations to support the program, including Convention Bureaus, venues and hotels. Each signatory to the Accord commits to taking ten actions to advance sustainable practices within the meetings and events industry (ICCA, 2012):

1. Publicly declaring participation in the Scandinavian Sustainable Meetings Accord and using our personal and business networks to encourage member organisations to sign this Accord.
2. Engaging our clients, partners and other interested parties in dialogue about economic, environmental and social sustainability for our industry.
3. Educating interested parties, sharing knowledge in sustainable business practices and recognizing ICCA members for their best practice and efforts in sustainable business.
4. Encouraging and supporting private-public collaboration with other destinations to share Scandinavian best practices and solutions and, in turn, to learn from others.
5. Providing resources to planners to identify responsible, sustainable and certified suppliers in our community in order to help planners create more sustainable events.
6. Advocating efficient, equitable and more sustainable use of resources.
7. Facilitating the increased use of environmentally friendly transport through better communication with visitors and collaboration with transport providers.
8. Calculating the CO2 footprint of a defined Scandinavian meetings industry and aiming to reduce this by 20% by 2020.
9. Upholding the highest standards of honesty and fairness and thus maintaining a society with integrity and strong ethical standards.
10. Giving back to the community by proactively creating links between the meetings industry and social responsibility initiatives.

A benchmark of the social and environmental sustainability performance of the cities is published annually by the International Congress and Conventions Association (ICCA) in the 'Scandinavia Destinations Sustainability Index' (ICCA, 2013). The benchmark is divided into two areas: 'hardware' and 'software'. Hardware assesses the sustainability commitment of the city government and performance of the local infrastructure; while software assesses the sustainability attributes of the meetings industry within each city, with a particular focus on hotels, venues and marketing. Göteborg topped the benchmark index in 2013, with an overall score of 83% (ICCA, 2013). In 2014, the Scandinavian Destinations Sustainability Index received the 'Most Innovative Project Award' at the 2nd United Nations World Tourism Organisation's (UNWTO) Knowledge Network Global Forum (MCI, 2014).

Case study 6: EUROCITIES: Greening of Events (Barcelona City Council, Belfast City Council, City of Helsinki, City of Göteborg, Madrid City Council)

EUROCITIES' Clean Cities Working Group published the 'Greening of Major Events' booklet in 2009. The document presents the results of a pilot project undertaken to assess the impact of major outdoors sporting events in European cities (with a particular focus on waste) and provides 'green' guidelines for such activities (EUROCITIES, 2009).
The project involved representatives of EUROCITIES members Barcelona, Belfast, Helsinki, Gothenburg and Madrid, who exchanged experiences and best practice cases on their respective cities. The brochure is a useful tool for any city organising major events, particularly street sporting events such as marathons and footraces and explores best environmental management practices across the following areas:

- Waste Management

- Mobility
- Energy
- Volunteers
- Communication

The guidelines and checklist contained in the booklet are based on the experience of a number of major events, including the 2008 Madrid Marathon which recycled 5,560kg of packaging (incl. plastic bottles) and 550kg of cardboard through installing 292 recycling points along the race course, a targeted communications campaign and eliminating a number of disposable items traditionally distributed, including plastic bags and single use bottled water (Madrid Council, 2009).

Belfast City Council has developed on the brochure by releasing a publically available guide for event organisers on 'Managing Litter and Waste', with a particular focus on outdoor events. The brochure contains guidelines on actions to take before, during, and after an event to minimise waste (Belfast City Council, 2014).

Applicability

This BEMP is potentially applicable across all typology and scale of Public Administration offices across Europe.

Economics

The employment of a sustainable events management system can produce substantial economic savings through the reduction of waste production and resource use (including energy, water, food, consumables etc.). For example, the EU2012 Danish Presidency delivered the event at a €40million reduction compared to previous presidencies which they attribute to the use of the ISO20121 management system (Danish Sustainable Events Initiative, 2013). Savings may also be achieved where a meeting or event is attended/hosted remotely, thus reducing travel and business expenses.

Driving force for implementation

The chief driving forces for implementation of sustainable events and meetings are to reduce costs, resource use and CO_2e emissions. A sustainable events policy and/or events management system can also influence stakeholders, enhance reputation, and drive innovation (for example see Brighton & Hove, Danish EU Presidency and Scandinavian Sustainable Meetings Accord case studies). Competitive advantage is an additional driving force, for instance the city signatories to the Scandinavian Sustainable Meetings Accord use their sustainability credentials to promote their region as leading international events destinations.

Reference organisations

Barcelona City Council (Spain)

In 2006, Barcelona City Council released 'Sustainable City Council', an educational guide to reduce the environmental impact caused by public activity, including events organisation.

Belfast City Council (UK)

Belfast City Council was part of the EUROCITIES' Clean Cities Working Group which published the 'Greening of Major Events' booklet in 2009; which provides best practice guidelines for major outdoors sporting events in European cities.

Brighton & Hove City Council (UK)

Brighton & Hove City Council has developed a Sustainable Events Programme; covering two internationally recognised standards for Environmental Management and Sustainable Events - ISO14001 and ISO20121.

Brussels-Europe Liaison Office (Belgium)
The Brussels-Europe Liaison Office and International Council for Local Environmental Initiatives (ICLEI) developed a practical guide on how to manage events in Brussels more sustainably.

City of Copenhagen (Denmark)
The City of Copenhagen is a signatory to the Scandinavian Sustainable Meetings Accord; committing to ten actions to advance sustainable practices within the events industry, with a benchmark of performance published annually by the International Congress and Conventions Association.

City of Göteborg (Sweden)
The City of Göteborg is a signatory to the Scandinavian Sustainable Meetings Accord; committing to ten actions to advance sustainable practices within the events industry, with a benchmark of performance published annually by the International Congress and Conventions Association.

City of Helsinki (Finland)
The City of Helsinki is a signatory to the Scandinavian Sustainable Meetings Accord; committing to ten actions to advance sustainable practices within the events industry, with a benchmark of performance published annually by the International Congress and Conventions Association.

City of Reykjavik (Iceland)
The City of Reykjavik is a signatory to the Scandinavian Sustainable Meetings Accord; committing to ten actions to advance sustainable practices within the events industry, with a benchmark of performance published annually by the International Congress and Conventions Association.

City of Trondheim (Norway)
The City of Trondheim is a signatory to the Scandinavian Sustainable Meetings Accord; committing to ten actions to advance sustainable practices within the events industry, with a benchmark of performance published annually by the International Congress and Conventions Association.

Danish Ministry of Foreign Affairs (Denmark)
In 2012 the Danish Ministry of Foreign Affairs became the first organisation in the world to achieve externally verified certification to ISO20121 sustainability standard for the Danish EU Presidency.

Madrid City Council (Spain)
Madrid City Council was part of the EUROCITIES' Clean Cities Working Group which published the 'Greening of Major Events' booklet in 2009, which provides best practice guidelines for major outdoors sporting events in European cities.

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3 BEST ENVIRONMENTAL MANAGEMENT PRACTICES FOR SUSTAINABLE ENERGY AND CLIMATE CHANGE

Chapter structure

This chapter deals with the role that local public administrations can play in addressing two important and very intertwinned global challenge of today's world: making the energy system more sustainable and reducing the negative impacts of climate change.

The chapter starts by framing the problem and introducing the different dimensions of the work of a local authority that have a considerable influence in terms of sustainable energy and climate change (Chapter introduction) and then describe best practices in these areas based on the practical examples of European cities that are well replicable and can guide other public authorities in improving their environmental performance (Sections 3.1 to 3.4).

Chapter introduction

Energy is a vital part of the daily lives of European citizens and a key ingredient of the economies of towns, cities and rural areas. But also a commodity that is becoming scarcer, less affordable and the source of a broad range of environmental impacts. Besides EU and national policies, there are many actions that can be taken at local level to improve security of supply (e.g. diversify energy sources and reduce demand), competitiveness (in terms of ensuring the availability of affordable energy for all citizens and businesses) and, especially, sustainability (by promoting energy efficiency and renewable energy sources). Local governments play a crucial role considering that 80% of energy consumption and CO_2 emissions is associated with urban activity (Covenant of Mayors Office, 2015).

Very linked to the move to sustainable energy, which is one of its key components, is the challenge of climate change. Without any doubt, this is one of the central topics public administrations have to deal with now and for the foreseeable future. Local authorities have a key-role to play for climate change mitigation (limiting the causes of climate change) as well as climate change adaptation (ensuring climate change is taken into account in all activities in their territory as well as all local policies and that adaptation measures are implemented to reduce their vulnerability to the impacts of climate change). First, they are in a privileged position to directly or indirectly influence the amount of greenhouse gases emitted within the boundaries of their territory. Directly through the sustainable design of the services they provide (e.g. public transport and waste management) and indirectly through setting the framework conditions for citizens and businesses alike. Second, since local authorities are responsible for a broad range of infrastructure and shape local living conditions to a large degree, climate change will present them with unique challenges and demands to adapt to: infrastructure like sanitation might need to be adapted to heavier rain while overall availability of water might decrease, new health risks might arise e.g. through increased occurrence of heat waves – to mention just a few aspects of adaptation.

In terms of environmental impacts of energy, most prominently, electricity and heat production from fossil fuels, as well as the direct consumption of fossil fuels (such as petrol used in road vehicles) are responsible for GHG emissions which contribute to climate change.

Besides the emission of GHG, energy production is also responsible for the release of particle matter, acidifying substances and NO_x into the atmosphere, which in turn harm ecosystems and endanger human health and threat the living environment (Borgan, 2011).
Another important impact of energy production is land use through the use of land for power plants, wind turbines and overhead power lines, resulting in loss of natural habitats and therefore biodiversity. Also the switch to biomass as energy source is creating problems, leading to the intensification of agricultural activities and even stronger reliance on pure cultures and

genetically engineered crop, which can result in a decrease in biodiversity or the release of invasive plants into the wild.

In terms of making energy more sustainable, public administrations need to embrace strategies promoting greater energy efficiency, which result in saving energy not only at the municipality level but especially at citizen and business level, by using energy more intelligently and looking for synergies within energy usage (e.g. using waste energy, for example, surplus heat produced in industrial manufacturing process or electricity generation for heating of commercial or residential buildings). Energy efficiency is the most important target to achieve a sustainable energy system.

While reducing CO_2 emissions, energy efficiency also reduces peaks of demand, which is particularly important for electricity consumption where demand and generation need to be balanced instantaneously. Reducing peak demand results in diminishing the need of back-up power plants, with large benefits in terms of materials used, land use, impacts on biodiversity and also contributes to avoid the lockout in old technologies with a long economic lifecycle.

Besides energy efficiency, the other pillar of sustainable energy is the deployment of energy from renewable sources as an alternative to fossil fuels. The EU is aiming to increase the share of renewables in the energy mix to 20% by 2020 and at least 27% by 2030, with some member states committing to take this even further. It is very important that the adoption of renewables go hand in hand with energy efficiency because only if energy is used efficiently, renewable energy will be able to provide a significant share of the energy demand.

Crucially a more efficient energy policy has tangible financial benefits. According to EU estimates creating a more energy efficient Europe will save €200 billion by 2020, whilst at a micro level renovating a building to make it more energy efficient can generate up to 60% in energy savings with no compromise in confort and quality.

Local governments have also the opportunity to create jobs through investing in increasing energy efficiency and in renewable energy sources. For instance, in Germany, the BMU estimates that over 367,000 jobs can be attributed to the field of renewable energies (Federal ministry for the Environment, nature Conservation and nuclear Safety, 2011), a field that can be easily boosted by local authorities with appropriate policy (e.g. see Section 3.3).

Techniques portfolio

Local authorities can have an impact on energy and climate change through the different dimensions of their work. This chapter is divided according to these dimensions which are:

- Policy setting role (Section 3.1): within the boundaries of their role, which differ from country to country, local governments can set the framework for all public and private activities on their territory by establishing and actively pursing a policy document or an action plan. Best practice in this area include: establishing an inventory of energy consumption and emissions by businesses, citizens and public administrations on their territory (both to establish the baseline and monitor over time); establishing and implementing a municipal energy and climate plan, identifying actions and measures to be implemented by the municipality itself but also that the municipality can trigger thanks to its regulatory/planning role or its influence on the territory, e.g. by working together with local businesses; establishing and implementing a specific strategy for climate change adaptation, which identifies the main threats and adaptation actions that can be implemented. If this section of the report is about setting objectives and planning actions to achieve them, the concrete elements they would include are most likely many of the elements addressed in detail in the three following sections (3.2 to 3.4), which are about more concrete actions that local authorities can implement.
- Public service provider role (Section 3.2): local public administration are also often responsible for the management of public services (such as street lighting, social housing, district heating networks) and for a large stock of public buildings (offices, but

also schools, etc.). These are referred to in this Section as the municipality's direct operations, although these services and buildings may be both directly managed and e.g. staffed by the municipality or these could be contracted to an external company; even in this second case, however, the municipality has a considerable level of influence (as the contracting authority that sets the terms of reference, monitor the execution of the contract, etc.). In terms of the management and reduction of the energy consumption in public buildings, the information on the set up of an energy management system to promote energy savings in the building(s) occupied by the offices of the municipalities (mainly from the point of view of the public administration as building occupant) is not included in this chapter but in Section 2.1. This chapter focuses instead on the concrete soft and hard measures that can be implemented across the building stock (mainly from the point of view of the public administration as building owner/manager). Other public services not covered in this section (such as public transport – section 4, waste management – section 9, water distribution – section 10, waste water management – section 11) are also relevant in terms of energy consumption but are covered in separate chapters because of their specific nature and the relevance of other dimensions beyond energy.

- Regulatory/planning role (Section 3.3): local authorities are in most cases in charge of taking urban planning decisions and providing building permits to citizens and businesses; the extent to which they can promote energy efficiency and renewable energy in doing so vary from country to country depending on the legal framework (e.g. the building code may be or not in the realm of responsibility of the municipality), but there are transferrable best practices that can be implemented in most cases. These are the focus of this section.

- Exemplary and enabling role (Section 3.4): municipalities enjoy also a large degree of influence on their territory beyond their direct responsibilities: firstly because of their ability to lead by example and demonstrate what is possible in terms of energy efficiency and renewable energy e.g. on public buildings or social housing; secondly thanks to the possibility of creating partnership or other kind of agreements with other actors (e.g. business, civil society organisations) or providing advice services that can stimulate private actors to improve their energy sustainability performance. Of significant relevance within the enabling role is also a specific provision of information/advice to citizens and businesses which is the use of thermography to identify priority for actions and target the efforts more efficiently.

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3.1 Policy BEMPs

3.1.1 Establishing an inventory of energy consumption and emissions of the territory of a municipality

Description

Understanding current energy consumption and greenhouse gas (GHG) emissions is a key first step to reducing environmental impact generated in a certain area. The data is very often used in sustainability planning (see Section 3.1.2) and to target interventions on specific sectors. For instance, the Covenant of Mayors methodology requires a Baseline Emission Inventory (SEI) to be established as a prerequisite to preparing a Sustainable Energy Action Plan (SEAP) (Covenant of Mayors, 2010b).

Items covered within this BEMP, and applicable in an EU-wide context, include:

- Methods for collecting energy consumption and emissions data of a territory
- Best practice for reporting on data and making results publically available

The scope of the inventory must include energy consumption and emissions across the territory from:

- o Industry and Commerce/Services (including agriculture, construction…)
- o Housing and domestic energy use
- o Transport

There are several methodologies for producing emissions inventories. ICLEI, the World Resources Institute and the C40 network of cities are currently developing a "Global Protocol for Community Scale GHG Emission Inventories (GPC)" with the latest draft released in July 2014 (C40, 2014). Methodologies generally include consideration of the following issues:

a. Greenhouse gases
b. Energy consumption
c. Emissions factors
d. Baseline determination
e. Geographical boundaries

a. <u>Greenhouse gases</u>

The most influential greenhouse gas in terms of overall impact on climate change is **carbon dioxide (CO_2)**, whose primary source is burning fossil fuels to generate energy. CO_2 emissions are distinguished in three categories:

- **Direct** – e.g. natural gas in boilers to heat homes, petrol in combustion-engine vehicles;
- **Indirect** – e.g. via electricity, where the power plant emits CO_2 to generate the electricity for the end user;
- **Embodied** – the CO_2 emitted to create a product, often outside the municipality (e.g. from energy use in a manufacturing plant and transport to the consumer).

Inventories of emissions at the municipality level usually include direct and indirect emissions, but exclude embodied emissions, which are much more difficult to estimate and can only be influenced by the municipality in terms of managing consumption.

Emissions of other GHGs are converted to **CO_2 equivalent (CO_2e)** according to their different impacts on global warming. The conversion factors for these are standardised. These GHGs are:

- **Methane** (CH_4) – mainly emitted by the agricultural sector, but also by landfill sites
- **Nitrous oxide** (N_2O) – used for a variety of purposes, including in the medical sector and food packaging
- **Hydrofluorocarbons** (HFCs) – used as refrigerants
- **Perfluorocarbons** (PFCs) – used in various industrial processes

- **Sulfur hexafluoride** (SF_6) – used in the electrical industry

Since CO_2 is the most important GHG in terms of overall global warming impact, and the majority of CO_2 is emitted for energy generation, energy consumption data is the main focus for most municipalities. Methane may also be a considerable contributor, particularly in municipalities with a large agricultural sector.

b. *Energy consumption*

Energy consumption can be broken down into three main types – heat, electricity and transport – and two main sectors – domestic and non-domestic (which in turn can be broken down into sub-sectors, e.g. commercial, public administration, etc.). Some methodologies use different combinations of these types, sectors and sub-sectors. For example the Covenant of Mayors (2010b) uses two categories, Buildings equipment/facilities and industry (broken down into subsectors), and Transport. The International Energy Agency (2014) uses four: Residential, Services, Transport and Industry. These different categorisations should be compatible as long as the data collection has enough granularity.

When calculating energy consumption, it is important that the consumption of all different fuels (including electricity, heat from district heating and decentralised energy production from renewable energy sources) is considered.

Fuel consumption is often not reported in the same units, for example:

- Natural gas (m^3)
- LPG (litres)
- Solid fuels (coal etc.) (kg/tonnes)
- Electricity (kWh)
- Petrol (litres/barrels of oil equivalent)
- Diesel (litres/barrels of oil equivalent)

In order to calculate the total energy consumption, all the different fuel consumptions need to be converted into a common unit, usually MJ or kWh, before they can be summed up. It is also important to distinguish between primary and final energy consumption. Primary energy is the energy form pre-transformation, e.g. crude oil. Losses from transformation to final energy forms, e.g. electricity, and transportation/transmission of the fuel, result in lower final energy consumption figures. This is an important distinction for energy balances and resource management.

c. *Fuel emissions factors*

In order to calculate the CO_2e emissions, each of the different fuel consumptions need to be multiplied by an emission factor (CO_2e/kWh). Standard emission factors are available for all common fuels and should generally be used unless there is a particular reason not to. The CO_2 emissions from electricity vary according to the national mix of energy generation technologies, therefore it is recommended to use the relevant national emissions factor for grid electricity.

d. *Baseline determination*

Emissions reductions reporting need to have a baseline year in order to monitor progress and provide context. The baseline year should be either:

- the earliest year for which the most comprehensive and reliable data can be collected in the areas being monitored; or
- a relevant year for national or international reporting, e.g. 1990 for the Kyoto Protocol and EU reporting.

The baseline year should always be referred to when communicating emissions statistics, e.g. "in 2012 the municipality reduced CO_2 emissions by 25% (compared to 1990 levels)". This is because emissions will vary annually according to multiple factors, including some out of the control of the municipality such as the outside temperature.

e. *Geographical boundaries*

Municipalities will be aware of their physical boundaries and these should correlate to national statistical areas. It can be very useful to analyse emissions or consumption from smaller areas within the municipality, to help target particular interventions. This can be done in two main ways:

- Using smaller statistical/political areas (e.g. postcode areas); or
- Grid mapping (GIS).

The appropriate method to use should be consistent with existing datasets and the intended use of the data. Both methods have advantages in particular situations. For example, energy consumption reported by postcode area can highlight properties in need of energy efficiency interventions, whereas transport emissions mapped by GIS can highlight particular roads that have high traffic levels.

f. *Exclusions*

Since municipalities are usually not isolated from the region and nation, some emissions are not appropriate for local reporting. These include emissions from large power stations feeding the national electricity grid (even if located in the territory of the municipality), national railways, aviation and shipping.

Exclusions should be considered in the context of the specific competences and responsibilities of the municipal government. For example a large power station would most likely serve a wider area than one municipality and so the emissions will be counted as part of the national grid emissions factor. However, a smaller scale renewable energy system owned by the municipality or another local entity should be counted. Similarly, aviation emissions from planes landing at a local airport should not be included, but emissions from the airport buildings should.

The Covenant of Mayors suggests that emitters taking part in the EU Emissions Trading Scheme (ETS) should be excluded (Covenant of Mayors, 2010b), however this may cause opportunities to be missed when deciding on actions. Where possible and practical it is worth noting these emissions in order to obtain as broad a picture as possible of local emissions but, eventually, excluding them from some of the analysis.

Sometimes exclusions that would be fair and appropriate are not currently possible. For example, at 43% of total emissions, the transport sector is the largest source of emissions for Girona (Spain). These emissions are based on the fuel sales figures for the city area. However, as Girona is on the main transport route between Spain and France (for exports to/from Europe) and many trucks refuel in the city area (fuel taxes are cheaper in Spain than in France). A methodology that considers and adjusts the allocation of transport emissions in a fair and proportionate way could be an advantage for the city (LAKs (Girona), 2011). Until this adjustment is made (if possible), analysis of the data should take these local facts into account when recommending actions and priorities.

g. *Data Collection*

Once the municipality has decided what data to collect, the following hierarchy should be used in order to build up the desired database, in order of sequence.

Firstly: Use existing datasets

National governments already collect large amounts of data – census, CO_2 emissions, transport etc. – some of which may be broken down by region, local authority or smaller areas. For example, the UK's Department for Energy and Climate Change publishes annual energy consumption estimates based on supplier reporting for local authority areas, MLSOAs and LLSOAs (medium and small statistical areas that sit within a local authority area) (DECC, 2014).

Some datasets may not be granular enough for the purposes of the desired database. It may be possible however to estimate more granular figures through modelling using other datasets and basic assumptions. The cost of modelling should be weighed up against the cost of collecting new data.

For example, if energy consumption by house type is a desired dataset, this could be estimated using energy consumption by area, information on house types by area (either existing or collected) and an understanding of heat loss in different house types.

Secondly: Data from market operators

The required data may already be collected by market operators such as energy suppliers and transport operators. This data will probably be seen as commercially sensitive and only aggregated data may be available, but could still be useful. However, many public authorities have contractual relationships with operators in their areas (e.g. public transport) and can require that certain data is reported as part of the contract. Note that market operators may already be reporting data to national/regional governments.

Local government itself will very often be the source of a significant proportion of emissions/consumption. Existing records can be used to estimate historic data and policies/processes can be put in place to ensure the desired data is collected in the future. Procurement requirements can also be used to collect data from suppliers.

Thirdly: Data collection from consumers

Collecting data from consumers is likely to be the most expensive option and may not be very effective at collecting good quality data. Surveys delivered directly to consumers often have low response rates and suffer from selection bias (i.e. those who respond have a particular profile, meaning data is not fully representative).

Good quality data could be collected by:

- Working with local organisations in the areas of interest that have direct relationships with consumers. This could be a hospital or doctor’s surgery, or a locally based charity or community group.
- Online surveys in combination with face-to-face and phone surveys for a sample of the population. Efforts must be made to ensure a representative sample is surveyed.

Fourthly: Direct measurement

It may be possible to make direct measurements, for example traffic monitoring. This may be more suitable than surveys but also has a cost associated.

h. Action plans and reporting

The main benefit of developing a database of emissions and consumption is to analyse and use the data to identify the actions that can be taken to reduce CO_2. A local action plan is usually developed, using the data to support the case for particular interventions. This can be an energy-focused action plan, like the Covenant of Mayors’ Sustainable Energy Action Plans (SEAPs) or they can focus on emissions, and therefore include CO_2 emitting activities beyond energy (e.g. agriculture), for example in the Climate Mitigation and Adaptation Action Plans (MAPs) from the LIFE+ supported project Local Accountability for Kyoto Goals (LAKs). Reports are generally made public and used as a basis to engage with the wider community on the actions.
It is possible to develop the software database, but there are also a number of freely available or commercial tools, including the LAKs toolkit (LAKs, 2014) and ICLEI’s Heat+ tool (ICLEI, 2014).
Making the underlying data openly available can bring wide economic and social benefits, which has been evaluated for various datasets such as the UK’s Ordnance Survey (physical geography) data (Ordnance Survey, 2013). This data can be used by other public authorities, commercial organisations and members of the public to produce a wide variety of tools, services, information and activities.

• Total annual carbon emissions of the municipality (tCO_{2e}) and per inhabitant ($kgCO_{2e}$/pers)
• Total annual carbon emissions of the municipality (tCO_{2e}) and per inhabitant ($kgCO_{2e}$/pers)
• Total annual carbon emissions of the municipality (tCO_{2e}) and per inhabitant ($kgCO_{2e}$/pers)

Achieved environmental benefits

Inventories in themselves do not produce any environmental benefits, but are key enablers to set objectives and monitor progress towards them. They are usually used for action planning to identify key sectors or areas for energy consumption and CO_2 emission reduction measures.

Appropriate environmental indicators

There are numerous indicators used in emissions and consumption databases, however the vast majority of them relate to:

- Total annual carbon emissions of the municipality (tCO_{2e}) and per inhabitant ($kgCO_{2e}$/pers)
- Annual energy consumption per inhabitant (kWh/pers)

Cross-media effects

There are no negative cross-media effects relating to other environmental pressures as a result of establishing an inventory of energy consumption and emissions of the territory of a municipality.

Operational data

Padova, Italy

Comune di Padova, the municipal government of Padova, produced a GHG inventory and a Mitigation and Adaptation Action Plan (MAP) as part of their involvement in the LAKs Project, supported by LIFE+ funding. This was approved by the city council in 2011 and forms a basis for its activities moving towards 2020.

The LAKs Project developed the LAKs GHG Inventory Toolkit: a calculator, with supporting reference documents, to help the quantification of municipality emissions by sector and by fuels used. The LAKs calculator is an easy-to-use spreadsheet (adapted for EU from ICLEI's CCP calculator) which converts data from energy used (fuels, heat and electricity) plus agriculture and waste activities into GHG emissions using appropriate nationally-acceptable emission factors. The emissions results are expressed in tonnes of carbon dioxide equivalent (tCO_2e) (LAKs, 2014).

Figure 3-1: LAKs GHG emissions calculator (LAKs, 2014)

In Padova, the community inventory highlighted the industrial sector as the largest area of community emissions – 36% of all local emissions. The residential sector comprised 29% and the transport sector 17%. Commercial and institutional sectors in Padova accounted for another 15% of total emissions. The inventory also provides a picture of the individual fuels and energy sources that cause most of the emissions.

Using this inventory, Comune di Padova developed a Mitigation and Adaptation Action Plan with targets to reduce its emissions and increase local resilience to climate change. The activity areas were:

1. **New low carbon energy**
   Installation of renewable electricity to produce a 4% cut in total emissions by 2020 (based on 2005 levels)
2. **A greener and more efficient city**
   Increase energy efficiency in public buildings and the residential sector
3. **Smarter city and services**
   Reduce emissions from street lighting and residential waste
4. **A city which moves better**
   Encourage a shift to low carbon transport – public transport, cycling and walking
5. **A low carbon economy**
   Reduce commercial transport by improving infrastructure and working with the local business association to implement energy efficiency measures
6. **A resilient city**
   Work with the local university to identify vulnerabilities and priorities for intervention

Genova (Italy)

Comune di Genova signed up to the Covenant of Mayors on 10 February 2009 and has been developing an integrated Sustainable Energy Action Plan (SEAP) which is part of a 10-point master plan for sustainable growth for the city. The scope of the SEAP is very broad and includes increasing the energy efficiency of council buildings, rationalising the transport system and improving uptake of renewable energy sources. (Schumacher Institute, 2011).

The “Baseline Emission Inventory” (BEI)” quantifies energy flows and the amount of CO_2 emitted due to energy consumption in the territory of Genova in the baseline year 2005, serving as the reference against which the reduction targets and the actual achievements of individual actions and related emission reductions in 2020 will be monitored and compared (Comune di Genova, 2010).

The final energy consumption sectors included:

- municipal buildings, equipment/facilities
- tertiary (non-municipal) buildings, equipment/facilities
- residential buildings
- municipal public lighting
- municipal fleet
- public transport
- private and commercial transport

The energy consumption data of industries and of long-distance transports (railway, highways, sea and air transport) were excluded in accordance with Covenant of Mayors SEAP guidance (Covenant of Mayors, 2010a).

The energy consumption data allowed Genova to identify that:

1. Energy consumption of the civil sector (buildings, equipment/facilities of the residential and tertiary) represents the by-far prevailing use of energy.
2. Natural gas is the main fuel source being used in Genova city, and it is used primarily in the residential sector.
3. Private transport is lower in Genova in comparison to the national average which is shown in the relatively high exploitation of public transports by inhabitants (approximately 43%).
4. Electricity consumption is significant and growing in the tertiary sector, which is evidence of increasing use of summer air-conditioning.

The trends identified in the SEAP allowed Genova to develop responses and embed them in local policy, for example:

- Adopting more stringent building regulations for new developments, promoting energy efficiency and renewable energy.
- Eco-friendly bus fleet transition plan to phase in more efficient buses by 2014
- Refurbish and upgrade several hydropower plant from local reservoirs with new generators totalling 1500 kW.

The target is to reduce emissions by 22.8% (2005 baseline) by 2020, around 113,000 tCO_2.

Applicability

This BEMP is applicable to all public authorities across Europe.

Economics

The costs of implementing an emissions/consumption database are largely due to staff time. However, the expertise may not exist within a public authority and external support may be required. The scope of the database and availability of existing datasets will determine the overall cost, but the categories of cost are:

- Analysis and modelling of datasets
- Engagement of market operators to obtain new datasets
- Development and delivery of surveys
- Direct monitoring
- Software licence to host database
- Licence fees for some datasets

Driving force for implementation

EU member state governments have carbon emission reduction targets and renewable energy targets set by international agreements such as the Kyoto Protocol and the EU 2020 climate and energy package. This has been translated into national legislation in different ways, but action will be necessary by local governments to meet these targets.

In order to implement these targets an evidence base must be established to inform the development of energy and climate change policies and plans as well as monitoring and evaluating their impacts. An inventory of emissions and consumption forms a major part of this evidence base. This also allows benchmarking of performance against other municipalities. Local governments may also have other drivers to implement this BEMP, for example:

- Reducing costs from its own energy consumption
- Improving public health
- Targeting measures for people in fuel poverty

Municipalities may also be required to establish an inventory as part of membership in schemes such as the Covenant of Mayors.

Reference organisations

<u>*LAKs*</u>

LAKs is a LIFE funded project running from 2009 to 2011 which involved municipalities from three EU member states:

- Reggio-Emilia (Italy)
- Padova (Italy)
- Bydgoszcz (Poland)
- Girona (Spain)

These municipalities developed emissions databases and action plans using a specially developed toolkit (LAKs, 2014).

<u>*Genova, Italy*</u>

Developed emissions database and implemented Sustainable Energy Action Plan using Covenant of Mayors guidance (Comune di Genova, 2010).

<u>*Burgas, Bulgaria*</u>

Developed a local strategy for sustainable energy using the Covenant of Mayors guidance (Sustainable Now, 2014).

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3.1.2 Establishing and implementing a municipal energy and climate action plan

Description

Once a municipality has established an inventory of energy consumption and emissions (see Section 3.1.1), the data can be analysed and used to identify the actions that can be taken to reduce CO_2 in the framework of the development of a municipal action plan. These plans are sometimes referred to as plans for sustainable energy and in other instances as plans for climate change mitigation. Although there are conceptual differences (i.e. the first aims at reducing energy use and meeting energy demand with renewables; the second aims at reducing GHG emissions), these result in considerably different approaches only in municipalities with high non-energy related GHG emissions (e.g. because of large agricultural activities). In some cases, a climate action plan deals not only with climate change mitigation (i.e. reducing the local contribution to the causes of climate change, thus reducing GHG emissions) but also with climate change adaptation (i.e. increasing the resilience of the local territory, including its infrastructure and activities, to the changing climate and the foreseeable extreme weather events). As a climate adaptation strategy is quite different from climate mitigation and deserves special attention, the aspect is dealt with in a separate BEMP (see Section 3.1.3).

The establishment of a municipal energy and climate action plan is very important to ensure consistency among the different measures implemented, including measures implemented by other actors (e.g. private companies) on the territory of the municipality, but also to ensure that a strategic approach is taken towards sustainable energy and climate change mitigation which allows taking advantage of opportunities which may arise from efforts (e.g. investments) in these areas.

A key step in the development of the plan is determining its level of ambition by setting targets. In some cases these are political targets set a priori (often long term targets); in other cases they can be developed bottom-up starting from the inventory data and are often more short term. An example of the first kind are the targets set by local authorities signing up to the Covenant of Mayors (CoM), which requires that cities commit to go beyond the 20% reduction in CO_2 mandated by the Europe 2020 policy (Covenant of Mayors, 2010).

In order to reach the targets that the plan wishes to set, an appropriate set of actions, building on the priorities identified in the inventory, must be identified. Depending on the areas to be address, a number of different sections and chapters of this document can provide inspiration and guidance about best practices for those areas. The most relevant are:

- For actions to reduce the emissions of private buildings and businesses within the municipality: Sections 3.3 and 3.4
- For actions to reduce the energy related emissions of municipal buildings and local public services (street lighting and social housing): Section 3.2
- For actions to reduce emissions from local transport/mobility: Section 4

The local action plan usually presents the actions to be implemented, using the inventory data to support the case for particular interventions.

It is very important that the actions are appropriate and the expected results are reasonable. A mechanism for monitoring the effectiveness of the measures applied and careful review of the progress made in view to eventually modify the plan is also needed.
Best practices in establishing and implementing a municipal action plan include:

- <u>Political commitment</u>

The plan needs to be supported by the political power and approved by the municipal council (or equivalent official body).

- <u>Participatory approach</u>

Public participation in planning ensures long-term acceptance, viability and support of the strategy and measures. It also ensures that the actions described in the plan are not just for the municipal administration but for society as a whole, which is a key dimension of this kind of policy instrument. Finally, stakeholders' involvement is also the starting point for creating the behavioural changes needed to complement the technical actions embodied in the plan (ICLEI, 2011).

– <u>No one-size fit all</u>

Planning the measures to be implemented on the basis of the specific data of the municipality is very important to select the correct measures. For instance, the share of emissions per sector can vary considerably from city to city.

Figure 3-2 presents the share of CO_2 emissions per sector in three different cities (CoM, 2010).

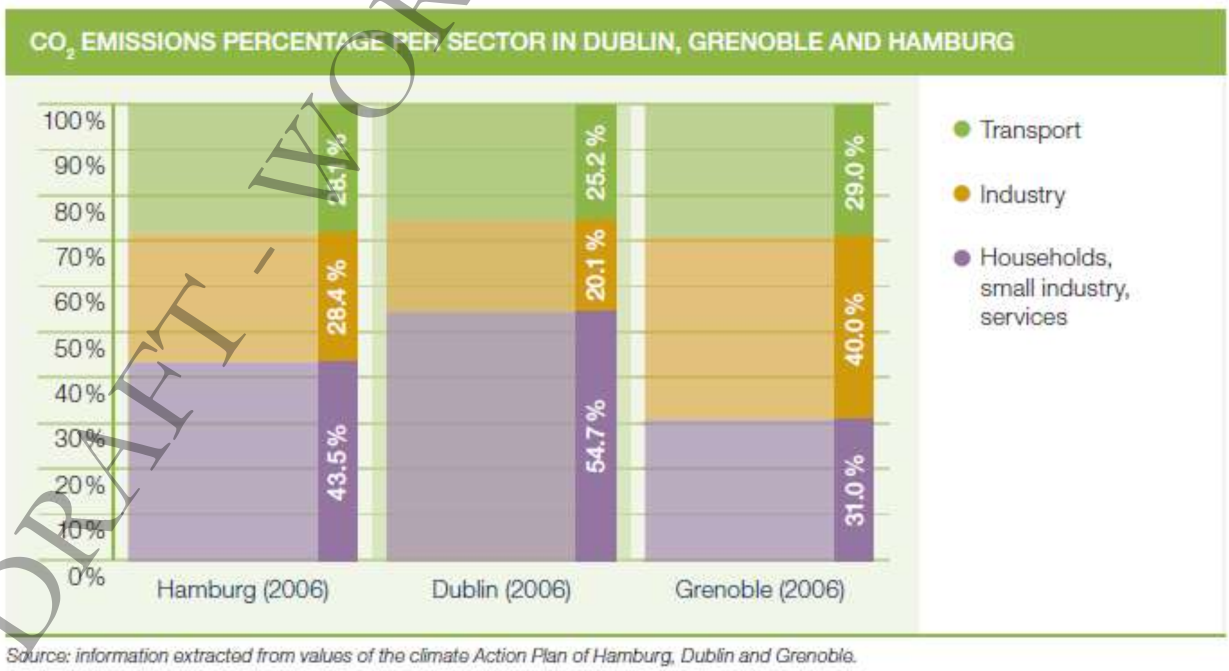

Figure 3-2: Share of CO_2 emissions per sector in Hamburg, Dublin and Grenoble. Source: CoM, 2010.

– <u>Thorough data analysis and understanding of drivers of changes in energy consumption</u>

Efforts need to be put into a proper and thorough analysis of the data, aimed at understanding which are the main drivers of energy consumption in order to tackle, as much as possible, the root causes and the areas with the most saving potential. Identifying external variables that influence energy consumption is also important for a more effective action plan.

– Broad set of actions

It is often the cumulative effect of a broad set of actions what allows achieving ambitious targets. Actions to decrease emissions in a single action plan can be as varied as changing public lighting lamps to LED technology or installing a co-generation power plant to "soft measures" such as energy auditing programmes to provide support to citizens, creating "green kindergartens" that run on renewable technologies and raising energy awareness through smart-metering.

– Scenario-based approach

Adopting a scenario-based approach to strategy development – considering the impact of a "do-nothing" scenario in which no action is taken and contrasting it with the projected consequences of a specific action plan - is a good way to judge the viability of different courses of action.

– Clear operational responsibilities

The plan must define who is responsible for what at the operational level (e.g. which department of the municipality or which other actor takes the lead in putting in place a specific measure).

– Planning the appropriate resources

For the implementation of concrete actions, the plan needs to include the allocation of dedicated human and financial resources. If financing is planned, the action plan should include a strong business plan that make the actions bankable (ICLEI, 2011).

– Publicly available and widely disseminated information

The environmental benefits of the implementation of such an action plan can be considerably increased by making it publicly available and widely disseminated. Not only it can motivate citizens to take action also beyond the plan, but can also serve of inspiration and guidance for other cities. Information on results and lesson learned should also be communicated publicly for specific measures.

In the specific case of the Covenant of Mayors' Sustainable Energy Action Plans (SEAPs), which are energy-focused action plans that are drawn according to a specific methodology and validated by the European Commission, specific guidelines for the development of the plan are provided (Covenant of Mayors, 2010). These can be helpful guidance both for municipalities willing to sign the Covenant of Mayors and enacting a SEAP as well as for all municipalities implementing an action plan for sustainable energy or climate change mitigation.

The development and implementation of a SEAP comprises four steps with sub-steps. These steps may overlap with one another, or may have previously been completed by the local authority. In order they are:

1. Initiation
- Political commitment and signing of the Covenant
- Adapting city administrative structures
- Building support from stakeholders

2. Planning phase
- Assessment of the current framework: Where are we?
- Establishment of the vision: Where do we want to go?
- Elaboration of the plan: How do we get there?
- Plan approval and submission

3. Implementation phase
- Providing long-term political support to the SEAP process

- Making sure that the energy and climate policy is integrated in the everyday life of the local administration
- Showing interest in the plan implementation, encouraging stakeholders to act, showing the example
- Networking with other CoM signatories, exchanging experience and best practices, establishing synergies and encouraging involvement in the Covenant of Mayors.

4. Monitoring and reporting phase
- Monitoring
- Reporting and submission of the implementation report
- Review

Achieved environmental benefit

The environmental benefits from the establishment and implementation of an action plan are those linked to the measures planned and then implemented described in the plan. Many of the other BEMPs described in this chapter and elsewhere in this report are examples of measures included by municipalities in energy and climate action plans. The related environmental benefits are described in the relevant sections.

Appropriate environmental indicators

Table 3-1: An example of set of environmental indicators used in municipal energy/climate plans

Name	Unit of measure (type A)	Unit of measure (type A/B)	Description
CO_2 emissions	t	tonnes of CO_2 emissions / population	CO_2 emissions related to the consumption of the whole administrative area, disaggregated by sector: household, services, transport, industry, agriculture. CO_2 equivalent: emission of global warming gas (CH_4, CO_2, SF_6) could be considered instead of CO_2.
Electricity consumption	kWh	kWh electric consumption / population	Electric consumption disaggregated by sector: household, services, industry, other
Natural gas consumption	m^3	m^3 natural gas consumption / population	Natural gas consumption disaggregated by sector: household, services, industry, other
Oil consumption	l	litres oil consumption / population	Oil consumption disaggregated by sector: household, services, industry, other
CO_2 emissions of the local authority	t	tonnes of CO_2 emissions / total number of employees	CO_2 emissions related to the local administration's activities (building, transport etc…). CO_2 equivalent: emission of global warming gas (CH_4, CO_2, SF_6) could be considered instead of CO_2
Energy consumption of public buildings	kWh	kWh consumed (heating + electricity) / total number of employees	Electric and heating consumption of public buildings. They could be disaggregated into different types of building (school, sporting structure,

		kWh consumed (heating + electricity) / total floor surface of public buildings	etc…)
Energy consumption for public lighting	kWh	kWh consumed / population	
Fuel consumptions of public vehicles	l	litres consumed / total number of employees	Consumption of fuel (gasoline, methane, LPG, petrol) for public vehicle used by employee during the working time

Operational data

This section sets out examples of measures implemented within municipal energy and climate plans as well as case study examples of local authorities having established and implemented such as plan, which demonstrate some of the methodologies outlined above and represent best practice.

Table 3-2: A selection of best practice actions extracted from Sustainable Energy Action Plans (SEAPs) established by municipalities signatories of the Covenant of Mayors. Further information on the individual measures can be found in the respective SEAPs available at: http://www.eumayors.eu/actions/sustainable-energy-action-plans_en.html

Aachen	DE	Residential	Micro CHP in social housing
Abbiategrasso	IT	Awareness raising	Thermographic survey of existing buildings
Abbiategrasso	IT	Transport	Shopping bus
All the municipalities in Province of Milan	IT	Awareness raising	Advisory services to citizens on energy saving potential at the household level.
Cardiff	GB	Residential	Producing a building standard to achieve a minimum SAP (STANDARD ASSESSMENT PROCEDURE) rating of 62 in private rental housing where possible - expected in 1,400 properties by 2016
Carugate	IT	Land use planning	Buildings regulation – Solar thermal and PV compulsory in new buildings
Carugate	IT	Transport/ Awareness raising	Walking bus (Piedibus) for children going to school
Copenhagen	DK	Land use planning	All new neighbourhoods in the city must be built close to metro or suburban train stations.
Dublin	IE	Local district heating	CHP using methane from sewerage works at Ringsend.
Dublin	IE	Residential	Social Housing Action Plan. Energy retrofit of void social housing.
Glasgow	GB	Residential/Tertiary	Conduct a building by building survey of properties that will benefit most from energy efficiency and energy management measures
Helsingør	DK	Municipal buildings	ESCO project: 165.000 m2 building area for energy renovation, including electrical installations and climate envelope.
Helsingør	DK	Transport	Electric bikes and cars for transport of employees between local administrative addresses.
Lodi	IT	Public lighting	MB 4 LED: Deployment of LED technology for

			traffic lighting and votive lighting.
Manchester	GB	Land use planning	Carrying out a co-ordinated Land Audit of the city region to assess current and potential future land use.
Manchester	GB	Land use planning	Ensure all new homes funded by Government or built by RSLs are in compliance with the escalating Code for Sustainable Homes requirements.
Manchester	GB	Land use planning	Creating a Business Travel Policy for all types of business and personal travel undertaken by the city council employees, including aviation.
Maranello	IT	Municipal buildings	Public building energy renovation through ESCO intervention, public building energy certification and monitoring of energy performance contracting results
Modena	IT	Public lighting	Street lighting (high pressure sodium - HPS lamps) and LED traffic lights
Modena	IT	Transport	Optimization of the waste transport logistics
Næstved	DK	Transport	Mobility management. Park and ride
North Tyneside	GB	Residential	Insulation of about 4000 cavity walls and 5928 loft spaces through partnership with a dedicated company.
Nynäshamn	SE	Land use planning	New residential areas should be within 900m to a bus or train station
Reggio Emilia	IT	Residential	Energy Performance Contracting in social housing
South Tyneside	GB	Public procurement of products and services	Driving higher energy efficiency standards amongst subcontractors by including environmental criteria as part of the process for selecting suppliers.
South Tyneside	GB	Transport	Smart Ticketing Initiative for public transport.
Stockton	GB	Transport	Pedestrian and cycle safety training to 2000 school children per year to encourage walking and cycling to school.
Stockton	GB	Transport	Encourage take-up of cycle to work scheme.
Stockton	GB	Transport	All significant new business developments to provide sustainable travel plans.
Worms	DE	Working with stakeholders	Screening of a business tax remission for small and medium enterprises when employing renewable energies and combined heat and power locally. Strengthening of local handcraft in the field of renewable energies and combined heat and power.

<u>Växjö, Sweden</u>

The Sustainable Energy Action Plan of the city of Växjö, Sweden - approved in 2008 - foresees a reduction of 65% of CO_2 per capita emissions in 2020 compared to 1993. The strategic vision of the city is to become fossil-fuel-free by 2030.
Energy efficiency enhancements have been promoted both in the residential and in the tertiary sector (in shops), also by mean of some soft measures (campaigns), dealing with behavioural

aspects and with the general climate issue. CO_2 per capita emissions from the building, equipment/facilities and industry sector are expected to be reduced by 90%.
As regards the transport sector, a reduction of 23% of per capita emissions is expected. The strategic measures identified are: a) a full mobility multi-modal plan coping with the freight transport to the city centre and further developing cycle paths; b) the construction of a biogas plant that will produce biogas to be used in public transport and private cars.

Maranello, Italy

After joining the CoM, the city of Maranello, Italy has developed its SEAP foreseeing 26 measures to decrease CO2eq emissions within 2020. These include, among others:

- Funding for energy improvement of external lighting of private property
- Energy efficient public lighting
- Energy efficiency refurbishment, monitoring and energy certification for public buildings
- Organisation of awareness raising events
- Improvement of public transport
- Creation of municipal and inter-municipal cycle paths
- Installation of solar plants on municipal soil and geothermal plants in public buildings
- Creation of purchasing groups for solar panels
- Creating a district heating and cogeneration plant
- Switching to GPP

The application of the SEAP will allow Maranello to cut its emissions by 22.452 CO2t/y, i.e. 21,5% in comparison to 1995. Figure 3-3 shows avoided CO_2 emissions share per sector and Table 3-3 shows reductions in tonnes per year

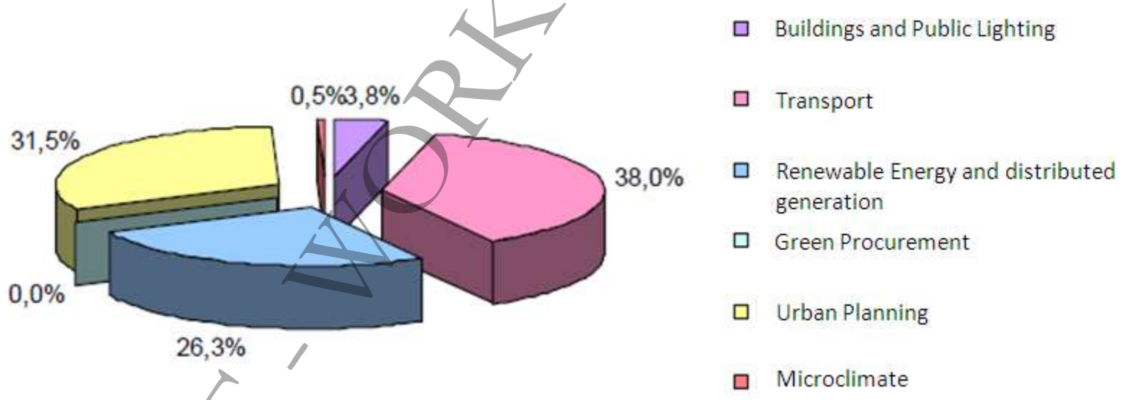

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Figure 3-3: Avoided CO2 emissions share per sector Source: Maranello Municipality, 2010.

Table 3-3: CO2 reduction in tonnes per year. Source: Maranello Municipality, 2010.
Avoided CO_2

	Tonnes/year
Buildings and Public Lighting	1,083
Transport	8,417
Renewable Energy and distributed generation	7,574
Green Procurement	0
Urban Planning	5,239
Microclimate	139
Total	22,452

Applicability

Municipalities of all types and sizes can establish and implement an energy and climate action plan.

For the plan to be effective, internal administrative structures and working processes/procedures need to reflect the programme. The development and implementation of the plan requires collaboration and coordination between various departments in the local administration, such as environmental protection, land use and spatial planning, economics and social affairs, buildings and infrastructure management, mobility and transport, budget and finance, procurement, etc. Often the set of a specific department with appropriate competencies is also recommended.

Economics

Two dimensions should be considered: the costs for the development and management of the action plan (mainly human resources at the local authority); the investment needed to implement the actions described in the plan.

For the first ones, guidelines suggest one employee per 100,000 citizens. Municipalities with limited in-house knowledge, may also require contracting experts to e.g. carry out the data analysis or evaluating different scenarios. Human resources and external contracts allocated to developing and managing the plan can be effective financially through saving on energy bills, increased access to funding schemes, etc.

As for the investments required to implement the actions described in the plan, financial resources should be identified prior to implementing the long-term strategy, and accommodated within the municipal budget. EU funding instruments, such as the European Regional Development Fund (ERDF), the European Social Fund (ESF), and the Cohesion Fund (CF) can also provide support both for the development of the plan and, more often, for the implementation of specific actions. Some EU instruments, such as the ELENA facility and European Energy Efficiency Facility, can support municipalities in the feasibility study of a certain action in order to turn it into a bankable project that can receive financing from other sources. Some municipalities manage also to obtain funding through public-private partnerships.

A good example of how the measures foreseen in a SEAP can be implemented in an economic advantageous way is represented by the case of Modena, Italy (Antinucci, 2011). The Municipality, in collaboration with the Province established an Agency for Energy and Sustainable Development (AESS – Agenzia per l’energia e lo sviluppo sostenibile) with technical and communication tasks. This agency is a not-for-profit organisation, offering consultancy to the public sector and private businesses. The agency is active in favouring the development of renewable energy on the territory of Modena and promoting energy efficiency and reducing pollution. The agency received initial funding from the European Union (30%) and by its associates (50 Municipalities, the University, the Chamber of Commerce and 3 NGOs), who are required to pay a membership fee. In order to be self-sufficient, the AESS offers services on a contractual basis. The creation of such an agency can also allow funding of actions under Public Private Partnerships. For instance, the AESS provided assistance to the province of Modena in preparing a tender to substitute thermal power plants without any additional costs for the public administration. As a result, 11 new plants were installed, guaranteeing 8% savings per year. The investment was funded by ESCO companies and a 7 years “sharing savings” contract was signed (under the ESCO model part of the savings pay back the company making the investment and managing the installation and the other part allow the public administration to save money).

Driving force for implementation

The main reasons why local governments set up energy and climate action plans are:

- Making a public statement of commitment to CO_2 reduction
- Creating or reinforce the dynamic on CO_2 reduction in their territory
- Making their territory known as a pioneer in sustainable energy
- Ensuring consistency among actions implemented or promoted by different departments within the municipality and/or on the territory (e.g. private businesses)

- Ensuring that public money is used efficiently
- Taking fully advantage of the opportunities that (early) action in the field of climate change mitigation can bring, such as new jobs created at local level, lower energy bills for citizens, comfortable living conditions.

Reference Public Administrations

Växjö, Sweden has set an ambitious target of 65% emissions reduction and implemented a robust action plan to work towards the target. The plan is available at: http://www.covenantofmayors.eu/about/signatories_en.html?city_id=317&seap

Modena, Italy has set up a local energy agency to develop and implement the action plans of the participating municipalities. It was able, inter alia, to implement actions under ESCO model contracting. Further information is available at: http://www.aess-modena.it/

Maranello, Italy has implemented a comprehensive sustainable energy action plan. It can be viewed at: http://www.covenantofmayors.eu/about/signatories_en.html?city_id=1162&seap

Berlin, Germany has implemented a comprehensive sustainable energy action plan, with a strong focus on energy efficiency renovation of buildings. It can be viewed at: http://www.berlin.de/imperia/md/content/sen-wirtschaft/energie/energiekonzept.pdf?start&ts=1302593601&file=energiekonzept.pdf

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3.1.3 Establishing and implementing a strategy for climate change adaptation within the territory of the municipality

Description

Climate change projections[13] show that there will be impacts from changing temperatures and climatic patterns across the whole of Europe. Some of these impacts will be more severe in certain locations than others and the nature of these impacts will differ depending on the geographic location and local context. In order to ensure that municipalities are protected against the detrimental effects of these impacts and benefit from any positive changes it is important that they develop a holistic climate change adaptation strategy.

Climate change adaptation strategies can vary in scale from a single site or building, a city, the territory of a municipality, a region or at the national and international level. It is important to ensure that the scale of the strategy is appropriate and aligned to the role of the Public Administration body and within the means of their delivery.

Climate change adaptation strategies should build on other local and regional strategies and ensure that they are linked together. Due to the size of many adaptation measures it is important that local climate change adaptation strategies are integrated into other local and regional adaption strategies and other relevant policies and strategies (such as water course management plans).

Stakeholder Engagement:
Cities cannot adapt in isolations; for the successful creation of a climate change strategy it is vital that there is collaboration between key stakeholders. Stakeholder mapping will ensure that administrations identify relevant and influential individuals and organisations to drive the creation and delivery of a strategy. Representatives should be drawn from a range of national, regional and local cross-sector groups, including city-region and sub-regional partners. Stakeholders could include representatives from national/ regional government, Public Administration, the health sector, emergency services, major institutions and businesses, infrastructure and utility companies, environmental agencies, community representatives, transport and highways etc.
It is also important to engage and consult with local residents and communities. However, care should be taken when undertaking community engagement at the early stages of creating a climate change strategy as evidence suggests that consultation on issues that communities may not have answers for (due to the technical complexity of the issue) can be counterproductive (Ricardo-AEA, 2011). Some examples of best practice in participatory approaches include Kalamaria (Greece) who included the input from the wider public by conducting a web-poll and organising a social network with meetings of local community stakeholders (unions). Another example is London where a web platform was created for Londoners to upload ideas and cast their votes on which paths to pursue (Adelphi, 2011).

One good example of a regional climate change strategy developed through a strong partnership is in North West England, UK. This partnership was initiated by the North West Development Agency, who in turn set up 'Climate Change North West', a partnership between Local and Regional Public Administration, business representatives, National Climate Change Partnership, forestry and natural environment organisations, community groups, utility companies, economic partnerships and academic institutions (NWCCP, 2010)

Strategy Development:

[13] For more information on European climate change projections please visit the European Environment Agency website : http://www.eea.europa.eu/themes/climate

Once relevant stakeholders have been engaged it is important to identify the potential scope and format of the strategy. There is no set rule relating to this and it will be dependent on the specific context of the municipality, the stakeholders involved and funding sources available. The scope of a strategy should be developed using the following guide:

- Will there be a specific focus – e.g. heat or flooding;
- what is the spatial scale – e.g. building, city, region;
- what format – policy document, a guide, statutory planning document, action plan;
- how will it relate to other local, regional and national existing and future policies and strategies;
- how will the implementation of the strategy be financed;
- where will the strategy sit within the PA, who has responsibility for delivering it;
- how will the strategy be monitored and reviewed;
- how will the strategy be communicated within the public administration (this will be dependent on the selected spatial scale)…
- assessment of the input from stakeholders (e.g. taking into account the above paragraph)

Key objectives of the strategy:
Adaptation strategies can cover many areas and some objectives will be very context specific and should be decided on a case by case basis. However, the following objectives have been identified by the GRaBS project[14] as useful in all contexts (GRaBS 2014):

- To raise general awareness and understanding of climate change and the need to adapt to its potential impacts within the local authority, municipality residents and relevant partner organisations;
- To strengthen the decision-making process in order to encourage the adoption of climate change adaption principles and practices
- To select the appropriate level for decision-making e.g. municipality, region etc.
- To improve the capacity to respond to changing climate vulnerabilities and risk;
- To ensure that new development and infrastructure is located, designed and constructed for the climate it is projected to experience over its expected lifespan;
- To promote and facilitate the adaptation of the natural and built environment;
- To help business, public sector organisations and other institutions incorporate the impacts of climate change into their strategy and plan-making processes.

Achieved environmental benefits
The development and implementation of climate change strategies will benefit the environment by protecting against the adverse effects and impacts of climate change. Where green and blue infrastructure is implemented as a result of a climate change adaptation strategy there will be benefits for the natural environment and biodiversity. There will also be multiple positive environmental impacts as a result of the insulation properties of some adaptation measures (e.g. green roofs) and the cooling effect of green and blue infrastructure reduce the need for building cooling resulting in lower energy consumption and resulting carbon emissions. Reducing runoff, flooding and erosion will have positive effects on water quality, contamination and the siltation of water ways.

The specific environmental benefits of implementing green and blue infrastructure as part of a climate change adaptation strategy will be dependent upon the scale interventions and their scale. However, the following generic benefits can be expected:

- Removal of pollutants by trees – in Mecklenburg County, north Carolina (USE) this amounted to economic welfare benefits of US$4 million based on the costs saving of preventing the pollutants from entering the atmosphere (Trust for Public Land, 2010).
- The sheltering effects of trees can save 3-9% of energy bills (Rawlings et al. 1999)

[14] The GRaBS project is a pan-European project made up of 14 project partners involved in integrating climate change adaption into regional planning and development, with a specific focus on Green and Blue Infrastructure http://www.grabs-eu.org/

- Increasing green cover by 10% in urban residential areas reduces run-off from a 28mm rainfall by almost 5%. This reduction is almost 6% if the tree cover is increased by 10% (eftec, 2013).

Appropriate environmental indicators

- Change in the level of protection against the impacts of climate change
    - E.g. the standard of protection (i.e. how well protected an asset or area is against the impact of climate change) and the resulting likelihood of flooding can change from 1 in 100 years likelihood of flooding to 1 in 300 years
- Percentage of homes and businesses protected as a result of the strategy
- Cost savings as a result of the measures implemented in the strategy
- Environmental indicators divided among:
    - energy: % involvement of renewables and/or % reduction of fossil fuels in building sector
    - public awareness: Y or N, e.g. implementation of actions
    - Skills and capacity building in municipality (number of staff trained in climate adaptation)
    - Number of vulnerable people taken out “at risk from climate change”

Cross-media effects

There are no negative impacts resulting from well-developed and implemented climate change adaptation strategies. However, when implementing changes to drainage systems and local water courses it is important to ensure that a full environmental impact assessment is carried out to minimise disruptions to local ecosystems.

Operational data

The operational data of this BEMP are presented in the listed real cases.

Rotterdam Adaptation Strategy, Netherlands

Research carried out in the context of the climate adaptation programme *Rotterdam Climate Proof* (Rotterdam Climate Initiative, 2014) the national research programme *Knowledge for Climate* (Knowledge for Climate, 2014) and the national *Delta Programme* (Delta Programme, 2014) provided a detailed insight into the specific vulnerabilities of Rotterdam (highlighting the importance of flood protection). This unique approach to an adaptation strategy, drawing on tailored research carried out by external parties, ensured that Rotterdam’s approach is based on detailed and localised scientific data and has enabled the creation of a targeted and bespoke strategy.

The organisation of urban planning in Rotterdam is horizontally dispersed across different agents within the municipality (and among the tree city divisions responsible for the physical environment) as well as vertically. However the governance of the Rotterdam Adaption Strategy is administered by one municipal body, the RCP. This deliberate placement within one department of the municipality avoids fragmentation in the early years of development and will ultimately mainstream adaptation into existing policy fields across the city (Mees, H & Driessen, P. 2010).

One of the principle priorities of the Rotterdam strategy is multi-layered flood protection based on adaptive construction and design. Examples include ‘flood-proof’ buildings, construction of flood proof public areas, floating communities and ‘building with nature’. The port and other areas of essential infrastructure are prioritised due to the high risk they face and their importance for the operation of the city. Although numerous adaptation measures exist in the city to cope with flooding, this strategy focuses on prevention; storm surge barriers are being optimised, rainwater storage to delay drainage is being created (including green roofs and facades, less paving and more flora in public streets and neighbourhoods, water squares and infiltration zones integrated into the infrastructure). These green and blue adaptation measures demonstrate best practice in the use of hard and soft infrastructure maximising natural flood attenuation mechanisms (Rotterdam Climate Initiative, 2013).

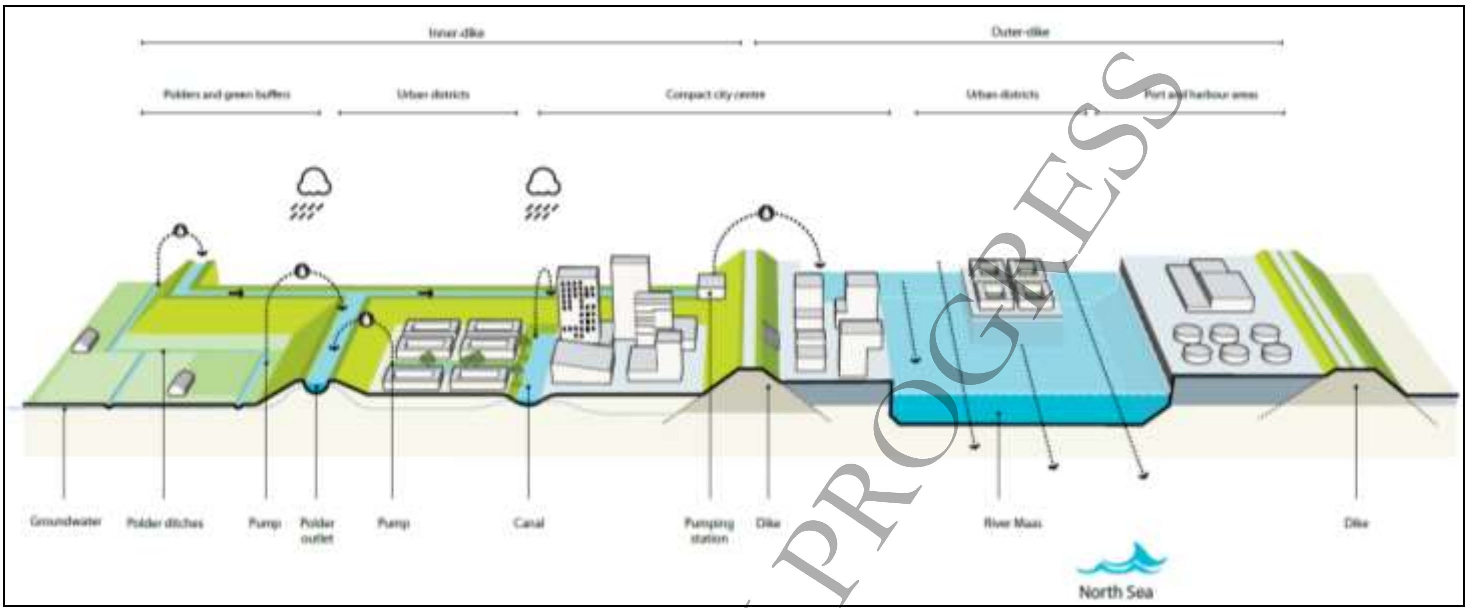

Figure 3-4: Diagram of Rotterdam's green and blue adaptation infrastructure (Rotterdam Climate Initiative, 2013)

<u>*A Climate Change Action Plan for North West England, UK*</u>

This case study provides a good example of where numerous Public Administration bodies have come together to create a regional climate change strategy. Lead by Climate Change North West, the regional climate change partnership[15], this strategy focuses the use of green infrastructure as an important mechanism to adapting the impacts of climate change.

The UK Climate Impacts Programme (UKCIP09, 2009) show that under a medium greenhouse gas emissions scenario for the 2080s the climate of the North West is projected to change significantly and experience:

1. An increase in average summer temperature with a central estimate of 3.7 degrees;
2. 21% less rainfall in the summer, possibly leading to subsidence, lower crop yields and water stress;
3. 16% more rainfall in the winter increasing the threat of winter flooding, transport disruption and risks to urban drainage;
4. Sea level rise in Liverpool of 30-32cm

This climate change action plan contains an extensive list of actions to tackle both the causes and effects of climate change. The plan focuses on the development of an adaptation framework which encompasses an approach to identifying the vulnerability of local communities, businesses, built and natural environment to future climate change and to understand how this adaptation capacity will be translated into adaptation actions (NWCCP, 2010). Key adaptive actions from the plan include:

- Create catchment and shoreline management plans to manage risk of coastal flooding

[15] Climate Change North West is a partnership between the Association of Greater Manchester Authorities, Business in the Community, CLASP, Cheshire and Warrington Councils, Climate UK, Community Forest North West, Cumbria County Council and the Lake District National Park, ENWORKS, Electricity North West, Environment Agency, Forestry Commission, Lancashire County Council, Liverpool City Region LEP, Manchester Metropolitan University, Natural England, North West Environment Link, United Utilities and the University of Manchester.

- Carry out a regional assessment of the risks, opportunities and priorities for green infrastructure in adapting and mitigating for climate change
- Create adaptation strategies for the region's distinctive landscapes, habitats and species and assess the contribution of natural systems to carbon sequestration and reduced flood risk.
- Assess the implication of climate change on health services and existing and future built environment.

<u>*Redcar cost-benefit analysis, UK*</u>

Redcar is a seaside resort in the North East of England and is situated in an area that is vulnerable to flooding and coastal erosion, particularly as a result of severe storm events from the North Sea. This case study provides an example of best practice in relation to using cost-benefit analysis to inform decision making and to prioritise responses to the potential impacts of climate change.

In order to inform the most appropriate and cost effective adaptation option Redcar carried out a cost-benefit analysis looking into three scenarios (UK Environment Agency, 2009):

1. Do nothing (to establish a baseline)
2. Do minimum
3. Do something (seawall improvements and groyne maintenance at various standards to defend along the existing line)

The options for adaptive measures were designed to provide a particular standard of protection (SoP) for 50 years, after which adaptive/management measures will be required to address climate change. Maintenance and future costs were calculated for each option with figures derived from the contractor's estimate and the current cost database for civil engineering works. The two tables below outline the results of the cost-benefit analysis and provide the rationale behind taking adaptive action.

Table 3-4: Overview of present value costs and damage (UK Environment Agency, 2009)

Values cost and damage / Scenarios			Present Value Cost	Present Value Damage		
				Flooding	Erosion	Total
Do nothing			0	28,832	120,502	149,334
Do Minimum			16,032	109,954	0	109,954
Do something	1 in 100 (1%) SoP	Precautionary	30,744	2,107	0	2,107
		Managed adaptive	27,995	7,676	0	7,676
	1 in 200 (0.5%) SoP	Precautionary	31,233	1,669	0	1,669
		Managed adaptive	28,383	3,408	0	3,408
	1 in 300 (0.33%) SoP	Precautionary	31,395	1,573	-	1,573
		Managed adaptive	28,520	2,425	0	2,425
	1 in 500 (0.2%) SoP	Precautionary	31,720	1,489	0	1,489
		Managed adaptive	28,794	1,489	0	1,489

Present values in thousand GBP (£)

Table 3-5: Summary of the cost benefit (UK Environment Agency, 2009)

	Do nothing	Do minimum	Improve – Managed Adaptive			
			1 in 100 (1%)	1 in 200 (0.5%)	1 in 300 (0.33%)	1 in 500 (0.2%)

Total present value of costs	-	16.03	27.99	28.38	28.52	28.79
Total present value of residual damages	149.33	109.95	7.68	3.41	2.43	1.49
Total present value of benefits (reduction in damage relative to Do nothing baseline)		39.38	141.66	145.93	146.91	147.85
Net present value		23.35	113.66	117.54	118.39	119.05
Average benefit/cost ratio		2.46	5.06	5.14	5.15	5.13

Present value in million GBP (£)

The Netherlands Live with Water: Public awareness raising campaign

The Netherlands is at severe risk of coastal and river flooding. It was acknowledged in 2000 that the current water management system based on technological solutions is inadequate, and that more space needs to be made for water. Running in parallel with this risk was a lack of recognition and acknowledgement by citizens of the impacts of these risks. Consequently, in 2003 "The Netherland Live with Water" public awareness campaign was launched (Kazmierczak, A & Carter, J, 2010).

This country level campaign focused on public engagement as an integral aspect of their climate change adaptation strategy. The campaign emphasises the need to store water along both the main national and regional water management systems during times of excessive rainfall or high levels of river discharge. The initiatives is run by national government[16] and highlights efforts the national government, provincial authorities and water boards are undertaking across the Netherlands to keep it safe and dry. The campaign also gave advice to residents about what they can do to reduce the impacts of flooding. The campaign has been assessed by independent reviews and has been promoted as a best practice example at an international level. One of the key reasons for its success was the high profile spokesman for the campaign; the Netherlands favourite weather presenter.

Key aims of "The Netherlands Live with Water" campaign (Kazmierczak, A & Carter, J, 2010):

- To increase the awareness of the water problem, stimulating a sense of urgency without frightening the people;
- To communicate that a new approach and policy for water management is needed and also the reason why;
- To increase knowledge of what the new policy ('giving more room to water') means and what the consequences will be;
- To get acceptance of the idea that far-reaching measures are needed now to keep Holland safe in the future, even if these measures have unpleasant personal consequences.

The campaign is integrated as part of three communication campaigns related to raising awareness of the risk of flooding. The other two are "Denk vooruit" (Think ahead), and a collection of risk maps on the internet. Much of the success of this project results from the range of partners involved; the lead Public Administration Authority responsible for the development and implementation of the initiative was the Ministry of Transport, Public Works and Water Management. Other partner organisations include the Association of the Provinces of the Netherlands, Association of Dutch Water Boards, Association of Netherlands Municipalities, Ministry of Public Health, Spatial Planning and Environment and Ministry of Agriculture, Nature and Food Quality (Kazmierczak, A & Carter, J, 2010).

[16] The lead authority responsible for the development and implementation of the initiative was the Ministry of Transport, Public Works and Water Management.

Figure 3-5:. Cartoon featuring Peter Timofeeff, a TV weather forecast presenter. The text reads: "With the climate change it gets warmer and wetter". (Kazmierczak, A & Carter, J, 2010)

The campaign has been a great success and by the end of 2003 82% of the population recognised the social importance of measures to protect against flooding has increased, and 72% endorsed the proposition that this would have to involve 'giving water more room' (Ministry of Transport & Public Works, 2004).

Applicability

This BEMP is potentially applicable across all typologies and scales of Public Administration areas and applicable across Europe. However, each adaption strategy should be developed in relation to the specific context of the Public Administration and respond to the projected climate change impacts of the region.

Barriers to development and implementation:

It is important to note that there are often numerous barriers to implementing climate change strategies. These barriers should be directly addressed at the start of the development of a strategy. Some common barriers include:

- Political resistance
- Lack of internal organisation capacity and support;
- Shortage of funds and resources;
- Lack of awareness and understanding (both of climate change and the value of green and blue space as an effective natural adaptation infrastructure);
- Lack of expertise and skills;
- Insufficient or non-existing community and other stakeholder networks

Economics

Calculating the costs and benefits of climate adaptation strategies can be very complex. Whilst the development and creation of a strategy can take time and some resource, it is the implementation of the strategy where significant investment is required. The return on this investment is often difficult to calculate on a financial basis alone due to the multiple benefits gained through some adaptation measures. E.g. the use of green and blue infrastructure does not only reduce the risk of flooding and reduce the urban heat island effect but also provides amenity value and can result in increased health and wellbeing (often associated in reduction in spending on health) and save energy through insulation and cooling effects. It is important to use a cost benefit analysis when identifying the suitability of adaptation options. However, where there are multiple objectives and impacts and the financial benefits are difficult to calculate it is often more appropriate to carry out a cost-effectiveness or multi-criteria analysis. A cost-benefit analysis should be carried out using the following steps (UNFCCC, 2011):

1. **Agree on the adaption objective and identify the potential adaptation options**. An adaptation objective must be well defined and its attainment must be quantifiable in monetary terms, it can, for example, be defined in terms of reducing vulnerability, such as achieving a particular standard of protection from flood risks
2. **Establish a baseline.** It is essential to define a baseline (the situation without the adaptation intervention being carried out) and the project-line (the situation with successful implementation of the adaptation option) to determine the costs and benefits by comparing the two situations.
3. **Quantify and aggregate the costs over specific time periods.** Costs of an adaptation action include direct costs (e.g. investment and regulatory) and indirect costs (e.g. social welfare losses and transitional costs)
4. **Quantify and aggregate the benefits over specific time periods.** Benefits of an adaptation intervention should include the avoided damage from climate change impacts and co-benefits, where relevant. If there is no market for the goods or services provided by the adaptation activity, benefits can be estimated in indirect ways through non-market-based approaches.
5. **Compare the aggregated costs and benefits.** The bottom line for choosing an adaptation option is the comparison of the monetised elements of costs and benefits. The costs and benefits need to be discounted to properly calculate their present value. Adaptation planners can choose between three indicators of whether their options are efficient
    - The net present value (NPV), i.e. the difference between the present value of the benefits and the present value of the costs.
    - The benefit-cost ratio (BCR), i.e. the ratio of the present value of the benefits to the present value of the costs
    - The internal rate of return (IRR), i.e. the discount rate that makes the NPV equal to zero.

One example of best practice example of informing adaptation decisions in relation to flood and coastal erosion management using cost-benefit analysis can be found in North East England. Redcar, a town in North East England considered various options in response to the threat posed by flooding and coastal erosion on its flood defences, putting 978 residents and 209 commercial properties at risk, for more information please see Reference Organisations (UNFCCC, 2011).

Driving force for implementation

The driving forces behind the implementation of climate change adaptation strategies are multifaceted and often quite complex. With climate change now affecting every continent on the planet it is vital that we not only tackle the cases of climate change but also the impacts and effects. Driving forces will vary depending on the location of the Public Administration and the conditions specific to it surrounding area. For example, land locked municipalities and cities will not be required to adapt to coastal erosion on possible sea level rise but may be at risk of flooding and extremes heat and drought. The economic implications of climate change impacts can be catastrophic and often far outweigh simple adaptation measure required to mitigate against them. More importantly there is often a risk to the health and safety of residents and in extreme cases people's lives. For example, prolonged periods of extreme heat can have lethal effects on vulnerable sections of society (e.g. the elderly and infirm).

Running in parallel with these social, environmental and economic drivers pushing adaptation into the mainstreamed there are also some positive benefits to adaptation measures driving change e.g. increasing green and blue infrastructure in a city will not only slow water runoff and reduce the urban heat island effect but will also improve the health and wellbeing of the population, benefit biodiversity and increase amenity value. There are also opportunities presented by climate change, such as the ability to grow new crop varieties, experience more pleasant temperatures with resulting opportunities for tourism etc.

Reference organisations

Climate Change North West, UK
A strong partnership approach to creating a regional climate change strategy where numerous Public Administration bodies have come together to create a proactive and cohesive plan to tackle the effects of climate change.

Kalamaria, Greece
Community engagement in the development of climate change adaptation strategies via a web-poll and organising social networks with meetings of local community stakeholder.

Live with Water: Public awareness raising campaign, Netherlands
A Country level campaign focused on public engagement as an integral aspect of successfully delivering a climate change strategy.

London, UK
Community engagement in the development of climate change adaptation strategies via a web-platform for Londoners to upload ideas and cast their votes on which paths to peruse in relation to climate change adaptation options.

Redcar, UK
Climate change adaptation options based on detailed cost-benefit analysis to ensure that finance was directs at measures with the greatest impacts.

Rotterdam Adaptation Strategy, Netherlands
Climate change adaptation strategy at a city scale based on independent scientific evidence relating to the impacts of climate change.

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3.2 BEMPs regarding direct operations

3.2.1 Implementing energy efficient street lighting

Description

Street lighting accounts for a small share of the total final energy consumption of a country (for instance, it accounts for 2% of the electricity consumption in Italy[17]) but is an important area of action for municipalities for three reasons:

1. Street lighting is often responsible for a large share of the direct energy bill of a municipality (for instance, 55% and 64% in two medium-sized cities according to Fiaschi et al., 2012; about 50% of the direct electricity consumption of municipalities on average in France in 2005 – ADEME, 2007).
2. Street lighting is an area where interventions are relatively easy to plan and implement (Lorenzoni et al., 2006): information on technology used, number of lighting points, power, energy consumption, maintenance costs, etc. is often readily available within the municipality; the service is usually under direct control or contracted by the municipality.
3. Street lighting can often offer a relatively large potential to reduce its energy consumption (with savings up to 60-86%[18]) with proven solutions and reasonable returns on investment. Moreover, with over 90 million street and roadway lamps in place only in IEA member countries[19] and a global energy consumption of about 114 TWh (IEA, 2006), a widespread deployment of the best technologies and management practices can have a considerable impact on energy consumption.

Street lighting is aimed at meeting two important societal needs: ensuring safety for road users (cars, motorbikes, bikes, pedestrians) and improving security for all citizens, during the hours of darkness. As human activity during the day extended beyond the hours of daylight, street lighting became essential and it is nowadays a very important service, mostly provided by municipalities. It has a very high visibility, because citizens can judge its effectiveness by direct experience and because it can be considered (indirectly) responsible for accidents and crimes.

It is thus of utmost importance to obtain the maximum benefits, and not only in terms of energy efficiency, when planning any upgrade of an existing street lighting system or a new installation.

The main benefits that should be sought are:

- <u>Reducing costs</u>

  Reducing or minimising the energy consumption of street lighting is a major factor in reducing the lifetime costs of such a system. Indeed, the energy bill represents a very large share of the lifetime cost of a luminaire (e.g. 69% in Baenziger, 2002).

  However, maintenance costs are also a key aspect to be considered. Lamps have a limited lifetime and can also fail because of malfunctions of the system or accidents. The frequency of the need for replacement is a considerable contribution to maintenance costs, although the need for luminaires cleaning or other operations should also be considered. Maintenance costs do not only include the costs for repair and

[17] Italian electricity statistics report a consumption for street lighting of 6201.8 GWh in 2011 out of a total consumption of 313 792.1 GWh (Terna, 2012)

[18] 60% in Huenges Wajer et al., 2009; 50-75% in MEDDTL, 2012; 62-86% in UBA (2011a, 2011b, 2011c, 2011d, 2011e, 2011f, 2011g).

[19] In 2006 the following countries were IEA members: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Republic of Korea, Luxembourg, The Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom, and the United States (IEA, 2013).

cleaning, but also those related with checking that the system is correctly in operation (e.g. checking if/which lamps need to be replaced).

- Improving street lighting quality
  There is very often scope to improve the quality of the public lighting service. Pursuing such an objective can make it much easier to obtain public acceptance for interventions in this field. In the meanwhile, better public lighting means better mitigation of the safety and security risks it addresses, and, therefore, indirectly, saving human lives.
  There are a number of dimensions in which the quality of the service provided can be improved: (i) the reliability of the system, (ii) the uniformity of the lighting, (iii) the colour of the light, (iv) the directionality of the light.

  1. Reliability
     Improving the reliability of a street lighting system is essentially reducing the amount of time the system as a whole or individual lighting points do not work. One common example of outage of a lighting point is a lamp burning out. Improving reliability is about being able to act as soon as possible after such a failure, or, better, foreseeing the failure through monitoring and being able to replace a lamp (just) before it would burn out, and/or limiting the number of such failures, e.g. thanks to better power quality or to the choice of lamps with longer lifetime.

  2. Uniformity
     Human eyes take a certain time to adapt to different lighting conditions. A good street lighting installation should thus avoid the alternation of brighter and darker zones. In technical terms, if we call E the illuminance (measured in lux), a good indicator for uniformity is the $E_{min}/E_{average}$ ratio. An increase of the ratio (i.e. a ratio closer to 1) indicates a street lighting installation with higher uniformity, i.e. less difference between the illuminance of the darkest areas (E_{min}) and the average illuminance ($E_{average}$).

  3. Light colour
     Different lighting technologies emit light at different wavelengths (or frequencies). For instance, Figure 3-6 shows the distributions of wavelengths (or emission spectra) for natural light compared with some lighting technologies. The emission spectrum for each lighting technology is often referred to as the colour temperature, given that how much light is emitted at the different wavelengths depends on the temperature of the body emitting the light.

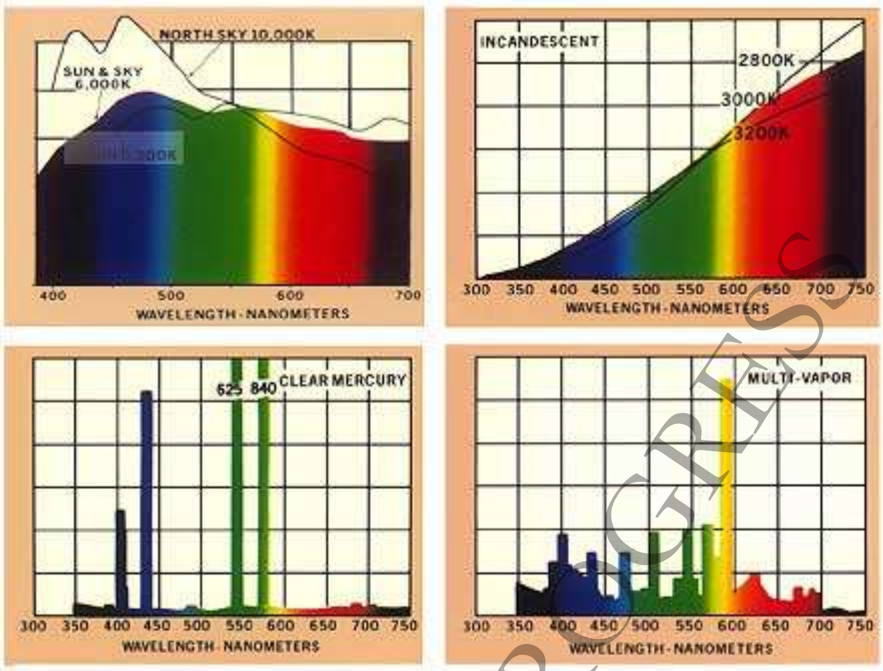

Figure 3-6: Emission spectra of natural light from the sun and the sky and of artificial light from incandescent bulbs at different temperatures, from a mercury vapour lamp and from a multi-vapour lamp. (Source: http://www.light-measurement.com/spectra/)

Different kinds of lamps and lighting technologies can thus be classified according to their *Correlated colour temperature* (CCT). For instance, incandescent light bulbs have a CCT of 2700 - 3000 K as this is their normal operating temperature range (about 2400 ºC – 2700 ºC), while mercury vapour lamps, have a CTT of 2900 - 4200 K. In general, lamps with CTT around 2700 K offer "warm white" light (more yellowish), while lamps with CTT over 4000 K have "cold white" (more blueish).

Figure 3-7: A light bulb with a CCT of 2700K ("warm white") on the left and one with a CTT of more than 4000K ("cold white") on the right.

(Source: http://ec.europa.eu/energy/lumen/overview/howtochoose/packaging/packaging_en.htm)

The CCT and the distribution of the intensities in the spectrum determine the colour of the light that is emitted (i.e. which colour components are more important) and, as a consequence, the ability for the human eye to distinguish colours under such kind of lighting. The parameter that describes this behaviour is called *Colour rendering index* (CRI). Incandescent light bulbs, with CRI = 100, allows to perfectly distinguish colours, while mercury vapour lamps, with CRI = 45, can only be used in applications where a correct perception of colours is unimportant, due to their very strong green-blue component.
Changing type of lamps means very often changing light colour, i.e. changing CTT and CRI. Such an intervention can thus offer a good opportunity to improve street lighting quality as far as light colour is concerned.

However, depending on the purpose of each lighting installation, different light colours may be appropriate.
For instance, a high CRI can be important in the historical centre of a town but not on countryside roads. Conversely, it may be important to avoid a strong blue component in areas where this can be an important source of disturbance for wildlife or human health (Falchi et al., 2011).

4. Directionality
   The purpose of street lighting is illuminating the streets, i.e. their surface, but also the vehicles, people, animals, trees, objects on them or on their border. However, in most cases, a considerable share of the light is dispersed in other directions: towards the sky, towards buildings, private land or other areas where street lighting is not needed. This can be referred to as "wasted lighting". Conversely, the share of the light actually reaching the surface that it is intended to illuminate is called "useful lighting".

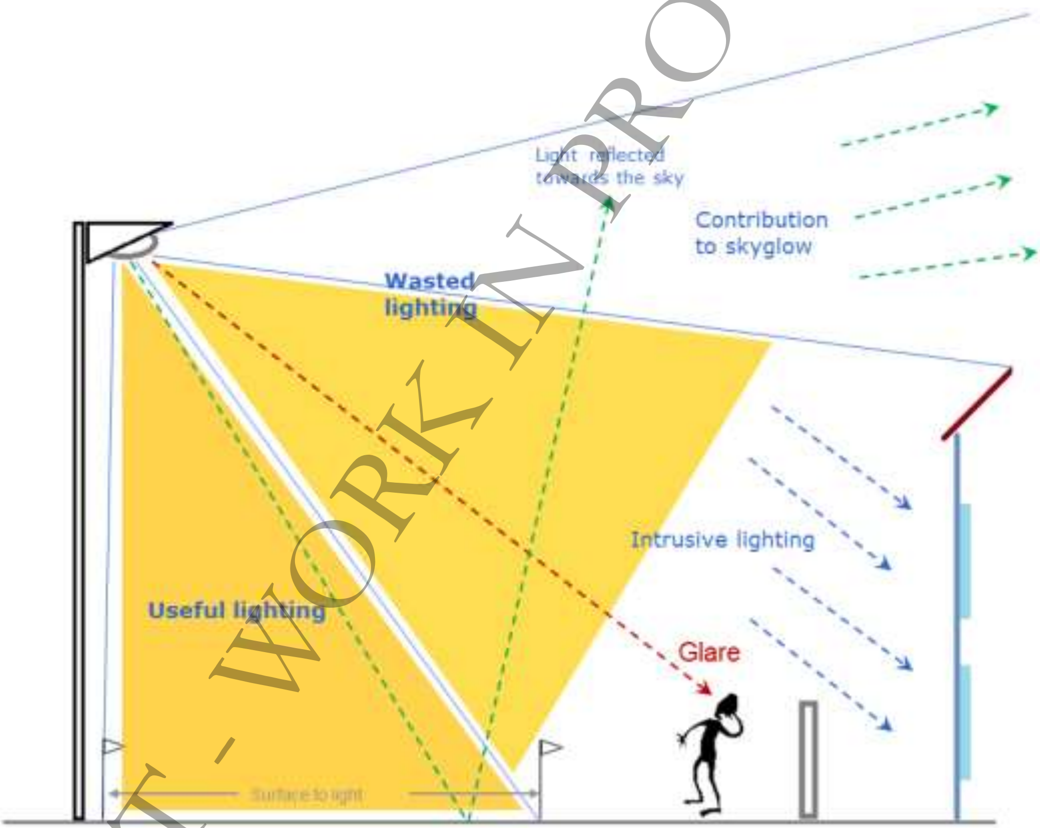

Figure 3-8: Useful lighting

The share of "useful lighting" can be substantially increased by improving the directionality of the luminaires, i.e. choosing luminaires that direct most of their light downwards. This depends mainly on the shape of the luminaire, but also on whether the lamp is visible or hidden and on the materials used.
To obtain the best results, changing the positions of the luminaires and thus a whole re-thinking of the installation taking directionality into account may be needed.

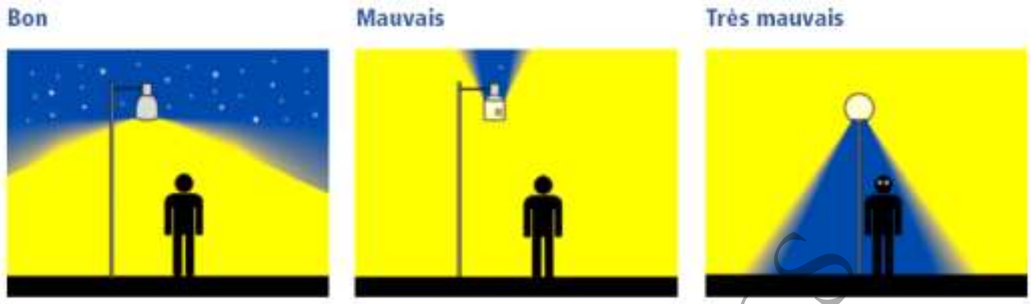

Figure 3-9: Directionality of the lighting (Source: Bruxelles Environnement, 2011 – where the stated source is ASCN : http://www.astrosurf.com/anpcn/)

Improving the directionality of the street lights and thus increasing the share of useful lighting has three benefits: first, lamps with lower illuminance levels can be used to provide the same level of lighting on the areas to illuminate, resulting in energy and costs savings; secondly, the so-called obtrusive lighting or trespass, i.e. the light from street lighting entering into buildings, gardens, etc. and potentially disturbing their occupants, can be drastically reduced; thirdly, this aspect is crucial in minimising glare. Glare is the reduction in visibility caused by the presence of intense light sources in the field of view.

- <u>Decreasing light pollution</u>

  Light pollution is an environmental issue that has so far received relatively limited attention (Lyytimaki et al., 2012). The term refers mainly to the veiling effect upon celestial objects of light emitted with an upward component from luminaires on the ground, on buildings or on infrastructures (Mizon, 2002). This light illuminating the sky at night is known as skyglow and is caused by upward light, scattered and reflected by particles such as aerosols in the atmosphere, and, when it is relatively intense, such as in the case of large towns, its effects are visible tens of kilometres away. Moreover, according to Holker et al. (2010a), artificial lighting of the night has been growing worldwide by around 6% per year.

  The concern for this form of light pollution, especially in the context of astronomy, has been raised for several years. It is caused by a number of sources of lights, such as illuminated buildings, infrastructures, factories, but also vehicles or gas flaring, all of which are likely to be locally significant and can have disproportionate effects compared to their aim. However, since it is very widespread, often operated all night long and sometimes rather intense, street lighting plays a major role in contributing to light pollution. The main mitigation measures suggested are: avoiding upward lighting, limiting the extension of the lighted areas; reducing lighting levels to what is necessary; and turning off the lights when not needed.

  Concerning the upward lighting, it is important to mention that the light causing the skyglow is, in most cases, wasted lighting (i.e. light that was not directed upwards intentionally), and that light does not need to be emitted vertically to cause skyglow: in fact, light emitted at a shallow angle above the horizontal will cause more skyglow since it will encounter more particles and droplets from which to be scattered (Mizon, 2002).

  A simple method to evaluate the contribution to skyglow of a luminaire is its ULOR. This acronym stands for "upward light output ratio" and it is the ratio between the light output that is emitted at an angle above the horizontal and the total light output of a luminaire. In order to reduce the contribution of street lighting to skyglow, the ULOR of its luminaires should be zero. However, ULOR of a few percentage points can sometimes be accepted in urban areas for lamps of limited luminous power. Conversely, if a municipality is really determined to mitigate the contribution to skyglow, it should

not only achieve a ULOR of zero but no light should be emitted also within the first 10º below the horizontal (Brunet, 2011).
In order to fully consider the properties of a luminaire concerning directionality and contribution to skyglow a more comprehensive system was elaborated by the Illuminating Engineering Society under the name of a luminaire classification system for outdoor luminaires (IES, 2011). This system includes the so-called BUG rating, where BUG stands for Backlight, Uplight and Glare. Backlight indicates the light emitted at the back of the luminaire, usually causing obtrusive lighting. Uplight is the light emitted above the horizontal and glare is an indication of the light emitted at a shallow angle below the horizontal. The space around the lamp is divided into a number of solid angles and the lighting flux in each of those angles is taken into consideration to determine the rating of the luminaire in terms of backlight, uplight and glare.

As mentioned before, however, light pollution does not only refer to skyglow. Another very relevant aspect is the impact of continuous lighting and of the absence of darkness during night time on animals, plants and ecosystems, as well as on human health. This can be easily understood considering that most organisms, including humans, have evolved circadian clocks controlled by day-night cycles and a substantial proportion of global biodiversity is nocturnal, with 30% of all vertebrates and over 60% of all invertebrates (Holker et al., 2010b).
Although there is an important need for further research in this field (Holker et al., 2010a), Lyytimaki et al. (2012) list a considerable number of recent studies about the detrimental effects of light pollution on animals, plants, ecosystems and human health. Davies et al. (2012) provide evidence that street lighting has an impact at higher levels of biological organisation than a single organism, such as changing the abundance of species within communities, with still unknown impacts on the functioning of the ecosystems.
Other recent studies highlight the crucial importance of the spectral composition of the light. As species differ in the wavelengths to which their visual systems are most sensitive and responsive, and as organism behaviour can be dependent on the presence of certain wavelengths of light, Gaston et al. (2012) state that lighting technologies that emit a narrow spectrum of light, such as LPS lighting, are likely to have less ecological impact compared with broader spectrum or "whiter" light sources, such as LED and metal halide lamps. According to Falchi et al. (2011), even when all the measures against light pollution mentioned above are implemented, there is a residual light pollution that should be mitigated by avoiding or limiting emissions of light at wavelengths shorter than 540 nm, corresponding to the blue component of light, which is the one with the most severe consequences for the environment and human health.

In order to seek the objectives of reducing costs, improving street lighting quality and decreasing light pollution, while also addressing the primary objective of reducing the energy consumption of street lighting, best practice is implementing one or a combination of several of the following measures.

1. <u>Auditing the status of the installation</u>
   Before any upgrade of an existing street lighting installation can be planned, it is crucial to assess the current situation, understand needs and problems and be able to prioritise interventions.
   This should include making an inventory of the technology currently in use, analysing the current energy consumption as well as the local needs and how well these are met.
   However, street lighting auditing can go much further. For instance, in August 2012, Viteos (2012a, 2012b, 2012c), a public electricity company owned by the municipalities of Neuchatel, Chaux-de-Fonds and Locle, in Switzerland, and responsible for the provision of street lighting in these cities, held an aerial street lighting audit. Thanks to a nocturnal helicopter flight together with measures on the ground taken at the same time to calibrate the aerial data, the levels of illumination of the whole territory could be

surveyed in a few hours. Moreover, thanks to a second survey carried out during the same flight with the public lighting being switched off, also the residual lighting caused by other lighting sources (such as building, lights in gardens, etc.) was measured, in order to study its importance and understand even better the role played by the street lighting. The analysis of the data allowed to both check the effectiveness of different new technological solutions implemented in different areas of the municipalities and identify under and over-illuminated areas requiring interventions.

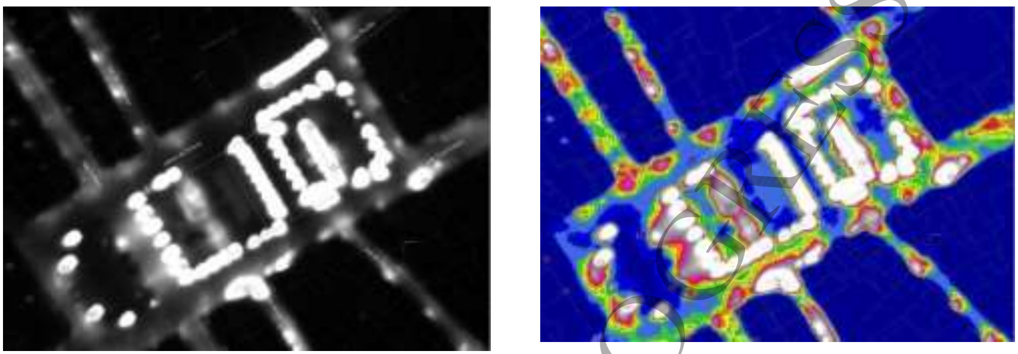

Figure 3-10: Examples of the result of the data acquisition by aerial photometry. Source: ALTILUM, 2013

Figure 3-11: Example of the final output of the analysis (after data processing to calculate illumination levels and its inclusion in a GIS system). Source: ALTILUM, 2013

The cost of this aerial auditing was about 40,000-50,000 CHF for a total of 11,482 lighting points, which corresponds to about 4 CHF (or 3,30€) per luminaire (Dreyer, pers.comm., 14 September 2012). This was considered a good investment by the company, given the usefulness of the detailed information obtained and how this would have allowed increasing the efficacy of the new investments on upgrading the street lighting system in terms of energy savings but also street lighting quality and light pollution.

2. <u>Replacing lamps</u>
   Upgrading the lamps used in street lighting with more modern and efficient technologies is the most common measure implemented to reduce the energy consumption of street lighting.

Table 3-6 presents the main characteristics of the main lighting technologies currently used for street lighting.

Table 3-6: Key characteristics of different street lighting technologies. Data from: Elvidge et al., 2010; Lorenzoni et al., 2006; Bruxelles Environnement, 2011; Eurelectric and UIE, 2004; Enel Sole, 2012.

	Luminous efficacy	Average lifetime	Light colour (CTT)	CRI	Notes
Incandescent	12-20 lm/W	1000-1500 h	Warm white (2700-3000 K)	100	Almost phased out because of the very low luminous efficacy.
Halogen	15-33 lm/W	2000-4000 h	White		
Fluorescent	50-92 lm/W	10,000-20,000 h	Cold white	5-82	
High-pressure mercury (HPM)	34-70 lm/W	10,000-20,000 h	Cold/blueish white (2900-4200 K)	45	About 4 minutes needed to switch on and off. Not dimmable. Relatively low luminous efficacy.
Low-pressure sodium (LPS)	68-177 lm/W	16,000 h	Orange monochromatic light (1807 K)		8-15 minutes to reach full power. Not dimmable. Extremely bad colour rendering.
High-pressure sodium (HPS)	59-150 lm/W (average 100-110 lm/W)	12,000-22,000 h	Yellow/orange (2000-2500 K)	7-32	5 minutes to reach full power.
Metal halide (MH)	62-100 lm/W	5000-10,000 h	White (2874-4600 K)	64-100	Higher sensibility to tension fluctuations.
Light emitting diodes (LED)	28-100 lm/W		White (1739-8357 K)	65-100	

The indicator used to describe the efficiency of different lighting technologies in generating light with a certain input of energy (or, in other terms, in generating a same lighting output with a lower power) is called luminous efficacy and it is measured in lumen/Watt (lm/W). As it can be seen from the table, it varies substantially between different technologies.

While the use of incandescent light bulbs for street lighting is today rather limited and declining, mercury vapour lamps, among the most inefficient, represent still a large share of the public lighting installations (e.g. about a third of all the lighting points in France according to ADEME, 2012b). In addition, also fluorescent lamps and old sodium lamps can have pretty low efficiencies.

There is thus a large potential to save energy by replacing these lamps with those with the highest luminous efficacy: the most efficient discharge lamps (mainly high-pressure sodium lamps and, in some cases, metal halide) and LEDs. Of course, the other characteristics of these lighting technologies (see Table 3-6) should be carefully taken into account when selecting what kind of lighting to install as well as a certain particular product.

a. Installing LED

This is an option that is growing in popularity in the last few years. For instance, most of the new street lighting installations or refurbishment by Philips are for the installation of LED lighting (Koster, pers.comm., 14 September 2012).

The main positive aspects are: the rather high luminous efficacy, the highest average lifetime, very little need of maintenance minimising thus maintenance costs, plenty of flexibility in terms of control and possibility to dim the light.

There are plenty of examples of successful implementation of LED lighting. For example, the municipality of Stadt Langen (DE) upgraded all of its street lighting (2551 conventional fluorescent luminaires) with LED, obtaining energy savings of 60% and winning the GreenLight Award 2012. Other examples are some the winners of the German energy efficient street lighting competition *Energieeffiziente Stadtbeleuchtung Bundeswettbewerbs* (Berliner Energieagentur, 2012).

The main resistances against the implementation of LED lighting are: the rather high upfront investment needed (which many municipalities find difficult to finance), the presence on the market of low quality products not fulfilling the foreseen lifetime or light quality, the spectral composition of the light they emit.

Concerning this last point, it should be noted that current LED street lighting technologies use a monochromatic LED emitting blue light and a yellow phosphor coating to convert it into white broad-spectrum lighting. However, there is potential for future developments of LED lights that create light with good colour rendering by mixing coloured light from three or more monochromatic LED sources. Such technology could give a higher degree of control over the wavelengths emitted and allow critical regions of the spectrum to be avoided (Gaston et al., 2012).

b. Replacing existing lamps with most efficient discharge lamps

This has been the most common option for several years and it is still very common. For instance, most street lighting upgrades funded under the French scheme to help small municipalities to adopt energy efficiency street lighting is about the installation of HPS lamps. These, together with MH lamps, are the most common choices.

The advantages are: lower investment costs, very well proven and established technology, and rather high luminous efficacy. MH lamps are slightly more costly and less efficient than HPS lamps but are chosen for some applications because of their better colour rendering.

Supporters of HPS lighting stress that it is currently possible to reach higher luminous efficacy with this technology rather than LED.

3. Changing ballasts

Discharge lamps need ballasts in order to be operated. A ballast is a device which limits the amount of current in an electric circuit.
There are two types of ballasts: conventional ballasts, also called electro-magnetic or induction ballasts, and electronic ballasts.

The first type consumes on average 12% of the energy consumption of the lamp they control, while the more modern, electronic ballasts, less than 10% (Bruxelles Environmment, 2011).
Electronic ballasts also increase the average lifetime of lamps and give much better control in terms of dimming. This last aspect is very often the factor determining the choice to change ballasts.

4. Dimming

The implementation of dimming in the field of street lighting refers to reducing the light output during certain hours of the night (often between midnight and 6am). This is usually based on fixed timings and allows saving energy as well as reducing light pollution and intrusive lighting.
This solution is broadly considered much better than switching off one of each two lighting points (a common practice in some municipalities in the past) which had the big disadvantage of heavily affecting uniformity and thus the very essential function of street lighting.
Dimming is possible in LED installations with very large flexibility, as well as with MH or HPS lamps. With a magnetic transformer it is possible to dim HPS and MV lamps up to 50% of their full lighting output, while electronic ballasts can allow dimming up to 50% all discharge lamps and up to only 10% of their full output HPS lamps (Baenziger, 2002). If correctly done, dimming can also allow to obtain lamp life extensions of up to 100% (Baenziger, 2002).

5. Changing luminaires to more reflective materials and better shapes for better directionality and higher luminaire efficiencies

A large share of the luminaires on operation are rather old and inefficient. For instance, ADEME (2012a) estimates that in France over 40% of luminaires are over 25 years old and mainly bowl type luminaires with very high ULOR values.
A 2004 study by Euroelectric reported that the average luminaire efficiency in Europe for the different lighting technologies was between 25 and 45% (IEA, 2006). This means that the average luminaire in Europe in 2004 wasted at least 55% of the light emitted by the lamp it contained, either by emitting light in unwanted directions or by trapping it in the luminaire itself.

Improving the luminaires allow thus reducing the installed power of each lighting point guaranteeing the same (or even better) illuminance on the ground.

The best luminaires have a good reflective coating around the lamp and such a shape so that all the light is emitted downwards and towards the area to be lighted (see information on directionality and light pollution above).

Figure 3-12:Luminaires with ULOR=0 in the bottom part of the picture and emitting light upwards in the top part. (Source: Philips, Hicksgate case study)

6. <u>Reduce the levels of illumination</u>
   There are many examples of areas that are illuminated more than needed. In these cases, permanently reducing the luminous flux can be an effective option to maximise the energy savings. This is very important to consider when planning a lamp replacement or any more thorough upgrade of the public lighting system.

   For instance, 250 W mercury high pressure lamps can be replaced by either 150 W sodium high pressure lamps, reducing power by 40% and increasing the luminous flux by 23%, or by 100 W sodium high pressure lamps with a 60% reduction of power but also a 24% reduction of luminous flux (Menga and Grattieri, 2009). If this reduction of luminous flux is acceptable, the additional energy savings mentioned can be obtained at negative additional costs (a lamp with lower power is likely to be cheaper).

   The best way to choose the appropriate level of lighting is considering standards and applicable laws as well as indicators such as lm/km, but also working together with the citizens to understand their real needs and how to cater for them.

   An example is the project for the street lighting upgrade of Parco Madonie, in Italy (Bruni, 2012), where a large portion of the savings is determined by the choice of substituting high-pressure mercury lamps with LED lamps with a rather lower light output but still sufficient to meet the lighting needs of the area.

7. Intelligent street lighting (dimming + sensors + remote control)

   Intelligent street lighting is the name that it is used to refer to a series of measures that allow to reduce the energy consumption of lighting by adapting the lighting output in each point of the installation to the needs over time and according to certain criteria. The most common uses of intelligent street lighting are the reduction of luminance based on traffic density or weather conditions. It is a more sophisticated way of implementing dimming without affecting the service provided by the street lighting to the citizens.

   The main features that intelligent street lighting installations can have are, from the simpler ones to the most sophisticated (Andrei et al., 2009):

   - switch on/off based on preset schedule
   - remote control of switch on/off (communication via wireless or power line communication between the lighting points and a central control centre)
   - possibility to dim lights at different levels (from remote)
   - monitoring functional parameters (such as current and voltage) from remote
   - automatic alert of potential defects
   - monitoring energy consumption at the level of each luminaire from remote
   - automatic switch on/off depending on level of natural light
   - dimming regulated by sensors of ambient lighting (to allow reducing the additional lighting provided by street lighting only to the minimum necessary)
   - presence sensors (to increase the lighting levels only when the street is in use),
   - weather sensors (to allow to provide more lighting when the weather conditions determine low visibility)
   - provide the possibility for the public to control, to a certain extent, the street lighting system (e.g. providing a telephone number to allow the public to switch on or increase the lighting outputs)

   According to Baenziger (2002), the implementation of intelligent street lighting has pay back periods within 3-5 years thanks to energy and maintenance savings, with energy savings of 30 to 40%.

   Moreover, as already said for dimming, good control means lamp life extension of up to 100% for HPS lamps (Baenziger, 2002).

   Another benefit of such a solution is the need for much less on-the-field maintenance, thanks to the possibility to monitor lamp failure and even to replace faulty lamps before they fail. This also increases the reliability of the street lighting installation.

There are however a number of main challenges to the implementation of this best environmental management practices by municipalities that should be taken into account:

- many municipalities do not have a proper street lighting maintenance scheme in place (Baenziger, 2002);
- the people in charge of buying replacement lamps lack knowledge on lamps and lighting and choose the options with cheapest initial costs (Baenziger, 2002);
- part of the savings can be offset by an improvement in street lighting quality (for instance, in Vilnius high-pressure mercury lamp luminaires were replaced by high-pressure sodium lamp luminaires reducing installed capacity by 50% but energy consumption only by 16% - Balsys et al., 2002).

The main steps to be followed are thus:

- Prioritise areas for interventions
  - e.g. start by addressing most inefficient solutions, such as globe shaped luminaires with mercury vapour lamps
- Run a lighting study to understand the real needs and how to meet them in the most effective and efficient way
- Explore which way can be the most suited to finance the implementation of the solution

Achieved environmental benefit

According to the European E-Street project (as quoted in Huenges Wajer et al, 2009), up to 36 TWh/year can be saved in Europe by implementing existing technology. If energy efficient street lighting is implemented in a municipality, energy savings up to 60-86% can be achieved with a substantial reduction in the energy bill.

Moreover, improved street lighting results in decreased light pollution, with positive consequences for biodiversity as well as human health.

Appropriate environmental indicator

Lamp/lighting point

- Lamp (luminous) efficacy (lm/W)
- Luminaire (luminous) efficacy (lm/W)
- Photometric luminaire Efficiency (%)
- ULOR (%)
- Energy consumption per lighting point (kWh/year)

Whole street lighting system

- Annual energy consumption for street lighting per inhabitant (kWh/pers yr)
- Annual energy consumption for street lighting per street kilometre (MWh/km yr)
- Luminous power per street kilometrer (klm/km)

Cross-media effects

The implementation of this BEMP does not lead to any environmental cross-media effect.

Operational data

The Swiss association for energy efficiency (SAFE) collected street lighting energy consumption data for a large number of municipalities all over Switzerland. The data highlights wide differences among the different municipalities, depending on the type of measures for efficient street lighting implemented. Values ranged from 1.1 MWh/km yr to 50 MWh/km yr. The average is 11 MWh/km year and the 20^{th} percentile (performance achieved by the 20% best performers) is 6 MWh/km year (SAFE, 2013).

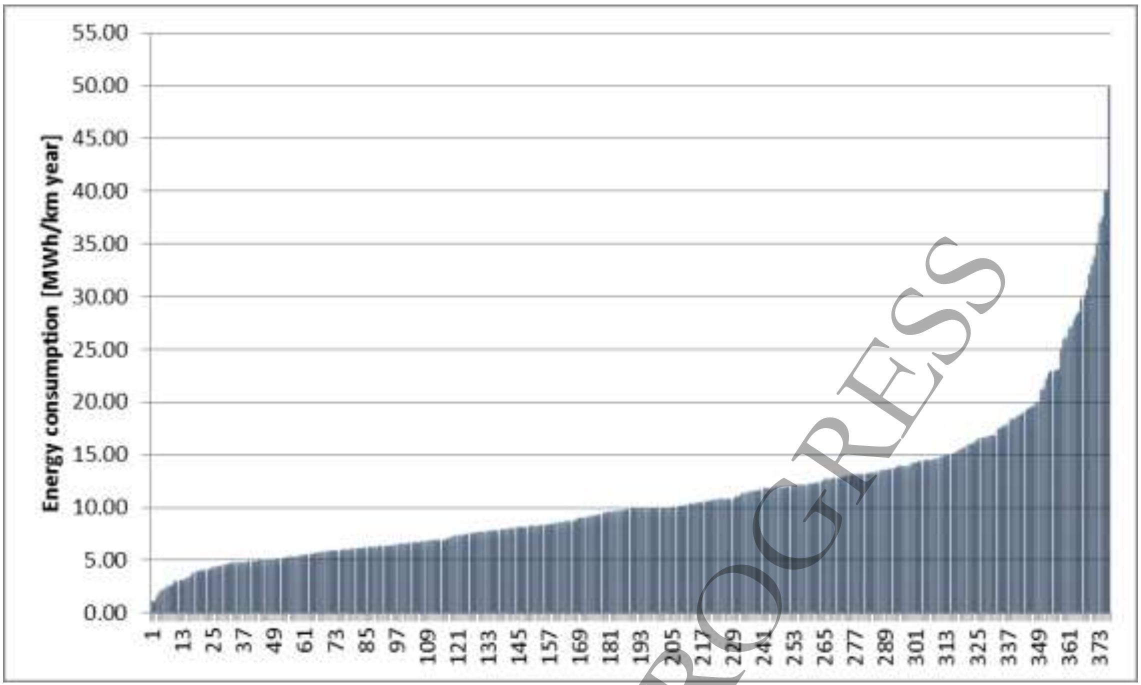

Figure 3-13: Energy consumption for street lighting in 377 Swiss municipalities (SAFE, 2013)

Applicability

This best environmental management practice is applicable to all municipalities managing directly or indirectly (through a public or private company) the provision of street lighting. As explained, not all of the measures described are the best solution for each municipality. Identifying priority areas of intervention, especially when based on an accurate inventory and auditing of the street lighting stock, is key.

Economics

Upgrading a street lighting installation as described in this technique makes economic sense, meaning that the costs savings mainly in terms of energy savings and maintenance cost savings can balance the investment costs within relatively short payback periods.
One of the main challenges to the widespread deployment of the best available technology and management practices is the rather large upfront investment often needed (IEA, 2006).

One solution to this problem can be using energy performance contracts for the provision of the street lighting service. This is the approach that a number of cities have adopted recently (Koster, Philips, pers.comm., 14 September 2012). Big cities can also finance feasibility studies for investment in sustainable energy at local level, including public lighting, through the ELENA technical assistance facility or the European Energy Efficiency Fund (EEE-F).

Driving force for implementation

Energy savings and reduced electricity bills for the municipality are the main driving force to implement this technique.

Reference organisations

Aalen (Germany) - http://www.bundeswettbewerb-stadtbeleuchtung.de/pdf_files/Aalen_Projektbeschreibung.pdf

Baltrum (Germany) - http://www.bundeswettbewerb-stadtbeleuchtung.de/pdf_files/Baltrum_Projektbeschreibung.pdf

Geseke (Germany) - http://www.bundeswettbewerb-stadtbeleuchtung.de/pdf_files/Geseke_Projektbeschreibung.pdf

Goettingen (Germany) - http://www.bundeswettbewerb-stadtbeleuchtung.de/pdf_files/G%C3%B6ttingen_Projektbeschreibung.pdf

Gothenburg (Sweden) – ESOLI project

Langen (Germany) – winner of the European Green Light award 2012

Lippstadt (Germany) - http://www.bundeswettbewerb-stadtbeleuchtung.de/pdf_files/Lippstadt_Projektbeschreibung.pdf

Main-Taunus-Kreis (Germany) - http://www.bundeswettbewerb-stadtbeleuchtung.de/pdf_files/MTK_Projektbeschreibung.pdf

Neuchatel, Chaux-de-Fonds and Locle (Switzerland) – see Auditing the status of the installation in the description of the technique

Oslo (Norway) – ESOLI project

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3.2.2 Improve the energy efficiency of public buildings

Description

Buildings are a key area of action, as they are responsible for nearly 40% of final energy consumption (and 36% of greenhouse gas emissions). Moreover, buildings provide the second largest untapped and cost-effective potential for energy savings after the energy sector itself (EC, 2013c). Public administration own or occupy a considerable number of buildings ranging across different building types: offices, schools, hospitals, warehouses etc., depending on their competencies/tasks in each country. For local authorities, public buildings are responsible for about 75% of their own direct energy consumption (ADEME, 2007).

It is key to maximise the energy efficiency of public buildings and minimise their energy consumption. This can be achieved by improving energy efficiency of the building envelop (walls, roof, and glazing) and increase the air-tightness.

Two cases need to be distinguished: the energy efficiency retrofitting of existing public buildings, and the construction of new nearly zero energy buildings[20].

Implementing several general retrofitting measures to improve building envelopes, higher energy efficiency in existing buildings can be achieved. These measures are included in Table 3-7 (EC, 2013b).

[20] The expressions high-performance house, low energy house, passive house, zero energy house, zero carbon house, energy savings house, 3-litre house, energy positive house, etc. are synonyms for a low energy building, used across Europe

Table 3-7: Retrofitting techniques for improving the energy efficiency of the building envelope

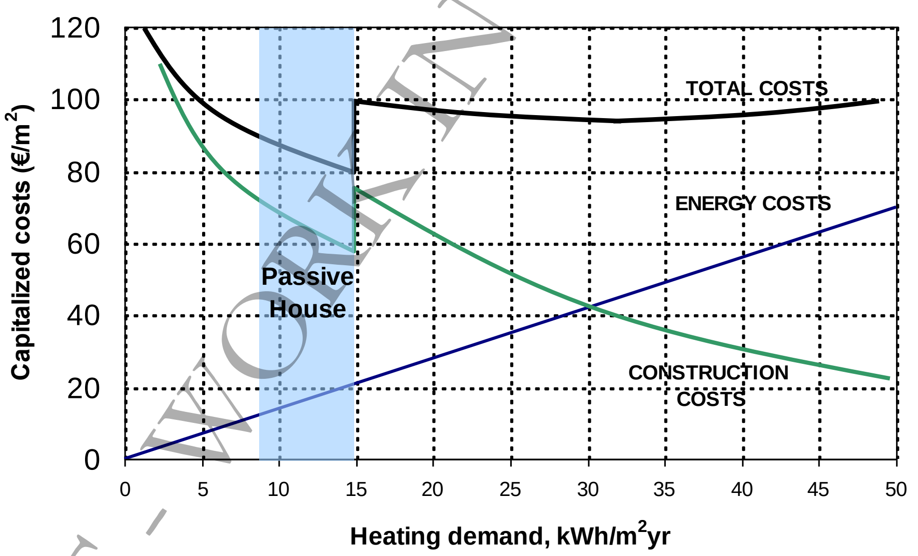
Envelope element	Technique	Description
Wall/façade/roof/floor – cellar ceiling	Change insulation materials	When an existing building is retrofitted, new and innovative materials (e.g. transparent insulation, vacuum insulated panels) have to be considered to increase the insulation and save energy.
	Techniques to increase the insulation thickness	The material thickness is an important aspect of insulation. Examples of techniques are: external thermal composite system , cladding with air circulation, cavity insulation, fixation to inner surface of walls, flat roof exterior insulation, waterproofing layer, insulation of cellar ceiling, crawl spaces for ground insulation, etc.
	Improving the environmental performance of roofs	Design and use cool, brown and green roofs to improve the thermal behaviour of the building, also with a positive effect on biodiversity, water drainage performance and on the mitigation of heat island effect.
Windows / glazing	Change to more efficient glazing	Glazing is the use of glass panes assembled into units of two, three, even four in order to increase its thermal and acoustic insulation properties. A gas (air) or vacuum fills the gap between two units. Multiple panes can give good insulation without sacrificing transparency. Examples of the most common retrofitting actions are: increase in the number of panes (up to four) low-e coatings CO_2, vacuum or argon filling
	Change to more efficient sashes and frames	Change to materials for frame, sash and other window components: wood (high thermal performance, high cost for maintenance), aluminium and other metals (bad thermal performance, zero cost for maintenance). Vinyl frames (high thermal performance and zero cost maintenance, but low resistance to heat). The replacement of metal parts of the frame and the sash is also a good practice, as it produces thermal breaks that improve insulation.

Envelope element	Technique	Description
Shading	External and internal devices	Solar shading devices should allow the control of direct, diffuse and reflected solar radiation and glare. They contribute to the energy performance of buildings by allowing interior exposure to low-angled sun in winter but not in the summer sun. Sometimes they perform other roles: some blinds can act as thermal barriers to prevent thermal losses. So, they have a direct influence on the energy requirements for the heating, cooling and lighting of a building. Some of the most common external devices are: overhangs, awnings, trees and vegetation, roller shutter, venetian blind, roller blind, etc. Examples of internal devices are: venetian blind, roller blind, and curtains
Air tightness	Improvement of doors	From the energy efficiency point of view, doors are important and generally have the same problems as portals. The most important measure for the energy efficiency of doors is to avoid air leakage, which can account for up to 20 % of building heat loss. Therefore, weather stripping and sealing must be implemented following examination. For the best performance, doors should be replaced for doors with more effective insulation (low U-value doors). Storm doors should also be used
	Fast acting doors	When a door has to be used frequently it is usually left open. This results in huge losses of energy for heating and cooling. The use of automated fast-acting doors can produce a significant contribution to energy savings.
	Sealing	Air leakages usually originate from window and door frames, lighting fixtures, ducts penetration, dryer ventilation, plumbing penetration and electrical outlets. These leakages can account for between 25 % and 40 % of the heating and cooling needs of a building. Two techniques can be used to reduce the air leakages from building envelope elements: weather stripping (installation of tension seal, felt, reinforced foams, tape, reinforce vinyl, door sweeps, magnets, tubular rubber, reinforced silicone, door shoe, etc.) and caulking (silicone, expandable polyurethane, butyl rubber, etc.)

Envelope element	Technique	Description
	Buffer sections	The use of buffer sections, like a draught lobby for the entrances, reduces the heating and cooling needs of a building, as the rate of exchanging air with the outdoor environment is minimised. The same can be done for vehicular accesses.
Overall envelope	Maintenance	The management techniques related to maintenances are the simplest solutions to saving energy. Some examples include: keeping main entrances and windows closed keeping the blinds opened for using natural light as much as possible making regular inspections to the construction elements in order to detect signs of damage: rips, cracks, gaps, damps, condensation

The reduction of heating and cooling energy demand is therefore achieved by employing energy efficient windows, high insulation levels and air tightness. Furthermore, active solar technologies, passive solar design techniques and water heat recycling technologies may be used.

For new public buildings, or existing building undergoing major renovation, best practice is to achieve the performance levels corresponding to the Passive House standard or equivalent standards. The aim of the Passive House standard is to provide an improved indoor environment (air quality and thermal comfort) with the minimum energy demand and cost, achieved improving the envelope to a point in which the heating demand becomes very low (Feist et al., 2005). For the Passive House standard, the maximum value of energy consumption for space heating or cooling is 15 kWh/m^{2}yr. This value is set ensuring that the costs are minimised when the building life cycle is analysed. Figure 3-14 shows the construction costs (initial investment), the energy costs during the lifetime and the total costs for buildings with different heating demands. In the chart of Figure 3-14, a drop at 15 kWh/m^{2}yr is observed: this point represents the minimum energy cost. Below this value, the construction costs increase due to the need of significant insulation and tightness. If the heating demand is higher than 15 kWh/m^{2}yr, the life cycle costs increase sharply (Figure 3-14) due to the need of more complex heating system able to provide the higher heating power needed (PassivHaus Institute, 2007). Instead, when the total installed heating power is less than 10 W/m^2 (usually when the demand is higher than 15 kWh/m^{2}yr), it can be achieved by the solar gains and a simple ventilation system.



Source: Laustsen, 2008

Figure 3-14: Total costs, energy costs and construction costs vs. building heat demand

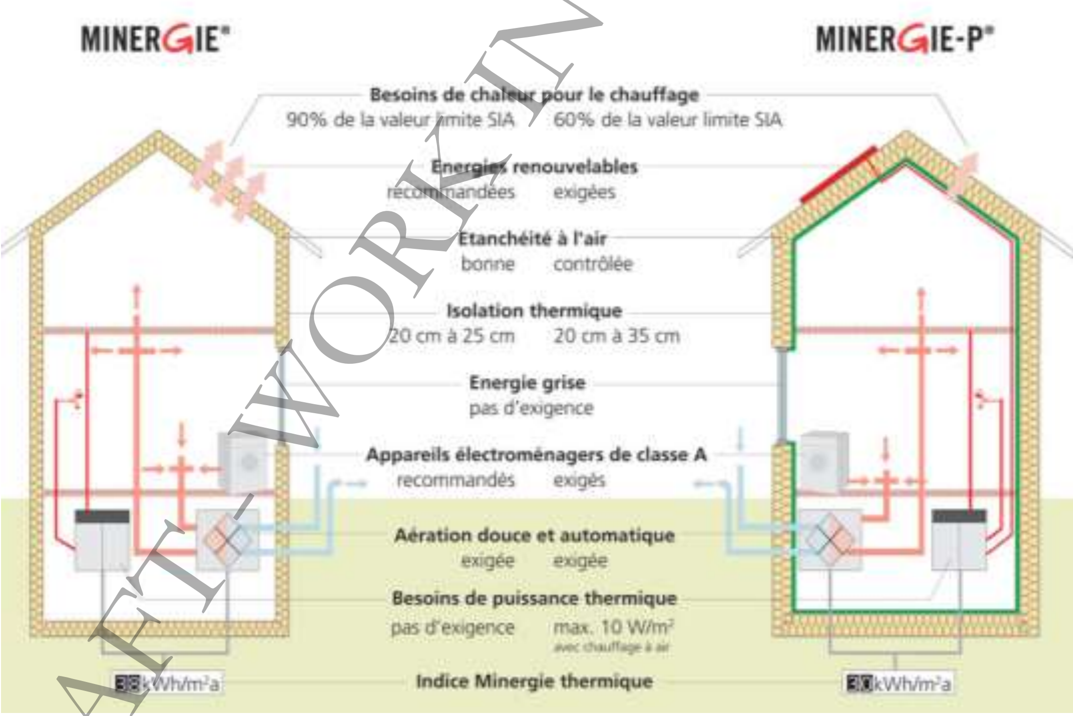
Table 3-8 gives an overview of what other requirements define the Passive House concept and how they can be achieved (Laustsen, 2008).

Table 3-8: Passive House requirements and measures to achieve them

Requirements	Measure to achieve them

The building heating + cooling demand must be lower than **15 kWh/m²yr** The specific heat load should be less than **10 W/m²** The building must not leak more air **than 0.6 times** the house volume at the 50 Pa test (n_{50} value) Total primary energy demand cannot be more than **120 kWh/m²yr**	Improved insulation. Recommended U-values less than **0.15 W/m²K** Design without **thermal bridges** Windows U-values lower than **0.85 W/m²K** Air tight. **Mechanical ventilation** with heating recovery from exhaust air **Innovative heating technology** (renewable sources would account for 0 kWh/m²yr of consumption)

Another set of exemplary standards for buildings, called Minergie, were developed in Switzerland and has been quite successful in its application, even outside Switzerland. The Minergie-P standard uses a similar approach to the Passive House. Figure 3-15 shows a comparison of the requirements and differences between Minergie and Minergie-P. One of the outstanding characteristics of Minergie is the development of a concept seeking comfort and energy efficiency, with a main feasibility approach stating that the actual costs should not be more than 10 % of the costs of the construction of an average building fulfilling legal requirements. Minergie develops the requirements for the primary energy consumption of the heating system, taking into account the efficiency of the heating system, hot water demand and the electricity used for ventilation. This should be taken into account when comparing with the Passive house standard, which sets thresholds only for the demand.



Source: Minergie, 2010

Figure 3-15: Summary of requirements for Minergie and Minergie-P

For new and existing buildings, the Passive House, Minergie and Minergie-P concepts are outstanding examples for energy efficiency. Reference values are given in Table 3-9.

Table 3-9: Different exemplary approaches and the associated requirements (EC, 2013)

Approach	Residential	Non-Residential
Passive House (New)	Heating: 15 kWh/m^{2}yr (cooling 15 kWh/m^{2}yr or heating + cooling = 15 kWh/m^{2}yr, see Passive-On, 2007)	Heating: 15 kWh/m^{2}yr (cooling 15 kWh/m^{2}yr or heating + cooling = 15 kWh/m^{2}yr, see Passive-On, 2007)
Passive House (Existing Buildings)	Heating: 25 kWh/m^{2}yr	Heating: 25 kWh/m^{2}yr
Minergie-P (New- Buildings)	HVAC and DHW primary energy consumption: Residential, 30 kWh/m^{2}yr	HVAC primary energy consumption: Public administration, schools, commercial 25 kWh/m^{2}yr Restaurants, 40 kWh/m^{2}yr Hospitals, 45 kWh/m^{2}yr Industry, 15 kWh/m^{2}yr Warehouse, 15 kWh/m^{2}yr Sports, 20 kWh/m^{2}yr
Minergie (Existing Buildings)	HVAC and DHW primary energy consumption: 60 kWh/m^{2}yr	HVAC primary energy consumption: Public administration, schools, commercial 55 kWh/m^{2}yr Restaurants, 65 kWh/m^{2}yr Hospitals, 85 kWh/m^{2}yr Industry, 40 kWh/m^{2}yr Warehouses, 35 kWh/m^{2}yr Sports, 40 kWh/m^{2}yr

N.B. HVAC: Heating, Ventilation and Air Conditioning; DHW: Domestic Hot Water

Any other equivalent building approach as ambitious as those proposed here (Passive House, Minergie) should be considered by public administrations also as best practice in the design of new buildings (and major refurbishment of existing ones), taking into account the specific needs of each type of building. In general, it can be stated that, for the energy consumption of buildings, outstanding standards constitute best practice if the approach:

- benchmarks processes, such as heating, ventilation and lighting;
- uses comparable indicators, such as kWh/m^{2}yr, not ratios or ratings (e.g. A-B-C) based on ratios;
- defines and uses an appropriate methodology to calculate the indicator and its calculation is simply enough to convert it to different approaches in order to allow comparability;
- does not offset energy consumption (or indirect CO_2 equivalents) with renewable energy in the calculation, so the demand is actually benchmarked; and
- is as ambitious as Minergie or the Passive House.

Achieved environmental benefits

The main environmental benefit achieved with very high energy performance public buildings is the reduction of the primary/useful/final energy demand, e.g. for space heating/cooling, water heating, air conditioning as well as a reduction in the consumption of electricity (EC, 2013a).

Table 3-10 provides some definitions and specific energy demands for low energy buildings in selected EU member states.

Table 3-10: Examples of definitions for low energy building standards (Engelund Thomsen et al., 2008; EC, 2009)

Country	Official Definition
Austria	• Low energy building = annual heating energy demand below 60 – 40 KWh/m² gross area (30 % better than standard performance) • Passive building = passive house standard: 15 kWh/m^2yr per useful area and per heated area
Belgium (Flanders)	• Low Energy Class 1 for houses: 40 % lower than standard levels, 30 % lower for office and school buildings • Very low energy class: 60 % reduction for houses, 45 % for schools and office buildings
Czech Republic	• Low energy class: 51-97 kWh/m^2yr • Very low energy class: below 51 kWh/ m^2yr, also passive house standard of 15 kWh/ m^2yr is used
Denmark	• Low Energy Class 1 = calculated energy performance is 50 % better than the minimum requirement for new buildings • Low Energy Class 2 = calculated energy performance is 25 % better than the minimum requirement for new buildings (i.e. for residential buildings = 70 + 2200/A m^2yr where A is the heated gross floor area, and for other buildings = 95 + 2200/A m^2yr (includes electricity for lighting)
Finland	• Low energy standard: 40 % better than standard buildings
France	• New dwellings: average annual requirement for hot water, heating, ventilation, cooling, and lighting have to be to be lower than 50 kWh/m² (in primary energy). This ranges from 40 – 65 kWh/m² depending on the climatic area and altitude. • Other new buildings: average annual requirement for hot water, heating, ventilation, cooling, and lighting has to be 50 % lower than current Building Regulation requirements • Renovation: 80 kWh/m² as of 2009
Germany	• Residential low energy building requirements = KfW60 (60 kWh/ m^2yr) or KfW40 (40 kWh/ m^2yr) maximum primary energy demand • Passive house = KfW40 buildings with an annual useful energy demand for space heating lower than 15 kWh/ m^2yr and total primary energy demand lower than 120 kWh/ m^2yr
England & Wales	Graduated minimum requirements over time: • 2010 level 3 (25 % better than current regulations), • 2013 level 4 (44 % better than current regulations and almost similar to passive house) • 2016 level 5 (zero carbon for heating and lighting), • 2016 level 6 (zero carbon for all uses and appliances)

Figure 3-16 shows the differences in the primary energy consumption between Passive House Standard buildings and the reference buildings built according to existing regulations. It is clearly noticeable the significant reduction (55-60%) of primary energy consumption of the buildings employing Passive House standard compared to the ones built according to existing regulations (Feist et al., 2005).

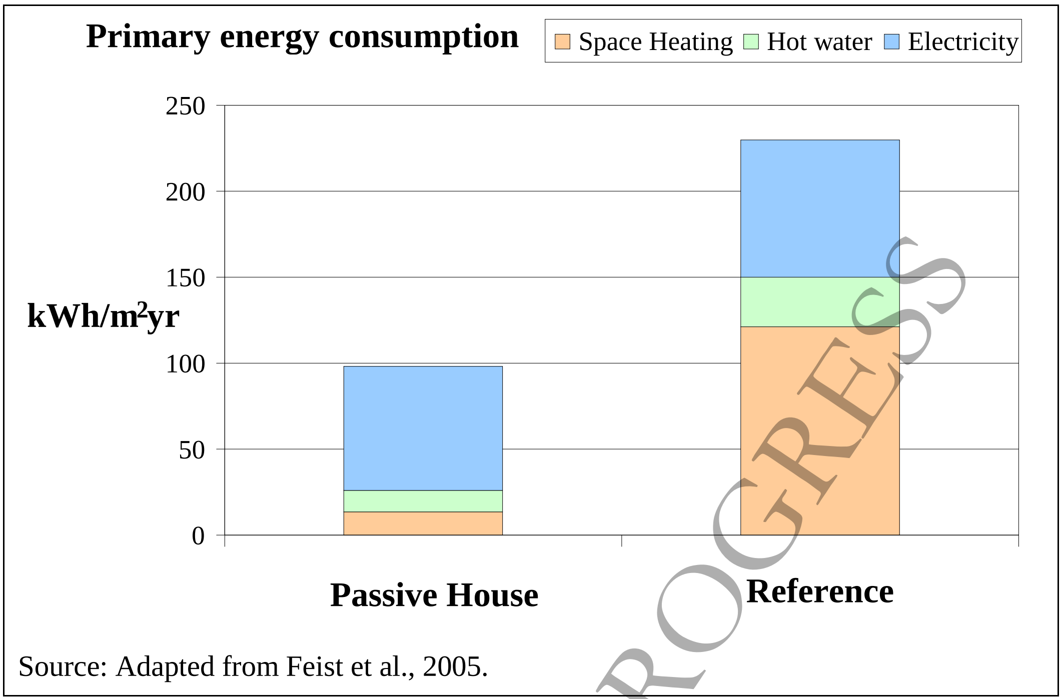


Figure 3-16: Comparison of primary energy consumption of Passive House projects with new buildings meeting existing energy requirements

Appropriate environmental indicators

The specific primary energy consumption (for heating, domestic hot water, auxiliary and household electricity) per square metre and year (e.g., kWh/m^{2}yr) is the most important indicator to control the energy performance. Thus, the easiest way to control the environmental impact of the HVAC system performance is to disclose the space heating and/or cooling load, defined per unit of area and year (kWh/m^{2}yr). This indicator would include all the techniques involving building envelope and the HVAC aspects. In order to compare different buildings, correction factors with a scientific basis can be used to calculate the area (e.g. height, use factors for corridors, stairs, etc.). The time of use of the building can differ for different regions across Europe, but it is not recommended to correct it unless comparisons between systems are being performed. Two alternatives can be used: the specific primary energy consumption, with factors from primary to final defined at national or regional level; or to calculate the energy demand of the building through the use of comprehensive estimation models (EC, 2013a).

Cross-media effects

Embodied energy of buildings is an aspect concerning the life cycle energy assessment. However, operating energy remains the main energy required (usually about 80-90%) while embodied energy is about 10-20% (Ramesh et al., 2010) as presented in Figure 3-17.

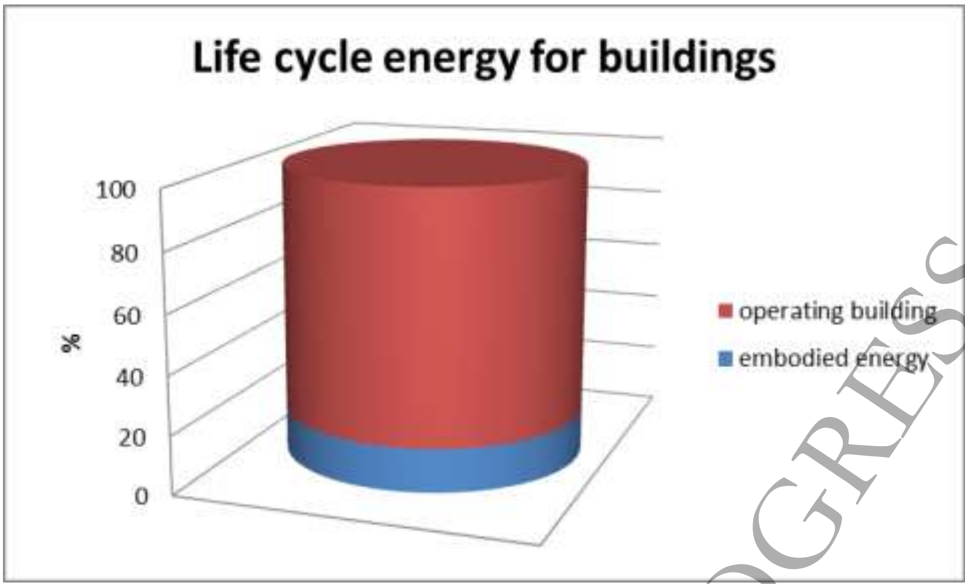


Figure 3-17: Life cycle energy for buildings: operating and embodied energy

When looking at cross-media effects, the use of passive house (or an equivalent standard to reduce the overall life cycle impact of a building) is usually regarded as increasing the embodied energy of the building. However, the increase in embodied energy between buildings meeting the current regulations and the ones built according to the passive house standard is limited. In fact, it has been reported that embodied energy was 1171 kWh/m^2 for normal buildings and just 1391kWh/m^2 for the Passive House buildings (Feist, 1996). Therefore, with an increase of 15-20% in the embodied energy a Passive House can reduce 55-60% of the primary energy consumption of an equivalent conventional building (Feist et al., 2005). Finally, when choosing the construction materials, reuse, recycling and greening the supply chain should also be a concern, and not only their embodied energy.

Operational data

Olbersdorf: Comprehensive refurbishment of a school listed as a historic monument
The school in Olbersdorf (Saxony-Germany), Figure 3-18, provides an example of a successful compromise between historic conservation and energy-based refurbishment. The building was constructed in 1928 and renovation aimed at reducing its energy demand.

Figure 3-18: Olbersdorf school in Saxony (Germany) (Build up, 2010)

The most important starting point was to provide consistent thermal protection for the building. The building is a four-storey masonry structure with a gable roof. 180 school pupils are taught in 22 classrooms across a total usable area of around 4,900 m² (Reiss and Schade, 2010).

Large parts of the building was constructed with a solid masonry structure that had a depth of 48 cm and achieved a U-value of around 1.25 W/m²K (Build up, 2010). In order to encourage a “learning atmosphere”, the refurbishment measures also intend to improve the acoustics and air hygiene, while lowering the indoor temperatures in summer.

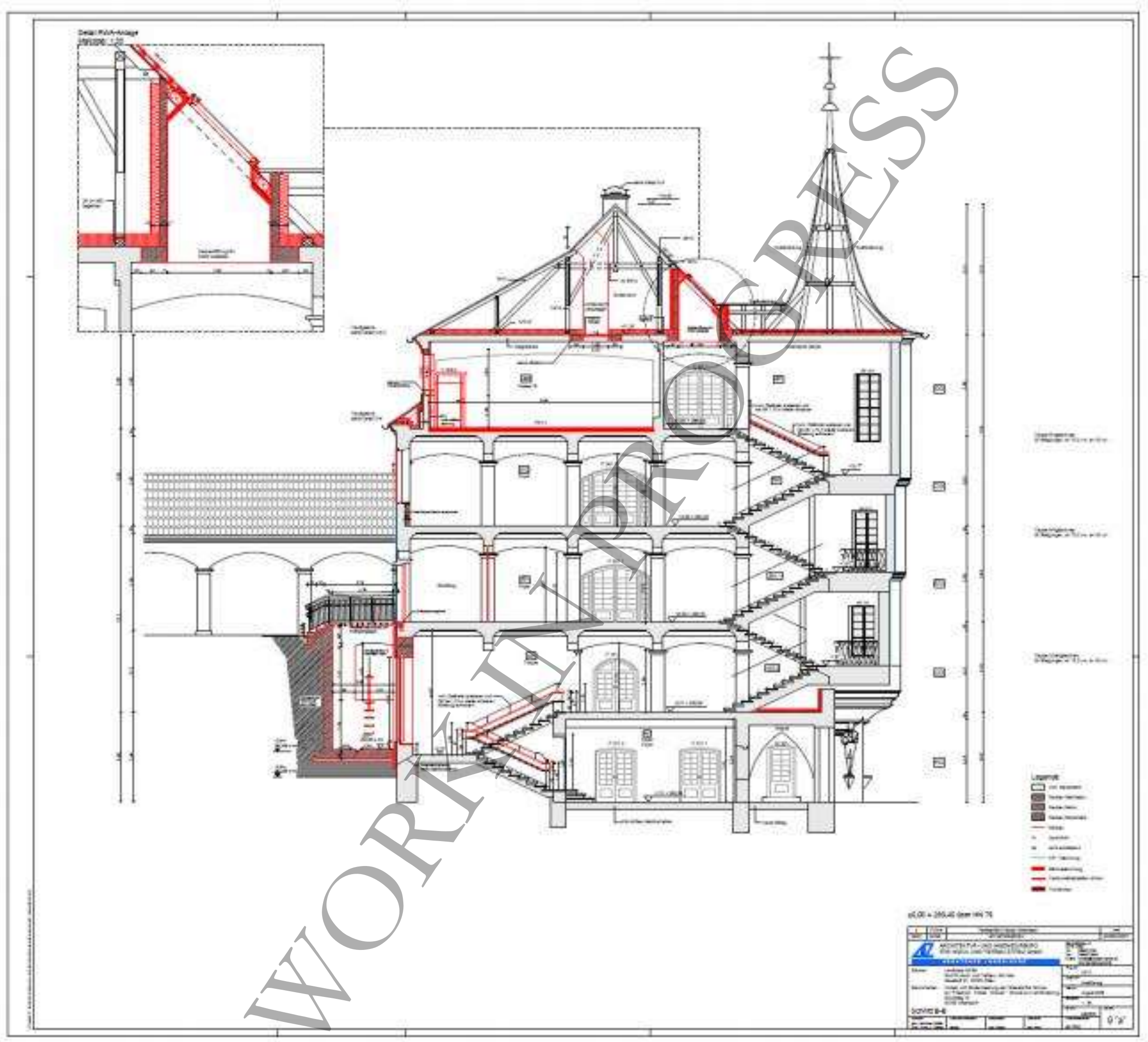


Figure 3-19: Cross-section of the Olbersdorf school (Reiss and Schade, 2010)

The key aspect of the renovation focused on facade systems, glazing and windows, daylight systems, optimised lighting, ventilation and heat recovery, active cooling, regenerative and passive cooling.

Firstly, the focus was to improve the thermal insulation of the building envelope in accordance with listed building requirements.

The thermal insulation composite system was developed using stepped profiles and adhesive technology preventing damage to the original facade and avoiding isolated or linear thermal bridges. The new energy concept reactivates existing ventilation and lighting systems.

Double windows were originally installed in the building. During the course of earlier refurbishment measures, the outer panes on the street side were replaced with double-glazed insulating glass and the inner panes of the double windows were removed.

Figure 3-20: Old and new windows at the Olbersdorf school (EnOB, 2010)

In addition to the structural improvements, energy savings were achieved also by deploying modern heating technology and efficient ventilation strategies. Before the refurbishment, the heat was provided with a gas boiler Figure 3-21.

Figure 3-21: Gas boiler providing heating before renovation of Olbersdorf school (EnOB, 2010)

As part of the energy-based refurbishment, a ground-coupled gas absorption heat pump was installed, with peak load compensation provided by the gas boiler. The use of the ground as an energy source for the heat pump system was provided as part of a comprehensive redesign of the open spaces to the east of the main building.

Before renovation, ventilation was provided via the windows and exhaust air ducts integrated into the masonry structure. However, these exhaust air ducts were only full functioning in the entrance areas and partly in the toilets, whereas in the classrooms they had been mostly blocked off during previous renovation work.

In the sanitary spaces, a conventional central exhaust air system was installed during renovation with a presence control. For the teaching spaces, customised ventilation was developed, substantially based on natural uplift and only boosted with fans with low electrical consumption as appropriate ("hybrid ventilation") as presented in Figure 3-22.

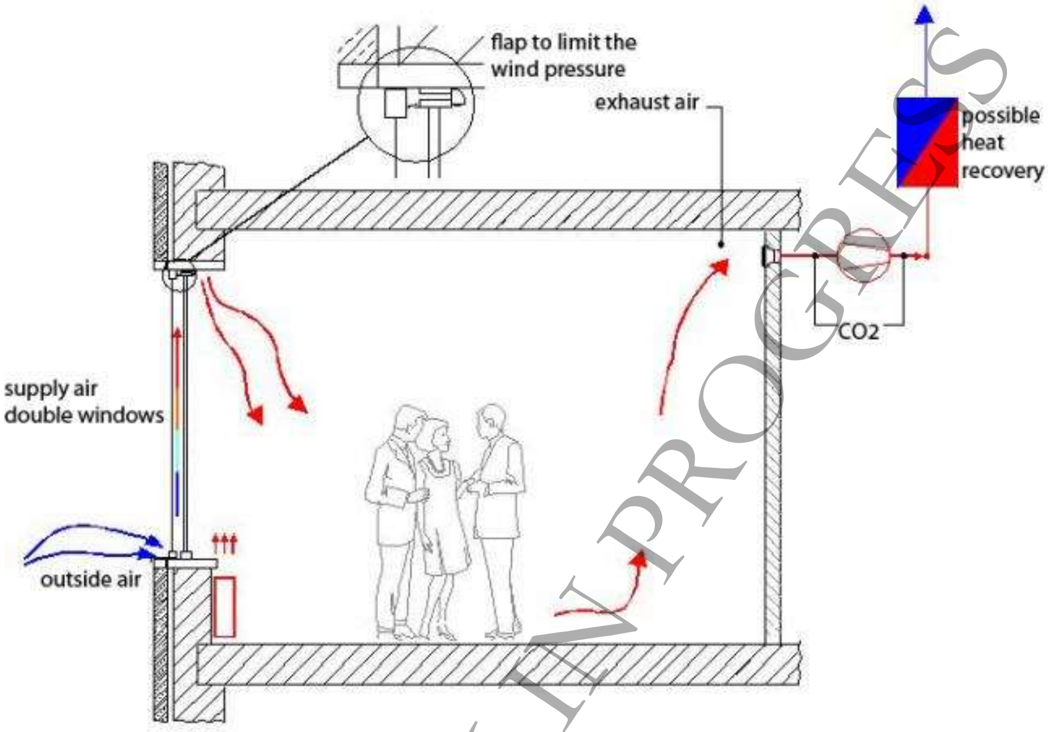


Figure 3-22: Ventilation scheme after the renovation of Olbersdorf school (EnOB, 2010)

The replaced windows were built with thermal insulation glazing installed in double air-supply windows. Via an opening in the lower frame, the external air enters the cavity between the panes, warms up and enters the room via the upper window frame. Because the air is pre-heated and supplied above the occupancy zone, this considerably reduces the risk of draughts. In order to prevent unwanted air currents, additional wind pressure reducers and check flaps are integrated in the windows. As soon as a specific external temperature is exceeded, the skylights in the inner panes of the windows are automatically opened, which increases the volume flow of the air change. The exhaust air ducts are also being reactivated so that used air can be removed by means of natural uplift. Should a sensor measure increased CO_2 concentrations, an exhaust fan will be switched on to provide support. If the respective teaching space is not or only partly occupied, the fan remains switched off. Compared to a standard system, this considerably saves on electricity for powering the vent.

The school is naturally cooled during the summer by means of effective night cooling, which is neutral in terms of the primary energy use. By utilising the double windows and exhaust air ducts and by controlling the exhaust airflow volumes, the existing building mass can be activated and a considerable drop in room temperatures achieved in large parts of the building.

Before renovation, daylight was provided in the teaching spaces by means of windows along one side of the classrooms, on either the west or east sides. Because of the building's position on a slope, the corridor spaces, entrance area and assembly hall received too little daylight and required artificial lighting throughout the day. During renovation, the floor plans were reworked to improve the daylight utilisation. Old light shafts were reactivated or supplemented, with louvre blinds integrated in the cavities in the double windows to provide shading, glare protection and to redirect light. In the windows on the east-southeast side, it was installed electrochromic glazing to provide solar shading that counteracts solar gain in these rooms. Any required artificial light is now controlled in accordance with the daylight and switched off centrally when the school closes at the end of the day.

The refurbishment of the school aimed at reducing the heating requirement by more than 80%. Insulation measures adopted and results in terms of levels of insulation achieved are reported in Table 3-11.

Table 3-11: Technical characteristics of the thermal envelope of the Olbersdorf school before and after renovation (BMWi, 2010)

Component	U-values [W/m2k]		Description
	Before renovation	After renovation	
External wall	1.25	0.34	7cm ESP insulation
West facing windows	1.70	0.90	Double air-supply windows electrochromic glazing
East facing windows	2.80		
Top floor ceiling	1.70	0.22	-
Floor	3.50	0.36	10 cm concrete 4 cm screed 2 cm vacuum insulation panel
	3.09	0.32	10 cm concrete 4 cm screed 10 cm XPS insulation

Energy consumption was reduced drastically after renovation as it is reported in Figure 3-23 and Table 3-12. The overall investment cost was 8.8 million € which means 1570€/m^2.

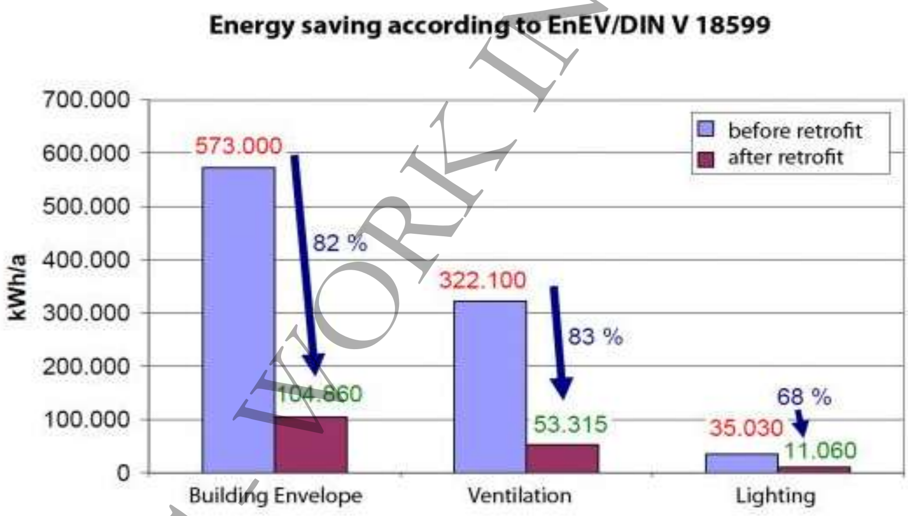


Figure 3-23: Energy savings in Olbersdorf school (EnOB, 2010)

Table 3-12: Energy efficiency improvement in Olbersdorf school before and after renovation (EnOB, 2010)

	Before refurbishment	After refurbishment
Heating energy demand [kWh/m^{2}yr]	122.7	31.8
Overall primary energy requirement [kWh/m^{2}yr]	174.2	48.9

Frankfurt (Germany): Implementing passive house standard in all new public buildings

The city of Frankfurt in Germany decided to reduce the operating costs of public buildings through less energy consumption and increased materials efficiency, taking into account an expected life cycle of 40 years. The municipality reduced the energy demand using the Passive House standards for new and existing buildings through "economic construction guidelines", mandatory for every new public tender (new buildings and renovations). The guidelines are based on the buildings' life cycle. The aim is to minimise capital, operating and environmental follow-up costs, all the way from the planning stage to demolition and disposal. All public construction projects and all contracts concluded with architects and engineers have been subject to the guidelines since 2005.

The Ridelberg school (Figure 3-24) is an example of public building implementing the Passive house standard in Frankfurt. It was opened in 2004 after 14 month construction period and the cost was about 5% more expensive compared to the same building fulfilling the current energy efficiency German regulation. The surface of the school is 7670 m^2, furthermore, a kindergarten and a sports hall are also present (Peper et al., 2007).

Figure 3-24: Ridelberg school, Frankfurt, Germany

High level of insulation is achieved thanks to a thickness of the walls of 30cm (Figure 3-25), leading to U-values of $0.1 W/m^2K$.

Figure 3-25: Wall section at Ridelberg school

Indoor comfort during winter and summer were investigated, reporting low temperature differences among rooms (19.5-20.6ºC during winter), low relative humidity (however acceptable) and comfortable temperatures also during summer (about 23ºC). During summer the building is cooled down during the night thanks to natural ventilation (Figure 3-26).

Figure 3-26: Summer natural ventilation at Ridelberg school

Air quality results also being comfortable, with 16.4 m^3/h/person, when the ventilating system is operated appropriately. The school has 6 heat-exchangers to recover the heat from exhaust air during the winter, providing new air into the building but reducing the energy demand for heating (Figure 3-27).

Figure 3-27: Exhaust air heat exchangers at Ridelberg school

Table 3-13 shows the main technical characteristics to assess the thermal envelope of the school. A technical and very comprehensive report of the performance of the school is given by Peper et al., 2007. Other characteristics are shown in Table 3-14.

Table 3-13: Technical characteristics of the thermal envelope of the Riedberg school in Frankfurt

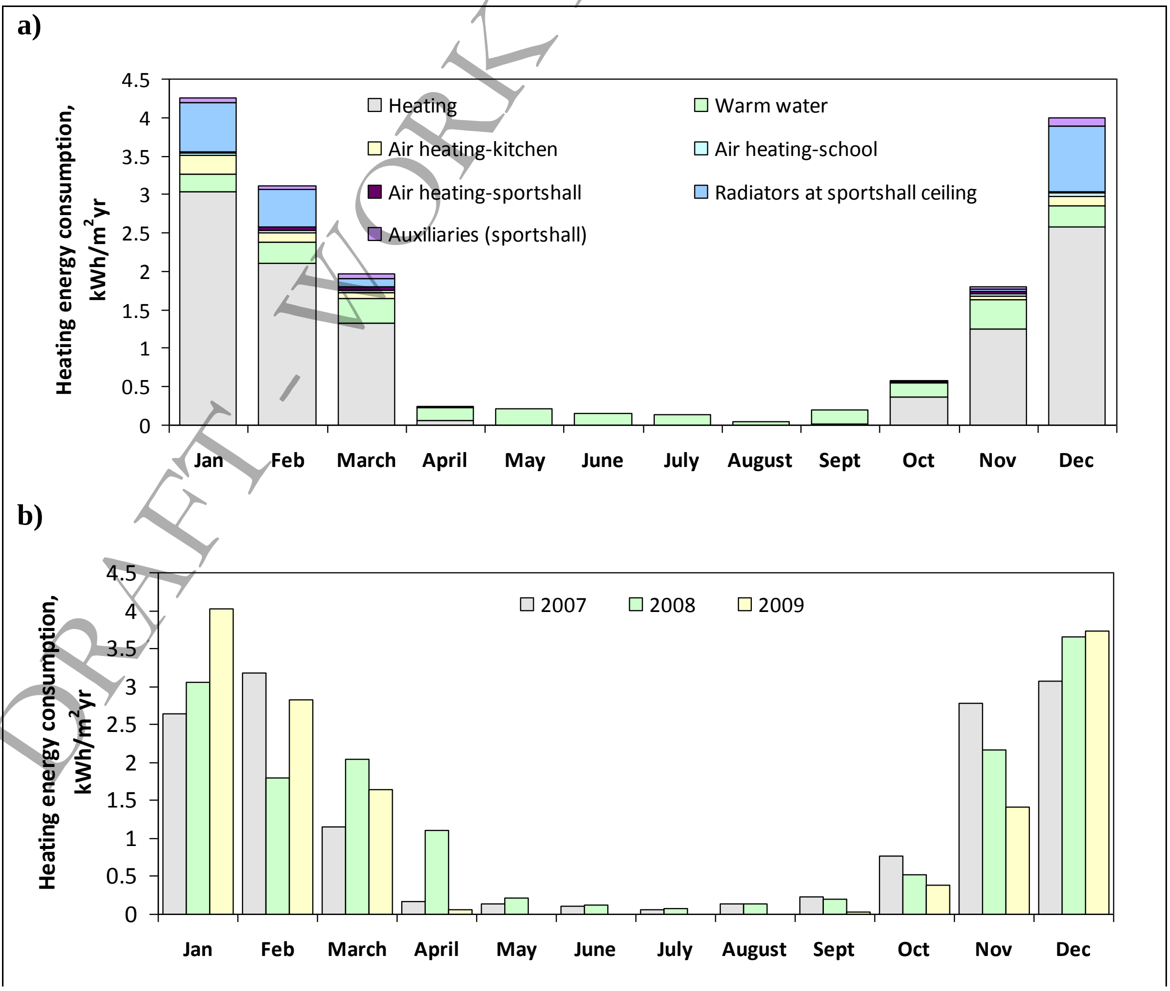
Element	Description
Façade	Modular, wood-aluminium substructure, U = 0.16 W/m^2K
Roof	0.11 W/m^2K
Floor	Frost barrier (20 cm of insulation extends 2m below the floor slab) U = 0.34 W/m^2K (with a reduction factor of 0.22)
Windows	Triple glazed, U-value of 0.74 W/m^2K
Internal Loads	25 students per room, where the internal gain is up to 2 kW per room. This reduces the need for insulation.
External blinds	Automatic control with a temporary manual switch
Ventilation	Central ventilation. 6 systems (3 of them are passive house systems and the other three are for the kitchen, cafeteria and sportshall) with a total capacity of 21700 m^3/h (estimate of 20 m^3/h per person). Heat recovery with an efficiency of 84 %. Consumption of 0.45 Wh/m^3 (meeting DIN 13779 and Passive House standards)

Air change rate	At fully occupancy is 2/h; n_{50} value is 0.46/h

Table 3-14: Other energy-related technical characteristics of the Riedberg schooling Frankfurt

Element	Description
Heating system	10.5 W/m^2; 2 automatic wooden pellet boilers of 60 kW each Heat demand coverage is made by radiators (stealing in the sportshall), individual rooms thermostat
Primary energy demand	59 kWh/m^{2}yr
Lighting system	< 6 W/m^2 (requirement of less than 2 W / 100 lux /m^2)
Others	Users: 400 primary school students in 16 classes plus 100 – 125 kindergarten children and 50 adults. Volumetric flow regulator including CO_2 and/or mixed gas sensors

Figure 3-28 shows the seasonal consumption of the school in 2009 for every internal process (a), and the monthly variation from 2007 to 2009 of the space heating demand (b), and of the heating degree days (c). In the charts, air heating refers to the energy consumed to heat the air entering to different parts through the six air intake systems and heating is the energy consumed to heat all the radiators, except for those in the sportshall, as they are differentiated. As shown, the heating energy consumption is almost constant for every month (except for August) and the variation between the energy consumption for heating and the heating degree days is proportional, though with some exceptions, such as February 2007.



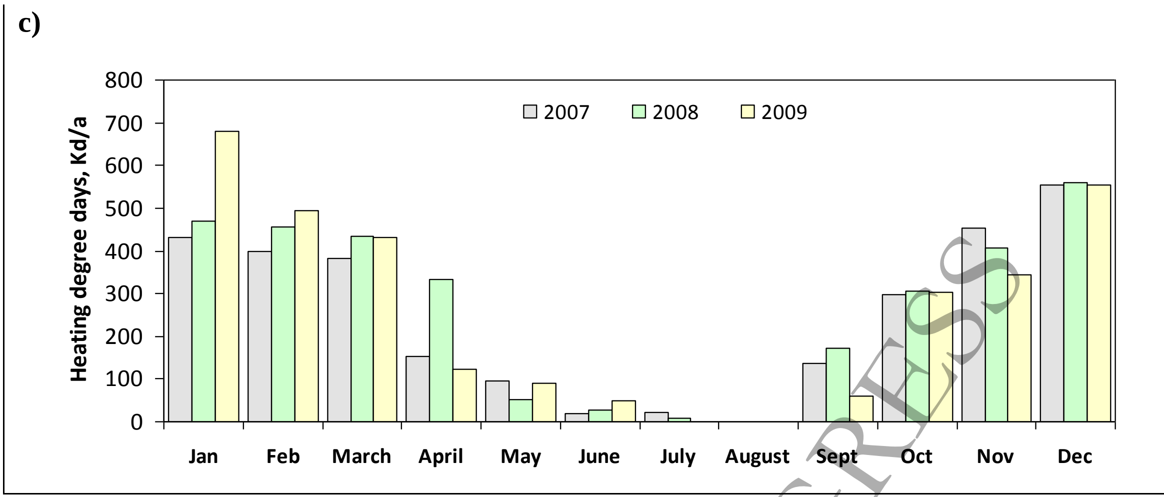


Figure 3-28: a) Monthly heating energy consumption at Riedberg school during 2009 for several internal processes. b) Monthly heating energy consumption (excl. hot water preparation) in 2007, 2008 and 2009. c) Monthly value of heating degree days in Frankfurt in 2007, 2008 and 2009. (Peper et al., 2007)

The overall energy performance of the Ridelberg school is outstanding with only 59kWh of primary energy consumption per square meter per year (without offseting the PV electricity generation), therefore the Passive House Standard energy requirement is more than fulfilled (120kWh/m^{2}yr).

Applicability

Every construction technique should adapt to the environment, climate and surroundings of the building location. The challenge for designers is to be able to build nearly self-sufficient buildings in any part of the world. The example of the Passive House concept can be seen as one exemplar way to achieve that objective. The Passive House approach is regarded as a simple solution for a low energy building and its applicability to warm or cold climates is not a complicated task. The Passive house concept relies on: insulation, heat recovery, mechanical ventilation and air tightness. This solution achieves a peak heat load of less than 10 W per square metre, easily achievable in warm climates and achievable in colder climates with careful planning (EC, 2013a).

Economics

In all cases, the additional costs for low energy buildings depend on specific conditions, but the extra upfront investments are about 10 % or less, with a clearly declining trend. Energy prices, labour cost, available experience, expertise and the way in which each construction project is executed differ significantly from one country to another, so that the transfer of cost estimations should be treated with caution. Especially, the transfer of price estimations from countries with an advanced diffusion of low energy buildings, such as Germany, to countries just beginning diffusion can be misleading. However, in general, the additional investment will be in the range of 100 EUR/m² or less (Lenormand et al., 2006) (more if expensive solutions are used), with payback returns of less than 20 years. Laustsen, 2008, also gives some important economic data (see Figure 3-14).

Some data were published in 2007 for the economic performance of the construction of Passive Houses in Europe (Passive-On, 2007). Data are shown in Table 3-15

Table 3-15: Economic performance estimation of Passive House standards application in Europe (Passive-on, 2007)

Item	France	Germany	Italy	Spain (Granada)	Spain (Seville)	UK

Extra capital cost (EUR/m^2)	103	94	60	24	20.5	73
Extra capital cost (%)	9 %	6.7 %	5 %	3.3 %	2.8 %	5.54 %
Energy savings, kWh/m^{2}yr	55	75	86	65.5	38	40
Life cycle cost (LCC) 20 years, standard construction, EUR	160300	204900	221000	118000	109000	118000
LCC 20 years, passive construction, EUR	160500	200600	198460	104000	102300	117000
Discounted payback time, years	19.5	19	8	4	5	19

There are two main characteristics of Passive House economics for new buildings: construction costs are relatively similar and only a 5 to 10 % increase is observed. Energy savings are significant, but payback time periods can be long for countries with better building practice traditions or standards. For Italy and Spain, current building practice would really benefit from the standard, with short payback periods.

According to the results, a variation from 8 to 17 % extra costs were observed in 2001. It was reported (Feist et al., 2005) that cost prices per kWh of energy saved where less than EUR 0.06 (uniform real interest rate of 4 % and service life of 25 years, taking into account the maintenance of equipment, the cost of electricity for ventilation and additional operating cost savings).

The main conclusion from the application of the Passive House standard or any other equivalent is that they will always payback investment costs for public buildings, when compared to current building practices.

Driving force for implementation

The crucial importance of energy savings from energy efficiency in buildings has been recognised by the energy performance of building directive (EPBD) in 2002 and its recast in 2010 (regulation (EC) 31/2010). In this directive it is stated that all new buildings, starting from 31st December 2020, should be 'nearly zero energy buildings' and public authorities that own or occupy a new building should set an example by building, buying or renting such 'nearly zero energy building' from 31st December 2018. The definition of very low energy building was agreed to: "nearly zero energy building means a building that has a very high energy performance, determined in accordance with Annex I. The nearly zero or very low amount of energy required should be covered to a very significant level by energy from renewable source, including renewable energy produced on-site or nearby". The directive also tackles existing buildings inviting Member States to develop policies and adopt measures to stimulate the transformation of refurbished buildings into very low energy buildings.

Furthermore, local authorities may increase the energy efficiency of their buildings when deciding to take part in voluntary schemes aimed at reducing the carbon footprint of municipalities. The Covenant of Mayors, for examples, requires municipalities to establish a sustainable energy action plan (SEAP) where the municipality presents all the actions which will be taken for reducing greenhouse gases emissions and measures for increasing energy efficiency in buildings can also be included.

Moreover, energy bills for municipalities are an important chapter in their annual economic balance. Therefore, reducing the energy bill is also a driving force for implementing measures aimed at improving the energy efficiency and this was also the case for the municipalities of Olbersdorf and Frankfurt. Paybacks times, as seen in the economics section, are reasonable for public buildings which aim at being operational for many years. Moreover, reduced energy consumption produces other benefits to local communities which are therefore also driving forces for implementation: reduction of CO_2 emissions, job creation, enhanced thermal comfort and indoor air quality in buildings and consequently health improvements.

Reference organisations and initiatives

In Germany, the **Passive House Institute** (PHI) is an independent Research Institute engaged in the research, development and promulgation of building concepts, building components, planning tools and validation for particularly energy efficient buildings: www.passiv.de

In Switzerland, the **Minergie Standard** can be easily met within central Europe in the design of building structures and the choice of materials. Economics is also considered within the standard: the budget for a certified new building (or for the renovation) should not exceed more than the 10 % of the typical cost of a similar uncertified building. The variant **Minergie-P** is considered as the equivalent to the Passive House standard: http://www.minergie.ch/home_en.html

Build up, the European portal for energy efficiency in buildings. A portal bringing together policy makers, building professionals and building occupants, reporting many examples and details of successful energy efficient buildings (new or renovated): http://www.buildup.eu/

Display Campaign, an initiative aimed and raising awareness of citizens about energy efficiency in buildings, by encouraging local authorities to publicly display the energy and environmental performances of their public buildings. Many successful examples of efficient public buildings are presented: http://www.display-campaign.org/ab_839_942

Olbersdorf school refurbishment project was carried out by the Fraunhofer Institute for Building Physics: http://www.ibp.fraunhofer.de/en.html and the person responsible was Heike Erhorn-Kluttig.

Frankfurt Ridelberg school project was managed by the Frankfurt Energy Agency**:** www.energiereferat.stadt-frankfurt.de

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3.2.3 Improving the energy efficiency of social housing

Description

Social housing has not a common definition across Europe, it can refer to the rent regime (if the rents are at sub-market rates), the legal status of the landlord, the way the social housing is funded, however, in general, social housing targets low income population. In Europe, the Netherlands has got the highest portion (34%) of social housing compared to the total housing stock, followed by the UK (21%) and France (20%). In southern Europe, instead, the percentages of social housing portion are lower, around 5%. (Houard et al., 2012).

New buildings in European cities account annually for about 1-3% on the total building stock, therefore it is important to focus on the energy efficient refurbishment of buildings and not only on new constructions. Refurbishment of buildings dated from 60s-80s could reach energy consumption reduction of 50-60% but also for newer constructions energy savings can be significant (CASH, 2010). Therefore, it is essential when planning the refurbishment of social housing (not only for the ones built more than 20-30 years ago) to implement measures aimed at improving the energy efficiency.

BEMP 3.2.2 reports detailed description of measures for improving energy efficiency in buildings. The same measures/techniques can be adopted for improving the energy efficiency of social housing both for refurbishment or new buildings. However, the design or refurbishment of the building must take into consideration the residential use, involving the availability of different sizes of flats with high accessibility (for people with disabilities) and the presence of shared premises (e.g. laundry and recreation rooms). Furthermore, engaging with local residents while planning the refurbishment or designing the new building is important, in order to understand their needs. Interaction with residents will also allow explaining the benefits of buildings with improved energy efficiency, increasing the awareness of tenants about environmental and social issues. A show apartment presenting how the refurbished/new flats will look like is a useful tool to engage with local tenants. Moreover, meetings where presenting the features, work plan and giving the opportunity to provide feedbacks and suggestion must be organised while planning the refurbishment or designing the new building.

Achieved environmental benefits

The main environmental benefit achieved with very high energy performance public buildings is the reduction of the primary/useful/final energy demand, e.g. for space heating/cooling, water heating, air conditioning as well as a reduction in the consumption of electricity, as presented in BEMP 3.2.2.

Appropriate environmental indicators

As presented in BEMP 3.2.2 the specific primary energy consumption (for heating, domestic hot water, auxiliary and household electricity) per square metre and year (e.g., kWh/m^{2}yr) is the most important indicator to control the energy performance. Thus, the easiest way to control the environmental impact of the heating and cooling system performance is to disclose the space heating and/or cooling load (when required), defined per unit of area and year (kWh/m^{2}yr). This indicator would include all the techniques involving building envelope and the heating and cooling aspects. In order to compare different buildings, correction factors with a scientific basis can be used to calculate the area (e.g. height, use factors for corridors, stairs, etc.). The time of use of the building can differ for different regions across Europe, but it is not recommended to correct it unless comparisons between systems are being performed. Two alternatives can be used: the specific primary energy consumption, with factors from primary to final defined at national or regional level; or to calculate the energy demand of the building through the use of comprehensive estimation models (EC, 2013).

Cross-media effects

Embodied energy of buildings is an aspect concerning the life cycle energy assessment. However, operating energy remains the main energy required (usually about 80-90%) while embodied energy is about 10-20%, as presented in BEMP 3.2.2.

Operational data

Brogården (Sweden): Refurbishment of social housing

The project carried out in Alingsås (Sweden) is a successful example of social housing refurbishment. The Brogården area (built in 1973) was extensively renewed (both interior and exterior) and the flats completed in 2013. The aim was to create a good and sustainable living environment.

The Brogården area consists of blocks of flats arranged around large courts. The area after refurbishment comprises a total of 265 flats, divided into 16 houses with 2-4 floors each. All flats have a balcony or a patio (Alingsashem, 2011).

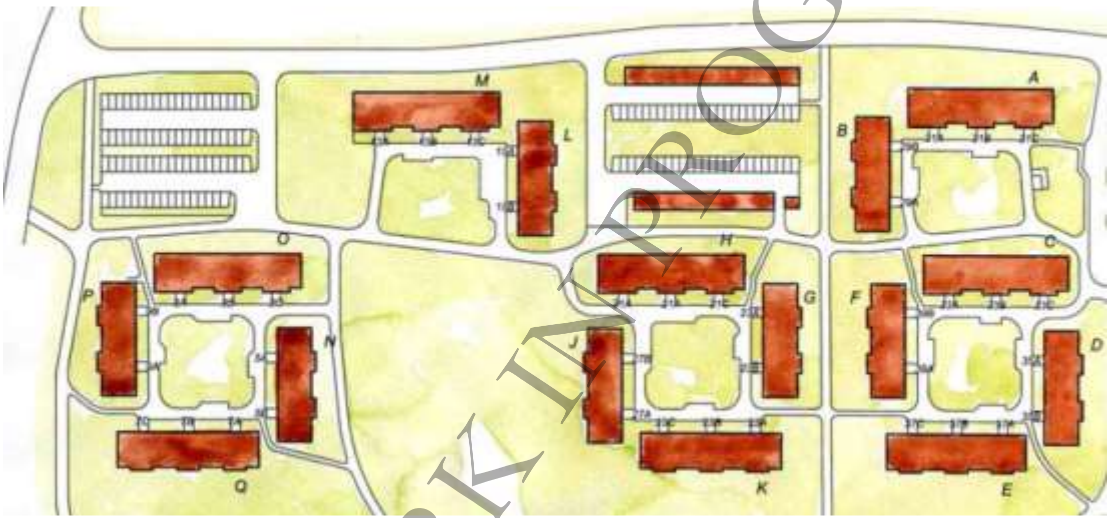

Figure 3-29: Site Plan of the Brogården area (Alingsås – Sweden) (Alingsashem, 2013)

The size of flats available ranged from 35 to 112 m^2 and from 1 room and kitchen to 5 rooms and kitchen. The defects of the flats before the refurbishment were the thermal bridges by indented balconies, crumbling bricks, draughty flats, high energy consumption and poor sound proofing. The refurbishment operations dealt with ((Alingsashem, 2013):

- Easily resolved obstacles
- Flats with high accessibility
- The need for larger flats
- Installation of lifts
- Improving laundry rooms
- Shared premises
- Complementary buildings
- Car parks
- Design issues
- Cultural historical value

- Planning for passive houses
- Simplicity, repetition, rationality, effective building
- Redress the technical defects

An important aspect when the refurbishment of the flats was planned was to ensure the opportunity of social interaction for elderly people thanks to flats with high accessibility and common areas for recreation activities, meals and hobbies.

The refurbished was carried out with the aim to achieve the passive house standard in the flats. The old bricks and all the old curtain walls were removed. A completely new wall with 44 cm mineral wool insulation (U value 0.09 W/m^{2}K) was installed against the existing concrete frame. The roofs were also better insulated with 40 cm insulation (U value 0.1 W/m^{2}K) (Alingsashem, 2011).

On the new facade tiles were mounted on horizontal support profiles, which gave a back-ventilated and damp proof construction. The tiles consisted of a hard-burnt light yellow clinker stone or brick that aesthetically gives an impression similar to the original. The original indented balconies caused thermal bridges and draughts, because of this they were replaced with externally mounted balconies with screens on the short sides and a roof even on the topmost balcony. All windows installed comply with passive house standards (U value 0.85 W/m^{2}K) and the ground slab was insulated with 20 cm insulation. The flats refurbished achieved the passive house standards for refurbished buildings (25 kWh/m^{2}yr and the energy consumption was drastically reduced (Table 3-16) (Alingsashem, 2011).

Table 3-16: Comparison of energy consumption in one of the flats at Brogarden, before and after renovation (Alingsashem, 2011)

	Before renovation [KWh/m^{2}yr]	After renovation [KWh/m^{2}yr]
Heating	115	19
Hot water	42	18
Household electricity	39	28
Residential electricity	20	21
Total consumption	216	86

The difference of the exterior aspect of the buildings before and after renovation can be seen in Figure 3-30.

Figure 3-30: After and before renovation of one of the buildings in Brogarden (Alingsashem, 2011)

The break-down of the energy savings achieved and the share of the costs between Ahem (Alingsåshem, the company in charge of managing the social housing on behalf of the municipality) and tenants are presented in Figure 3-31.

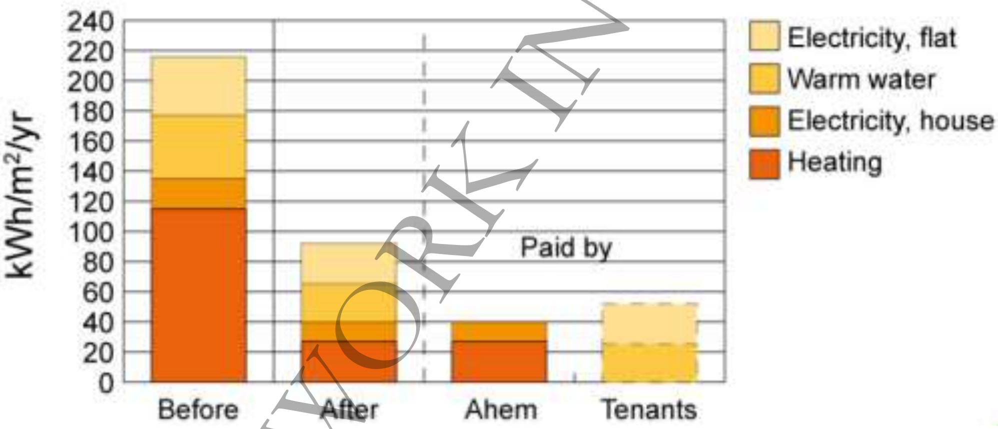

Figure 3-31: Break-down of energy consumption and cost share between tenants and the company managing the social housing (Alingsåshem, 2011)

A continuous contact with the tenants was upheld during the entire refurbishment at Brogården. Information to the tenants was distributed throughout the project. A show apartment was established in the area since before the building works began. The tenants were invited to the show apartment to receive information on what would have happened to the area and their flats, as well as practical and economic issues concerning evacuation and resettlement. The show apartment was also used for regular and well attended "open house"-arrangements. It was an appreciated social activity that offered an opportunity to share information and give feedback to the tenants. The show apartment had made evident that there was a need for shared social premises (Alingsashem, 2011).

The total cost of renovation was approximately 48,000,000€ (Alingsashem, 2011).

<u>*Paris (France): Conversion to social housing and refurbishment of an old school*</u>
Another successful example of passive house retrofitting in social housing was carried out in Paris (7-19, Rue des Orteaux), where 20 flats where delivered at the end of 2012 after 2 years of refurbishment. The project started with consultation among the different actors involved, namely residents, associations, developers and technical services for the city. This interaction

allowed understanding the needs of the tenants, coordinating and developing the process to ensure its success. The building which was refurbished was previously a school and the project involved also action on the green spaces in the yard at the centre of the block (Build up, 2014).

During the refurbishment, glass double skin coatings were applied to the walls facing the sun. Insulated solid walls were used on the shaded façades of the building. The "double skin" assemblage walls rely on the use of passive solar thermal energy. In fact the solar energy is absorbed and stored within the collector walls which then heat the surrounding air before its arrival for air renewal to the interior space of the rooms. The preheating process reduces most of the energy needs used for heating the rooms during winter. The design optimizes the natural light in the apartments, in fact most of them have a south, south-east orientation and face the street or the garden (Build up, 2014).

Apart from capturing the solar energy, the refurbishment aimed at achieving high energy insulation. When possible, the insulation was placed on the outside, limiting thermal bridges ($R \geq 5$ Km² / W) otherwise on the inside ($R \geq 5.3$ Km² / W) coupled with thermal bridge breakers at the slab ($\Psi \leq 0.25$ W/ml.K). On the roof, external insulation was also applied ($R \geq 5$ Km² / W) while on the ground level, the parking floors have been re-insulated on the underside ($R \geq 6$ Km² / W), with a vertical drop of insulation of at least 50 cm - the floors on the mezzanine were also insulated on the underside ($R \geq 5$ Km²/W, cellular glass type "foamglass" or equivalent). Thanks to these insulation measures the performance of the refurbished envelop achieved 0.56W/m^{2}K (Build up, 2014)

After refurbishment the primary energy requirement of the flat achieved 49.8 KWh/m^{2}yr meeting the passive house standard. Greenhouse gas emissions were calculated as 10kgCO_2/m^{2}yr.

The cost of the refurbishment was 3,750,000€ which was partially funded (60%) by the municipality of Paris and by SIEMP (City of Paris Real Estate) which is a Public-Private Joint Venture (Build up, 2014)

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Figure 3-32: Outside view of the refurbished social houses in Paris (Build up, 2014)

Freiburg (Germany): Refurbishment of high-rise building

Weingarten is a city district in Freiburg which was built between 1960 and 1965 and consists of four types of buildings: 16-storey high-rise buildings, 8-storey and 4-storey blocks of flats. In Freiburg the public company Freiburger Stadtbau GmbH is in charge of managing social housing in the city. The Weingarten area is undergoing renovation which started in 2007 and is planned to be completed by 2018. The renovation of the first 16-storey high-rise building was completed in 2011 and this was the first residential high-rise building worldwide to reach Passive House standards through renovation. The works dealt with refurbishing the building envelop (achieving U value between 0.11-0.13 W/m^{2}K), installing new balconies, photovoltaic systems and fire protection. Moreover, the heating system of the building was connected to the district heating available in the area. Thanks to the refurbishment, the heating requirement achieved in the building was 15 KWh/m²yr (EnEff, 2014). Figure 3-33 presents final and primary energy demand before and after renovation of the high-rise building. It is interesting to see the great reduction for heating demand and distribution losses thanks to the refurbishment.

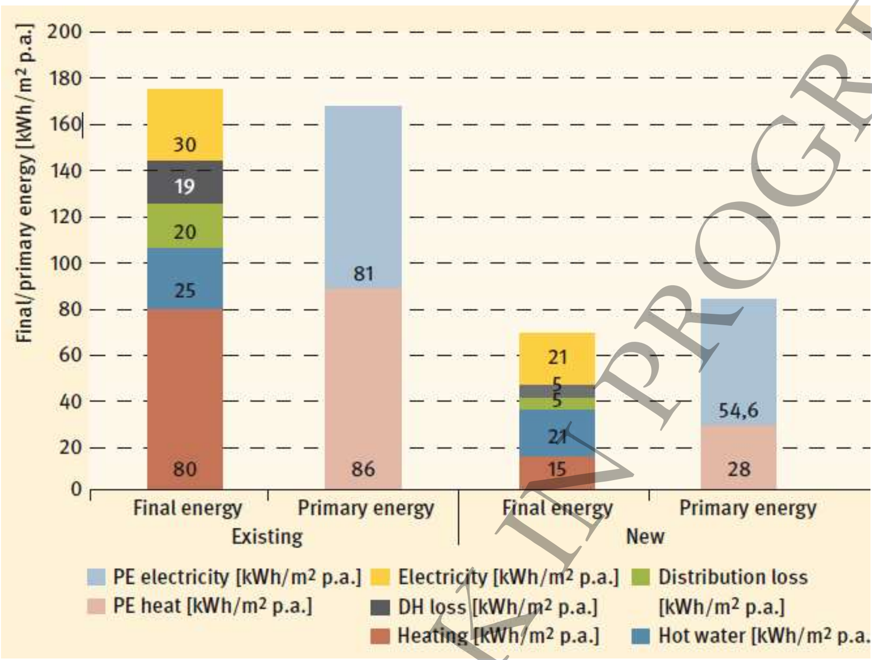

Figure 3-33: Primary and final energy demand, before and after renovation of the high-rise building in Freiburg

When planning the refurbishment of the high-rise building in Weingarten, it was decided to reduce the size of flats, since nowadays, compared to the '60s, average families are smaller. Consequently, from 90 flats before the refurbishment, 136 were the flats obtained at the end of the works. In order to engage with residents, Freiburger Stadtbau GmbH, after the refurbishment, organised some meetings with tenants in order to explain the features of the passive house flats, together with guidelines and tips on how to best use them.

The cost for the refurbishment of the first high-rise was about 13 million € which correspond to 1700€/m^2, while, for the following buildings it is estimated to be about 1500€/m^2.

Figure 3-34: Refurbishment of 16 storey high-rise building in Freiburg (EnEff, 2014)

Applicability

Technical applicability for low energy refurbishment and construction of new buildings are reported in BEMP 3.2.2. Low energy refurbishment of social housing is recommended when major refurbishment of the old flats/buildings is required in order to improve the facilities (e.g. installation of new bathrooms and kitchens, water boilers etc.). Interventions to improve energy efficiency can be therefore coupled with the other works.

In the case of social housing, all tenants should agree for the refurbishment to be carried out, in fact it would not be successful to refurbish only a part of the flats of a building. This may be more difficult when refurbishing high-rise buildings rather than building with a limited number of flats or semi-detached houses. Depending on how social housing is managed in different EU countries, the municipality or the company should interact with the tenants, communicating the aims and benefits of such refurbishment. As presented in the description section, meetings and a show-apartment are valid tools which allow engaging with local residents. The work plan must reduce at a minimum the period when local residents should be moved to a different accommodation. When possible, flats can be divided in batches and they can be refurbished once at a time in a short period of time, before moving to the next batch. In order to improve the number of tenants agreeing with the refurbishment, municipalities can offer to local residents the opportunity to move to a different accommodation while carrying out the works and then decide if they prefer to move back to the refurbished flat or to stay in the new accommodation. This choice was given in the refurbishment of the high-rise buildings in Freiburg, when only about 50% of the initial tenants moved back to their refurbished flats.

Economics

In BEMP 3.2.2. upfront costs and paybacks times for low energy refurbishment and construction of new buildings are reported. Depending on how social housing is managed in different EU countries, the municipality can finance the entire/partial cost of the refurbishment or new construction. In some cases, instead, publicly/private owned companies in charge of social housing fully finance the works.

The energy savings achieved thanks to the improved energy efficiency benefit tenants, public administrations or companies managing the social housing, depending how the energy bills are shared. For instance, in the refurbishment of Brogården area, the main energy saving was achieved for heating (from 110 to 30 KWh/m^{2}yr, Figure 3-31) and the company managing the social housing (Alingsåshem) has been in charge of paying the heating bill. Therefore, the main energy saving has economically benefitted Alingsåshem. In other cases, when tenants are in charge of paying their heating bill, the municipality will benefit reducing subsidies given against fuel poverty, since tenants will have to pay substantially lower energy bills. Another option for municipalities to economically benefit from the renewal is to increase the number of flats in the refurbished building raising the total income from the rents. In Freiburg, for example, the number of flats increased from 90 before renovation to 136 after renovation, since nowadays the average number of family members is lower compared to the '60s. In conclusion, when assessing the economics of the refurbishment or construction of new social housing, public administrations must consider all the direct (e.g. lower energy bills, higher income from rents) and indirect (e.g. lower subsidies) economic benefits.

Driving force for implementation

Improve energy efficiency would reduce the energy bill of social housing which can be completely or only partially paid by the municipality or any company publicly owned managing the social housing building stock.

From social point of view, refurbishing or building new social housing with high energy standard improves the living environment. This leads to positive social and health effects for the low income tenants.

Reference organisations and initiatives

Build up – the European portal for energy efficiency in buildings. A portal bringing together policy makers, building professionals and building occupants, reporting many examples and details of successful energy efficient buildings (new or renovated): http://www.buildup.eu/

Alingsåshem (Sweden). Swedish company managing social housing in the municipality of Alingsås: http://www.alingsashem.se/

City of Paris Real Estate (SIEMP): Public-private joint venture in charge of social housing in the municipality of Paris: http://www.siemp.fr/

Freiburg - Weingarten West Project: the aim is achieve a sustainable energy supply in the city district of Weingarten, refurbishing the buildings which were built between 1965 and 1969 : http://www.eneff-stadt.info/en/pilot-projects/project/details/model-city-district-refurbishment-weingarten-west-freiburg/

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3.2.4 Achieving energy efficiency in public buildings through ESCO models

Description

Increase energy performance in public buildings can be achieved by implementing energy performance contracts (EPC) which involve a contractor called energy service company (ESCo). The ESCo identifies appropriate energy efficiency improvements for public buildings (including development and design of energy efficiency and emission reduction projects, installation and maintenance of energy efficient equipment, monitoring and verification of the project's energy savings), develops them, builds them, provides a guarantee that a set level of energy savings will be achieved, and in many cases arranges financing to pay for the projects with repayments less than the savings. The idea is that energy cost savings will exceed the cost repaying the cost of investment. The ESCo model therefore allows sharing the economic advantages gained thanks to improved energy efficiency. Usually, for public administrations, the EPC overcomes the investment barrier for implementing energy efficiency measures.

Measures for improving energy efficiency in buildings which can be adopted by ESCos are presented in BEMP 3.2.2 and involve improvements of the envelop insulation and air tightness. Furthermore, more efficient heating and air conditioning systems can be achieved by:

• Replacement/modernisation of boilers

• Replacement, reduction of water storage volumes

• Decentralisation for heat generation

• Modernization of cooling systems

• Replacement of ventilation motors/rotors/automatic control

• Operation on demand for ventilation systems (CO_2 sensors, frequency converters)

• Heat recovery for ventilation systems

Moreover, efficient lighting systems (installing electronic ballasts, energy saving lamps, control systems and sensor technology, such as presence detectors) contribute also to reducing energy consumption in buildings.

EPC consist of two main different models (Fang et al., 2012): shared-saving and guaranteed-saving models. In the shared-saving model, the ESCo and the client share the cost savings at a pre-determined percentage for a fixed number of years. In the guaranteed-saving model, the ESCo guarantees a certain level of energy saving for the customer which receives a cheaper energy bill. However, the real savings are higher compared to the guaranteed ones and the ESCo benefits economically from this difference. In Europe the guaranteed-saving models seem to be the most common.

Measures implemented by ESCos can be of different complexity. The basic ESCo approach consists in the replacement of installations and regulation of energy systems such as monitoring, light steering, heat regulation etc. These operations involve relatively simple and inexpensive technologies which have a high energy saving potential, therefore, the payback period is limited. A more complex ESCo approach consists of ESCo projects including monitoring and regulation in combination with the building envelope. Investments required are much higher than the basic ESCo approach and paybacks periods longer. Finally, ESCos may be introduced by municipalities as learning process to develop local competences on energy retrofitting to all public buildings (e.g. schools, offices, social housing etc.) and public-private collaborations. Experience from public administrations implementing ESCos can then be transferred to other private buildings (e.g. private schools). In this more complex approach investments required are much higher and paybacks longer than the previous examples.

Comparison In-house and ESCo approach

Improve energy efficiency in public buildings can be carried out by municipalities also as in-house project, investing the budget available and planning measures employing the staff already working for the public administration. The two different approaches (ESCo and in-house) are characterised by different aspects and Table 3-17 compares the in-house approach with the ESCo approach for energy efficiency improvement for municipalities.

Table 3-17: Comparison between in-house and ESCo approach (Jensen et al., 2011)

	In-house	ESCo
Financing	• Step-wise renovation due to budget limitations • Long-term financing uncertain	• Guarantee for energy savings is politically attractive • Energy savings from 'day one'
Capacity building	• Keeps competences in-house, more hands-on influence on solution	• Learning and innovation from ESCO partnership (also depends on ESCo approach)
Fixation and flexibility	• Flexible in relation to uncertain future building portfolio	• ESCo reduces the risk of reductions in future investments in energy savings due to possible changes in political priorities

However, in-house approach should not be seen in contrast with the ESCo approach but they should reinforce each other. In fact, the ESCo approach could be a first step towards improved energy efficiency able to develop in-house capacity over time. Furthermore, for small municipalities it would be difficult to carry-out an in-house model comparable with the ESCo project. Therefore, ESCos tend to develop solutions more suitable for small municipalities where it is more likely that they are going to be involved for improving energy efficiency in buildings.

Achieved environmental benefits

The main benefit for implementing the ESCo model in public buildings is to allow implementing energy saving measures which otherwise would not be possible to realize due to the cost of investment.

Appropriate environmental indicators

Appropriate environmental indicators are the same presented in BEMP 3.2.2. The specific primary energy consumption (for heating, domestic hot water, auxiliary and household electricity) per square metre and year (e.g., kWh/m^2yr) is the most important indicator to control the energy performance.

Cross-media effects

The ESCo model itself does not have any environmental cross-media effect. For cross-media effects related to improve energy efficiency in buildings see instead BEMP 3.2.2

Operational data

Berlin: Improving energy efficiency in buildings

An important aspect of Berlin's sustainable energy action plan (SEAP) is to increase energy efficiency in public buildings. Energy efficiency is not only an environmentally responsible path for local governments to adopt, it is also fiscally beneficial. The city of Berlin used energy efficiency as means to lower their budgetary expenditure (through reducing energy costs) and to improve their environmental record. Today over 1,400 buildings have been retrofitted in the greater Berlin area.

In the 1990s the city of Berlin made the decision to increase the energy efficiency of its building stock to both create savings and improve the city's environmental aims, resulting in the setting up of the "Energy Saving Partnership" scheme. The primary focus of the scheme is on retrofitting large complexes, such as schools, prisons, universities, recreational facilities and offices and administration buildings. 75% of the buildings retrofitted were public authorities and 20% hospitals. The Berlin Energy Agency (BEA) was put in charge of managing the process. The BEA draws up tenders for the retrofits and establishes Energy Performance Contracts (EPC) between the building owners and Energy Systems Companies (ESCos). EPCs comprehensively cover planning, implementation, operation and optimisation of building installations and are based on cooperative work. As part of the EPC ESCos guarantee the level of energy savings (which must be on average 26%), and that they will maintain required comfort levels and provide verification and documentation of the energy savings. The ESCos also agree to carry out required maintenance on any new hardware installed.

The initial investment required to retrofit the buildings is refinanced through the energy cost savings over a period of time. The BEA assists building owners and ESCOs in determining the terms of repayment. Average payback periods are 8 to 12 years.

The Division for Climate Protection of the Senate Administration of Berlin, who works in partnership with the BEA, offers building owners financial and technical assistance with the tendering procedure. The process runs as follows:

- The BEA manages the process up to contract negotiation.

- Building owners combine several buildings into building pools, which are grouped for tendering. Building pools may contain kindergartens and schools, universities and opera halls, etc.

- The pools must have a minimum energy bill of around €200,000 annually to take part in the scheme.

- To reduce energy consumption in buildings, ESCos offer sustainable technologies and systems (see below). The proposed EPC did not include window replacement or wall insulation due to the cost of this extending the savings repayment period to unfeasible lengths.

- ESCo finances retrofit investments in advance and depending on the achieved energy savings, building owners repay in annual instalments over an agreed period (usually 8 to 12 years).

- Building owners do not pay to retrofit investments and see energy savings immediately.

Since the scheme was established in 1996, 1400 buildings have been upgraded through the system, resulting in CO_2 emissions savings of 500,000 tonnes in Berlin.

Each building is a minimum of 26% more energy efficient than it was prior to the retrofit, as stipulated in the energy performance contract. Berlin is now looking to increase this figure to 35%. This increase in energy efficiency is achieved through introducing a mixture of sustainable technologies, including a revised energy management system, combined heat and power generation (CHP), environmentally friendly lighting systems, automatic control engineering, etc, as shown in Figure 3-35.

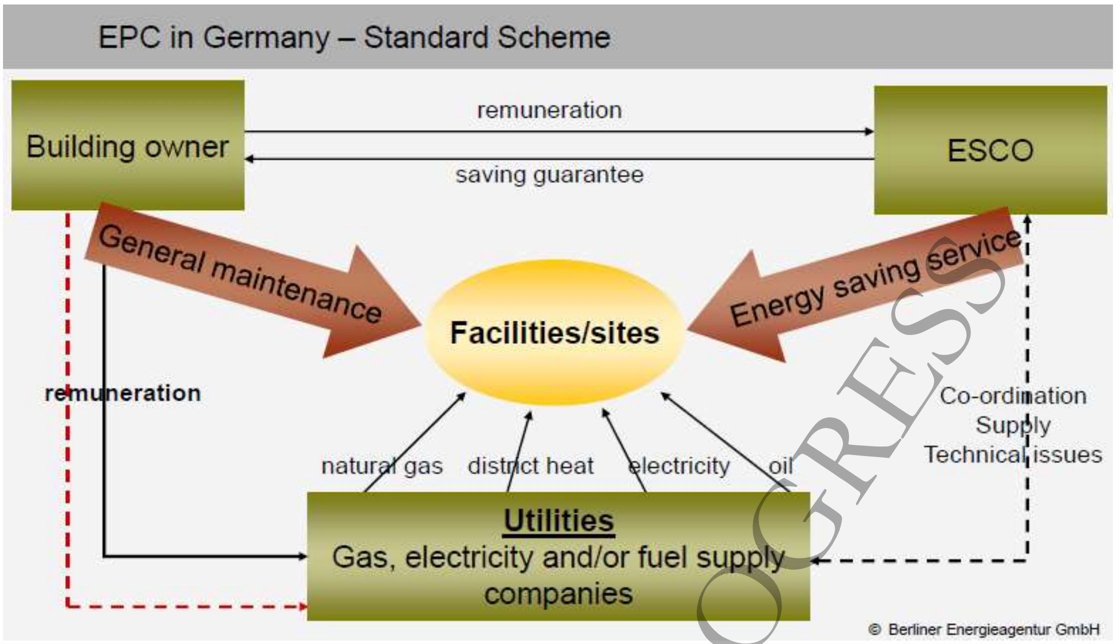

Figure 3-35: Graphical representation of the Energy Performance Contracts. Source: Berliner Energieagentur GmbH

In general, changes are made to the central heating, ventilation and cooling devices within the buildings. These changes include:

Heat generation

• Replacement/modernisation of boilers

• Conversion of energy source

• Reduction of heat power

Hot water generation

• Replacement, reduction of storage volumes, decentralisation

• Optimisation through interval timers, waterborne pathogen control

Ventilation systems

• Replacement ventilation motors/rotors/automatic control

• Operation on demand (CO_2 sensors, frequency converters)

• Heat recovery systems

Lighting

• Electronic ballasts, energy saving lamps, control systems
• Sensor technology, such as presence detectors

Energy management

• Digital energy management systems / building automation

Others

• Individual control equipment for rooms, sealing of windows, water savings measures, operation of CHP, modernisation of cooling

Berlin's Energy Saving Partnership has been replicated successfully with assistance from the BEA's division "International Know-How-Transfer." This division has initiated more than 20 projects in Europe and worldwide. Projects include the Railway depot / train station in Ostrava, Czech Republic, the Municipality of Kranj in Slovenia and the Municipality of Nyköping in Sweden. Program success can be attributed to communication, political will, transparent procedures, support of the Senate Administration of Berlin and enforceable standards.

Berlin has also attributed smooth interaction between stakeholders which, with the economic support from the Senate Administration of Berlin, produces enforceable standards and the involvement of independent experts.

The establishment of a coordination unit to implement the scheme may require administrative adjustments within the local government.

The degree of innovation is linked with the capacity of the ESCo implementing the retrofitting. Some technologies require a specialised knowledge and understanding. The availability and introduction of this technology is tied to the contractor and its capacity. In the Berlin scheme, only accredited ESCos with specific competences are contracted. Currently there are 15 ESCos and around 100 sub-contractors, each with their own expertise. Berlin has found that as the scheme progresses contractors gain experience and expertise, and effectiveness increases. In Berlin the Division for Climate Protection of the Senate Administration offers building owners both financial and technical assistance with regard to the tendering process.

The scheme can be instituted virtually anywhere with the requisite technical know-how and political will. Political will is essential to the scheme and, without it, it is highly unlikely energy efficient retrofits will occur. To see the scheme brought to fruition political will must extend the commitment of expertise, time and financing.

There are few geographical restrictions to implement the scheme. It is however essential that EPC projects are managed by people with a local knowledge of the current infrastructure and energy system.

The cost of implementation varies in relation to the work required by the building, or building pool, to achieve the stated energy efficiency objectives. The initial investment can be high (around €100,000 for example), but it is mitigated by energy cost savings over time. In Berlin the Senate contributes 50 % of project development costs to encourage building owners to adopt the scheme. Already ESCOs have invested nearly €52 million to retrofit almost 1,400 buildings.

Initial investment in energy efficiency is refinanced through energy cost savings over a specific period of time, usually 8 to 10 years.

In Berlin's experience, building owners are unlikely to develop an EPC without financial assistance. 50 % of the initial retrofitting investment in Berlin is covered and without this funding it is likely the scheme would have struggled. Local governments must be prepared to address the initial lack of financing on the part of building owners. Implementing energy efficiency and EPC is a possibility, but without local government intervention and available financing channels, is unlikely to occur in any serious capacity. Most building owners need local government support / incentives to make retrofitting a reality.

The scheme also cultivates an effective partnership between the public and private sectors. For building owners the retrofits resulted in increased economic efficiency, and so increased renting attractiveness.

The scheme provides a compensation payment to building owners if the guaranteed levels of savings are not achieved.

Lowering energy costs, improving energy security and contributing to a reduction in CO_2 and GHGs are increasingly urgent matters as Europe develops (BEA, 2013)

Applicability

Public administrations can all apply the ESCo model for introducing improvements to energy efficiency in their buildings. Especially small municipalities with a small budget to be invested for energy retrofitting and limited expertise among their employees may consider more convenient and feasible the ESCo model. Big municipalities, instead, which may have larger budgets to be invested and an in-house team competent for energy efficiency measures already available may consider more the in-house approach. However, there may be different cases of big municipalities employing the ESCo model for improving their energy efficiency (e.g. Berlin).

Economics

ESCo contract have the advantage for municipalities of financing the improvements of many buildings over a short time; within a two-year period of analysis the ESCo supplier provides a sufficient basis for a full-scale implementation in the entire building portfolio, where energy savings are guaranteed by contract. Therefore, municipalities can start saving money thanks to improved energy efficiency after a short period of time. The in-house approach, instead, foresees municipalities operating with a smaller in-house staff, which prolongs the period of analysis before building retrofitting is implemented, and energy savings are reached. Results from an in-house approach are reached gradually, as a contrast to the ESCo model that includes more instant results (Figure 3-36). Moreover, if the municipality finances directly the measures for improving the energy efficiency, due to the limited budget, reduced energy consumption would be achieved in longer timescale.

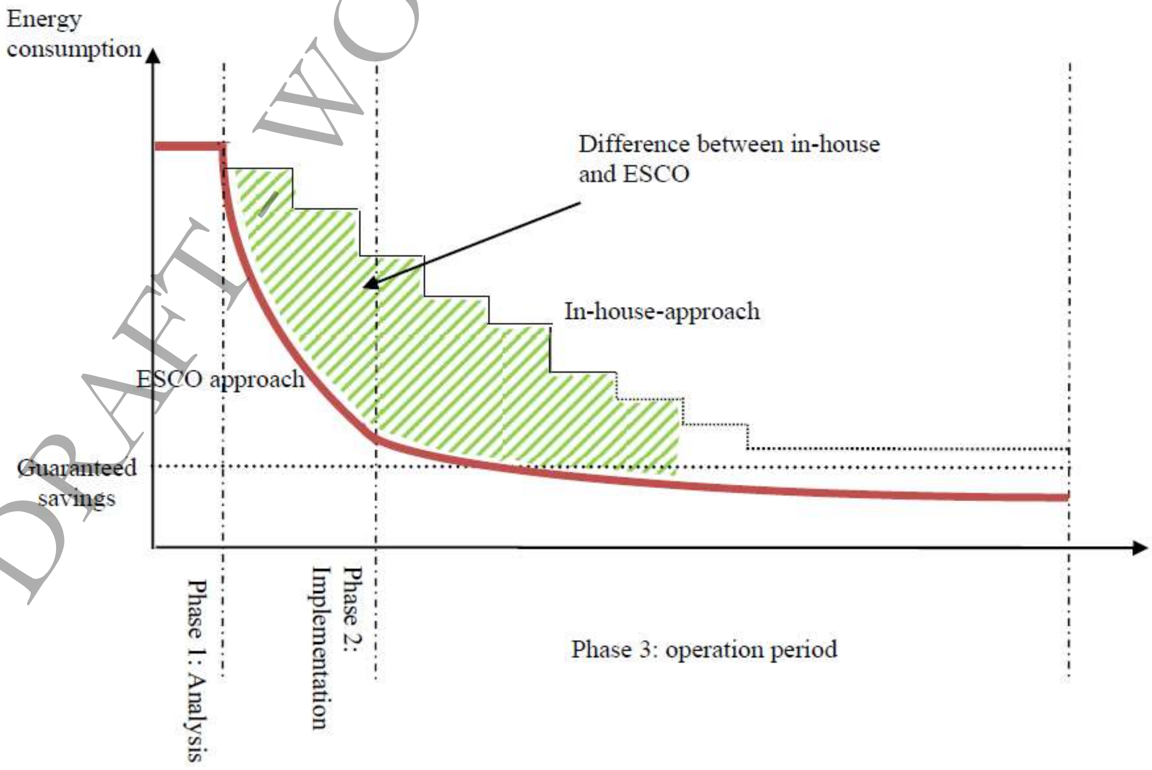

Figure 3-36: Comparison saving achieved with in-house and ESCo approaches (Jensen et al., 2011)

In the case of Berlin, ESCOs the city has invested nearly €52 million and the energy savings already achieved implementing the ESCo model are €11.7 million (including €2.7 million public budget savings).

Driving force for implementation

The main driving force for municipalities to implement an ESCo model is the limited resources (economic and human) to be employed for achieving large energy savings.

Reference organisations

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3.2.5 Improving the energy performance of existing public buildings through monitoring, energy management and fostering of behavioural change

Introduction

Public authorities have significant control over the energy performance of their current buildings. Very often they also have a large potential for improvement. However, sometimes the influence of a public authority on changes to the building fabric is limited (e.g. because of lack of funds or when it does not own the building it occupies). Moreover, increasingly, Public Administration bodies are under growing pressure to reduce their spending and increase efficiency. This is currently being driven by substantial cuts in public funding. It is therefore important that low and no cost interventions are available to ensure that municipalities can improve the energy performance of buildings even without significant investment.
Items covered within this section, and applicable in an EU-wide context, include:

- Staff engagement and training
- Behaviour change campaigns
- Energy Performance Certificates (EPCs)/ Display Energy Certificates (DECs)

The following sections present these aspects in 2 sub-BEMPs.

3.2.5.1 Staff training and behaviour change campaigns

Description
Behaviour change campaigns (staff engagement) and training can have dramatic effects on the energy consumption of buildings. These low cost and widely applicable interventions can drive energy efficiency across Public Administration and inspire staff to lead more sustainable lives both in their work place and back at home. Numerous opportunities for energy reduction which are within the control of building occupants can be easily implemented through behaviour change campaigns, staff engagement and training.

<u>Behaviour Change Campaigns:</u>
Over recent years behaviour change campaigns have been increasingly used in Public Administration as a low cost mechanism to drive reductions in energy consumptions, water consumption and waste production.

There are many important elements to consider in the implementation of a successful behaviour change campaign. Understanding the target audience is paramount; this will vary within different areas of Public Administration bodies. In general it is best to include all staff in behaviour change campaign to ensure that maximum impact is delivered and all Public Administration employees are engaged and empowered to deliver reductions in energy consumption over a sustained period. In order to ensure that the campaign is a success it is important to focus attention on "Behaviour Change Champions" and to use multiple channels of communications; this will also ensure that costs are kept to a minimum and resources can be focused in key areas.

<u>Behaviour Change Champions:</u> These champions should be well respected and influential in the organisation but do not necessarily need to hold a position of significant responsibility. Training efforts and engagement activity should be channelled through Champions who will help communicate the various aspects of the campaigns and ensure that actions be followed up on.

<u>Multiple Channels of Communication:</u> To encourage positive environmental behaviour to reduce energy consumption it is important that the campaign is run in conjunction with an effective communications plan. In order to create maximum awareness for the plan numerous channels for communication should be implemented, these could include;

- E-bulletins and newsletters
- Campaign website or webpage
- Social media (e.g. Twitter and Facebook)
- Posters
- Stickers
- Tools, resources and training guides (for more information on this please see the staff training section)

Encouraging and incentivising behaviour change will ensure that staff are engaged over the long term. Campaigns which are participatory and fun will also be more effective. Using social norms is often a very effective way to drive collective energy saving; social norms can be powerful motivators of change. Examples of ways in which social norms can be used to change behaviour include the following:

- Publishing monthly performance league tables showing progress towards a previously agreed target. This helps to induce a competitive element to inter-departmental performance and a strong incentive for departments to avoid the reputational loss of being seen to perform poorly.
- Installing real-time energy displays in Public Administration buildings feeding into online reports can have a significant impact. This can help to ensure that awareness of the programme is maintained, while also giving departments much richer data about their ongoing performance. By making these real-time displays available to the public this can further encourage positive behaviour change through transparency and

accountability of Public Administration to the public. Best practice in Public Administration organisations implementing this include Frankfurt-am-Main (Frankfurt am Main, 2014) and the UK Government's Department for Energy and Climate Change (Carbon Culture, 2014).

- Breaking down conventional social barriers and expectations can help reduce energy consumption. For example changing strict dress codes in the summer can enable people to wear more appropriate clothing and therefore reduce the amount of air-conditioning required. One very successful example of this is the 'Coolbiz' campaign launched by the Japanese Government in 2005 (Japan Times, 2014)

The gamification of campaigns and an element of competition will further drive the success of positive behaviour change. Humans are naturally motivated by competition and inspired by team working. Collective energy saving between teams or Public Administration buildings will ensure that a campaign has the greatest impact possible. User driven projects using behavioural economics and the gamification of energy through online platforms and real-time data can be incredibly successful and engage with many employees. For example the UK Governments 10:10 campaign worked with 1,000 staff at the Department for Energy and Climate Change's (DECC) Headquarters using gamification and an online platform to get full commitment from 40% of employees which resulted in significant saving in energy consumption (DECC, 2014).
Incentivisation is a good mechanism to motivate positive changes in behaviour. Incentives can range from financial payments to gifts and public recognition. Good examples of this include using small gifts (e.g., chocolates) to reward people for switching of their computer monitor and putting post-it notes on computers with their monitors left on informing the employee that they have missed out on getting a free chocolate. Financial incentives can be awarded to departments, buildings or organisations who demonstrate significant reductions in energy consumption. E.g the Euronet 50/50 gives back 50% of the financial savings made by schools and other Public Administration buildings to spend on energy saving programmes (Euronet 50/50, 2014). Where appropriate, financial rewards can be given to key individuals in the organisation. These key individuals should have a direct responsibility for energy management and consumption in Public Administration buildings. For example Energy and building managers, caretakers and cleaners all have a direct role in energy management within buildings. Cleaners and caretakers are often overlooked, however, they are often the last members of staff in the building and can therefore save significant amount of energy by switching off lights and electronic appliances at the end of the day. Frankfurt-am-Main is a front runner in this aspect of incentivisation and has a long history of staff engagement; since 1998 they have been paying bonuses to building and energy managers for saving energy in their Public Administration buildings (Frankfurt-am-Main, 2014).

Staff Training:
Behaviour change campaigns on their own are often not enough to ensure that significant reductions in energy use are achieved and that these reductions are long term. In order for this to happen it is important that key individuals in the organisation receive in-depth training so that they can manage buildings properly to deliver energy efficiency. Key staff should include any energy champions and members of staff with direct responsibility for building and energy management (see above – e.g. Energy and Building Managers, Caretakers, Cleaners, Facilities Management).

It is important that training is tailored to the specific role of individuals. E.g. cleaners should be trained in the importance of turning off lights and appliances at the end of the day and which appliances are safe to turn off. Caretakers and Facilities Management should be trained in building controls and heating and power systems. At the very least, training should cover the following areas

- Adjustment and controlling of the proper room temperatures and application of natural or mechanical ventilation
- Lighting, applying the appropriate and efficient lighting equipment and bulbs etc.
- Thermostatic valves and changing default settings in heating and power systems

- Check of the boiler insulation and lagging
- Training on the orientation of the building and proper use of the sunshades if applicable in the building.

There are various methods for training, as mentioned it is important for the training to be tailored to the specific audience in question. Training should involve a mix of presentations and learning in conjunction with site visits and practical sessions to ensure that all participants are able to carry out measures on the ground. To ensure that the training has a long lasting effect, manuals and guides should be produced. Guides should include information on energy saving measures, room temperature information and riles for room temperatures, inspection manuals and schedules for inspection, checklists, carbon footprint calculators and monthly energy report templates. One best practice example of a guide for Energy managers come from Sustainable Energy Ireland and covers sections for Energy Managers, Senior/Middle Management, Technical Managers/Engineers and Human Resources (Sustainable Energy Ireland, 2005)

It is possible to train all staff in energy efficiency through less resource intensive methods, such as including the importance of saving energy in staff inductions and distributing Environmental Education Guides to all staff. These guides should raise environmental awareness and should provide hints and tips to help improve the environmental performance of Public Administration buildings. One good example of this is the *Green Office Guide* (Barcelona City Council, 2014) created by Barcelona City Council.

Achieved environmental benefits

The achieved environmental benefits from staff engagement and training relate to reductions in energy consumption and correlating reductions in carbon dioxide emissions. Stand-alone energy efficiency technologies and building energy management systems have limited impact on in isolation. In order to drive real change in carbon reduction it is vital that Public Administration staff are engaged, trained, educated and enabled to change their behaviour to create reductions in energy consumption.

Appropriate environmental indicators

Key environmental indicators:

- kWh energy consumption per annum per employee
- kWh energy consumption per annum per m^2
- number (or %) of staff engaged
- number (or %) of staff who continue to be engaged after one year of programme launch
- hours of environment-specific training provided (/employee /year)

Other indicators:

- Tonnes of CO_2 emissions emitted per annum per employee
- Tonnes of CO_2 emissions emitted per annum per m^2
- Tonnes of CO_2 emissions emitted per month per employee or m^2 (this is only possible with automated meter reading)
- kWh energy consumption per month per employees or m^2
- Replacement of fossil fuels by renewable energy sources - offset
- number of key individuals trained and number of qualifications gained
- % of employees which have received educational materials

Cross-media effects

There are no negative impacts on other environmental pressures relating to this BEMP. In fact it is often the case that raising awareness about energy consumption often fits into wider engagement campaigns concerned with the environment. As a result staff engagement and training can have positive and long lasting effects on waste reduction, sustainable transport and other environmental areas. It is important that, where possible, educational material (e.g.

training guides, manuals and checklists) available in soft copy to ensure that the use of paper is minimised.

Operational data

Geislingen, Germany

The annual energy, water and waste cost for Geislingen municipality in Germany was approximately 1,700,000 Euro prior to the commencement of their staff training and engagement project. The project involved working across 80 facilities in the City of Geislingen, including Town halls, Public Administration buildings, fire station, schools, municipality owned gyms etc. Energy teams were created and energy managers were elected for the supervision of various areas of energy management (e.g. room temperatures, lighting, thermostatic valves etc.). Energy saving activities were incentivised through an annual competition with category winners for the best school, best project work and best caretaker. An internet based electronic management system with automatic data collection was installed which helped highlight areas of excessive energy use and measure savings (Intelligent Energy Europe, 2014).

As a result of Gielingen's energy saving project the following reductions in energy consumption were achieved (EC Directorate General for Energy and Transport, 2014):

- 1st Year: savings of 8% of the total energy costs (approx. 140,000 Euros)
- 2nd Year: savings of 12% of the total energy costs (approx. 200,000 Euros)

UK Government – 10:10 campaign

In 2010, the entire UK central government signed up to the independent 10:10 campaign, which encouraged people and organisations to reduce their CO_2 emissions by 10% in 2010 and by 25% by 2015. This covered 300,000 civil servants and 3,000 buildings. By May 2011 the government had achieved an overall 13.8% cut, a 100,000 tonne CO_2 reduction.

This was achieved largely through two main actions:

1. Changing default settings in heating and power systems
2. A pilot Behaviour Change Campaign

1. Changing default settings in heating and power systems in government departments was shown to be one of the most effective ways of reducing emissions in them. Examples of this included:

- changing the defaults around when heating and cooling systems were turned on and off through the identification of 'optimal core hours' windows;
- aligning operating temperatures with best practice for the public sector, so that buildings are never over-heated or over-cooled (space should not be heated above 19°C or cooled below 24°C) – see figure 1;
- ensuring that buildings were shut down effectively during relatively quiet periods. Some departments did this between Christmas Day and the New Year bank holiday, which included minimising unnecessary lighting and heating.

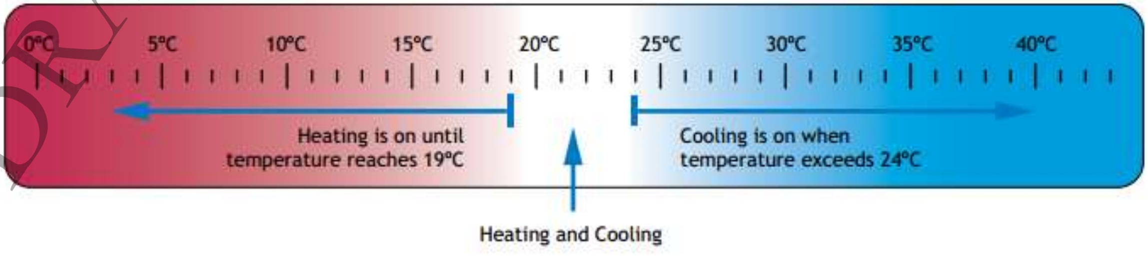

Figure 3-37: Operating temperatures indicating recommended temperatures (Carbon Trust, 2014)

2. The UK Department for Energy and Climate Change (DECC) "Carbon Culture" behaviour change campaign involved 1,000 employees across 19 government buildings. Targets were set early on as part of the 10:10 campaign and progress towards targets is being reported annually. While it is clear that the target is very ambitious for the government as a whole, by the 2012/13 report (the latest available) 11 out of 21 departments met or exceeded the 2015 target and all departments reduced consumption compared to 2009/10 (although this was a particularly cold winter). The government has recognised that a step-change is necessary in order to meet the targets. (HM Government, 2012).

The UK government aimed to achieve a 10% cut in CO_2 emissions over 12 months from a 2009/10 baseline and has committed to a 25% cut by 2015. Table 3-18 outlines the annual reductions as a result of the campaign.

Table 3-18: Annual reductions in Carbon dioxide emissions as a result of the UK Government's behaviour change campaign (Data.gov.uk, 2014)

Year	**CO_2 savings (tonnes)**	**% reduction on 09/10 baseline**
2010/11	103,316	14%
2011/12	378,000	12%
2012/13	431,000	14%

Barcelona City Council

Barcelona City council has an impressive programme of staff engagement and training to drive behaviour change and reduction in energy consumption. The Ajuntament més Sostenible (A+S) Programme has been developed by Barcelona City Council and includes specific training for professionals working with the City Council to achieve a cultural change in favour of sustainability. The A+S Programme includes training across a range of environmental areas related to the greening of municipal building services. One of the priority areas of action is the greening-up of its own operations, the initiatives for improvement are detailed in the "+ Sustainable City Council" programme which is part of Barcelona's Agenda 21 and another example of the city council's commitment to local and global sustainability. Another main area of focus is sustainable and responsible procurement to which ensures the inclusion of environmental and social criteria in certain products and services. The programme is widely communicated both internally and externally via an e-bulletin, the website, training and specific campaigns.

Leicester City Council

Leicester City Council were involved in a project across 4 countries (UK, Austria, Denmark and Germany) looking into energy saving from intelligent metering and behaviour change. The consumption of 70 public buildings was made available online in graphic form in order to give occupants an idea of consumption trends. Via training sessions, the building users were shown the impact of their behaviour which was immediately and visibly demonstrated on their computer screens by the intelligent metering system. Over 600 people were trained as part of the programme.

The training programme at Leicester City Council spanned 26 Public Administration buildings. Individual training sessions were carried out and a training folder was provided with a copy of the training manual and other training material form the project (e.g. energy efficiency best practice guide, posters, stickers). Training included an energy walk around the building and findings from each session were summarised in a short action plan for each building

As a result of this programme Leicester City Council were able to make significant reductions in energy, water and gas in 280 Public Administration buildings. However, there is a cost associated with measuring energy performance, in Leicester these costs were between 3,750 and 4,500 Euros per building depending on the metering system. However, many buildings demonstrated short payback periods of below a year due to the saving opportunities resulting from raised energy awareness and savings identified by the half hourly consumption information and follow up actions (Intelligent Energy Europe, 2014).

City of Lahti
The City of Lahti (Finland) has set itself the target of becoming a leading environment-focused city and a pioneer in climate work. One of the main aims of the Lahti City Strategy is to direct the city Public Administration organisations towards sustainability. In order in increase the staff's environmental awareness and improve communications the City of Lahti has decided to adopt the Green Office environmental system, developed by WWF. The programme helps increase the staff's environmental awareness, motivating them to act in an environmentally friendly ways, while also generating cost savings. Lahti has also compiled and Eco-Guide for all employees.

Applicability

This BEMP is potentially applicable across all typologies and scales of Public Administration areas and applicable across Europe.

Economics

Many behavioural change interventions are no cost, however, for staff training and engagement there will be implications for staff time. In many cases financial incentives are offered in return for reductions in energy use, these are often met by the saving made by energy saving interventions. E.g. Euronet 50/50 http://euronet50-50max.eu/en/
There is a cost associated with measuring energy performance; this will vary greatly depending on the type of technology used and the extent to which it is deployed. E.g. the costs of intelligent metering project in Leicester were between 3,750 and 4,500 per building depending on the metering system. However, many buildings demonstrated short payback periods of below a year due to the saving opportunities resulting from raised energy awareness and saving identifies by the half hourly consumption information and follow up actions. The current annual savings in Leicester are in the order of 250,000 Euros per annum (Intelligent Energy Europe, 2007)

Driving force for implementation

The key driving force behind staff engagement and training is the ultimate reduction in energy use (and GHG) and costs associated with energy. By ensuring that Public Administration staff understands the effect they have on the energy consumption of their buildings, they become empowered to act. Behaviour change campaigns provide the incentives for staff to ensure that they minimise their energy use, and staff training ensures that members of staff responsible for specific areas of Public Administration operations have the knowledge and the skills to ensure that energy is used as efficiently as possible.

National or local legislation can also be an overarching driving force; in 2008 the UK government implemented the Climate Change Act, requiring government to reduce CO_2 emissions by 80% by 2050 and to set 5-year carbon budgets to achieve that goal.

Reference organisations

Barcelona City Council, Catalonia
An impressive staff engagement and behaviour change campaign involving the publication of a *Green Office Guide* and using numerous channels for communication.

Department of Energy and Climate Change, UK
Signing up to an independent campaign to commit to reducing energy consumption by a significant amount. Used technological interventions and behaviour change to drive energy efficiency.

Geislingen, Germany
Staff training and engagement project across 80 facilities in the city to reduce the municipality energy, water and waste cost from 1,7000,000 Euro.

Leicester City Council, UK
Energy saving project using intelligent metering and behaviour change. Over 600 people were trained and various engagement materials were distributed.

Lahti Municipality, Finland
Lahti has set a target to become a leading environment-focused city. Lahti has adopted the Green Office environmental system developed by WWF and also compiled and Eco-Guide for all employees.

Sustainable Energy Ireland:
Developed a guide to enable Energy Managers to reduce the energy consumption of their buildings. Contains specific sections for Energy Managers, Senior/Middle Management, Technical Manager/Engineer and Human Resources.

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3.2.5.2 Energy Performance Certificate (EPCs)/ Display Energy Certificates (DECs) as engagement tools

Description

Energy Performance Certificates (EPCs) and Display Energy Certificates (DECs) were introduced in the UK (similar schemes exist throughout the EU) under the impetus of the Buildings Energy Performance Directive (EPBD) starting in 2003 (European Commission, 2014). The principal objective of the Directive is to promote the improvement of the energy performance of buildings within the EU through cost-effective measures. The certificates rate the building on an A-G scale (A being the highest efficiency) and are presented in a similar way to other efficiency ratings for items such as refrigerators.

EPCs assess the energy efficiency of the fabric of a building, based on the U-values of materials and installed technologies and estimates of their performance under real conditions. DECs assess the actual energy consumption of a building, benchmarked against an "average" building of the same type, e.g. school or hospital.

The reports are produced by independent accredited assessors, although these can be employed by the organisation that is responsible for acquiring a report (with appropriate independence safeguards). The assessment usually consists of a site visit and survey, followed by data input into approved software to generate the report in a standard format.

One of the requirements of DECs is that the poster has to be displayed in a prominent place clearly visible to the public, e.g. near the building's entrance. This is the minimum requirement however and some administrations have chosen to use the poster as an engagement tool, either through a specific campaign or through its display.

One example of the successful implementation of DECs, the European Display Campaign is a voluntary scheme designed by energy experts from European towns and cities. When started in 2003 it was initially aimed at encouraging local authorities to publicly display the energy and environmental performances of their public buildings using the same energy label that is used for household appliances. Since 2008 private companies are also encouraged to use Display for their corporate social responsibility CSR activities (Display, 2014).

With its strong emphasis on local communication campaigns and large variety of communication tools Display goes beyond the basic requirements of the EPBD.

General information:

EPCs and DECs are produced by accredited assessors with a visit to the site usually required. However, the following information should be provided for the assessor to make an accurate and useful assessment:

Building type and use

- Building floor plans
- Breakdown of usage of different parts of the building (e.g. café, office, sports hall)
- Occupancy hours for staff and public
- Meter locations, areas/buildings covered and units used (m^3, kWh)

Energy Consumption

- Details of high energy usage equipment, e.g. boilers, pumps
- At least 12 months' energy consumption – gas, electricity etc.
    - meter readings
    - billing information

Achieved environmental benefits

EPCs and DECs in themselves do not directly impact on CO_2 emissions; they are a tool that can be used to:

a) Allow the public to hold public authorities to account for their CO_2 reduction commitments
b) Act as an engagement tool for public authorities to engage with their own staff and citizens on energy efficiency in buildings
c) Measure the energy performance of the building and improve it continuously over time through implementing the measures recommended in the accompanying Advisory Report
d) Support the business case for making energy efficiency improvements

Appropriate environmental indicators

EPCs and DECs use energy consumption figures to derive carbon emissions, so the main environmental indicators are:

- kWh energy consumption/generation per annum (per m^2)
    - heating fuel (natural gas, coal, oil etc. converted from m^3 and other units using calorific values of each fuel)
    - grid electricity
    - use of renewable energy sources (solar PV etc.)
    - share of hot water generated from renewables if applicable and possible (e.g. solar panel)
- Carbon intensity figures for different fuels and grid electricity
    - Dependent on each member state's mix of energy generation technologies
- Tonnes of CO_2 emissions emitted per annum per m^2
    - Calculated using the consumption and carbon intensity as well as the floor area for the building

Cross-media effects

There are no negative impacts from the implementation of this BEMP.

Operational data

Some example benefits, due to awareness campaigns and physical changes made to buildings, supported by EPC and DEC information (or similar audits). As mentioned in the environmental benefits section, the reports do not reduce energy or carbon themselves, so there are numerous possible measures that could be implemented.

Ivanić-Grad, Croatia

Ivanić-Grad joined the Display campaign before it was a legal requirement and before Croatia joined the EU. During a public building renovation programme the municipality decided to engage the public with the works by highlighting the poor performance of the buildings. This was done by producing a very large (>5 m tall) version of the Display poster (similar to the EPC/DEC posters), displayed on the outside of the building.

Figure 3-38: Large Display poster on the side of Ivanić-Grad Municipal Headquarters (Display, 2014b)

<u>Schools in Hamburg, Germany – fifty/fifty campaign</u>

The fifty/fifty campaign incentivised schools to make savings by allowing them to keep 50% of the savings generated by any behaviour change campaigns. This money could then be used for additional energy saving/generating measures such as solar panels.

Each school set up a team of teachers, the caretaker and a member of the staff management team. Their job was to inform the school about the project and their plans to implement it.

Some schools set up teams of pupils to monitor energy and water consumption. Undertaking monitoring encourages the pupils to think about energy waste and on how to save water and energy. Many of the suggestions were integrated into lessons; for example, in the arts class posters were made to advertise the project.

After 12 years 470 schools saved 21.8 Million EURO (=10%), 100,000 tons of CO_2, 355 GWh of heating energy, 49 GWh of electricity and 391,000 m³ of water and the programme has been rolled out to other schools in Germany and other countries.

<u>A school in Odense, Denmark</u>

A 1970s school in Denmark with a poor energy rating was upgraded via a national energy efficiency programme. Before the project the school used 1,955 MWh per year corresponding to the key figure of 120 kWh/m². Once the improvements had been completed, this consumption dropped to 1,490 MWh per year, or 92 kWh/m². This represents a reduction in energy consumption of 465 MWh or 24%, which equates to 75.6 tonnes of CO_2 saved per year.

<u>An administrative building in Cork County, Ireland.</u>

An 1850s administrative building used by Cork County Council was upgraded with better heating controls, new boilers running on natural gas rather than oil, and new lighting.

The results achieved were:

- 35% reduction in heating costs
- 30% reduction in CO_2 emissions
- 50% reduction in lighting load

- Reduced ecological footprint
- Much improved comfort levels
- Better working environment

Applicability
EPCs and DECs are required for many buildings, particularly in the public sector, particularly in the public sector, but can be undertaken voluntarily by any building. Awareness campaigns and energy efficiency measures are optional, but are applicable in any type of building.

EPCs are required for all buildings that are rented, sold or under construction (in both private and public sector). DECs are currently required for all public buildings with a floor area of > 500 m^2.

EPCs and DECs can be used to show commitment to environmental targets without necessarily taking any action in practice ("ticking the boxes"). No action is specifically required from an organisation after receiving their EPC/DEC, although some legislation is now being introduced in some member states based on the ratings, e.g. the UK Energy Act 2011 makes it illegal from 2017 to let property that falls below a specified minimum EPC rating.

Economics
The cost of obtaining an EPC or DEC is relatively low per building, although it can be relatively costly for smaller organisations. Usually the cost will be in the range of €500-5,000, although this will vary.
EPCs and DECs do not save money directly, but can identify the potential cost savings from implementing behaviour change and energy efficiency measures.

Driving force for implementation
Most public authorities and organisations will be required to produce EPCs and DECs on a regular basis or on specific occasions, e.g. the sale or rental of a building. The EU-wide Buildings Energy Performance Directive (EPBD) has been implemented in member states since 2003. However, generally the only requirement is to obtain the report, not to actually implement any of the suggestions. There are, however, often benefits of using the reports as a basis for public and staff engagement as well as making the case for measures that save carbon, energy and costs.

For organisations or buildings that obtain an EPC or DEC voluntarily, often the motivation is to get some initial information on the current performance of the building in order to identify potential cost and CO_2 savings.

Reference organisations

Hamburg, Germany
The "Fifty-Fifty" project - Pupils examine their school
http://www.display-campaign.org/example477

Ivanić-Grad, Croatia
Prominent display of poster during renovation

Odense, Denmark
School district heating
http://www.display-campaign.org/example162

Cork County, Ireland
Administrative building
http://www.display-campaign.org/example538

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3.2.6 Implementing district heating and/or district cooling networks

Description

District heating networks (DHNs) are where hot water is produced by a central boiler plant or other heat source and is piped into buildings to provide their space heating and domestic hot water for cooking and cleaning. Where possible, "waste heat" is used to power the network. This is heat that is produced as a by-product of another process such as electricity generation and so is classed as "emission free", since all emissions have already been attributed to the primary product.

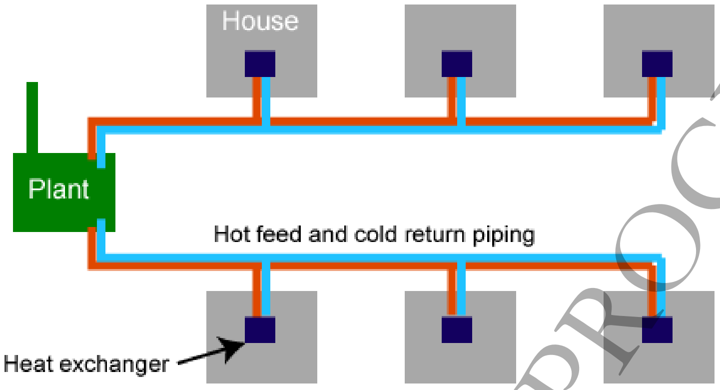

Figure 3-39: Basic schematic of a district heat network (BioRegional, 2012)

DHNs are most suitable where there is a steady and large heat demand, and/or a source of waste heat. This often leads to a mix of domestic and non-domestic users, e.g. housing and hospitals. This is important in particular for CHP, where the generation of electricity should be continuous, and without a continuous heat demand there will be efficiency losses.

DHNs are more common where there is a higher heating demand, such as Northern Europe and mountainous areas (e.g. the Alps). However there are some examples of heat networks in warmer climates, e.g. Barcelona .

District cooling runs on the same principle as district heating, but uses waste heat to drive a refrigeration process, usually with absorption refrigerators. This is more efficient than an air-conditioning system which uses electricity directly to provide cooling. Heat exchangers are again used to transfer the cold into the building network (the reverse of district heating).

Trigeneration combines electricity generation with district heating and district cooling where there is demand for both heat and cooling, e.g. in a warmer climate or for large data centres.

The network itself consists usually of well-insulated pipes often laid underground, with heat exchange units in the buildings for individual heating control. Usually an Energy Services Company (ESCo) manages the network and provides billing services to the users. This can be owned or operated by the local authority itself, depending on local legislation. Sometimes the provider(s) of the heat and the management of the network are separated, as in Copenhagen (C40, 2011), particularly when there are multiple sources.

Individual consumption can be monitored via heat meters installed in each unit, although historically many networks used flat rate billing due to the expense of individual metering.

It is common for the central boiler plant to be a combined heat and power unit (CHP). CHP involves the production of electricity and useful heat from a single plant, which is more efficient than generating electricity and heat separately. This is because during the generation of electricity from fossil fuels heat is also generated. With electricity from the national grid, this heat is mostly wasted as there are few heat users next to the power generation facility. Wasting the heat means that the efficiency of the conversion from fossil fuel to electricity is only around 40%. If that heat can be used, the thermal efficiency increases to 70% or even more, although there is a trade-off between electricity generation and heat production, so if electricity generation is the primary aim CHP may not be the best solution (Carbon Trust, 2010).

The fuel can be fossil fuel based or renewable energy based, e.g. a natural gas CHP plant or a biomass boiler. Geothermal energy has also been used in several instances, e.g. Vienna

(Fernwärme Wien GmbH, 2012). Energy from residual municipal waste plants are also common. Multiple fuels and heat sources can be used to provide the heat, but in smaller networks usually only one source is used (perhaps with a backup system). One major benefit of a DHN from an environmental perspective is that the heat source can be changed, meaning more carbon intensive heat generation can be replaced with low or zero carbon sources without affecting the consumer. This contrasts with natural gas networks connected to individual boilers, common in most of Europe, where apart from biogas injection into the network, the consumer is locked into a carbon intensive heating technology. This BEMP focuses on the network itself rather than on the generation technology. It should be noted that although heat networks with CHP can be a more efficient way of using fossil fuels, they are not truly sustainable. Similarly Energy from Waste plants have disputed environmental benefits (Friends of the Earth, 2006).

Network implementation

In general, the following design principles should be observed for a heat network:

- The heat network must be capable of supplying hot water to the consumers with sufficient temperature and temperature difference to meet the heat demand;
- It must be designed to minimise heat losses;
- The pressure across the entire network must not allow hot water to boil at any time;
- Pressure differences between flow and return pipes must always be sufficient to meet the required heat at all consumers;
- The network route should be designed to ensure long pipe lifetime, through minimising pipe stresses;
- The network route should be practical and distances should be minimised; and
- The pipes in the network should have sufficient capacity for all heat loads that may reasonablybe expected to connect in the future (GLA, 2013).

The route should be planned to minimise the amount of piping required to reach the consumers, which optimises both cost and efficiency. However, in many cases the disruption caused by running pipes down a main road, for example, may favour an alternative, longer route. Land ownership issues can also a cause non-ideal route to be taken. Consideration should also be paid to future connections and expansion phases, and appropriate measures incorporated into the design.

The main delivery route is through insulated steel pipes. The pipes should be designed for higher flow velocities in order to minimise diameter and therefore heat losses (which are proportional to surface area). For smaller networks and individual connections, plastic piping can be used. A substation may be required to reduce the pressure for these pipes. Heat losses through plastic piping are greater, so these pipes should only be used over short distances.

Return temperature

The return temperature of the water should be as low as possible and there are a number of ways to ensure this in the design of the system (GLA, 2013). This is important as the CHP efficiency is dependent on the difference in temperature between the outgoing and return water. DHN operators may instruct customers to make changes to their system to adjust the return temperature and can even reject the hot water and charge the client in certain systems (Cofely, 2013).

Consumer units

For the connection to the consumer, there are two options:

1. Hydraulic separation in the form of an interfacing heat exchanger. This is the most common system in modern DH systems. This keeps primary DH water entirely separate from water in the secondary consumer building system. The arrangement of heat exchanger, valves, shunt pumps and controls is termed a heat substation and is normally installed in a plant room in each consumer building. For individual houses, the substation will be outside the property and shared between multiple buildings, with the heat exchanger inside.

2. Direct connection; this allows the primary system DH network water to circulate around the secondary or consumer building system, feeding heat interface units directly within individual dwellings (GLA, 2013).

To account for variations in heat demand, local heat storage is usually installed to cover peak demand. This can be in an individual building or as part of the network infrastructure.
In order to bill customers for the amount of heat used, heat meters are usually installed in each unit. The billing is then managed by an ESCo which has a relationship with the customer. Older systems did not have individual metering which led to problems (see cross-media effects section) and does not encourage energy efficiency.

Achieved environmental benefits

Environmental benefits, in terms of CO_2 savings compared to the original heating options, result through:

- Fuel switching – e.g. from electric heating to natural gas or "waste" heat; fossil fuels to renewables
    - Electricity generally has a higher carbon intensity than gas
- Increased overall efficiency of CHP
    - Although CHP can decrease the efficiency of electricity generation, where there is a high and constant heat demand it can be an efficient energy generating technology
- Improved thermal efficiency of buildings
    - Often the building fabric of the buildings is improved during a retrofit district heating project

The CO_2 savings will vary depending on the system and the original fuel, but as a rough example replacing an electric heating system with a gas-fired CHP connected to district heating would reduce emissions by 66% (based on UK grid electricity carbon intensity and assuming the same energy consumption)[21]

Appropriate environmental indicators

- CO_2 emissions of the system providing heating or cooling, before and after the implementation of district heating/cooling (or compared to an alternative system for new developments)
- kgCO2/kWh of heat or cooling energy
- Efficiency of the system (%) – overall or thermal + electric
- Share of renewables in DHN (%)
- Water replenishment rate/year

Cross-media effects

Negative effects of other fuel types

Different fuels may have different negative impacts on other environmental pressures. For example sustainably sourced biomass would generally be preferable to natural gas in terms of CO_2 emissions, however particle emissions will be higher, impacting on local air quality.

Suitability of District Heating

A full analysis should be undertaken when installing a district heating system, including estimates of the heat demand and maintenance costs. Networks installed in unsuitable locations lead to poor performance which can negate CO_2 emission reductions and waste money.

[21] UK grid electricity carbon intensity 0.591 kgCO_2/kWh, heat from CHP carbon intensity 0.204 kgCO_2/kWh (BRE, 2009).

Metering & Controls

Heat meters can be more expensive and require more maintenance than electricity or water meters. In many older developments, particularly in Central and Eastern Europe, meters were not installed, leading to heat being wasted by consumers opening windows instead of turning off/down the thermostat (World Energy Council, 2004). Flat rate billing disincentivised energy saving due to the lack of financial cost associated with wasting heat.

Some systems were installed without individual temperature controls, which led to unsatisfactory heating where the temperature has been set too high for the comfort of the consumers. Again, this led to waste through opening of windows. (ACEEE, 2002)

Disincentivisation of retrofit

Because of the cost of installing new piping and heat exchangers into buildings, it is cheaper to do this in a smaller number of buildings each with a higher heat demand. This is a disincentive to improve the thermal efficiency of the building, whose heat demand would reduce as a result. However, from a carbon and system efficiency point of view, it is better to have more buildings connected to the system, each with a lower heat demand. When the heat demand per building is extremely low, for example with near-Passiv Haus standard buildings, it is worth considering alternative heating methods as it may not be cost-effective in that situation.

Operational data

Case Study – Aberdeen, UK

Home energy use is responsible for over a quarter of UK carbon dioxide (CO_2) emissions, and fuel poverty, due to poor insulation, expensive fuel and low incomes, is a key government concern. Many multi-storey housing blocks were built in the 1950s-60s with poor insulation and electric heating via storage heaters. The blocks are usually owned by the local authority and tenants have low income. Combined with a high fuel cost and poor insulation, the effect on CO_2 emissions and fuel poverty is high.

In 1999 Aberdeen City Council (ACC) developed a strategic approach to district heating for existing property upgrades (Energy Saving Trust, 2011). Their approach consisted of:

1. Initial surveys of all the buildings led to an understanding of total costs for repair, maintenance and like-for-like replacement over a 30 year period.
2. In addition to the individual building assessment, an appraisal was made of buildings in close proximity to each other. This allows consideration of connecting buildings to a centralised heating plant if they were close enough together to form a heat network.
3. All potentially viable upgrading options were investigated. The predicted running costs and CO_2 emissions were also considered when selecting the most effective option.
4. A financial strategy was developed to fund and deliver the optimal solution.

One of the clusters appraised was identified as the most appropriate for the development of a CHP scheme. This cluster, Stockethill, comprises 288 flats in four multi-storey blocks. The flats had electric storage heating, which had been installed in the 1970s. 70% of the residents of these dwellings were estimated to be in fuel poverty. The tenure of these properties was 98% council tenants and 2% owners.

The most attractive option for improving the buildings was CHP with external insulation. However, external insulation would have been prohibitively expensive in capital terms for ACC. Instead they decided to opt for CHP only. This would improve energy efficiency and reduce both tenant heat costs and CO_2 emissions by approximately 40%. The heat is distributed to the four blocks via pre-insulated underground pipes, which comprise the heat network. Each unit has a new heat exchange unit for individual control. Approximately 47% of the electricity produced by the CHP is also sold on-site.

From the initial feasibility report it was recommended that ACC set up a separate not-for-profit company to develop and manage CHP schemes across Aberdeen. A contract between ACC and the company Aberdeen Heat and Power Limited (AH&P) provided £215k (€271k) a year and allowed AH&P to access additional capital through loan funding. Central government funding

also supported the capital investment[22]. Profits from the scheme are used to develop new CHP district heating schemes in other areas of the city.
The scheme has grown since the initial projects and now supplies around 1,530 flats in 22 multi-storey blocks and 9 public buildings. CO_2 emissions from these buildings have reduced by 45% and typical fuel costs to tenants have been reduced by 50% over the previous heating systems (Aberdeen Heat & Power, 2014).

<u>Case Study – Helsinki, Finland</u>

Helsinki district heating network is a multifuel network that covers over 90% of the heat demand in Finland's capital, with 14,500 connections and 3,300 MW of heating capacity (Helsingin Energia, 2013). The power plants are CHP using a mixture of fossil fuels, which is more efficient than producing heat and electricity separately. Electricity is also supplied and district cooling is now offered as well, with cooling partly provided from natural temperature difference of sea water and heat pumps (FinPro, 2013).
Waste heat from data centres is also provided to the system and there is a plan to be carbon neutral by 2050. This demonstrates the benefit of the fuel-agnostic network, allowing lower carbon heat sources to be added to the system without major disruption or the expense of new equipment for users.

<u>Case Study – Eno Energia (Finland)</u>

Located in North Karelia (Finland), with a heating season lasting for about 9 months and surrounded by great supplies of wood, the city of Eno is a good example of a partnership between public authority and community, providing renewable heat to public buildings, managed by a local energy cooperative.
The energy cooperative manages three heating plants using waste woodchip from local forestry activities. The heating plants supply a number of municipal buildings including primary and secondary schools, health centres and community centres through three networks with a total of 10 km of pipes (Eno Energy Cooperative, 2014).
Benefits of the system include:

- Almost all the capital investment stays within the municipality
- Positive effects on the areas' local forestry and landscape
- Positive effects on employment
- Local energy security
- Renewable fuel, approx. 5,000 tonnes CO_2 saved per year compared to previous system
- The ashes from the woodchip and its nutrients can be returned back to the forest to improve the soil

Although the energy cooperative is independent from the municipality, the development was supported by them. At the beginning, government and local organisations provided funding of the project. Good communication between Eno Energy Cooperative, local authorities and experts was also of vital importance for the project to be successful (Convoco, 2010).

<u>Case Study – Barcelona</u>

Districlima was set up in 2002 to implement, for the first time in Spain, a district heating and cooling network for use in heating, air conditioning and domestic hot water. The energy from residual municipal waste plant providing much of the heat also supplies power to the local grid.
The project was initially located in a redeveloped area of Barcelona that includes the Cultures Forum 2004 (Besòs seafront). In 2005, after the awarding of a public tender, a second stage started with the extension of the network to the 22@ technology district. With a 27 year concession, the network is being extended in line with the area's urban development and new users' connection requirements.
The project is a joint venture between Cofely/GdF-Suez, Tersa (owned by the local public authorities) and other partners, and uses energy from waste plant with a natural gas backup system.

[22] This project was completed in 2003. The financial model, particularly the need for central government funding, will now be different

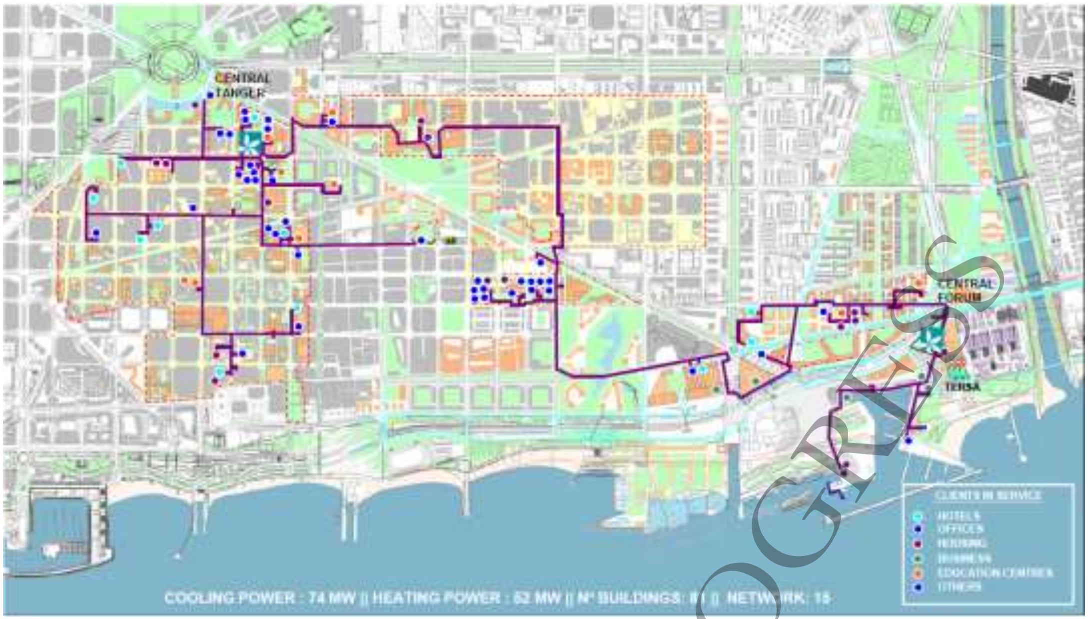

Figure 3-40: Schematic of the Districlima Heating and Cooling Network

Benefits achieved (Districlima, 2014):

- Residual energy sources are generally used (urban solid waste or others) in high performance energy equipment, thus minimising fossil fuel primary energy consumption
- Reduction of greenhouse gas emissions as it is a more efficient energy solution than traditional heating and cooling technologies - approximately 7,000 tonnes CO_2 equivalent per year
- Significant reduction of refrigerant losses into the atmosphere compared to conventional systems
- Noise and vibration reduction in buildings connected to the system
- No visual impact as the system ensures that roofs and façades remain completely unobstructed

Applicability

In general, district heating, cooling and trigeneration can be used in many situations, but is not very suitable for low-density areas or where the heat generation is a significant distance (>5-15 km) from the heat demand (DECC, 2013).

District heating is most suitable where there is:

- A continuous overall heat demand (particularly for CHP)
    - This can be a mixture of buildings, e.g. hospitals, offices and housing
- A requirement for relatively high temperature water (80-120°C), therefore it can be less efficient in warmer climates due to the lower heat demand
- At least 3,000 kWh/km^2 annual heat demand (Pöyry, 2009)

District cooling is most suitable where there is:

- A significant and continuous cooling demand
    - Usually due to high summer temperatures

Trigeneration is most suitable where there is:

- A continuous requirement for both heating and cooling

Economics

District heating networks are expensive to install and larger networks are usually developed with the public authority providing the funding and run the network (via a subsidiary). Networks are long-term (>20 years) investments which are generally not attractive to the commercial sector without government backing. However, once installed they are relatively low

risk and have wider benefits such as reducing carbon emissions and fuel poverty if lower cost heat can be sold to residents.
Networks connecting multiple large heat loads will often cost €10-100m to develop and require a long-term commitment and purchasing agreement to be financially viable. They do however generally make financial sense over this long period and are attractive to organisations with a long-term stake in the development.

The costs for installing the network into properties can range from:

Table 3-19: Indicative district heating costs (Pöyry 2009)

Item	Range of costs
Domestic property connection and metering	€5,000-14,000 per property
Commercial connections	€10-21/m^2
Network installation costs (based on medium scale pipe connected to 10 sites of 5 MW each; and large scale 15 km 200 MW transmission pipeline)	€150-300/kWp

This excludes the cost of the heat generation plant and the ongoing maintenance costs.
The market for district heating is very strong, some example figures from Finland are given in the table below.

Table 3-20: District Heating market figures from Finland (FinPro, 2013)

Heat sales (incl. taxes)	€2,250 m
Sold heat energy	33.6 TWh
Average price of DH (incl. taxes and domestic hot water)	67 €/MWh
Inhabitants in DH apartments	2.7 m
Market share of district heat	47%
Sold district cooling energy	124 GWh

Driving forces for implementation

Reducing heating costs for consumers, particularly those in social housing
Public authorities are often responsible for social housing tenants who are on low incomes. District heating is often cheaper for the consumer than alternative heating systems, so this allows the authority to provide a material benefit to the tenant. Prices are usually fixed over long periods of time to provide the long-term stability for investment into construction of the network, insulating the consumer from price rises and short-term peaks.

Reducing carbon emissions
Even when using fossil fuels, district heating can reduce carbon emissions by utilising heat that might otherwise be wasted (e.g. from a power plant). Public authorities have local, national and international commitments to reduce CO_2 emissions and district heating provides one option for achieving their targets. The network itself is separate from the heat generation, allowing upgrades to lower or zero carbon technologies.

Security of supply
One of the drivers for heat network expansion in Scandinavia was concern about the cost and security of energy supply in the 1970s, whereas in the UK this did not take happen due to the abundance of North Sea oil and gas. This remains a relevant driver due to the dependence of most countries on imported oil and gas. DHNs allow for a greater mix of fuels and technologies to be used, reducing the dependence on one fuel type (e.g. natural gas).

Reference organisations

Aberdeen City Council, UK
Retrofit district heating into tower blocks, via an independent publicly-owned company with a remit to reinvest profits into more networks in other tower blocks

Districlima, Barcelona, Spain
A public-private initiative to provide trigeneration – electricity, heating and cooling – in the Barcelona metropolitan area.

Eno Energia, Finland
A community energy cooperative supported by the local authority using wood waste to provide heat for public and private buildings.

Helsinki, Finland
City-wide district heating and cooling network using multiple fuels

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3.2.7 Implementing on-site renewables and mini-CHP on public buildings and social housing

Description

Public authorities have large portfolios of property and influence over other property e.g. social housing. These properties need heating and electricity, and providing these with low carbon technologies allows to substantially decrease the environmental impact of these buildings.

Electricity is generally provided by a national grid outside the influence of the authority but options for on-site electricity generation are also available. Among them, renewable energy systems like solar photovoltaic panels allow to generate zero carbon electricity, contributing to national targets and local objectives.

As for the heating, this is generally generated on-site, usually with a boiler running on gas or other fuels. Low/zero carbon options include biomass boilers and solar thermal systems. Another option is adopting small scale Combined Heat and Power systems (mini-CHP) using gas or biomass which allows generating jointly the heat and the electricity at a higher overall efficiency.

1.0 *<u>Energy Efficiency Measures</u>*

Energy efficiency measures, such as designing an efficient building envelop or retrofitting insulation in existing buildings, reduce energy needs and should always be done first. Behaviour change measures should also be implemented before meeting energy needs by renewable energy is considered. These measures are likely to be more cost-effective, but there is also an important technical reason for doing so – energy efficiency reduces the overall consumption of the building, and, if the renewable energy system is sized to pre-retrofit consumption levels, it will be oversized once the efficiency of the building is improved. This is particularly a problem for heating systems, where operational and maintenance problems can arise if the system is not properly sized (Biomass Energy Centre, 2011).

2.0 *<u>Renewable Electricity</u>*

The most common renewable energy options available to generate electricity on-site on public authority buildings and houses are:

Solar photovoltaic (PV) panels

Solar PV generates electricity from sunlight. PV panels are ideal for placing on flat or pitched unshaded roofs and can also be mounted on facades or ground-mounted in suitable locations (e.g. gardens, parking lots). Pitched roofs and facades should be broadly south facing to maximise generation. There are also construction elements (e.g. tiles, roofs, glass surfaces) integrating PV elements. These are convenient when integrating renewables while constructing or refurbishing a building. There is a significant difference in generation potential between northern and southern Europe, but it can still be cost-effective to install PV in northern areas, for example a Finnish University recently installed a 220 kW system (LUT, 2013).

Small scale wind turbines

Wind turbines generate electricity from the wind, and can be vertical-axis or horizontal-axis. Building-mounted systems are usually vertical-axis and range up to around 10 kW in capacity.

Geothermal

Electricity generated from naturally occurring geological heat sources can provide significant amounts of renewable energy. Water heated by the heat source (as steam) is used to drive a turbine, generating electricity. Geothermal energy resources are very localised but where available can supply a significant percentage of local energy demand. For example, Siena (Italy) generates 97.6% of its electricity from a geothermal plant (Terre di Siena Green, 2014).

Biomass/biogas

Sustainably sourced biological materials such as wood or gas produced by anaerobic digestion can be burnt to generate electricity. However, these fuels are primarily used for heat production or CHP.

3.0 *Renewable Heat*

The most common renewable energy options available to provide space heating and hot water to public authority buildings and houses are:

Solar thermal

Solar thermal panels or tubes can be used to generate hot water using heat from the sun. This can then be used for domestic or commercial hot water, in homes, offices or where there is a relatively high heat demand during summer daytimes, e.g. swimming pools or sport centres with large shower rooms. Because heat is not easily stored, solar thermal works best in combination with back-up technologies such as biomass or natural gas hot water systems which can generate heat when the sun is not enough. In locations where there are many sunny hours also when the external temperatures are low, solar thermal can also be used (at least partially) for space heating.

Biomass/biogas

Sustainably sourced biological materials such as wood or gas produced by anaerobic digestion can be burnt to generate heat in a boiler or in a mini-CHP system. The most common systems are biomass boilers that burn wood in the form of logs, chips or pellets to heat water used in a central heating system.

4.0 *Low Carbon Energy*

When generation of renewable electricity and heat is not technically or economically feasible or can only cover part of the energy needs of a building, low carbon energy options should be considered. The main ones are:

Mini-CHP

CHP involves the production of electricity and useful heat from a single plant, which is more efficient than generating electricity and heat separately[23]. Mini-CHP refers to small scale CHP systems that may power individual buildings or complexes such as hospitals, schools or social housing blocks. CHP can be fuelled using fossil fuels, being a lower carbon system[24], or by renewable fuels such as biomass, where it is zero carbon. Mini-CHP systems should be appropriately sized to match the heating needs of the building. This would usually generate part of the electricity needs. Generating more electricity would often mean reducing the overall efficiency or producing extra heat. The latter only makes sense if this heat can be exported to

[23] This is because during the generation of electricity from fossil fuels heat is also generated. In large power plants, the heat is mostly wasted as there are few large heat users next to the power generation facility. Wasting the heat means that the efficiency of the conversion from fossil fuel to electricity is only around 40%. If that heat can be used, the overall thermal efficiency increases to 70%+ or even more.

[24] Under the assumptions that grid electricity is mainly from fossil fuels and that heat would be generated anyway locally with

nearby buildings. In this sense, CHP can be used in combination with a district heating network (see BEMP 1.4).

Heat pumps

Heat pumps use electricity to drive a refrigeration cycle to extract heat from the environment (air, water, sea, ground). Although the heat is renewable (it comes indirectly from the sun), heat pumps still need electricity or another fuel to drive the system. However, for every 1 kWh consumed it is possible to get 3 kWh of heat or more. The ratio between the heat which is extracted from the environment and made available and the consumption of the system is called the Coefficient of Performance (CoP). The normal range of CoP is between 2.5 and 5. Heat pumps can be used for space heating and hot water, as well as cooling. Heat pumps are most suitable in well-insulated environments where low temperature heat is required and in climates with mild outdoor temperatures, since the temperature difference between the environment and the heat required lowers the CoP as the difference increases.

5.0 *Choice of the appropriate technology and appropriate siting*

The choice of the appropriate technology depends on whether it is for an existing building or for newbuilt, on the position and orientation of the building, on the local climate… This also applies to the specific siting chosen (e.g. PV and solar thermal can be placed on the roof, on the parking lot, on the ground around the building…).

From an environmental point of view, zero carbon heat and electricity technologies (including biomass-fuelled mini-CHP) should be preferred to mini-CHP running on gas and heat pumps. Between these two options, heat pumps should be preferred when the carbon intensity of grid electricity is low and mini-CHP when this is high[25].

6.0 *Project implementation*

1. *Audit*
The first step in implementing a renewable energy or low carbon solution is to understand the current situation of the building(s), in terms of:

- Fuel costs
- Carbon emissions
- Maintenance costs
- Lifespan of current system
- Current and future usage of the building(s)
- Strategic objectives of the public authority
- Potential for (further) reducing the energy needs of the building by implementing energy efficiency measures (such as improving the building envelope performance) or fostering behavioural change[26].
- Potential for / availability of renewable energy sources in the examined area

This will include a physical audit of the building(s), but also a detailed analysis of the results and the strategic and policy context. This audit and analysis may cover multiple buildings with those most suitable being targeted for specific interventions.

[25] Heat pumps usually run on electricity. Although they generate 2.5 to 5 times as much heat as electricity they use, if this electricity is generated from carbon intensive sources and/or very inefficiently, there will be little overall environmental benefit. In those cases, the higher environmental benefit is offered by mini-CHP, which would be more efficient at generating heat and electricity than grid electricity generation.

[26] As explained above, reducing the energy needs of a building should always be preferred and prioritised to implementing renewable energy systems.

A similar exercise can also be carried out when designing a new building. There are a number of key differences however which can lead to different technology choices being made compared to retrofitting an existing building. This can be because there may be additional cost of retrofitting systems compared to incorporating them within the construction plan, or because the design can be altered to accommodate a preferred technology. For example, a ground-source heat pump may not be economically beneficial or practically achievable for an existing building, however if the boreholes/trenches for the pipes are dug during the construction phase this could be the most viable option. Additionally, some technologies, e.g. solar PV roof tiles, may not be cost-effective to retrofit (if the roof is in good condition) but could be cost-effective for new construction if they replace other building materials (i.e. new roof tiles).

***2.** Setting of objectives*

The second step is deciding what the public authority wants to achieve. Objectives may span from minimising the life cycle cost of a building (i.e. choosing the option to provide heating and electricity with the lower life cycle cost) to an environmental objective such as achieving carbon neutrality.

***3.** Analysis of the different solutions*

Once the objectives for the intervention are established and the current situation and potentials are known, all the solutions should be examined with a thorough cost-benefit analysis and outline business case options.

***4.** Business case and Finance*

Once the preferred solutions have been identified, the business case is prepared. This will compare the solutions with the "business as usual" option and will include strategic targets as well as financial considerations.

Renewable energy solutions often require a large up-front capital investment and generate long-term income through sales, savings and subsidies. Financing the capital investment can be achieved from several sources (including a combination of these sources). Each has its own advantages and disadvantages, some of which are outlined in the table below.

Table 3-21: Advantages and disadvantages of different funding options

Funding option	**Advantages**	**Disadvantages**
Authority investment from own funds	• Low interest rates required by the authority improve business case • Long-term interest in project	• Legal limits to authority lending • Investment competes with other strategic priorities
Private investment via bank or commercial organisation	• No cost to the authority	• Higher interest rates required to service investment, impacts on business case
Community investment	• Usually lower interest than commercial funding • Involves wider municipality in project • Retains financial benefits in local area	• Not suitable for very large investments • Large number of stakeholders

***5.** Consultation/stakeholder engagement*

Some projects may require consultation with the public and stakeholders. This could be a planning requirement for major projects, but can be a good way to engage with people about the

Renewable energy generation per internal floor area (kWh/m^{2}year)
- Percentage of total energy needs met by renewables (%)
- On-site generation of renewable electricity out of the total electricity consumption of the building (%)

project and any broader sustainability objectives and schemes. Projects in social housing require serious engagement to reassure residents, particularly if there are changes to their income or environment (e.g. changed heating system and billing).

***6.** Procurement, Installation and Monitoring*

Once the project has been approved and financed, the installer will be procured and installation will take place. Where an installation involves disruption to building users or residents, on-going engagement should take place to explain the installation process, notify of disruption and reassure them. Where users or residents have to change their behaviour, a suitable handover should be arranged to explain the new system and how it works.

Post-installation monitoring is an essential part of the process. This should include technical monitoring to ensure the system is working as expected, but should also include ongoing engagement with users or residents. Proper use of the system is a key aspect to ensuring it works as expected and that the environmental benefits are achieved. Poor handover can lead to technical problems with the system as well as additional costs, for example if usage is higher than modelled.

***7.** Dissemination*

Public authorities are expected to play a leading role in reducing energy consumption and carbon emissions. One of their responsibilities is to disseminate knowledge on successful and unsuccessful projects so that other people, business and authorities can learn from the experience, replicate the successes and be aware of the potential issues.

Achieved environmental benefits

Renewable energy and low carbon energy systems described in this BEMP can significantly reduce CO_2 emissions of buildings. In some cases, renewable energy systems can also produce more than a building requires and export green electricity to the national electricity grid.

Appropriate environmental indicators

- Renewable energy generation per internal floor area (kWh/m^{2}year)
- Share of total energy needs met by on-site renewables (%)
- Share of total energy needs met by locally generated low carbon energy (%)
- On-site generation of renewable electricity out of the total electricity consumption of the building (%)
- Percentage of water heating provided by on-site renewable heat generation (%)
- Renewable electricity capacity in kWp (kilowatt peak)[27]

Cross-media effects

Renewable energy systems can impact on other environmental pressures by competing for space (e.g. solar PV vs green roofs), or through unsustainably sourced biomass. Below is a table of example negative impacts of building-scale renewable energy technologies. These impacts can usually be mitigated by proper siting choice and design features.

[27] This is the theoretical capacity of a system under ideal conditions, e.g. full sunlight in July for a south-facing PV system at 30° tilt. Due to the variability of the resource it is not possible to produce at this capacity all year. It is also applicable to wind and other renewable technologies which do not always generate at full capacity

Table 3-22: Possible Negative Impacts of low carbon technologies

Technology	Possible negative impacts
Solar photovoltaic	•
Wind	• Can cause damage to wildlife if sited in bird migration routes or near bat nesting sites
Biomass	• Can impact on deforestation if produced unsustainably • Can cause habitat damage if sourced from a poorly managed site • Generation of particle emissions
Heat pumps	• Ground source can freeze the ground under certain conditions, e.g. if too many heat pumps are located close to each other

Operational data

Ostrava, Czech Republic: Biomass (heat)

An old nursery building in Ostrava was changed into a multi-purpose low-energy house for children, their teachers and families using solar energy, a biomass boiler for wood chips, and an underground heat exchanger for heat recovery. Although the building area increased during refurbishment, fuel consumption decreased. The annual energy consumption for heating decreased from 220 kWh/m^2 to 46 kWh/m^2, and energy is 100% supplied from renewable energy (LG Action, 2010)..

Woking Borough Council, UK: Mini-CHP

As part of its energy efficiency programme, Woking Council implemented its first CHP system in 1992 and the UK’s first small scale CHP/heat fired absorption chiller system in 1994 for which the Council won the CHPA 1996 CHP in Buildings Award, followed by a series of private wire residential CHP systems (the first and still the only systems of their type in the UK). There are also other renewables on site, including solar photovoltaics. The integrated photovoltaics roof and CHP system will have a reverse winter/summer electricity profile with the potential to achieve 100% sustainability in electricity (CHPA, 2014).

Lyon, France: Heat pumps

In 1997, the Lyon CAF (Family Allowance Centre) moved into new offices. The building has office space, meeting rooms, a conference room and a reception area for beneficiaries. Concerned about future running costs, the Lyon CAF asked its design division to look into the different heating and cooling systems that could be used for the site. Research revealed the ground source heat pump to be the most efficient (REHVA Journal, 2011).

The system can be used for heating and cooling and saved 48% in operational costs compared to a standard alternative. CO_2 emissions reduced by 72% and the system operated with a CoP of 3.73, which is within the expected range for the age of the system.

Applicability

The suitability for implementing a renewable energy or low carbon system on a particular site depends on numerous factors. However, there should be a solution applicable to most situations. A brief summary of applicability of different technologies is outlined below.

Table 3-23: applicability of different on site-renewable and mini-CHP technologies

Technology	Suitable sites	Less suitable sites
Solar	Flat/pitched roofs, ground mounted. Little	Shaded areas. Ground-

photovoltaic	shading, E-S-W facing.	mounted when competes with productive land. Historic buildings.
Wind	Large buildings (vertical axis turbines).	Areas with high natural or heritage value.
Geothermal	Naturally occurring heat, site-specific.	Cannot be used where there is no naturally occurring heat.
Biomass	Rural areas relatively near fuel source.	Highly urban areas (due to transporting fuel). Buildings with limited storage.
Biogas	Feedstock is usually rural, so gas production is generally in rural areas.	Highly urban areas (due to transporting fuel).
Solar thermal	Flat/pitched roofs, ground mounted. Little shading, E-S-W facing.	Shaded areas. Ground-mounted when competes with productive land. Historic buildings. Low hot water requirement.
Mini-CHP	Depends on fuel. Natural gas CHP suitable where gas is available.	Natural gas CHP - Off-grid areas.
Heat pumps	Well insulated buildings requiring low temperature heat	Poorly insulated buildings, high heat requirements,

Economics

The technologies mentioned in this BEMP are commercially available, but the business case depends heavily on geographical location and national incentives, as well as national energy prices. In general the financial benefits can be calculated using:

- Capital cost (€)
- Incentives for installation (Feed-in Tariffs, grants) (€, €/kWh)
- Estimation of on-site usage (kWh per year)
- If applicable, unit price for exported generated energy (€/kWh)

Compared with:

- Current energy costs (if relevant) (€)
- Current and future fuel prices (natural gas, electricity) (€/kWh)

An example hypothetical calculation for a 33 kWp solar photovoltaic array costing £50,000 is detailed below. This assumes finance is arranged at 5% over 25 years. Generation is assumed to be 33,000 kWh per year for a UK-based system. Feed-in tariff rates are based on 2014 UK rates. Other countries have different support mechanisms for renewable energy although many are similar in structure.

Table 3-24: hypothetical calculation of solar photovoltaic system installation

Item	Income (annual)	
Loan payment @5% interest over 25 years on £50k capital	-£3,547.62	-€ 4,505.48
Maintenance (including inverter replacement)	-£1,000.00	-€ 1,270.00
FIT @£0.12/kWh	£3,960.00	€ 5,029.20

Export Tariff assuming 50% on-site use @£0.047/kWh	£775.50	€ 984.89
Savings from 50% on-site use assuming grid electricity @£0.10/kWh	£1,650.00	€ 2,095.50
Outgoings	-£4,547.62	-€ 5,775.48
Income	£6,385.50	€ 8,109.59
Net income	**£1,837.88**	**€ 2,334.10**

The FITs ensure viability of the project in this example, giving a small profit for the public authority. In other EU countries, particularly in Southern Europe, the project may be viable without subsidy due to the higher solar irradiation.

Driving force for implementation

The two main drivers for the implementation of on-site renewable energy generation and low carbon technologies are: lower life cycle costs and environmental considerations.

Indeed, many public administrations are keen in delivering carbon reduction, driven by legislated or voluntary commitments to reduce CO_2 emissions in the municipality.

The price of fossil fuels is on a long-term upwards trajectory and the cost of renewables has reduced significantly over the last 20 years. In some parts of Europe (e.g. Spain, Italy, Germany) electricity from solar PV is now at "grid parity", meaning it is the same cost as or lower than the cost of grid electricity (Eclareon, 2014). Since the price of electricity produced from renewables is fixed once the system is installed (for most technologies), and increases in fossil fuel prices will ensure that grid electricity increases above the rate of inflation, it can be financially beneficial to invest in renewable energy.

Some municipalities benefit from an abundance of natural resources where the fuel (e.g. biomass) is significantly cheaper than the market average, for example Eno (Finland) which has implemented a biomass district heating system using sustainably managed wood from local forests.

Reference organisations

Wierzchosławice, Poland
Solar PV

Samsø, Denmark
Wind, biomass

Provincia di Siena, Italy
Geothermal

Xanthi, Greece
Hydroelectricity

Ostrava, Czech Republic
Biomass

Woking Borough Council, UK
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Lyon, France
Heat pumps

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3.3 BEMPs regarding the regulatory/planning role of municipalities

3.3.1 Imposing higher energy efficiency standards and renewable energy requirements in land use planning for new-built and buildings undergoing major renovations through local building regulations and planning permissions

Description

In the majority of European countries building codes and standards for energy efficiency and renewable energy generation are set at the national level. However, municipalities, through the local planning system, have a mechanism to go beyond national building codes and standards and ensure that new-build and renovations within their territory are carried out to exemplary energy standards. Local improvements in planning regulations can play an extremely significant role in promoting the use of energy efficiency and renewable energy technologies at scale.

Setting local standards and regulations

Local building regulations, planning permissions and energy standards in land use planning provide an effective mechanism for local government to drive reductions in carbon emissions relating to commercial and residential buildings. Local autonomy enables most municipalities to go beyond the energy standards and renewable energy requirements set by national government and implement positive changes at a local level. Setting local regulations will not only reduce the per capita emissions of a municipality but will also upskill and develop the local construction industry and help drive growth in environmental technologies.

It is important that local standards and regulations are well integrated and thought through and that they are not carried out in isolation. For example, it is not effective to impose high renewable energy requirements on new buildings if these are energy inefficient. An example of standard driving improvements of both energy efficiency performance and renewable energy generation is the requirement to generate a certain percentage of the energy demand by on-site renewable energy, which can be met best by both minimising the energy demand and implementing renewables. Moreover, the most effective standards and regulations co-exist with a combination of other push and pull factors to improve the energy performance of buildings. Policy instigated by municipalities should comprise integrated packages of measures (e.g. incentives, soft loans, information and other actions) aimed at improving market efficiency, as technical solutions alone are not sufficient if the awareness, skills and resources are lacking to implement them. Some of these measures are described in BEMP 3.4.2.

To be effective it is essential that building codes and regulations are dynamic and change over time. They need to adapt to the constantly changing construction market, to shifting national targets in relation to energy standards, and to the emergence and increasing affordability of new technologies. It is also vital that any changes in the regulatory regime are announced well in advance to give the construction industry time to prepare and develop the right solutions to make the new requirements as cost effective as possible. For example, in Land Oberösterreich (Austria) there have been incremental increases in energy efficiency requirements since 1993, these have been transparent and consistent, enabling the construction industry to proactively prepare for changes and plan ahead.

The following summary presents matters to consider in the preparation, content and implementation of standards and regulations.

PREPARATION

Issues to consider before developing standards and regulations include the following:

- Scale – it is important that any standards are set at the appropriate scale; this will be dependent on the specific context of the municipality and the measures proposed:
  - Regional standards and regulations (where there is strong regional government and/or adjacent municipalities develop joint standards and regulations) can have multiple benefits in relation to wide spread energy reduction and a step change in the regional environmental construction industry.
  - Local standards can be set at various scales from the whole territory of the municipality, specific sites or individual buildings and building types. It is often easier to create standards in relation to a specific site and can be an effective way to test a new approach or a higher performance level. However, the impact of site specific standards will be lower in comparison to municipality-wide standards and regulations.
- Scope – it is important to identify what will be included in standards and requirements:
  - New build and/or renovations: best practice is to integrate policies aimed at new build and renovations to ensure that the maximum impact is achieved and the existing housing stock is improved.
  - Energy efficiency and/or renewable energy: in general renewable energy regulations should not be implemented where energy efficiency standards do not exist. When implementing renewable energy requirements it is important to define the scope of technology to be used, i.e. which renewable energy technologies are accepted (e.g. Solar Ordinances refer purely to solar thermal). However, it is often appropriate to define a range of technologies so that the most appropriate, cost effective and efficient technology mix can be implemented.
  - What aspects are included in the scope (building fabric, embodied carbon, fixed lighting, white goods).
- Timescale for development, implementation and review:
  - Provide sufficient lead-in time and ensure standards and regulations are communicated well in advance to enable the construction industry to prepare for future changes.
  - The strategy should have the ability to adapt over time to keep ahead of national policy and adjust in relation to the development of new technologies.
- Funding and resources:
  - If funding is required for the implementation of standards (e.g. if subsidies are to be applied) it is essential that potential funding sources are identified in advance.
- Capacity building of individuals:
  - It is particularly important for municipality staff involved in planning and development control to have the knowledge, skills and resources needed to implement and enforce the requirements.
- Mechanism for enforcement and control:
  - Standards and regulations are not effective if a mechanism for ensuring that they are implemented does not exist.

CONTENT

Standards and regulations should include the following aspects:

- Building subject to the obligation and exceptions:
    - It is not appropriate to have a blanket policy incorporating all buildings within a municipality. For example exceptions to regulations may include buildings of high cultural or historic values or buildings within areas of special conservation.
    - Respect of the architecture of the examined area – application of passive measures (e.g. insulation, natural ventilation, orientation (if possible in existing buildings) etc.)
- Definition of the required energy standard or renewable energy contribution:
    - It is important to define the required energy standard (usually expressed in kWh/m²/year) and/or the percentage of energy needs to be met by on-site renewable energy generation. For example the maximum energy consumption in new buildings could be sat at >50kWh/m²/year and 30% of electricity and heat used on site to be produced by renewable energy technologies.
    - Requirements can vary across buildings types. Best practice municipalities often set stricter requirements on buildings under the control of public administration.
- Technical parameters for the calculation of the fulfilment:
    - It is vital that a technical procedure used to calculate the energy performance of the building is standardised. Where possible these should be based on actual performance rather than planned efficiency to ensure that the "performance gap" is minimal. These should also be linked to the national building code and the energy labelling of buildings scheme.
- Quality assurance/ certification mechanism:
    - All works carried out to bring a building up to requirement should be carried out by an accredited installer and only certified products should be utilised (e.g. MCS accreditation in the UK or Solar Keymark certification across Europe)
- Definition of the accountable persons:
    - Standards and regulations should clearly set out who is responsible (usually the developer or landowner) for delivering buildings to the required standards and who will be accountable to sanctions if required standards are not met. It is usually the case that municipality Development Control and planning officers will be responsible for ensuring that building standards are clearly set out and enforced. Where planning consent has been granted and standards have not been met then the developer and/or land owners will be accountable for any sanctions incurred.
- Control procedures:
    - Standards and regulations must include a description on how they will be controlled and enforced – this is often carried out by scrutiny on development plans and impromptu site visits at various stages of development
- Sanctioning regime:
    - Any potential sanctions for not meeting standards and regulations must be clearly outlined.

IMPLEMENTATION

Public Authorities should control the effective implementation of the requirements at three main points:

1) On paper, at an early stage of the planning of the buildings (or renovation): comparing the proposed installation/measure with the legal requirements.
2) Before the building is commissioned, comparing what has been effectively installed with the legal requirement.
3) After one or two years of operation, inspecting a sample of systems to see if they perform according to the requirements.

Achieved environmental benefits

The main environmental benefit achieved by the implementation of this BEMP relates to the reduced consumption of energy, and greenhouse gas emissions as a result of increased energy efficiency and the production of renewable energy. Due to the scale of these interventions the positive impact on the environment can be dramatic; in Europe approximately 40% of emissions are as a result of building energy consumptions and therefore any intervention that can reduce emissions related to buildings will have a significant environmental benefit.

The implementation of Bologna's Town Planning Building Regulations has also resulted in significant energy savings over and above the requirements of Italy's National Policy. Over just two years 371,961.55 kWh/year were saved as a result of the regulations (Bertocchi, 2011).

Appropriate environmental indicators

Indicators relating to the establishment of plans/ regulations

- Establishment of regulations/plans etc. (Y/N)
- Level of energy performance required by the local building code (kWh/m²/year)
- % of on-site renewable energy generation as a ratio of total energy needs (for electricity, space heating and hot water) required by the local building code
- % improvement in comparison to regional and national building regulations and energy standards

Indicators relating to the outcome of plans/ regulations

- Threshold in U-values and/or R-Values for new and existing buildings
- m² of solar collectors installed in the municipality because of the local building code
- KW of energy generation from biomass installed

Cross-media effects

There are no major negative cross media effects relating to other environmental pressures as a result of implementing energy standards and requirements for on-site renewable energy generation. However, it is worth bearing in mind the competing pressures between various renewable energy installations and other environmental options (for example solar competing with green roofs).

Operational data

Imposing higher energy efficiency standards in land use planning for new built and buildings undergoing major renovations through local buildings regulations.

Freiburg City Council, Germany

The city of Freiburg, in South West Germany, has gone beyond Federal and European energy efficiency and renewable energy obligations as a requirement for the 38 hectare development of Vauban. Planning for Vauban began in 1993 and construction was completed in 2006, the site is now home to 5,000 residents and employment space for 600 people. As a requirement of planning permission all buildings were required to achieve minimum low energy standards of 65 kWh/m^2/annum heating energy requirement; additionally, 100 units were built to “passive house” standard of 15 kWh/m^2/annum or to “plus energy” standard (“plus energy” houses produce more energy than they use) (SECURE, 2007).

The achieved environmental benefits go beyond the local planning requirements of the site with all buildings achieving 45 kWh/m^2/annum for heating energy through a combination of district heating, CHP, solar PV, solar thermal, biomass and refuse and heat recovery (SECURE, 2007).

Vauban is an exemplary development driven by standards set by Freiburg Local Authority. These high standards are starting to be implemented in other developments in the city and are being integrated into Freiburg’s city-wide energy standards. For example Freiburg’s building design standards initially required that all new houses built on municipally-owned land (or land sold by the municipality) use no more than 65 kWh/m^2/annum (which in 1992 was 30% below the national standard); this minimum standard continues to be reduced - in 2005 it was reduced to 50 kWh/m^2/annum and there are plans in place to bring building emissions to Passivhaus standard (15 kWh/m^2/annum) (Wömer, 2006).

Wien City Council, Austria

Wien has a strong track record of high energy standards in social housing and corresponding high levels of subsidised housing, comprising almost 60% of all homes. Each year the city supports the construction of 5,000 to 7,000 social apartments, approximately 85% of the volume of new homes built annually (Covenant of Mayors, 2013). Since 2007 strict environmental standards and legal regulations for construction new social housing have been in place. These standards require a maximum energy consumption of 30 kWh/m^2/annum for heating. However, many new developments exceed this, reaching Passivhaus standard (less than 15 kWh/m^2/annum). As a result of these standards in 2010, 20 to 30% of the new homes built in Vienna were to Passivhaus standard (Covenant of Mayors, 2013).

Bologna City Council, Italy

Bologna’s Town Planning Building Regulations (RUE), approved by the Local Administration in 2009, set out a variety of innovative performance indicators without stipulating which specific technologies/solutions must be implemented. The RUE requires, as a minimum, that all new buildings and renovations be designed so that their energy consumption is between 60 and 90 kWh/m^2/annum. However, higher performance is required to receive a volume incentive, applying standards of “improvement” (40 to 60 kWh/m^2/annum) and “excellence” (bellow 40 kWh/m^2/annum) (Bertocchi, 2011).

The RUE applies to both commercial and residential buildings. However, particular attention is paid to residential buildings due to their significant contribution to the energy consumption of the municipality (37%) (Bertocchi, 2011).

Including requirements on on-site renewable energy generation in local building regulations/ planning permissions (e.g. the Merton Rule, the Solar Ordinances).

Barcelona City Council, Spain

Barcelona's Solar Thermal Ordinance, entered into force in its current form in 2006, makes it compulsory to use solar energy to supply 60% of running hot water in all new buildings, renovated buildings, or buildings changing their use. The Ordinance applies to both public and private buildings and forms an integral part of Barcelona's overall strategy to encourage the installation and use of solar energy in the city (LG Action, 2010). The Solar Thermal Ordinances resulted in an increase in solar thermal square meters in the city from 1.1m² per 1,000 inhabitants in 2000 to 59m² per 1000 inhabitants in December 2010. Licences requested for the installation of solar panels also increased from 1,650m² in 2000 to 87,600m² in 2010. As a result 20% of the total area of buildings in the city approved for solar thermal are now installed with solar systems. Due to the success of this innovative approach solar ordinances have been adopted by numerous local authorities in Spain, Portugal, Italy and Germany (Intelligent Energy Europe, 2013)

The London Borough of Merton, UK

The Merton Rule is a ground-breaking planning policy developed by the London Borough of Merton in 2003. The Merton Rule requires all new major developments to generate at least 10% of their energy needs from on-site renewable energy technologies. The implementation of the Merton Rule was ahead of its time and preceded many building requirements relating to energy generation and reduction. Although the emphasis was on generating energy from renewable sources the Merton Rule also had a profound effect on increasing the energy efficiency of buildings. This results from the fact that if you reduce the energy demand of your building then the scale of the renewable energy installation will reduce proportionally. Since the application of the rule in Merton it has gone on to be implemented within numerous Local Authorities in the UK and across Europe and became part of the UK national planning guidance. (IEA, 2009).

Imposing higher energy standards in land use planning AND including requirements on on-site renewable energy generation

South Dublin County Council, Ireland

In 2008 South Dublin County Council approved the 180 hectare Clonburris Strategic Development Zone (SDZ) Planning Scheme which provides a framework for the future development of the Clonburris area. The planning requirements relating to the SDZ go above and beyond regional and national requirements in relation to energy standards and on-site renewable energy generation and will ensure that the 15,000 new homes are designed to exemplary sustainability standards. The following requirements relating to energy standards and renewable energy generation have been stipulated for detailed planning permission to be gained on site (SDCC, 2008):

- Renewable/ low emissions energy sources
    - In situ renewable energy generation will cover a minimum of 30% of total space and water heating energy needs;
    - Dedicated or directly funded off-site electricity generation from renewable sources to provide 30% of electricity needs (in combination with on-site generation described above);
    - Integrated energy/heating systems will be provided at district, neighbourhood and/or block scale where feasible
- Primary energy reduction

- o At least 80% of residential floorspace to employ a communal space heating and hot water supply system connected to a district heating network ;
- o 60% carbon reduction from base case analysis of commercial buildings (i.e. standard Building Regulations)

- Internal lighting
  - o Minimum of 75% of fixed internal light fittings in new buildings will be dedicated energy efficient fittings
- External lighting
  - o All outdoor street lighting to be energy efficient or run on renewable energy sources

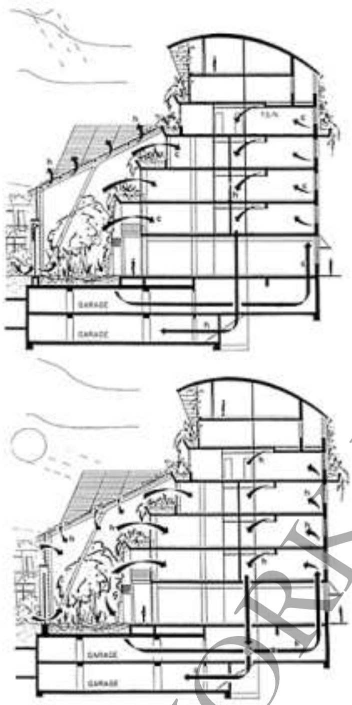

Figure 3-41: Sustainable technology and environmental design are promoted in the building form of Clonburris plan (SDCC, 2008):

Oberösterreich, Austria

In Austria the Länder are responsible for building code and as a result Oberösterreich, one of the nine Austrian Länder, has included energy efficiency requirements in housing programmes for both new construction and renovation since 1993. The innovative element is that there is a mechanism for support through a soft loan to support energy efficiency improvements. The soft loan is available to residents below a specific income threshold, however it is so high that over 90% of all home owners qualify for the programme. An integral part of this policy is that the energy thresholds have been increasingly tightened through the years, allowing the construction industry to adapt and housing associations to plan ahead (O. Ö. Energiesparverband, 2009). Between 2001 and 2008 the average energy performance indicator for new single-family homes reduced from 66 kWh/m²/annum to 44 kWh/m²/annum, see table 1 for more information.

Table 3-25: Energy performance indicators of new homes in Upper Austria, in kWh/m²/annum (O. Ö. Energiesparverband, 2009)

	Max kWh/ m²/ annum	2003	2004	2005	2006	2007	2008

Energy-efficient homes	**60**	56%	47%	24%	20%	0%	0%
Low energy home	**50**	42%	51%	70%	74%	85%	70%
Lowest energy homes	**30**	0%	0%	4%	5%	14%	28%
Passive homes	**10**	2%	2%	2%	1%	1%	2%
Average (kWh/ m²/ annum)		**55**	**54**	**50**	**49**	**47**	**44**

The Land Oberösterreich (the Upper Austria state government) also has regulations relating to solar thermal; all newly constructed multi-apartment buildings must install a minimum of 2.5 m² solar thermal collectors per apartment. Certain exemptions apply, for example if there is a year-round supply of energy from a district heating system fuelled by biomass, waste heat or geothermal then the building is exempt from the regulation (O. Ö. Energiesparverband, 2009).

The uptake of energy efficiency and renewable energy requirements in Oberösterreich has been so successful that energy consumption in 95% of all new single-family houses has been cut by more than 30% since 1993 (O. Ö. Energiesparverband, 2001). As a result of this policy low energy buildings have taken the major part of the market for one family houses and residential buildings in general; in Oberösterreich low energy and passive house buildings account for over 85% of new buildings (IEA, 2008).

A unique aspect of this building standard is the inclusion of obligatory energy advice sessions for each future home owner involved in the scheme. The future owner spends one hour with a trained energy advisor discussing his/her individual house and the possibilities to save energy in addition to the minimum requirements.

Fingal County Council, Ireland

National government in Ireland traditionally had an exclusive role in defining energy standards for buildings in the framework of the national Building Regulations. In 2005 this position was challenged by a group of Green Party councillors who proposed a motion in Fingal County Council for the introduction of improved building and energy standards in their Local Area Plan which related to a specific development site of 29 hectares. After much debate this plan was approved and stated a requirement that all new buildings must achieve the following energy standards as a prerequisite to receiving planning approval (Dubuisson, X. 2014):

- Annual heating requirement to be lower than 50 kWh/m²/year; and
- At least 30% of the building space and water heating requirements to be supplied by a renewable energy system.

Although the required levels of renewable energy production are not exemplary, Fingal is an example of a municipality leading the way and setting a strong example in the country. Their decision to impose higher on-site generation standards put local government in control and enabled them to go beyond national building regulations. The decision made by Fingal in 2005 has since influenced national panning and encouraged the national energy agency (Sustainable Energy Ireland) to review their existing renewable energy targets.

Applicability

This BEMP is applicable across all typologies and scales of local and regional government and applicable across Europe. However, the scope of this BEMP will vary depending on the role of the municipality. For example a local planning authority may be able to influence the implementation of solar ordinances whereas other municipalities may only be able to set higher energy standards on buildings directly under their school (e.g. schools and municipality offices). Through setting higher standards across their own property portfolio municipalities have the ability to influence wider building codes and help raise local standards in sustainable construction. Energy standards and building requirements set will be dependent on the ambitions of the municipality or region and may be affected by the local climatic condition (due to differential heating and cooling requirements across Europe).

Economics

It is very difficult to calculate the cost and benefits of the implementation of planning regulations relating to energy standards. This is partly due to the time between the adoption of regulation and the implementation of measures and enforcement. There are clear benefits relating to reduction in fossil fuel energy, however the aggregated energy savings will be determined by numerous factors, including (ESTID, 2007):

- the number of buildings subject to the obligation (and exemptions);
- the number and types of new and renovated buildings in a region or city;
- the specific requirement concerning the share of energy to be achieved;
- the quality of the technologies, their installation and maintenance;
- the behaviour patterns of the users;
- the intensity of the positive effects of the obligation on the voluntary market (i.e. the installation of larger solar systems than required, and the increase of solar energy use in buildings not subject to the obligation.)

It is important to note that the majority of the costs relating to implementing higher energy standards fall directly with building owners and property developers.

Driving force for implementation

There are numerous driving forces for implementation and these vary in scale and scope depending on the specific context and location of the Public Administration body. Some driving forces for implementation include:

- EU directive on the energy performance of buildings requires all member states to set standards for energy efficiency in new buildings based on the energy performance of the building. This takes into account air-tightness, heating and cooling installations, ventilation, the orientation and position of the building, passive solar gain etc.
- Legal obligations to provide a specified percentage of heat and power via renewable sources e.g. the German federal *Renewable Heat Act* requires a certain percentage of heating and water demand to be met with renewable energy (15% in the case of solar heating systems) (Schönberger, P 2013).
- Implementation of this BEMP will help stimulate the local construction industry, drive innovation in low carbon buildings and lower the costs of energy technologies.
- Ultimately the main driving force for implementation is the reduction in municipality carbon dioxide emissions, which will help meet local, regional and national carbon reduction targets.

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Imposing higher energy standards in land use planning for new built and buildings undergoing major renovations through local buildings regulations.

Freiburg City Council, Germany
A zero-energy housing standard to achieve a maximum of 65 kWh/m²/year was established for all new house construction and house renovation in the city

Wien City Council, Austria
Environmental standards and legal regulations for the construction of new social housing.

Bologna City Council, Italy
Town Planning Building Regulations requiring a minimum level of energy consumption for all new buildings

Including requirements on on-site renewable energy generation in local building regulations/ planning permissions (e.g. the Merton Rule, the Solar Ordinances).

Barcelona City Council, Spain
An obligation imposed by the Barcelona Energy Agency requiring specific levels of solar thermal to be applied to all new buildings.

The London Borough of Merton, London, UK
A ground breaking planning policy developed by the London Borough or Merton in 2003 requiring new developments to generate at least 10% of their energy needs from on-site renewable energy technologies

Imposing higher energy standards in land use planning AND including requirements on on-site renewable energy generation

South Dublin County Council, Ireland
Local planning requirements for the 180 hectare Clonburris Strategic Development Zone relating to energy standards and renewable energy generation.

Oberösterreich, Austria
Energy efficiency requirements in housing for both new construction and renovation

Fingal County Council, Ireland
Local leadership in defining energy standards for buildings and influencing national planning policy.

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3.4 BEMPs on municipalities' influence on their territory

3.4.1 Exemplary role of the public sector

Description

Public administration has a leading role to play in driving carbon reductions and it is important that successes (and failures) are showcased in order to encourage individuals, organisations and businesses to play their part. Research shows that although the general public is concerned about climate change and understands the need to take action, they want government in general to take the lead in driving change. Because of its direct relationship with citizens, the engagement and leadership of local government in delivering change can have a particularly positive knock-on effect in changing residents' and businesses' behaviour and encouraging them to take individual actions.

Municipalities that have taken a leading role have undertaken the following actions:

- Showing ambition and engaging stakeholders;
- Leading by example;
- Communicating effectively with the general public;
- Supporting the creation of incentive schemes;
- Helping overcome institutional and infrastructural barriers; and
- Delivering flagship schemes and buildings.

1. *Showing ambition and engaging stakeholders*

The most successful municipalities are usually the ones that show ambition and encourage residents and businesses to share that ambition. This can involve committing to being carbon free (e.g. Siena, Italy), aiming to become a European Green Capital (e.g. Copenhagen, Denmark) or a One Planet City (e.g. Brighton & Hove, UK). These ambitions are impossible for the public authority to achieve on its own and require engagement of the wider municipality.

Ambitions should:

- Exceed existing national or international targets;
- Involve commitment from the highest levels of the municipality (mayor, council); and
- Require engagement of other stakeholders.

Such ambitions should be supported and delivered through an explicit strategy and action plan (see Section 3.1.2). This could focus purely on carbon or energy, but ideally should be broader and cover issues of economy, culture and environment. Authorities should be aware that carbon cutting is not the primary concern of the majority of people and to get broad engagement wider benefits should be highlighted, for example household savings or improved health.

An independent forum to engage with the municipality and hold it to account on its ambition is a good way to encourage wider "ownership" of the programme. This forum can be formal or informal, but often requires the authority to support its development. For example, the Bristol Green Capital Partnership has over 500 member organisations and an independently elected chair and vice chair, while also receiving funding from the City Council to support its operations. The partnership meets quarterly on a formal basis and has monthly informal meetings to encourage dialogue between its members (Bristol Green Capital Partnership, 2014).

2. *Leading by example*

The public authority should show the same ambition for its own properties and operations as the wider municipality. In fact, it should hold itself to a higher standard in order to show best practice. This can involve:

- Embedding the ambition in its operations (e.g. via EMAS) and communications;
- Inducting staff and ensuring job descriptions are consistent with the ambition;
- Having a strategy to address its own properties and operations;

- Supporting external organisations to help deliver the ambition;
- Showcasing successes and being honest about failures; and
- Sharing knowledge with other municipalities.

3. *Communicating effectively with the general public*
It is not enough to simply deliver the actions required to meet the ambition, the municipality needs to be seen to be delivering the ambition in order to encourage other stakeholders to follow. This could involve:

- Creating a brand around the ambition, e.g. "Terre di Siena, carbon free 2015", and encouraging others to use the brand if they meet certain requirements. Usually these requirements are not too expensive or onerous. For example in Siena, organisations need to "undertake environmentally sound practices that reduce CO_2 emissions". These brands generate a sense of collective action and encourage organisations and people to take additional action (Terre di Siena Green, 2014).
- Publishing brochures and reports, delivering TV/radio/internet campaigns, and holding events and workshops to discuss the ambition and individual projects.
- Prominently displaying and explaining Energy Performance Certificates in public buildings. (For more information see BEMP 3.2.5)

4. *Supporting the creation of incentive schemes*
Financing the installation of reduction and generation measures can be a major barrier to reducing energy use. Municipalities are often able to access finance that is not available to private residents or commercial entities. This power can be used to leverage additional funding and create local schemes to deliver low carbon measures. For example, Bristol City Council applied for funding from the European Investment Bank's European Local Energy Assistance (ELENA) programme to develop investment programmes in energy efficiency and renewable energy projects in the city and the wider region – with an estimated potential investment of up to £140m (€175m) (Bristol City Council, 2014). This involved delivering measures in its own offices and other properties, but also in private residential properties, resulting in a city-wide retrofit programme launched in autumn 2014.
More information on private-public energy schemes can be found in BEMP 3.4.2.

5. *Adopting an enabling approach*
Municipalities have a unique role in towns and cities and their power extends beyond actively delivering projects. Some barriers are created by the municipality, for example their policy towards renewable energy on council housing or buildings may hinder installation if permission is too difficult to obtain, and they can facilitate change by changing policies and engaging with ambitious local organisations. Other issues are not barriers but the municipality can help enable sustainable practice, for example, Brighton & Hove City Council adopted a voluntary measure (Planning Advice Note) into their planning policy guiding new developments to facilitate local food growing where practical, e.g. in rooftop allotments for high density apartment blocks (Brighton & Hove Council, 2011). As a result 38% of proposed developments in the city contained food growing provisions (Sustainable Food Cities, 2014).
Authorities can also help overcome barriers where they deliver services such as waste collection, or have powers over infrastructure or transport.

6. *Delivering flagship/demonstration schemes and buildings*
Flagship schemes and buildings can showcase the public authority's commitment to sustainability, generating widespread public awareness of its ambition. These schemes demonstrate best practice and highlight the authority's role in reducing the energy and carbon emissions of the wider municipality.
Flagship projects could include:

- *New buildings* - For example, Brent Civic Centre (London Borough of Brent) is a large public building, which accommodates a number of different functions under one roof, including library, local authority offices and wedding venue. The building has been designed to streamline the efficient delivery of services to Brent's diverse community.

The building at the design phase is BREEAM Outstanding (92.5%) and is on track to receive an Outstanding rating at the Post Construction Review stage (Brent London Borough Council, 2013).

- *Green refurbishments* - The Autonomous Province of Bolzano/Bozen in Italy refurbished the public building “Ex-Post” to PassivHaus standard, the first public building in Italy to do so (PLEA, 2008). The building houses the local environment department employees.

Achieved environmental benefits

The environmental benefits are varied but can be substantial. Some example benefits are:

- Siena achieved its ambition of being carbon free (net zero carbon) by 2015 two years early (EC, 2014a).
- Bristol domestic energy use reduced by 16 % (2005 to 2010), and the energy efficiency of housing improved by 25% (2001 to 2011) (EC, 2014b).
- Salerno (Italy) installed a 24 MW solar photovoltaic plant (UCLG, 2011), reducing total municipality emissions by 2.5% (Salerno Council, 2012).
- Freiburg achieved an 18% reduction (1992 baseline) in CO_2 emissions by 2009, below the target of 25% by 2010 but still a significant achievement (Freiburg Council, 2010).

Appropriate environmental indicators

- Delivery of flagship/demonstration schemes and buildings (Y/N)
- Achievement of ambitious level of performance across all buildings and activities of the public administration (Y/N).

Cross-media effects

Individual projects undertaken by a public authority may have negative impacts on other environmental pressures, but the exemplary role of the public sector that this BEMP describes does not in itself.

For example, a ground-mounted solar photovoltaic array could be installed on land that could be used for producing food or for wildlife. This would be a negative environmental impact in terms of food production or biodiversity, although this does not mean the project should not go ahead as it may be judged that the sustainable energy benefits outweigh this negative impact. However, if the project creates controversy or is seen to be at odds with the municipality’s public commitments it could damage its reputation.

Operational data

<u>Salerno, Italy</u>

The municipal government of Salerno, Comune di Salerno, mobilised a multi-disciplinary team including universities and private organisations to develop a City Energy Plan to reach or surpass the goals set by the European Union in terms of reducing CO_2 emissions, reducing energy consumption and generating energy from renewable sources. The plan includes an energy audit together with a very advanced and comprehensive energy monitoring system; a list of specific actions for implementation as well as proposals for new laws, incentives and regulatory frameworks.

Targets and actions included:

Driving carbon reductions:

- Set target to exceed the goals fixed by the EU in terms of CO_2 emissions, energy saving and renewable energy production;
- Installed a 24MW solar photovoltaic plant; and
- Converted conventional cars into hybrid solar vehicles.

Energy strategy:

- Prepared an extensive City Energy Plan covering: street lighting; buildings; urban planning; water savings, water catchment and management; mobility through smart traffic lights and incentives for car-pooling, use of bicycles, park and ride; and improved waste recycling and re-use;
- Developed the Plan with input from many experts from the university – there is a strong link between universities and researchers and the City of Salerno to ensure researchers are able to help policy makers better define energy initiatives and what is effective, sustainable and feasible; and
- Used mathematical modelling to prioritise actions.

Knowledge sharing:

- Adopted a multidisciplinary approach, bringing together a team of experts within the City Energy Plan including City of Salerno Energy Office, many researchers and departments of the University of Salerno, University of Naples and also private consultants etc.

Promoting carbon saving:

- Promoted energy efficient appliances.
- Initiated 'Solidarity Purchasing Groups' – to help consumers build PV gazebos on their roof and install highly insulated windows.

Engagement:

- Ran a display campaign to monitor energy and water consumption in schools – clear visuals, easy to understand.

<u>Freiburg (Germany)</u>

Freiburg has a history of environmental awareness stretching back to the 1970s and the municipal government, Stadt Freiburg, already adopted an ambitious and long-term carbon emissions reduction target in 1996 (25% by 2010, 1992 baseline). Although it did not achieve this target the city has continued to set itself new targets and deliver practical projects and schemes. Activities include:

Knowledge sharing:

- Private and state research into renewable energy generation, organic farming, climate science, sustainable forestry etc.
- Since 2010 City of Freiburg has been making the ECOfit programme available to companies – this trains companies on environmental management issues in workshops and on-the-spot teaching events.
- Hosts international events and has an international reputation for solar engineering, traffic and transport policy.

Exemplar:

- Renewable energy: zero emission hotel, solar panels on Bedenova football stadium roof, City Hall, schools, churches, prison as well as private houses.
- Transport – strong local centres along main transport routes, all major urban development decisions are subject to overriding principle that traffic must be prevented, 420 km long cycle network, lots of pedestrian zones.
- 12,000 employed in environment management and science.

Promote carbon saving:

- 'Energy Efficient Restoration' – grants of 450,000 euro for the restoration and renovation of old buildings.
- Waste avoidance is rewarded by a system of financial incentives – grants for textile nappies, discounts for collective waste disposal schemes and for people who compost their green waste.

Communication campaigns:

- Targeted public awareness campaigns have been launched to mobilize the city's residents. The CO_2LIBRI and CO_2 Diet climate campaigns call on all Freiburg's residents to play their part in cutting CO_2 emissions. The successful series of events entitled 'Sustainability as the Art of Living' lives on in the project '200 Families Proactively Protecting the Climate'. For a whole year, Freiburg residents can experiment with creating greater quality of everyday life through climate protection, fitting them out to be ambassadors for sustainability.

Engagement and education:

- Lots of events run through 'Freiburg's Agenda 21',
- Various venues that promote sustainability including Freiburg Planitarium and Freiburg Eco-station.
- Lots of university courses as well as a 'Solar University'.

Brighton & Hove, UK

Brighton & Hove is the world's first endorsed One Planet City. In 2013, the city's Sustainability Action Plan received accreditation from sustainable development pioneers BioRegional for its plans to enable residents to live well within a fairer share of the earth's resources (Brighton & Hove City Council, 2013). One Planet Living is a model based on ten simple principles (Zero Carbon, Zero Waste, Sustainable Transport etc.) which provide a framework to make sustainable living easy and affordable (BioRegional, 2014).

The action plan is supported and scrutinised by the City Sustainability Partnership, an independent body bringing together business and civil society leaders working to promote the sustainable development of the city.

Targets include:

- A 42% reduction in CO_2 by 2020 and an 80% reduction by 2050, from a 2005 baseline
- By 2025, 70% of domestic waste by weight will be recycled or composted
- Reduce the element of the ecological footprint related to food from the current level of 1.43 global hectares per person to 0.67 by 2025
- Reduce flood risk to homes vulnerable to surface water flooding

Achievements so far include:

- Securing UNESCO World Biosphere status for the Brighton & Lewes Downs (in partnership with neighbouring local municipalities and organisations)
- From 2015 a **Low Emissions Zone** in the city centre will contribute to improved air quality
- Supporting community groups in the city, for example Brighton Energy Co-op raised £500k (€625k) (for a 500 kWp solar photovoltaic plant, having already installed 500 kWp previously

Copenhagen, Denmark

Copenhagen aims to be the first carbon neutral capital city in the world (City of Copenhagen, 2012) and was designated the European Green Capital for 2014. An estimated 75% of the CO_2 reductions will come from initiatives in relation to the city's energy system mainly involving an increase in the share of renewable energy in the City's district heating (EC, 2014c).

A large offshore wind farm was built just off the coast of Copenhagen, producing about 4% of the city's power. Planners took on the challenge of potential public resistance by giving the local community an interest in the project. The wind farm is run by a cooperative, half owned by the city, and half by almost 9,000 small investors (EC, 2013).

This will be achieved via a number of initiatives including:

- An ambitious retrofit strategy for the city's buildings
- Building 100 new wind turbines by 2025
- 60,000 m^2 of solar panels will be installed on both existing municipal buildings and on new build
- Aim for 75% of journeys to be by bike, walking or public transport
- Improving flood defences to adapt to predicted future sea level rises

Siena, Italy

Siena has made a commitment to become (net) carbon free by 2015 and achieved this by 2013, largely due to excellent geothermal energy resources. However the municipal government, Comune di Siena, has also undertaken a number of projects and initiatives to help reduce emissions and communicate with its citizens (Terre di Siena Green, 2014).

Reporting:

- First province in Italy to earn the Environmental Certification ISO 14001 and ISO 14064/1 Certification for GHG Emissions Balance.
- One of the first provinces in Italy to obtain EMAS registration because of its will to communicate its activities for environmental improvement.

Driving reductions:

In 2001, the municipality started an in-depth study of the region calculating ecological footprints and lifecycle analysis in partnership with Siena University.

- Aimed to become net carbon free by 2015. Succeeded in 2013, largely due to good geothermal resources.
- Energy audits have been carried out to all of the municipality's real estate
- Siena province consumes 1,334,000 MWh. They generate 1,386,000 MWh through renewable sources, 97.6% through geothermal, 2.1% through PV and 4.2% through biomass and waste.
- New energy efficiency standards for buildings were introduced.
- Improved boiler controls - homes are normally heated by individual boilers and Siena Province are responsible for ensuring the plants are running efficiently. They are carrying out checks to ensure efficiency which will save 30,000 tCO_2 per year.

Promote carbon reductions:

- Promote PV installation through a radio and TV campaign and provide funds to incentivise their installation (up to 20 kWp).
- Public and private entities that use energy from renewable sources, reduce consumption and 'undertake environmentally sound practices that reset CO_2 emissions' can use the brand "Terre di Siena carbon free 2015" to give a sense of belonging.

Sharing knowledge/engagement:

- The regional government, Provincia di Siena, releases brochures and reports on specific topics and holds events such as Energy week to communicate their environmental work. It also uses TV/radio campaigns, brochures and meetings to try and reach everyone in the province.

<u>Bristol, UK</u>

Bristol was designated the European Green Capital for 2015 and is developing a comprehensive strategy covering 12 areas including energy, transport, waste, economy and wildlife. This is being developed with the independent Green Capital Partnership which consists of over 500 local organisations committed to greening the city.

- Ambitious targets to reduce energy use by 30% and CO_2 emissions by 40% by 2020 and 80% by 2050 (from 2005 baseline).
- €100m investment programme in energy covering public and private buildings.
- Was designated the UK's "Cycling City" in 2008, with ambitious plans to improve cycling rates in the city.
- Reducing council travel CO_2 emissions by 32% through improved staff awareness and driver training, business travel planning, more efficient vehicles (Bristol City Council, 2013).
- Developing a 6 MW wind energy project on council owned land at the industrial port area.
- Supporting community energy groups in developing the UK's first community energy strategy (Bristol Energy Network, 2013).
- Supporting green open homes organisation Bristol Green Doors, which allows people to visit homes that have implemented energy saving measures.

Applicability

This BEMP is applicable to all municipal and regional governments across Europe

Economics

As a minimum this BEMP requires staff time and promotional costs. However, much of this should fall within existing budgets. Individual projects are usually subject to cost-benefit analysis and many projects generate significant financial benefits or help achieve strategic aims for the authority (such as job creation).
For example, City of Copenhagen's total cost reducing energy consumption in buildings in Copenhagen is expected to be at least €22.8m up to 2025. However, there will be a total economic saving of about €210m by reducing heat consumption by 20% and electricity consumption by 20% respectively in companies and 10% in households (City of Copenhagen, 2012).
Bristol City Council's Strategic Energy Unit received €3m European Investment Bank funding to deliver energy saving and renewable energy measures in the city, with a requirement to secure 25 times the funding in external investment to finance the projects. Some of the projects will reduce the council's own energy consumption, delivering direct financial benefits.

Driving force for implementation

There can be multiple reasons for public administrations wishing to be exemplary. These may be political (a desire for the governing party/parties to show that they are achieving the public's ambitions), or to foster a sense of civic pride in its citizens. However, possibly the most important reason is that the administration may have commitments in the following areas and cannot achieve them without engaging the wider community.
These include:

- Carbon reduction commitments
- Reducing costs
- Mitigation against rising energy costs
- Improving the local economy (green jobs)
- Reducing poverty
- Reducing vulnerability to climate change impacts
- Improving health (e.g. via improved air quality from reduced transport)
- Reducing waste

Reference organisations

Provincia Autonoma di Bolzano/Bozen, Italy
The Autonomous Province of Bolzano/Bozen in Italy refurbished the public building "Ex-Post" to PassivHaus standard, the first public building in Italy to do so (PLEA, 2008).

Brighton & Hove City Council, UK
One Planet City

Bristol City Council, UK
European Green Capital 2015

City of Copenhagen, Denmark
European Green Capital 2014, aiming for carbon neutral by 2025

Stadt Freiburg, Germany
Green City

Provincia di Siena, Italy

Carbon free by 2015

Comune di Salerno, Italy
Energy strategy and public engagement

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3.4.2 Information and advice services on sustainable energy for citizens and businesses and public-private partnerships

Description

Local government has a unique role in that it is responsible for multiple issues that affect people's lives, whilst having a more direct relationship with citizens than does central government. This gives local government the opportunity to deliver schemes which have multiple benefits, for example in terms of public health, carbon saving and job creation.

Items covered within this BEMP, and applicable in an EU-wide context, include:

- Strategic partnerships to involve the wider community in the development and delivery of carbon reduction schemes;
- Information and advice services to help residents reduce their energy consumption;
- Public-private energy-related projects/schemes; and
- Low carbon pilot projects.

Stakeholder engagement is not included in this BEMP as this is covered in BEMP 3.4.1.

Local governments have a unique connection with citizens. They are non-commercial, which means the information they provide and the projects they deliver are generally trusted. They have certain responsibilities and statutory obligations towards their citizens. This gives them the opportunity to deliver services and projects which otherwise would not be provided. Although regional and national governments share some of these responsibilities they lack the local presence and accountability of local government.

Strategic Partnerships

One of the most important factors in delivering a municipality-wide scheme is having a strong strategic partnership with local organisations and institutions. Local government often doesn't have the street-level understanding to successfully deliver schemes without the support and insight of organisations like neighbourhood associations and community groups. Even though local government is generally trusted by people, there is additional value in hearing information from one's neighbour or at a regular meeting place.

Strategic partnerships generally:

- Share information between public, private and community sectors;
- Provide a means to address cross-sectorial issues and opportunities;
- Provide a forum for communication between organisations, and between the organisations and the general public
- Allow the wider municipality to hold the authority to account over its commitments

Potential strategic partners include charities, religious communities, community centres, business associations, sport clubs and other communities of interest (social clubs). In cases where there is no local organisation in a given sector, local government can adopt a supportive role - bringing together local people and helping them with resources and advice for institutional development and capacity building.

Strategic partnerships need to be accountable for the use of public funds and effective in the delivery of project activities. Arrangements for good governance can include:

- A board containing members of the partnership, often including representation of local government
- A chair/coordinator
- Regular meetings
- Workshops involving members and other stakeholders
- Engagement with the general public (for example through a website or social media)
- Working groups for particular topics, e.g. transport, energy

For example, the "Munich for Climate Protection" partnership has the following structure:

Table 3-26: Munich for Climate Protection structure

Role	Description	Responsibility
Chair	Facilitate the activities of the partnership, represent the partnership publicly.	Mayor of Munich
Coordination	Ongoing management of the partnership activities	Department of Health and Environment
Administration	Membership management	K. GREENTECH GmbH / PICS GmbH
Development	Develop projects and actions within the partnership's remit	Club members and working groups

Other partnerships, e.g. the Bristol Green Capital Partnership, have a chair that is not a representative of the authority.

It is important that the partnership includes but is independent of local government, so that it can hold it to account on its commitments and provide continuity when local government changes political control. However it is also essential that authority involvement is included, since it has in-depth knowledge and major influence over many aspects of the municipality.

Successful partnerships encourage the involvement of organisations and individuals from across the spectrum of civil society, including business, non-profit organisations and activists. A common theme such as "climate protection" or "Green Capital" provides an opportunity for these organisations to work together.

Information & Advice

The most basic service local government can provide is information and advice. This can be in response to a change in the law or local regulations, or as part of an environmental improvement campaign.

For example Barcelona made it compulsory to use solar energy to supply 60% of running hot water in all public and private new buildings, renovated buildings or buildings changing their use. In order to disseminate information and advice about this change in regulations, the Council worked with Neighbourhood Associations and building associations to educate people on how to measure their energy savings and keep the systems maintained. It also opened a public information centre where people can get information and advice on solar panels. (NYC Global Partners, 2011)

Information and advice can also include free household audits or lifestyle surveys. This can help individuals and businesses understand what services they are eligible for, for example free insulation or additional benefits. It is also a way to disseminate useful tips on behaviour change at the same time. For example, Leicester (UK) offered free audits to local SMEs (small-to-medium sized enterprises) and access to grants for energy-saving measures, funded by national government grants. (Leicester City Council, 2013)

It is important to identify the optimal time and situation to provide information and advice. For example, people applying for a construction or renovation permit are likely to be more receptive to information about energy efficiency measures. Such information is also unlikely to be effective in warmer months, because residents are not thinking about this issue and won't be able to put the advice into practice until the heating season. (UNECE, 2013)

Public-private energy related projects/schemes

It is often impossible for local governments to deliver schemes beyond information and advice with their own resources. Retrofit and renewable energy projects require specialist knowledge that local governments do not have. It is logical to partner with private organisations with those skills that can help deliver the project. This can be a commercial or a non-profit organisation.

For example, the public authority would generally provide:

- Initial publicity and facilitation of links with citizens;
- Quality assurance;
- Finance (or facilitate the financing); and

- Project management of the delivery partners.

The private organisations would generally provide:
- Expertise in the subject matter;
- Delivery of the project (e.g. installation); and
- Private finance.

For example, the London Borough of Sutton supported a pilot project to deliver retrofit to private households via ‘soft’ loans (low interest or non-commercial repayment terms). They partnered with national DIY retailer B&Q who ran the project, delivered the surveys and installations. The local authority managed the finances and loan system (the funds were supplied by central government). Sustainability charity BioRegional supported the project with advice, monitoring and evaluation. In this case the private partner project-managed the scheme, but the funds could only be accessed by the municipality. (BioRegional, 2011)

Low carbon pilot projects
Local government is also in a unique position because it does not have to make a profit and can invest in less commercial ideas. Pilot projects can help develop an idea, which, if successful, can be replicated in other areas. With regards to public authority pilot projects, the ideas generally involve property or infrastructure under its responsibility, e.g. road infrastructure, bus stops, public buildings.
Finance and delivery of the project is often via a private partner, however pilot projects differ from the public-private schemes detailed above in that they involve unproven concepts or technologies. The backing of local government is often crucial to the scheme gaining funding because the risk is reduced for the funders or project partners.
For example, Barcelona delivered a pilot project for solar-powered bus stops to provide bus times and information. This was in partnership with a private design company and a higher education institute. The pilot started with 100 bus stops, with plans to expand to 2,000 across the city.

Achieved environmental benefits

Since every project has different aims, benefits can vary significantly. Some example benefits are:
- Barcelona has saved 70,000 MWh per year, increased the surface of solar thermal square meters in the city from 1.1 m^2 per 1000 inhabitants in 2000 to 59 m^2 in 2010 due to its changed policy and information campaign (NYC Global Partners, 2011).
- A biogas cooperative set up by farmers and supported by Beckerich municipality in Luxembourg provides heat and electricity to householders. Combined with a wood incinerator supplied with waste wood from local forests, the town now supplies 90% of its electricity and 30% of its heat from low carbon sources, as well as delivering lower bills (around €500 saving) to consumers (Covenant of Mayors, 2012).
- Saerbeck in Germany decided to become self-sufficient in renewable energy and reach a positive energy balance by 2030, and through a cooperative with citizen membership to install 29 MW of renewable energy the municipality reduced CO_2 emissions per capita from 9.9 tCO_2 to 5.5 tCO_2 (Climate Alliance, 2014b).

Appropriate environmental indicators
- Delivery of information and advice services (Y/N)
- Support of low carbon pilot projects, e.g. through public-private partnerships (Y/N).

Cross-media effects

This BEMP is relatively broad in scope and examples of best practice are varied, so there are no specific negative impacts on other environmental pressures. Individual schemes and projects may have possible negative impacts. For example if an incentive scheme inadvertently encourages people to take action which impacts on other environmental issues. Careful thought should be given to incentive schemes and the possible negative impacts.

Operational data

Barcelona, Spain

Barcelona is the first European city to have Solar Thermal Ordinance (STO) making it compulsory to use solar energy to supply 60% of running hot water in all public and private new buildings, renovated buildings or buildings changing their use. Barcelona Energy Improvement Plan (PEMB) ran from 2000-2010 and covered regulations, financial aid for facilities, training and education programs. The revised plan for 2011-2020 is the Energy, Climate Change and Air Quality Plan for Barcelona and involves projects both related to technological improvements and awareness raising measures (NYC Global Partners, 2011).

Information/advice

- To ensure people are educated on the use of their solar panels, the Council has been running education campaigns – working with Neighbourhood Associations and building associations to ensure people know to measure their energy savings and check the panels are working.
- The Environment Department has an information centre open 6 days a week where people can get information on solar use and maintenance.

Public-private partnership/Low carbon pilots

- Barcelona Metropolitan Transport Department sponsored the development of solar powered bus stops in partnership with CAPMAR, S.L., a private design company and the Investigation and Education department of the Istituto Europea di Design Barcelona.
- The solar bus stop scheme initially started with 100 bus stops in Barcelona but has since expanded and replaced 2,000 bus stops with the new solar model.

Benefits

- The city has saved 70,000 MWh per year of fossil fuel consumption, increased the surface of solar thermal in the city from 1.1 m^2 per 1,000 inhabitants in 2000 to 59 m^2 in 2010.

Provaglio d'Iseo, Italy

Public-private partnership

Using government subsidies for solar photovoltaic panels, the municipality of Provaglio d'Iseo in northern Italy partnered with a local bank to provide free solar panels to local residents. In exchange for lending the municipality use of their roof, the residents receive a 50% reduction in their bills and the municipality receives the subsidy which allows it to service the loan from the bank. After twenty years, the ownership of the plant and the benefit of all of the generated electricity reverts to the families themselves. Assuming a 30 year life-span for the panels, this will save them an additional €14,000 (Corriere della Sera, 2007).

The driver for this project was a local plan supported by the municipality which contained a strategic environmental assessment, with targets to reduce the area's use of fossil fuels and CO_2 emissions (Provaglio d'Iseo Council, 2005).

Picardie, France

Incentive scheme

The Picardie Region of France launched a zero interest loan scheme for energy efficiency improvements in partnership with local banks. The main aims of the scheme were to:

- Achieve 30% reduction in heating consumption, saving approximately €300-350 per year per household

- Stimulate the insulation market in Picardie and generate €100m in work for local building companies

The loan scheme was aimed at tenants and owners for energy efficient insulation works. Residents could apply for up to €6,500. The individual sends their application to the bank with the seal of the company who will complete the work. The bank replies in 48 hours and pays the company directly when the work is finished. The individual pays off the loan but Picardie Region pays off the interest. The first phase of the scheme enabled €18m of works to be completed, at a cost of €1.2m to the region. The scheme was then expanded, generating over €100m in work at a cost of €10m to the region (FEDARENE, 2010).

Beckerich, Luxembourg

Public-private partnership

Beckerich in Luxembourg aims to become energy self-sufficient by 2025 and has undertaken a number of projects to do so.

In 2004, 19 farmers founded a biogas cooperative, treating manure to produce energy. The total investment amounted to €5m 50% funded by the Ministry of Agriculture and 50% financed by a loan. The municipality buys the heat produced and resells it to the citizens. In 2010 the municipality was able to raise €400,000 by selling heat, while each family saved around €500.

In 2008, a wood incinerator plant for heat energy was created as another alternative energy source. The wood comes from the 700 hectares of Beckerich's forests, out of which 400 hectares belong to 260 private owners. The municipality developed an exchange system based on a 15-year contract with forest owners who benefit from a discount on their energy bill in exchange for providing wood to the incinerator. Friendly prices were set for low-income households so that every person can access the system.

What makes Beckerich's alternative-energy solutions so popular is the fact that they meet several objectives at the same time: there is a reduction in CO_2 emissions, jobs are created at the local level and money re-injected in the local economy.

In addition, the long-term vision and ambition of the authority has led to a decrease in electricity use (compared to an increase in the rest of the country) and 15% of the municipality's households installing renewable energy or additional energy efficiency measures (Covenant of Mayors, 2012).

Munich, Germany

Strategic Partnerships

Munich for Climate Protection is a partnership between the City of Munich authority and local members committed to reducing the city's impact on the environment, including major companies and NGOs. A number of projects have been developed such as "Climate Friendly Oktoberfest" which encourages local hotels to adopt measures to reduce their and their guests' carbon footprints. Measures include energy auditing, advice on renewable energy and electric scooters. (München für Klimaschutz, 2014)

Incentive schemes

Munich has for many years been funding energy efficiency in private and commercial buildings. Subsidies cover a wide range of measures such as building insulation, heat generation and solar thermal systems. Investments triggered by the programmes are ten times higher than the subsidy input, and CO_2 emissions have dropped (Climate Alliance, 2014a). Grants are combined with loans from banks and national energy efficiency schemes.

Eligible measures include (Munich Portal, 2014):

- Establishment of energy retrofit schemes
- Thermal insulation of exterior walls of dwellings with and without exchange of lying in the outer wall surface of window.
- New construction or retrofit to PassivHaus standard (residential and commercial use)
- New connections to district heating networks
- Solar thermal systems

Vienna, Austria
Information and advice
The Wien Energie Haus is a joint initiative launched by the three utility companies owned by the city of Vienna. The programme provides assistance in energy matters adapted to customer needs and the services required, for example hot water, light or heat. The Wien Energie's customer care centre does not first and foremost sell the energy provider's products, but conveys the energy-political objectives of the City of Vienna. Running the centre costs €1.9m per year, which are part of the city's budget, some of which is recouped through providing services such as Energy Performance Certificates.
Energy counselling is free of charge and constitutes an essential element in the push to a resource-minded, cost-efficient and environmentally-friendly energy supply. Assistance is youth-oriented and aims to make young people aware of how to use valuable energy sensibly. The exhibition includes real-life situations where people can actually feel how simulated winter conditions affect different types of windows. Customers are made aware of differences in quality and technical problems such as condensation; they can measure for themselves the different inside surface temperatures. By 2011, a million visitors had been to the centre (Wien Energie, 2011).

Applicability

This BEMP is applicable to all municipalities across Europe

Economics

The costs and benefits of these schemes are varied, but generally they require staff time to coordinate and deliver projects. Additional finance is often gained through grants and loans for each project. A public authority may have funds available for local pilot or community projects which can be used for these schemes.
In general, public advice schemes will incur a cost to the authority – possibly already budgeted for – but private-public partnerships will have their own cost-benefit analysis and often involve additional external funding. The authority may wish to contribute financially where the project meets its objectives.
Although some incentive schemes cost the authority significant sums, they can leverage significant additional funding. For example, the Picardie incentive scheme cost the authority over €10m, but delivered €100m in overall investment, which was mainly spent with local businesses, providing a boost to the economy. Similarly, the Munich incentive scheme triggered investments over 10 times the initial subsidy (Climate Alliance, 2014).

Driving force for implementation

Public authorities have a duty to their citizens to provide information and advice about current legislation and policies. Local policy changes also need to be communicated.
In addition to these responsibilities, public authorities have obligations to reduce carbon emissions and poverty. It is not possible to achieve these aims without involving the wider municipality, and the authority will not have all the required knowledge and expertise to deliver the necessary actions.

Reference organisations

Barcelona, Spain
Barcelona was the first city in Europe to implement Solar Thermal Ordinances

Beckerich, Luxembourg
Public-private partnerships to help Beckerich become energy self-sufficient by 2025

Munich, Germany
Strategic Partnership between the City of Much Authority and local members commuted to reducing the city's impact on the environment.

Picardie, France
Incentive scheme for energy efficient improvements in partnership with local banks

Provaglio d'Iseo, Italy
Public private partnership to subsidise solar photovoltaic panels

Vienna, Austria
Information and advice initiative between three utility companies owned by the city of Vienna.

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Covenant of Mayors (2012). *30 years working towards energy self-sufficiency*. Available at: http://www.eumayors.eu/IMG/pdf/Beckerich_Case_Study_Covenant_Mayors-1-2.pdf [Accessed 13 August 2014]

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3.4.3 Thermographic surveying of municipalities' built environment

Description

Municipalities have an opportunity to enable large-scale energy efficiency efforts on the territory under their responsibility, both by prioritising their own efforts and also through the action of the citizens and businesses living and operating in the area.

One of the ways to enable these performance improvements is to understand how the built environment is a source of energy loss and where energy efficiency solutions need to be deployed as a priority. Thermography is a tool which enables the collection of data at various scales and provides visual information on "hotspots" of heat radiation, highlighting potential inefficiencies.

Principle of thermography

Current thermographic methods use infrared (IR) cameras to record the differences in heat radiated by different landscape features, such as buildings, paved roads (covering piping) and light fixtures. The images provided by the IR cameras provide a picture of temperature differences against the background. For this reason, thermography when used to detect energy leakages is used in winter when ambient air is cold, buildings are heated and the temperature contrast between the two is high.

Following the collection of infrared camera images, the data is then processed to produce images of buildings with a colour scale to illustrate the intensity of temperature differences and therefore (Axelsson, 1988) heat loss. When image capture is aerial, the data can be superimposed on a map of the territory. The main output of the thermographic survey will then be (literally, in this case) a "heat map" of a geographical area where the location of heat losses (hinting typically at poorly insulated buildings) can be visualised instantly. Buildings can then be outlined for further analysis; a typical example is provided below:

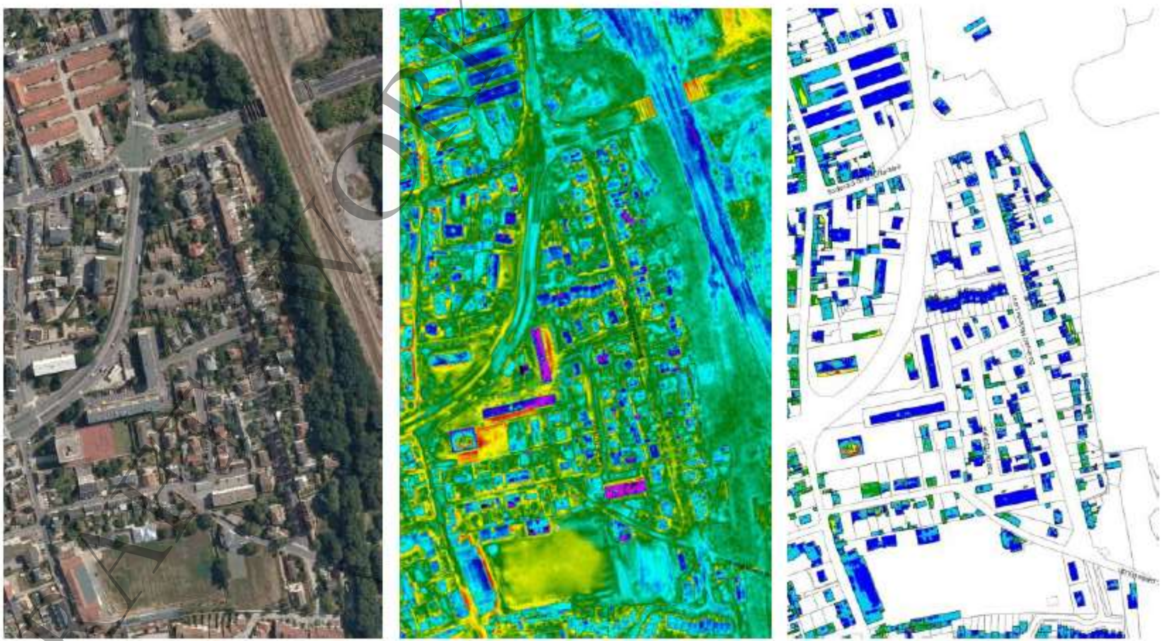


Figure 3-42: example of thermographic mapping output (source TCC sas). Left: satellite picture; centre: thermographic map; right: processed buildings map

Further data processing can then be used to complement the thermographic data, e.g. to include further relevant cartographic features allowing the interpretation of the data or the illustration of specific phenomena (heat distribution networks, fuel poverty…).

Application and options
Thermographic data can be collected using different methods, usually yielding complementary results. In particular two main surveying methods can be highlighted, land-based or aerial thermography. Land-based methods are preferable for smaller areas (e.g. streets inside a neighbourhood) and will provide information about building facades as well as building roofs (e.g. if the collection equipment is equipped with extension poles). They can be used to provide finer information about a group of buildings.

Figure 3-43: example of land-based thermographic imaging (source TCC sas)

Aerial thermography allows the collection of data from above and will provide imaging for building roofs. However, a roof typically represents 25-30% of the energy losses of a building and aerial thermography will provide a good initial hint for further investigation of a built area. While individuals and businesses can invest in the thermal photography of their own building to audit their insulation, from a municipality's perspective, aerial thermography will provide an overview of the whole territory and achieve economies of scale by providing data for a whole town and enabling comparisons between different areas in the same territory. This will in turn enable informed policy- and decision-making.
Aerial surveys can be conducted using various methods including tethered balloons (aerostats), drones, helicopters, or airplanes.

Thermography is only the start
Once the thermal imaging has been performed, the data can be used as a basis for energy conservation efforts: however as thermal imaging will not improve environmental performance in itself, the tool is only as good as the follow up action that will be undertaken on the basis of the diagnosis. The following key actions can be taken to build on the output of a thermographic survey:

Direct impacts:
- diagnosis of energy efficiency/insulation of public buildings (see BEMP 3.2.2)
- diagnosis of the insulation of district heating and cooling networks (see BEMP 3.2.6)
- diagnosis of the efficiency of street lighting (see BEMP 3.2.1)

Indirect impacts:
- Awareness raising campaigns (see below)
- Communication on the municipality's broader efforts in terms of energy efficiency

Policy actions:
- Encourage energy efficiency actions to tackle the issues highlighted by the thermography, e.g. provide counselling on insulation, subsidise insulation projects
- Identify and address risks of fuel poverty. Economic and geographical data (e.g., "heat maps" of median household income by neighbourhood) can be combined with thermographic data to help assess the areas where risks of fuel poverty are high and design policy actions. To identify risks of fuel poverty, care must be taken to assess a variety of cases e.g. households where energy costs represent a large part of the budget because they cannot afford insulation investments with long term paybacks (which will show up 'red') or households who simply cannot afford to heat their dwellings (which will show up 'blue'). A simple reading of the

thermographic map will not provide this kind of essential information and further analysis by social services is generally warranted.

The major steps to be followed in a thermographic survey project are depicted below:

Figure 3-44: simplified steps for carrying out a thermographic survey

In this context the importance of the follow-up communication campaign that will be led to share the results of the actual survey is paramount, as it will leverage individuals and businesses to deliver the largest gains in terms of energy efficiency.

Communication and information strategy

The output of the thermographic survey is a very valuable communication tool in an outreach effort to raise awareness regarding the municipality's energy efficiency. In particular it offers:

- Technical information in a user-friendly and visually appealing format
- Global (town level) trends as well as individual information on a citizen's own house / office

Maximum value can be derived from the data if adequate technical and economic information or counselling from engineers or trained municipal staff can be provided to assist in interpreting the data and taking action to address any identified issue. This counselling should ideally include advice also on financing and subsidies/tax breaks that are available (at local but also e.g. national level) to implement energy efficient solutions. This aspect of the follow-up can in fact represent a much larger budget than the thermography itself, even when the latter is carried out aerially.

The dissemination of thermographic data will also be much more effective if it is part of a broader, communication effort on the challenges of climate change and energy efficiency (see Chapter 13) and the municipality's coherent strategy to tackle these aspects (see BEMP 3.1.2).

Practical dissemination of the information can take many forms, e.g. workshop / information sessions; dedicated helpdesk in town hall offices or dedicated venue, staffed by trained advisors; online tool, presenting the global data for the entire town but also allowing a personalised search by address (example opposite).

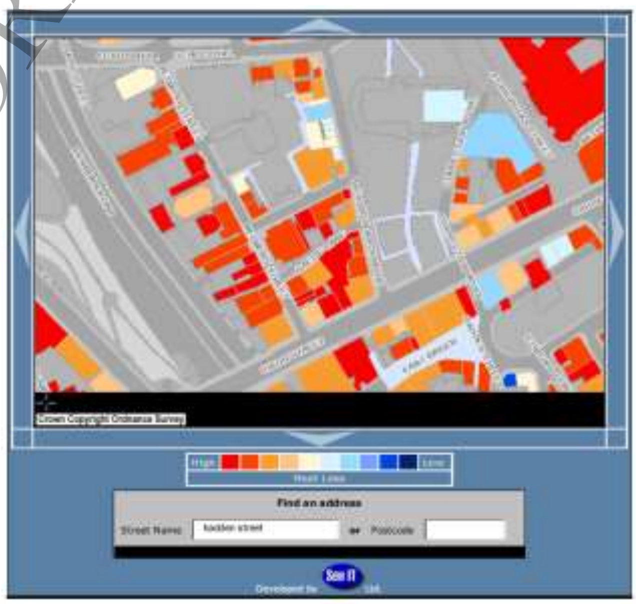


Figure 3-45: zooming on an individual address for survey results (Aberdeen city council, in (CSE, 2004)

Some aspects of this BEMP are further elaborated in a number of related BEMPs. For further information please see Sections:

3.1.2 Enacting a sustainable Energy Action Plan
3.1.3 Establishing an inventory of energy consumption and emissions of the territory of a municipality
3.2.1 Implementing energy efficient street lighting
3.2.2 Improving the energy efficiency of public buildings

3.2.3 Improving the energy efficiency of social housing
3.2.6 Implementing district heating and/or district cooling networks
Chapter 13 Environmental education and dissemination of information

Achieved environmental benefits

This technique is an energy auditing / diagnosis tool which will not achieve environmental benefits in itself.

The benefits will be derived from action taken both at the local government and individual level to tackle the energy efficiency issues highlighted by the survey. For this reason it is important to consider thermographic surveys and the valuable data that it can provide as part of a broader strategy and policy approach to energy efficiency and energy conservation (see BEMP 3.1.3).

Appropriate environmental indicators

- % of the built area of the municipality covered by thermographic surveying

- potential energy savings identified (kWh / heating season) (or €/heating season)

The potential energy savings (see Economics section below) can be estimated by integrating the thermographic outputs (W/m^2) over the surface area.

Cross-media effects

The potential cross-media effects for this technique are low. As for any awareness campaign the message has to be formulated carefully to avoid any backfiring in citizens' behaviours (e.g., residents of a building or neighbourhood which has been displayed as good-performing on the global map could relax their energy conservation efforts).

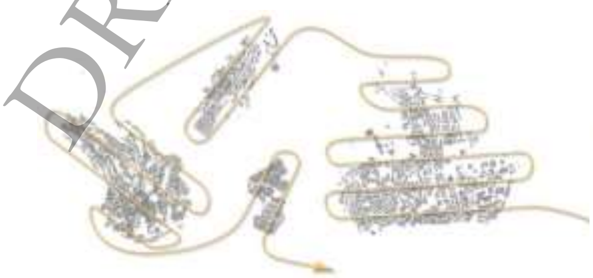
Operational data

Details on the data collection methodologies:

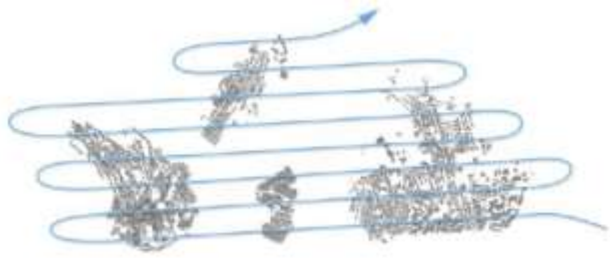
IR data is usually collected in the 0.2-20µm range, allowing a relevant reading of the temperature ranges to be considered in normal heat requirements of residential and office buildings.

For aerial thermography, precision can be adjusted according to the requirements, with typical definition in the 20-30cm range for aerial surveys (carried out at 500m-1000m altitude).

The choice of instrument (drone, aerostat, aircraft…) should be determined according to the needs, in particular the total surface area to be covered, the clusters of built-up area to be covered, topographical configuration etc. The following figure illustrates the difference between aircraft flight patterns.



Helicopter flight pattern



Aeroplane flight pattern

Figure 3-46: choice of surveying methods: flyby patterns for different aircraft. Source TCC sas

Regarding the output data, different grades of raw and processed data can typically be obtained from a survey campaign.

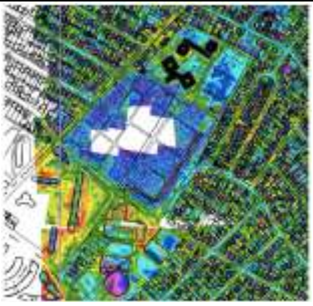
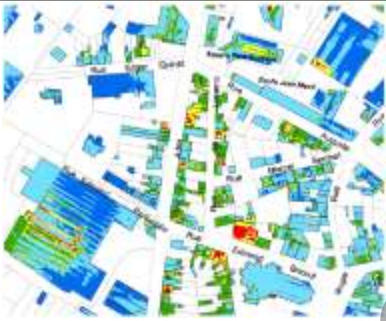
 Raw data (raster map)	 6-color heat loss map	 256-color emissivity (W/m^2) map

Figure 3-47: examples of thermographic mapping output (aerial survey). Source: TCC sas

For instance, one contractor produces, in addition to raw data, basic or fine definition maps which can help precisely locate insulation problems such as thermal bridges at the level of individual buildings. Other mapping features are available such as integration in Google Earth data for web-accessible interfaces.

Applicability

An essential constraint of the technique are the operational conditions in which the thermographic survey itself has to be carried out (most importantly, only in winter) and under specific circumstances. In particular the following conditions have to be met:

- Maximum 5°C outside temperature (to enhance the temperature contrast with built surfaces)

- Dry weather for the past 24-36 hours and <75% relative humidity

- For aerial surveys, flyby in the early morning (between 6am and 9am)

- ideally, low wind speeds

Economics

Costs

Preparatory studies will outline the needs and appropriate scale for a thermographic survey, which will in turn determine the scale of costs to be considered. Land-based surveys involve the utilisation of specialised equipment and trained specialists for a few hours to a few days, plus the additional costs of specialist data processing.

Aerial surveys (with manned aircraft) will be a larger-scale and more expensive option. Dourdan (FR, pop. 10'000) spent 14.5k€ + tax on a cartography project including some technical support to dissemination). Birmingham city council (CSE, 2004) had an aerial survey covering approximately 400,000 residential properties carried out in 2002 for 37 k£ (52 k€ then). Other documented costs from France (including also some follow-up such as data interpretation and analysis as well as dissemination, (DA, 2008;, ADEME, 2015) appear in the 100-300k€ range and rapidly diminishing with the size of the surveyed territory. For instance, data indicates 100k€ for a town of 30'000 (Aix-les-Bains); 170k€ for a town of 53'000 (Annecy); 200k€ for a town of 210'000 (Dunkerque) and 262k€ for an urban area of over 700'000 (communauté urbaine de Bordeaux).

The follow-up communication costs from the local authorities can vary widely. According to J-C Barré of TCC, cartography itself represents 30-40% of a thermographic survey budget.

N.B. Interreg financing may also be available to support thermographic surveys.

Benefits

Thermographic data collection works by measuring observable temperature differences (and heat radiation) between the built environment and the background. Therefore, the data can be processed to calculate an estimation of the loss which could be avoided if buildings were insulated well enough to radiate little or no energy. The simplified example below (data collected for the city of Aix-lesBains, France) performs an estimate multiplying each surface by its measured radiative emission level:

Table 3-27: Estimation of the energy loss which could be avoided from buildings (city of Aix-lesBains, France)

Loss range	**Ref value (W/m^2)**	**Surface (m2)**	**Loss (Wh)**	**Heating day (Wh)**	**Heating season (kWh)**
Not noticeable	**2**	**242 191**	**484 382**	**2 906 292**	**435 944**
Low	**5**	**523 121**	**2 615 605**	**15 693 630**	**2 354 045**
Medium	**11**	**369 452**	**4 063 972**	**24 383 832**	**3 657 575**
Large	**15**	**110 777**	**1 661 655**	**9 969 930**	**1 495 490**
Very large	**20**	**72 655**	**1 453 100**	**8 718 600**	**1 307 790**
Excessive	**22**	**41 156**	**905 432**	**5 432 592**	**814 889**
Total		**1 359 352**	**11 184 146**	**67 104 876**	**10 065 731**

Then, by plugging in data on energy costs, an estimate of savings can be obtained (in the example below – continued from above – 6c/kWh for gas and 10c/kWh for electricity):

Table 3-28: Money savings which could be achieved thanksto better building insulation (city of Aix-lesBains, France)

	Heating season (kWh)	**Estimate of losses (assuming gas heating)**	**Estimate of losses (assuming electrical heating)**
Not noticeable	**435944**	**26 157 €**	**43 594 €**
Low	**2354045**	**141 243 €**	**235 404 €**
Medium	**3657575**	**219 454 €**	**365 757 €**

Large	**1495490**	**89 729 €**	**149 549 €**
Very large	**1307790**	**78 467 €**	**130 779 €**
Excessive	**814889**	**48 893 €**	**81 489 €**
Total	**10065731**	**603 944 €**	**1 006 573 €**

The study concludes a rough estimate in the order of 1m € of annual energy losses at roof level for the city. N.B. reducing this loss substantially would require massive upgrading of energy performance across building.

Driving force for implementation

The technique is an enabler for energy efficiency in buildings, street lighting and district heating/cooling networks, and therefore follows the same driving forces.

The main drivers behind this technique are therefore:

- Direct savings in the operation of public buildings, lighting and heat networks

- Raising awareness across the residents and businesses of the local area

- Targeting and addressing fuel poverty

Reference organisations

- Dunkerque city council, France
- Bordeaux city council, France (makes available an online tool to look up results at individual house level: http://www.bordeaux-metropole.fr/plan-climat/thermographie-aerienne)
- Aix-les Bains, France

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4 BEST ENVIRONMENTAL MANAGEMENT PRACTICES FOR MOBILITY

Chapter structure

This chapter provides a practical look at mobility, presenting pragmatic examples of European cities that are taking steps to improve the sustainability of their transport. Each environmental management practice contains replicable measures to guide public authorities in improving their environmental performance. Firstly, an introduction to mobility in Europe is provided, followed by a technique portfolio introducing the BEMPs included in this chapter. Finally, the different BEMPs are presented in the following sections.

Chapter introduction

Environmental impacts from transportation stem from the operation of vehicles on the one hand and the implementation of infrastructure like roads, rails and airports, on the other hand. The first is usually associated with a variety of emissions – mostly noise and a variety of air-pollutants – the latter is associated with the consumption of land.

Road-traffic and other transportation are among the most important contributors to fine particle matter and NOx emissions (EEA, 2011) emitting about 8.000 gigagrams of NOx[28]. Although, private households and industrial processes contribute more emission, since air-circulation is limited, the surplus over the emission limits in urban areas is usually strongly associated with road traffic. Besides air-quality issues, noise emissions – especially from road transport – are affecting the environment in urban areas: About half the citizens in the European Union living in agglomerations with more than 250.000 inhabitants are exposed to noise levels above 55db at daytime, about 17% of the inhabitants are exposed to harmful noise-levels, also mostly originating from road transportation, during night time (EEA, 2009). Of course, transportation is also a major contributor to greenhouse-gas-emission: in 2012, up to 20% of GHG-emissions in the European Union originated from transport activities, mostly from road transport (EEA, 2014).

The infrastructure necessary for modern mobility usually consumes land, thereby destroying habitats directly, or disturbing other habitats by being an insurmountable obstacle for the local wildlife.

The transport sector allows people and goods to move quickly, efficiently and cheaply, and in doing so facilitates future prosperity. The challenge for Europe in the coming years is to create efficient, publically and commercially accessible, sustainable mobility solutions that maintain economic growth.

Statistically, the transport sector requires pressing environmental improvement, and is one of the few sectors in which the contribution to CO_2 emissions is increasing rather than decreasing.

According to the European Environment Agency, transport greenhouse gas (GHG) emissions went up by around 34% between 1990 and 2008 - in contrast, between the same period energy industries reduced their emissions by about 9% (EEA, 2014).

Part of the reason for the high emission levels is the sector's reliance on fossil fuels (the majority of the world's petroleum reserves are utilised by transport). In the EU, 96% of energy for transport depends on oil and oil products. 84% of oil used in the EU is imported, costing around €210 billion annually. This reliance brings correlative energy security and scarcity issues.

The intensive use of fossil fuels releases harmful vapours such as nitrogen dioxide (NO_2), carbon monoxide (CO), and sulphur dioxide (SO_2), pollutants such as Particulate matter, as well as GHGs including carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). These emissions can result in serious health consequences (Mcnair, 2011).

Congestion is a major barrier to efficient transportation and a problem intensifying in severity. In cities such as London, Brussels and Amsterdam, drivers spend over 70 hours on average

[28] http://www.eea.europa.eu/data-and-maps/data/data-viewers/air-emissions-viewer-lrtap

stuck on roads in traffic. Cities across Europe have started to address this problem through emphasising other modes of transport over the private vehicle.

Technological, infrastructural and behavioural change

New technologies have an important role to play in the greening of transport. Innovations such as reduced emission engines, electric vehicles, compressed natural gas (CNG) vehicles, biofuel vehicles and fuel cell technology can go a long way to making our air cleaner, our cities healthier and lessening the impact of climate change. CNG vehicles produce 30% fewer greenhouse gas emissions than traditional gasoline or diesel and natural gas costs less (Durbin, 2012). Biofuels have similar benefits, with domestic production widely possible. Electric vehicles are discussed in-depth below.

The draw-back of these forms of transport is that the vehicles themselves are generally more expensive to purchase than their fossil-fuel counterparts, meaning the payback period from fuel savings can be quite long, and is contingent on high fossil-fuel prices.
Smaller / lighter vehicle size can also contribute to reduced emissions through reduced fuel consumption. It was found that a 30% decrease in weight can reduce GHG emissions by about 15% in both petrol and diesel cars. (Nemry, 2008)

Citizen behaviour is a crucial factor. Educating citizens as to the harms and benefits of various transport methods is necessary to ensure that new mobility infrastructure and technologies are properly utilised. The benefits of soft modes of transport, such as cycling and walking, as well as the disadvantages of some traditional forms (decreased air quality, high congestion levels) is important to present.
As well as lowering traffic levels and decreasing emissions levels, public transport usage can drastically influence the character of the urban area. Private vehicle use in fact leads to urban sprawl.
Intermodality is a key component in increasing citizen use of public transport. Facilitating commuters to easily and efficiently switch between integrated transport methods improves efficiency and ensures that travellers spend a larger part of their journey using public transport. Integrated travel helps public transport companies to gain a larger market share than previously possible. It also helps to create a change in public perception and a modal shift towards sustainable transport.

Technique portfolio

This chapter aims to gather a range of helpful management techniques that can be tailored for implementation within public authorities. Mobility for public administrations is an important area of influence in order to reduce the negative environmental impacts generated in the municipalities. In the following sections 9 BEMPs are presented, with the main aim of promoting public and soft transport and reducing the use of private vehicles in cities. This has the main benefit in reducing air emissions (e.g. CO_2, NO_x, particle matter) and noise in cities and consequently improve the environmental performance of the municipality and health of citizens. The case studies selected outline ways in which cities across Europe are implementing innovative environmental transport techniques.

Sustainable Urban Mobility Plans provide an excellent starting point for any public authority looking to create a more environmentally friendly mobility strategy. This should be used as the blueprint for implementing further measures outlined.

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4.1 Enacting a Sustainable Urban Mobility Plan

Description

A Sustainable Urban Mobility Plan (SUMP) is a tool for cities to create a modern, sustainable transport system. The plan should provide an integrated approach to all modes of transport whilst taking into account planning for the surrounding environment.

A mobility plan is designed to satisfy the needs of people and businesses in cities and their surroundings, whilst simultaneously building a better quality of life. It builds on existing planning practices and considers integration, participation, and evaluation principles. A successful transport policy is one that improves safety and security, reduces air and noise pollution, lowers emissions and energy consumption, improves efficiency and cost-effectiveness of transportation and enhances the attractiveness and quality of the urban environment and urban design.

A SUMP builds on the existing regulatory and policy frameworks in a municipality. It requires (Eltis, n.d.):

- A participatory approach - involving citizens and stakeholders from the outset and throughout the process of decision making, implementation and evaluation, building local capacities for handling complex planning issues, and ensuring gender equity;
- A pledge for sustainability - balancing social equity, environmental quality and economic development;
- An integrated approach – of practices and policies between policy sectors (e.g. transport, land-use, environment, economic development, social inclusion, health, safety), between authority levels (e.g. district, municipality, agglomeration, region, national, EU), and between neighbouring authorities (inter-municipal, inter-regional, trans-national, etc.);
- A focus on the achievement of measurable targets, derived from short term objectives, aligned with a vision for transport and embedded in an overall sustainable development strategy;
- A review of transport costs and benefits, taking into account wider societal costs and benefits, also across policy sectors;
- A method comprising the following tasks: 1) status analysis and baseline scenario; 2) definition of a vision, objectives and targets; 3) selection of policies and measures; 4) assignment of responsibilities and resources; 5) monitoring and evaluation arrangements.

The plan should have the positive benefit of fostering a culture amongst planners and decision makers to strive for a truly sustainable development of urban transport.

Achieved environmental benefits

The emphasis of a SUMP is in integrating and improving existing plans, creating an integrative approach to the issue. Environmental benefits include lower levels of atmospheric pollutants and GHG emissions, more public spaces, greater biodiversity and improved mobility and access for citizens.

Appropriate environmental indicators

Table 4-1: Appropriate environmental indicator - Public transport

Name	Unit of measure (type A)	Unit of measure (type A/B)	Description
Modal share of journeys	%		Survey about the % of journeys made by car, motorbike, public transport, bicycle and foot The modal share can be referred to: - systematic (work and school) or non systematic journeys; - the inner area of the city or the whole administrative area.
Passengers travelling on	number	n. public transport	Passengers travelling with urban public

public transport		passengers within the urban area/ population	transport within the urban area, disaggregated by means of transport: bus; underground, rail, trolleybus and tram
Public transport network's length	km	km public transport network/ km total street network	Length of public transport network disaggregated by means of transport: bus; underground, rail, trolleybus and tram. The length of reserved lanes could be highlighted separately.
Public transport km travelled	vehicle-km	Km travelled by public transport/ population	km travelled by all the public transport means in a year, disaggregated by means of transport: bus; underground, rail, trolleybus and tram
Accessibility of public transport	number	people living within 300 metres from public transport stop/ total population	Number of people living within 300 metres from an urban public transport stop with a minimum frequency of 15-20 minutes.
Registered cars	number	n. registered cars/ population *1,000	Number of registered cars owned by the citizens
Registered motorbikes	number	n. registered motorbikes/ population *1,000	Number of registered motorbikes owned by the citizens

Cross-media effects
There are no cross-media effects in the implementation of this BEMP

Operational data
The main phases of a SUMP are:

• Planning (process): the core of the transport plan methodology.

• Plan (content of the document): beyond providing a plan outline, this section should focus on actual examples of effective measures.

• Policy (implementation process of the plan and its final appraisal): the final element to facilitate the actual implementation of the plan.

For a SUMP to be effective it is necessary to define SMART targets. These targets should be **S**pecific, **M**easurable, **A**chievable, **R**ealistic, and **T**ime-bound. SMART targets are not solely applicable to SUMPs but are an integral part of any Environmental Management System.

It is also necessary to have a communication plan in place, to inform the public as to the changes that will take place as part of the SUMP and the reasons for this change. This can take the form of a newsletter, dedicated website, dialogue cafe and so on.

Case study 1: Creating an intermodal SUMP, Nantes, France

The city of Nantes in Southern France is widely praised within Europe for its public transport strategy. In France national legislation requires agglomerations above 100,000 inhabitants to develop a Plans de Déplacements Urbains or PDU (a French SUMP). Nantes' public transport measures have garnered awards for their sustainability - in 2009 the city won "CIVITAS city of the year" for its sustainable urban transport policy and was awarded the title of European Green Capital 2013. Measures that led to the award include the development of a clean bus fleet 80% powered by compressed natural gas, and a quality and performance mark for bus lines. The promotion of bicycles as a means of transport, including fold away bicycles capable of being taken on public transport also contributed, as did the remodelling of city centre roads to favour public transport over private vehicles. The city's excellent tram system was also noted by judges.

Nantes was one of five cities that took part in the CIVITAS Vivaldi project, an EU funded transport initiative. The project sought to implement "an integrated package of innovative transport strategies and measures" that would improve urban vitality, economic success, social inclusion, health and sustainability. VIVALDI led to a substantial reduction in emissions of air pollutants and noise.

As part of the programme Nantes modernised its bus fleet, bringing the bus system up to the same level as the tram system. Working with CIVITAS, the city set goals to (Eltis, n.d.):

- provide public transport services with non-polluting vehicles for 70% of the total mileage and 90% of total trips by the end of 2005 (vehicle kilometres)
- renew the bus fleet by purchasing 155 new Compressed Natural Gas (CNG) buses (125 standards, 30 articulated)
- provide the necessary infrastructure for the renewed fleet in the form of a new CNG fuelling station in the south east of the city

This was achieved in 2005. As a result of the measures, fuel costs decreased by 7% and emissions of particulates by 90%. Today 282 buses run on natural gas out of 352 (80% of the total fleet).

The city's public transport fleet has undergone numerous upgrades to increase their efficiency and sustainability. Nantes was the first city in Europe to introduce the electric tram, which was opened in 1985. Today the city has 79 trams and one of France's longest tramways.

Nantes has also reclaimed road space from private vehicles and allocated it to public transport. The highway RN801, previously only suitable for private vehicles, has been dramatically narrowed for cars, and a bus lane has been incorporated in the centre. Space has also been provided for cyclists.

One of Nantes major infrastructure improvements has been the implementation of the innovative "Busway" into its public transport network. The Busway combines the advantages of a tram way with a bus route. Much like a tram, the bus has dedicated lanes, priority at intersections, modernised stations, a high frequency of leaving times, extended operating hours and four park-and-ride facilities. The route connects the ring road circling the city with the city centre. The Busway has been a resounding success, attracting 28,000 daily passengers by 2010, reducing car traffic by between 40 and 70% (depending on the section of the road), and creating a calmer environment for other road users.

The city has also implemented the Chronobus and Bus Express – high frequency buses with dedicated lanes and roundabouts to improve efficiency.

Car-pooling options have been improved, with specific carpooling areas created and access for companies running corporate travel plans made more feasible.

Nantes is reducing traffic through utilising parking spaces as a way to encourage public transport use. Since 2002 there has been a 64% increase in “Park and Ride” stations constructed, leading to a 10 – 15% rise in use annually.

Planning

Nantes realised that transport is a major contributor to emissions within the city (responsible for 29% in total) and uses its SUMP to ensure it is providing the most efficient transport possibilities for citizens. The City has enacted two SUMPs previously (1991 – 2000, 2000 – 2010), and is currently on its third SUMP (2010 – 2015), as illustrated by figure 3.2 below.

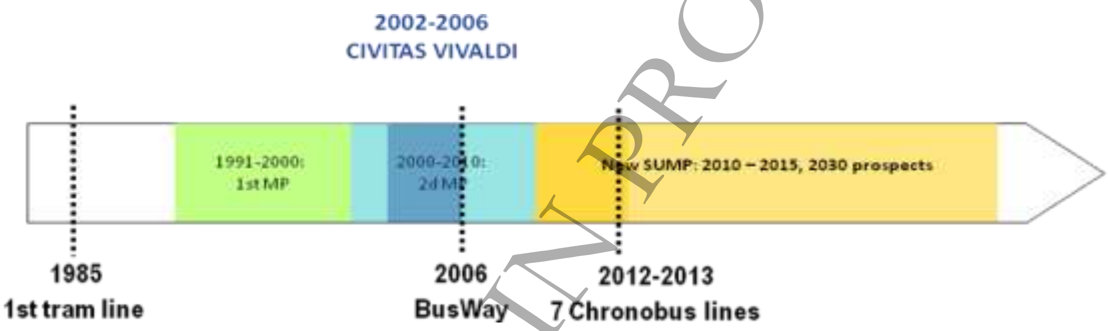

Figure 4-1: Chronology of Public Transport and Mobility in the Greater Nantes

The most recent SUMP is based on four axes: Living centres, Proximity, Networking and Behaviour.

Living centres aims to promote alternative transport methods to private vehicles and to create a city of “short spaces”, reducing distances travelled within living centres, ensuring that amenities are nearby and do not require motor vehicles to access.

Proximity concerns allocating space previously reserved for private vehicles to public transport and “soft” means of transport.

Networking relates to connecting living centres through transport networks, including rail, bus and bicycle paths.

Behaviour aims to effect behavioural change through information campaigns, awareness raising and other measures such as the continued adaptation of mobility services.

The cities action plan is broken down into five aspects: 1. Creating the city of short spaces, 2. Building quality public spaces, 3. Organising mobility networks, 4. Encouraging behavioural change, 5. Monitoring and assessing the SUMP (Nantes Métropole, n.d.).

In order to create intelligent mobility solutions, it is important that mobility and urban planning are integrated in so far as possible. Mobility solutions feed into the city’s Sustainable Energy Action Plan (SEAP) and territorial climate action plan, aimed at reducing the territory’s emissions.

Ultimately the city hopes to achieve a complete panel of alternative mobility solutions: Car sharing, carpooling, rental bicycle, intelligent information, etc.

Nantes public transport measures are reaping tangible benefits. Between 1999 and 2009 the number of people living within 300 metres of urban public transport increased from 80% to 95% and in the last ten years car journeys under five kilometres have fallen by 5%. Cycle paths have also increased, going from 225km in 2001 to 376km in 2009 (a 66% improvement).

Nantes is leading the way nationally - in 2008 public transport amounts for 50% of transport in the metropolitan area, while the average in the 14 French metropolitan areas with populations of more than 300,000 was 11%.

Dedicating public spaces to public transport rather than vehicles has a calming effect on living areas (pacification) and leads to greater public transport efficiency. The proper development of good quality public spaces also increases soft modes of transport. Good quality spaces increase the rate of walking above 30%, whilst poor quality spaces reduce walking rates to between 10-15%.

Sources: Nantes Métropole, (n.d.) European Green Capital Award Nantes 2012 2013, local transport, available from http://ec.europa.eu/environment/europeangreencapital/wp-content/uploads/2011/05/EGCNantesUKChap2-F.pdf

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Case study 2: Örebro, Sweden

A SUMP requires a new way of thinking for many local authorities. This can cause problems in cities where previous transport plans were centred around the use of cars. This change in thinking was the challenge facing the city of Örebro, Sweden, during the development of their sustainable urban mobility plan, within the BUSTRIP project.
In many public authorities, the personnel and skills required to undertake a SUMP is often spread over many departments that have had no previous experience of working together. The idea may be often unusual for the key stakeholders but it is necessary to achieve a successful high quality sustainable urban mobility plan.

The city of Örebro is the administrative capital of Örebro County in Sweden with approximately 107,000 inhabitants and was one of the cities included in the BUSTRIP project. When the city began the initial steps of the sustainable urban mobility planning process, the understanding of sustainable transport was not strong in Örebro. In order to change the situation, the city used various measures, one of which was a capacity-building assessment which was carried out in a working group as part of the self-assessment, identifying the knowledge gaps among the employees. The outcome was that, whilst the municipality had a good detailed knowledge of transport-related issues, there was no history of this knowledge being integrated to create a sustainable urban mobility plan.

"For many professionals a more holistic way of thinking can be a bit of a revolution," says Per Elvingson, who started as a process manager for sustainable transport soon after the assessment.

To facilitate the implementation of sustainable urban transport, a special unit – also responsible for raising awareness among employees and politicians – was set up. The unit has, among other things, planned seminars focusing on the reduced need for cars through spatial planning.

In general, a new way of thinking was the key. An important part of capacity building has been getting all key staff to agree on a common analysis of the current situation. In this respect, the SUMP template has been a very good tool.

Meanwhile, it is important to look around at what others are doing beyond municipal borders.

International cooperation has become more important in this process. Over the past few years, Örebro has focused on exchanging experiences. Study visits are an important part of that work. "On a national level, we are trying to build up an informal network for sustainable transport among cities of our own size in the region," Elvingson says.

For many the SUMP process requires a new way of thinking. Previous transport plans revolved around the car and were road dependent, but with a SUMP, there has been a shift towards using more sustainable terms such as 'intermodality', 'modal shift' and 'mobility management'.

This change in thinking can often leave skills gaps within a local authority or, as in the example of Örebro shows us, a lack of integration between them. Thus it is one of the many challenges the Local Authorities need to overcome in the sustainable urban mobility planning process.

Source: Elvingston, P. (2012, January). Promoting a new way of thinking, Örebro, Sweden. Retrieved from: http://www.eltis.org/index.php?id=13&study_id=3058

Applicability
The applicability of different aspects of a SUMP will be influenced by the city itself. Contextual factors from city layout to public finances can determine what is feasible to enact in the urban area. Limiting factors include narrow streets, which can act as a barrier to tram lines, ribbon development which can make it difficult to widen roads for bus lanes (and by their nature encourage use of private vehicles), whether public transport companies are publically or privately owned, public resistance to modal change (e.g. banning city centre car access, allocating space and resources to cycle lanes over car transport, lowering city speed limits, etc.) and so on. There are six main barriers to implementing an effective transport plan (i) resource barriers, (ii) institutional and policy barriers, (iii) social and cultural
barriers, (iv) legal barriers, (v) side effects, and (vi) other (physical) barriers (European Parliament, 2010). Approaches to overcome these barriers need to be identified. Cost, of course, is another limiting factor for the scope of public authority measures.

Economics
The cost of implementing a SUMP varies from city to city and is difficult to have an exact figure. Possible funding sources include (Rupprecht Consult, 2007):
• Local taxes: a special local transport tax for public transport paid by public or private enterprises, developers;
• Revenue funding: tickets, parking fees, city centre pricing, congestion charging, advertisements;
• Private sector operators, developers, industry; knowledge and skills – SMEs;
• Fundraising activities involving appropriate sponsors;
• Local budgets: from different municipalities and different policy domains;
• State subsidies (regional sources if applicable);
• EU subsidies.

In France, authorities generally spend between €200,000 and €400,000 on the development of a mobility plan. The city of Aachen in Germany has come up with a scheme to jointly finance a part-time mobility manager through its environment department cooperating with its chamber of industry and commerce. This inter-department funding provides the necessary human resource in a tight financial situation.
A SUMP may also allow a city access to certain funding pools that would have previously been unavailable, as well as contributing to fulfilling EU legal obligations. When implementing measures it is important that they are assessed with an eye to costs and benefits as well as value for money.

Driving force for implementation
Apart from environmental benefits a SUMP can provide improved mobility and accessibility for citizens, can enhance the reputation of the city internationally, and can contribute to a better quality of life in terms of noise reduction, cleaner air and improved road safety. A well executed SUMP also has the possibility to utilise land previously reserved for transport and make it a more social, publically useable space, improving the quality of the urban area.
SUMPs provide an opportunity to engage the public and stakeholders in the planning process, and in doing so gain a level of "public legitimacy" in the measures that are to be carried out. SUMPs allow a direct form of democracy and can foster positivity towards the political decision making process.
The integration potential within a SUMP is a major positive for many cities. SUMPs allow sectors, departments and institutions to work together for a common goal. The policy relevancy of a SUMP expands across sectors, taking in, for example, land use, economic development, social inclusion, etc.
The starting point for any city within Europe that wishes to enact a SUMP should be a desire to improve not only the mobility of citizens, but quality of life overall. Enacting a SUMP takes dedication and a tangible commitment, but the benefits are sizeable.

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4.2 Fostering cycling and walking through cycling infrastructures, bike sharing schemes and promoting walking

Description

The benefits of walking and cycling are well known; they provide mobility at low cost with very limited impact on the environment and have positive health impacts on the users. In addition, they contribute to the quality of life of the entire city, as by nature they create an accessible city that can be enjoyed safely by children, mobility impaired and the growing number of older people in our cities. Walking and cycling are further very space-efficient modes of travel, which is an important aspect in ever more crowded cities. Walking and cycling have many similarities, but it important to remember that they are two different modes of transport, demanding separate attention and with different infrastructure requirements.

A large proportion of trips in all cities are short. Trips of around 2 km or less lend themselves to walking, distances shorter than 10 km are ideal for cycling. However, across European cities, there are huge differences in the modal share for walking and cycling. For cycling, it can range from below 1 percent of all trips up to 40 percent or more, e.g. in the most cycle friendly cities in the Netherlands or Münster, Germany. Walking can be a very significant travel mode in cities as well, with figures as high as 30 to 50 percent of all trips in a city, e.g. in Madrid or Paris (EPOMM, 2014).

The significant differences in walking and cycling shares between cities can partly be explained by local traditions, whether the urban planning structures encourage or discourage non-motorised modes. Generally speaking, the modal share of walking and cycling is particularly high in dense cities where they are the fastest and most viable options for most trips. Whether non-motorised modes are recognised as important elements of the transport system with appropriate policies, quality infrastructure, funding and measuring is another important aspect. Topographic and climatic factors are often used to explain high or low levels of walking and cycling, but little evidence can be found that these factors are very significant.

Although cites with a high level of walking and cycling should be regarded as inspiration, in the sense of BEMPs it is especially cities that have achieved significant increases in the share of non-motorised modes in recent years that are relevant examples and forerunners. It is less important whether they have started from a low level or not and sometimes examples with a low starting point can be more relevant, since their situation resembles more closely the situation in the majority of other cities.

This BEMP will have four thematic fareas that will be illustrated by local case examples to showcase how both medium-sized and larger cities can foster cycling and walking. The thematic focus will be on appropriate policy measures, physical infrastructure, applied methodological tools and behaviour change campaigns.

1) Policy and strategy

Walking and cycling need to be recognised as separate and important modes of transport in policy and planning documents and strategic plans of the city. This can be illustrated by the City of London, U.K. which has a clearly stated policy to improve the modal share of cycling, which is strongly supported by the Mayor (Greater London Authority, no date). Also the cities of Berlin, Germany (Berlin Official Portal, no date) and Malmö, Sweden (Gatukontoret Malmö Stad, 2012) both have explicit strategies and programmes to improve conditions for walking. Several tools for cycle policy evaluation have been developed, e.g. BYPAD (no date) and within the CHAMP-project (2014). High-level political support is another important aspect for successful strategies for increasing walking and cycling.

2) Infrastructure

Good walking and cycling infrastructure is essential for fostering these non-motorised modes. Appropriate high-quality infrastructure should make these modes of travel safe, fast and attractive. Coherent, recognisable design, appropriate width and a continuous routes without fragmentation are important quality features. Walking infrastructure should generally be separated from vehicular traffic. Cycle-infrastructure can include both shared traffic facilities such as low-speed residential roads or on-street facilities such as cycle lanes and segregated cycle tracks. Also parking facilities are an important part of cycling infrastructure. Walking and cycling should not only be made safe and fast, but also enjoyable, e.g. with attractive surroundings, the possibility to rest and low levels of noise.

An example is Aalborg, Denmark, where high quality cycle routes have encouraged commuters to shift to cycling. These routes provide direct access to the city centre on high quality cycle tracks and with as few stops as possible. Another example is the Workplace Cycle Parking Programme from London that has encouraged businesses near cycling corridors to build cycle parking infrastructure (Transport for London, 2006).

Super Cycle Highways are another example of cycling infrastructure built to encourage people to bike over longer distances and to make cycling more attractive. The Highways are designed to have high standard, green waves at intersections, overtaking possibilities et cetera. The Copenhagen-Albertsund route in Denmark was the first in a planned network of Super Cycle Highways in the Copenhagen-region covering 300 kilometers. The network is expected to reduce public expenditure by € 40 millions annually thanks to health benefits from increased cycling (Official Website of Denmark, no date).

An example for provisions of infrastructure for walking is New York. In 2008, parts of central Manhattan, were transformed into pedestrian areas, either with car traffic limited or completely prohibited. For some places, cars were occupying 90 percent of the space but 90 percent of the people were pedestrians (Gehl Architects, 2007). With reversible and quick methods, the public space was turned over to make the city more livable and reduce the number of cars in the area. Other examples are the transformation of parts of the inner city of Nantes, France, to low-traffic zones in 2012, providing improved conditions and a more attractive surrounding for pedestrians.

3) Applied methodological tools

In many European cities data on walking and cycling is simply not being collected and therefore only little knowledge on the importance but also development of these modes exist. This often means that the importance of walking and cycling is not properly recognised, their volume and effect not quantitatively demonstratable and related policy efforts insufficient. Zürich, Switzerland, has made advances in systematically collecting data on walking and cycling, which was used as a justification to receive funding for walking and cycling. Also in Gothenurg, Sweden, efforts to measure cycle traffic have been increased, with several continuous measuring posts installed during the last years. Measuring walking and cycling traffic both makes the importance of these modes of transport more visible and makes it possible to follow its development and to evaluate the effectiveness of chosen measures. Another example of methodical tools to foster non-motorised transport is the systematic follow-up of accidents with cyclists and pedestrians by the City of Gothenburg, Sweden. All accidents that lead to hospitalisation are registred and analysed and infrastructure measures are initiated in places where accidents are frequent. This systematic approach has significantly reduced the rate of severe accidents amongst pedestrians and cyclists.

4) Communication

Communication is vital to change behavioural factors and to gain wider acceptance of walking and cycling. Creating a positive image of walking and cycling is important. A successful example is the extensive campaign *Radlhauptstadt München (Munich Cycling Capital),* which caused increased acceptance for cycling in Munich (Radl Haupstadt München, no date). Communication is also an important factor in changing the image of the city to a more bike- and pedestrian-friendly one which will encourage people to shift from car driving to alternative transport modes.

Targeted communication to specific groups has proven successful. As an example, Donostia – San Sebastian, Spain has made successful efforts in engaging with schools to encourage more walking and cycling to school. Targeting school children is particularly important as their mobility routines are still developing and they might continue with that behaviour also in their adult life. Other examples are Gothenburg, Sweden, where separate, targeted cycling campaigns aimed at men between 30-49 and at students were launched and Parma, Italy which focused on university employees (Carma 2012).

Achieved environmental benefits

An increase in the modal share of walking and cycling in a city implies a decrease in the use of motor vehicles, predominately cars, mopeds and motorcycles – in some cases also of public transport. This leads to a wide range of positive environmental effects as well as benefits for public health. Walking and cycling are inherently non-polluting, quiet and space-efficient modes of transport and a shift to these modes almost always leads to environmental benefits.

Air pollution, globally and locally, will be reduced by a decrease in motorised traffic. Lower levels of NO_x, PM, SO_2 and ozone will all be achieved by shifting trips to walking and cycling, as well as a reduction in CO_2-emissions.

When walking and cycling replaces motorised traffic, it further leads to the reduction of noise emissions. Noise from motorised traffic is a significant and growing problem in most urban areas. According to the World Health Organisation (WHO Europe, 2011) noise is one of the most important environmental factors causing health problems in Europe, second only to air pollution.

Cycling and walking are highly efficient transport modes in terms of land use. Per transported person, infrastructure for cars demands approximately ten times more space than bicycle infrastructure for streets, parking spaces and feeding areas such as ramps in parking garages, roundabouts etc (Ott, R., 2012). Increases in walking and cycling can thus free space in the city. This space can be used for additional improvements for pedestrians and cyclists, creating a virtuous circle of boosting non-motorised traffic. Alternatively, it can allow for more green areas or additional housing. For growing cities, more efficient use of traffic space can also imply that increased travel demand can be accommodated without costly expansions of road space.

Cycling and walking further increase the liveability and attractiveness of the city. The barrier effect, where heavy traffic prevents people from moving easily betweens differents areas in the city, is lessened.

Appropriate environmental indicators

There is a huge difference among European cities when it comes to levels of walking and cycling. For cycling they can e.g. range from below 1 percent of trips to over 50 percent. Walking levels in Europen cities typically range between 20-50 percent of all trips.

This large variety makes it especially important to focus on the appropriate indicators. Modal split figures for walking and cycling are the most central ones. However, especially for cities with low levels of non-motorised transport, it might be discouraging to compare their modal split data with cities with a head start of several decades of dedicated work on non-motorised transport. It is therefore recommended to also use *relative indicators* to track changes compared to a base-level, e.g. the modal split of cycling at a certain year. An increase from 1 percent cycling to 2 percent might not look very impressive, but in fact it is a great achievement and an increase by 100 percent.

Absolute figures measuring through traffic along major streets can also be used as indicator to track the development of walking or cycling. Figures from traffic counts can, however, not determine with certainty whether a change is due to a change in modal split, since they can also be due to general traffic growth or shifts from other streets.

Increased modal shares for walking and cycling are ideally achieved by a decrease in car use. This means that the direct environmental benefits are mostly the same as for measures directed at limiting car use, e.g. reduced emissions and energy use, reduced noise levels and land-use. It is however difficult to directly relate data from primary environmental indicators to changes in walking and cycling. To estimate the environmental impact of walking and cycling measures, it is recommended to measure or estimate the effect on car-use, expressed in vehicle-km or passages on a certain road. Based on this information, the environmental impact can be estimated and expressed with indicators as below.

Table 4-2: Appropriate environmental indicators for environmental impact

Indicator		Unit	Example and/or explanation
Primary Environmental Indicators			
Air pollution reduction	CO_2 Emissions	Tonnes CO_2	Levels of other air pollutants are often correlated with these, so depending on the resources a city possesses, different pollutants can be measured as "lead-indicators" of air quality.
	Sulphur dioxide (SO_2)	µg/m^3	
	Nitrogen dioxide (NO_x)	µg/m^3	
Noise pollution reduction	Day – evening – night equivalent level	L_{den}	The Environmental Noise Directive (2002/49/EC) aims to define a common approach intended to avoid, prevent or reduce on a prioritised basis the harmful effects, including annoyance, due to the exposure to environmental noise. Harmonized indicators for developing strategic noise maps are recommended.
	Night equivalent level	L_{night}	
Contributory indicators			
Modal split and Changes in modal split (compared to a base-year)		Expressed as % and %-change	Modal split data for different travel modes should be analysed in relation to each other, so as to estimate whether an increase in walking or cycling has led to reductions in car use. For cities with low levels of walking and cycling, it is recommended to also use the change of modal split figures compared to a base year as an indicator of change.
Number of walking/cycling trips and Changes in number of walking/cycling trips (compared to a base-year)		Passage /hour or day and %-change	Must be compared to the total change in number of trips in the city

The key indicators in this group are the modal split figures and changes in the numbers of walking and cycling trips. Based on these, the reduction of CO_2 emissions can be estimated.

Besides the pure environmental indicators, other indicators can be useful to follow the progress on walking- and cycling, e.g. financial, policy and health indicators. These are especially recommended to starter-cities with relatively low levels of walking and cycling and little previous experience of actively supporting non-motorised travel.

Measuring the quality of the walking and cycling experience is difficult and only using modal split data might provide insufficient information. For example, a large number of pedestrians is not necessarily an indicator of a high-quality walking experience as pointed out by Gehl Architechts when preparing for the New York transformation: If people choose to engage in outdoor experiences in the city then it is most likely that the public realm is excellent (New York City DOT, no date a). Indicators of bicycling- and pedestrian friendliness are therefore to be chosen with some care. Surveys on satisfaction levels can be used, but also the relative share of more vulnerable groups (elderly, children, women) amongst pedestrians and cyclists can provide important information. Ideally, their relative share should be comparable to the population at large, indicating that walking and cycling is possible and perceived as safe and attractive by all groups of the population.

In the following tables, some appropriate indicators are suggested.

Table 4-3: Appropriate environmental indicators for safety and infrastructure

Indicator	Unit	Example and/or explanation
Accident-rate Number of accidents involving cyclists or pedestrian that require hospitalisation, in relation to the walked/cycled km	Accidents/ travelled km	Measures the safety of cyclists and pedestrians. It is important to relate the number of accidents to the total volumes of walking and cycling to avoid misleading results. If it is difficult to estimate the total distances travelled by pedestrians and cyclists, accident rates could be related to modal split figures instead.

Indicator	Unit	Example and/or explanation
Infrastructure provision Total length of cycle infrastructure (cycle lanes, cycle tracks) , in total and in relation to the length of the total road network	km and %	Measures the extend and the relative importance of cycle infrastructure
Bicycle parking	no per 100 000 inh.	Measures the provision of cycle parkings in the city
Proportions of vulnerable groups amongst cyclists and pedestrians (children, elderly, women), in comparison to the proportions in the population at large	Differences in %	Small differences in the representation of vulnerable groups amongst cyclists and pedestrians compared to the population at large indicates that the infrastructure is considered safe and secure.

The key indicators in this group are the accident-rate and the the indicator on infrastructure provision.

Table 4-4: Appropriate environmental indicators for policy, working methods, finance and health effects

Indicator	Unit	Example and/or explanation
Does the city have an explicit policy (or equivalent) for increasing walking/cycling	Yes/no	The policy should be approved by city council. This is an indicator that shows whether the city has non-motorised transport on its agenda or not.
Does the city have goals for walking and cycling; are they measurable and timed?	Yes/no	This indicators show whether the city has taken the step from policy to measurable goals.
Is there a follow-up of the goals?	Yes/no	
Annual investments in walking- and cycling infrastructure (two separate indicactors), e.g. in €/inhabitant	€ or local currency / inhabitant	This indicator shows the financial commitment to walking and cycling. It can also be compared to the total investments in transport infrastructure per capita to show the relative importance given to walking and cycling.
Investment in maintenance	€ or local currency / inhabitant	Maintanence of sidewalks and cycle lanes is important for increasing the modal share
Satisfaction levels among the citizens		Measuring the overall satsisfaction among the pedestrians and cyclists; see Copenhagen Bicycle Account as an example (City of Copenhagen, 2013)
Public health benefits	DALY29	Expresses the expected healt benefits due to walking and cycling-measures expressed in increase in life expectancy. The WHO has developed a specific tool (HEAT) to estimate these benefits (WHO, 2014 b).

The key indicators in this group are the indicators on investments and policy but also the indicator on satisfaction levels.

Cross-media effects

An unwanted but possible side effect is that increases in walking and cycling are mainly fed by decreases in public transport use rather than decreases in car driving. In this case, the positive environmental effects are more limited. Measures to increase walking and cycling should therefore ideally always be accompanied by measures that aim at reducing the use of cars, e.g. parking measures, speed reductions or changes in accessibility.

[29] DALY is Disability-Adjusted Life Year, a WHO metric. For further info, see http://www.who.int/healthinfo/global_burden_disease/metrics_daly/en/ (WHO, 2014 a)

Operational data

Strategy and goals for cycling

The City of London has a clearly set out strategy to improve the cycling experience in the city, described in the Cycling Revolution London strategy from 2010. The explicit goal of the city is to increase cycling by 400 percent by 2026, compared to the levels of 2001. According to Transport for London, the city has already increased cycling by 173% by 2014. The key aims of the Cycling Revolution London Strategy (Transport for London, 2010) are quoted below:

The city's strategy intends to:

- make sure cycling is recognised as a major transport mode right across the capital, from central London to the outer boroughs
- create streets and spaces where everyone respects each other's right to use the road, where they stick to the rules of the road, and where everyone recognises their duty of care to other road users
- reduce in cycling casualties, with a particular focus on reducing the risk of collisions between cyclists and heavy goods vehicles
- increase in secure cycle-parking on streets, in workplaces, and at stations and schools
- reduce cycle theft tackled through dedicated police attention so that people can be confident that they will find their bike where they locked it
- promote cycling as an enjoyable, everyday, healthy activity
- embed cycling into the way our city is planned and run
- maximise investment in cycling - from both the private and public sectors
- get key partners working together to deliver cycling initiatives
- provide new routes and opportunities for commuting, leisure and local cycling trips

The strategy is implemented with considerable investments in cycle infrastructure in the city, accompagnied with marketing and communication campaigns. Comprehensive information on the efforts to increase cycling in London can be found on Transport for Londons dedicated homepage on cycling (Transport for London, 2014).

Improve safety and encourage walking

New York City works continuously to improve safety for pedestrians and to make the streets more walking friendly. Measures include, among others, traffic calming, added greenery, traffic light adjustments and increased public space. Within the NYC Plaza programme, local authorities work closely with non-profit organizations to create neighbourhood plazas that are social public spaces. It is part of the city's effort to ensure that all citizens live within a ten minute walk of quality open space. The plazas can be created in underused street areas, by narrowing car lanes or reducing car parking spaces. About one percent of the NYC traffic budget is used for plazas where no advertising is permitted. NYC also has the Safe Streets for Seniors programme, that specifically focuses on the especially vulnerable group of senior citizens (+65 years), thereby increasing safety for all. Since the start of the program in 2008, fatal injuries among senior pedestrians have decreased by nineteen percent. The measures included among others, adjusted traffic lights adding more time to cross the streets, reducing the number of car lanes, narrowing car lanes, introducing pedestrian safety islands between lanes and sidewalk extensions (New York City DOT, no date b).

Cycle routes

Cycle infrastructure can have many forms and has to be adapted to the needs, possibilites and situation in each city. Residential streets with little car traffic can be suitable for cycling if it is assured that speed is low. Along roads with high traffic volumes and/or high speeds, segregated facilities are preferable. Important aspects are in all cases that cycle infrastructure is not fragmented but providing uninterrupted, direct and fast access to important target destinations. A successful example of this approach are the bicycle commuter routes in Aalborg, Denmark. Three main commuter routes between 5-15 km, especially designed for cyclists, allow fast and safe access to and from the city along main commuter corridors. The routes are fully segregated from car traffic and special attention has been given to provide safe crossings.

Cycle parking
Cycle parking is an important part of cycle infrastructure, especially around places where bicycles can be expected to be parked for longer periods of time, e.g. train stations. High quality cycle parking provides security from theft, safety and good accessibility. Good parking facilities can significantly increase the use of cycling to a destination and are an important tool to increase commuting by bicycle. Examples of successful implementations of bicycle parking facilities can be found in Basel, Switzerland, Groningen, Netherlands and Borås, Sweden.
In *Basel*, more than 1600 weather protected bicycle parking spaces have been built in direct connection to the train station, providing safe parking and direct access to trains. The parking facilities are in high demand and a furher expansion is planned (Kanton Basel-Stadt, 2012).
The city of *Groningen*, with very high levels of cycling, has used the area below a square in front of the train station to accommodate an attractive and wheather protected parking facility for more than 4000 bicycles (EPOMM, 2014).
The city of *Borås*, Sweden, has analysed its current situation for cycle parking in the entire city centre by means of an inventory of existing parking facilities, their quality and use, but also where many bicycles are parked without facilities. Based on this information and on the policy goal to significantly increase cycling, the city has developed a strategy to gradually expand and improve cycle parking facilities in the city. Important elements of this systematic strategy are mandatory cycle parking facilities in building permits for new developments and the transformation of on-street car-parkings to cycle parking facilities.
Local trade
Local trade associations are often opposed to efforts to increase walking and cycling at the expense of car driving due to the fear of loosing business. Studies from New York show that this is an unwarranted fear. When the first protected bike lane in the US was opened on 8th and 9th Avenues in Manhattan, a 49 percent increase in retail sales was reported (New York City DOT, 2012). Also a Swedish study from the city of Växjö on the shopping expenditures and patterns of pedestrians, cylists and car-drivers showed that the spending of cycling customers is fully comparable to that of car-drivers (AB Handelns Utredningsinstitut, 2010).

Applicability

Measures to improve conditions for pedestrians and cyclists and to increase the share of non-motorised transport are applicable in almost all cities, regardless of climate and topography. An increase of these soft travel modes almost always has a positive impact on a city's liveability, transport effiency, environmental situation and can often be achieved at compareatively low cost.
To actively shift trips from car traffic to walking and cycling is especially applicable in cities with air quality and noise problems, but also for cities that experience growth in travel demand but have only restricted financial resources available for additional road infrastructure.
To facilitate an increase in the number of cycling and walking trips, a city can choose very different approaches. It can be small changes done over a longer period of time, or a radical transformation of (parts of) the city within months.
Listed below are several conditions or goals for which efforts to increase walking and cycling are especially applicable and promising.

- **Improving the city image:** If the city wants to change its overall image to a more sustainable one, or to increase the attractiveness of the city, high walkability and good bicycle facilities are key. Cities with high modal shares of non-motorized traffic are often ranked highly in surveys on quality of life. A walkable city is also important for attracting tourists and to suppport visitor revenues.
- **Bicycle/walking infrastructure is intermittent:** Intermittent or fragmented infrastructure is a frequent problem for cyclists and pedestrians and it significantly

reduces the attractiveness of walking or cycling. Small measures that link separate sections and fill gaps in the network can make a significant difference at low cost.

- **Densification of the city area:** When densification is hindered by noise from motor vehicles and lack of space for traffic, changing the modal split to more cycling and walking opens new possibilities.
- **Separation or speed-regulation:** To make streets more available to pedestrians, but also cyclists, space is required. If the streets are wide, the space can be redistributed to enable broad sidewalks, cycle lanes as well as reduced lanes for motorised traffic. If there is not enough space for this, low-speed-zones or shared-space areas are recommended, where cars share the space with pedestrians and cyclists, but are to give way for them.
- **Geographic conditions:** In theory, cycling is especially suitable for flat cities with favourable weather conditions. However, comparisons between modal split data of different Europena cities shows very little correlation between topography and weather conditions and the share of cycling and walking (EPOMM, 2014). Therefore, authorities should not be discouraged by hills and rain to invest in these modes.
- **Political support:** There is frequently a lot of opposition towards more cycle lanes and reduced speeds for cars, and therefore strong political backing is a success factor. If the political situation does not favour large-scale measures, a more gradual but consistent introduction of infrastructure and policy-measures is recommended.

Economics

Many studies demonstrate the economic benefits of investing in increased cycling and walking, the former being more extensively investigated than the latter. The costs of establishing walking and bicycle facilities vary greatly with different preconditions, but some general examples of the economic benefit to society at large are available. The initial investments for changing the infrastructure do not necessarily need to be high – as shown by New York, cheap and reversible changes in the street environment can be sufficient to begin with.

A change towards more cycling and walking leads to general positive effects on public health by improvements in air quality and noise-reduction. Furthermore, increased walking and cycling has a significant effect on public health due to increased physical activity.

For example, the predicted health-cost savings due to the planned network of Super Cycle Highways around Copenhagen are estimated to be €40 millions annually thanks to health benefits from increased cycling (Official Website of Denmark, no date). A recommended tool to assess what health impacts can be achieved by increases in walking and cycling is the *Health economic assessment tool (HEAT) for walking and cycling*, developed by the World Health Organisation (WHO, 2014 b).

For the Stockholm Region, a socio-economic assessment of the benefits of implementing the regional cycle plan, including added infrastructure, showed the return of every invested Swedish crown to be 13-22 crowns, which is a large return compared to other assessed projects (WSP Sverige AB, 2013).

A model commissioned by Cycling England, shows that a small number of additional cyclists will pay for investment in new infrastructure. Regular cycling is defined as three times a week and over a 30 year time frame, an investment of 10 000 pounds requires only one additional cyclist to break even (SQW Conculting, 2008).

For three Norwegian cities, a cost-benefit analysis of walking and cycling track networks has been carried out. The analysis included improved safety and health benefits, as well as external costs such as reduced air pollution and noise, reduced parking costs for employees and cuttings in the cost for school bus transports. The estimated benefit was at least 4-5 times the investment costs and thus more beneficial to society than many other transport investments (Saelensminde, K., 2004).

There is a certain risk that accident numbers can grow with increasing rates of walking and cycling, if they are not supported by improvements in safety infrastructure. However, several studie (ECF, no date) suggest that increased levels of walking and cycling actually can reduce the risk of injury when measured per walked or cycled kilometre, improving the *relative* safety of these modes. This effect is often called the “safety in numbers” effect.

Driving force for implementation

The driving forces for aiming to increase walking and cycling are the strong, positive effects it has on the environment, public health, accessibility, liveability and attractiveness of the city as well as the large economic savings that can be made from it.

For both local and global environmental issues, sustainable transport is a key factor. Motorized traffic is the main source of air and noise pollution in the city areas around the world, the levels often exceeding air quality norms. This leads to enormous heatlh impacts, lower house prices and reduced quality of life for citizens. For cities deciding to improve the situation, investing in cycling and walking is a fast and cost-efficient way to do it. Many cities have ambitious goals for overall energy savings. By keeping the motorized modal share on today’s levels, these goals are often unobtainable. Expanded walking and cycling is an effective way for the city to reduce its energy use within the transport sector.

Public health issues are a growing economic and emotional burden in both developed and developing countries. Obesity in children is rising alarmingly and physical activity is a vital part of the solution (WHO, 2014 c). By reducing the modal share for car trips in favour of cycling and walking, a lot of positive effects on health are created. Apart from lessening the consequences from air pollution and noise, increased physical activity is a key motivator for fostering cycling and walking.

The majority of big cities have accessibility and congestion problems. Increasing the proportions of walking and cycling can be a tool to relieve the situation, since these travel modes are very space-efficient (Ott, R., 2012) and flexible. Increases in walking and cycling can offer improved accessibility and capacity within the restrictions of accessible space and road capacity in cities. By transferring a larger proportion of shorter trips (under 10 km) to walking and cycling, capacity is freed on overcrowded roads and in public transport. This leads to reduced congestion and waiting times, improved accessibility, comfort and travel times for all travellers, especially in rush hours.

High accident numbers among pedestrians and cyclists can be a strong driving force when investing in these modes. In Paris, pedestrians injuries and fatalities due to motor vehicles were a driving force for the extensive efforts the local athourities have made to change the city’s traffic situation with speed limits and pedestrian priority as some of its measures (Razemon, O., 2013).

All in all, there are many driving forces that support efforts to increase walking and cycling in cities – air quality, noise, traffic safety, public health issues, livability and quality of life in cities. Especially for growing cities, a key driving force, however, is the space efficiency and cost-effectiveness of non-motorised travel modes. If space is scarce and budgets are tight, increasing walking and cycling offer high capacity potential at far lower costs than car traffic infrastructure or even public transport.

Reference organisations

Many European cities have successfully worked on increasing the modal shares of walking and cycling, some starting from a very low level and some with already high levels of non-motorised transport.

For inspiration and to better understand the potential of non-motorised transport, champion cities which already have achieved very high levels of modal share for walking or cycling are recommended as reference and study visits. Examples are:

Copenhagen, Denmark: Copenhagen is one of the leading cycling cities in Europe with very high levels of cycling. For further information, the Copenhagen cycling strategy and the cities’ bicycle account, visit:

http://subsite.kk.dk/sitecore/content/subsites/cityofcopenhagen/subsitefrontpage/livingincopenhagen/cityandtraffic/cityofcyclists.aspx

Münster, Germany: Münster calls itself the bicycle capital of Germany, with twice as many bicycles than inhabitants and extensive bicycle infrastructure. For more information, visit: http://www.muenster.de/stadt/tourismus/en/city-of-bikes.html

Groningen, Netherlands: In Groningen the bicycle is the dominant mode of transport and the city has extensive cycle infrastructure and world-class cycle parking facilities. For a visual impression on cycling in Groningen, visit:
http://www.citylab.com/commute/2013/10/city-where-bicycles-rule-road/7202/
Further information can be found on:
http://www.champ-cycling.eu/en/The-Champs/Groningen/Groningen/

Malmö, Sweden: Malmö is a leading cycling city in Sweden and has in the recent years expanded its cycling network and parking facilities considerably, attracting even more cyclists. For further information, visit:
http://www.malmo.se/English/Sustainable-City-Development/Mobility.html

Madrid, Spain: Madrid has already achieved very high levels of walking for transport in the city, but strives to further improve the conditions for walking in the city. For further information, visit:
http://www.eltis.org/index.php?id=13&lang1=en&study_id=4015

But also cities with currently low levels of walking or cycling but ambitious strategies and measures to increase these levels are valuable references. Examples are:

London, U.K.: London has a very ambitious strategy to dramatically increase cycling in the city and has taken a wide range of measures to achieve its goals. For further information, visit: https://www.london.gov.uk/priorities/transport/cycling-revolution

Szolnok, Hungary: The east Hungarian city of Szolnok has invested heaviliy in improving accessibility for pedestrians by investing in a new pedestrian bridge rather than a car bridge. For further information, visit:
http://www.eltis.org/index.php?id=13&lang1=en&study_id=4015

Toronto, Canada: Toronto has lower walking levels than many European cities, but has an ambitious strategy to increase pedestrian traffic. For further information, visit:
http://www1.toronto.ca/wps/portal/contentonly?vgnextoid=380f7e5921f02410VgnVCM10000071d60f89RCRD

Many more examples on walking and cycling measures and strategies are provided by the following organisations:

ELTIS: The urban mobility portal supported by Intellingen Energy Europe provides a huge, searchable database with case studies and examples of implemented measures for walking and cycling in European cities. See: http://www.eltis.org

Bicycle Portal: The German bicycle portal by the Federal Ministry of Transport and Digital Infrastructure collects information and good practice examples on cycling from Germany and beyond – not only in German. See: http://www.nationaler-radverkehrsplan.de/en/

ECF, Europea Cyclists' Federation: The ECF is the European umbrella organisation of national cyclist organisations and provides resources but also contacts to national cyclist organisations. See:
http://www.ecf.com

Fietsberrad CROW: Fietsberaad CROW is the Dutch knowledge bank on cycling, filled with cycling related examples from the Netherlands. See: http://www.fietsberaad.nl/?lang=en

Walk21: Walk21 is an organisation with a focus on pedestrian traffic. It is a resource for best practice examples and research papers on pedestrian traffic and organises the international Walk21-conferences. See: http://www.walk21.com

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4.3 Implementing a large scale car sharing schemes

Description

Car sharing provides its users with access to a car without the need to own one. Electronically controlled 24/7 access, decentralised stations (with reserved parking spots) and a variety of vehicle types provide a reliable, flexible and cost-efficient alternative to car ownership that supplements the sustainable modes of walking, cycling and public transport. The availability of a variety of vehicle types in a wider mobility context allows one to choose the mode and vehicle that best fits the purpose of each journey.

Car sharing services are not generally run by the city in which they operate. But while a private operator runs the service, there are significant actions that a city can take to create a supportive atmosphere that encourages and increases car sharing as a supplement to walking, cycling and public transport. These can include setting up supportive infrastructure, establishing appropriate policy and legislation to integrate car sharing into the city fabric and integrating car sharing with public transport. It can also include becoming a business customer of the local car sharing service, creating public awareness and promoting the service and establishing standards that operators must meet in order to be able take advantage of the city's supportive infrastructure. In some cases, cities may also decide to subsidise a car sharing operator to expand or accelerate the rate of growth.

Car sharing levels of use and services vary greatly across Europe, with services currently provided in 14 European countries. The largest operator by far is Mobility in Switzerland. Run as a cooperative and the only car sharing provider in Switzerland, Mobility has roughly 112,000 users who have access to 2650 vehicles parked at 1395 stations in 500 towns and cities across Switzerland (Mobility Car Sharing, 2013).

According to the EU momo project, if Swiss car sharing levels were achieved across Europe, there would be 6,000,000 car sharers, meaning removing up to 600,000 cars from the cities of Europe, the equivalent of a row of cars end-to-end from Stockholm to Madrid (Momo Project, 2011) – a substantial environmental benefit both in reduced emissions and in public space gained.

The potential role of cities in supporting and encouraging large-scale car sharing in European cities is the focus of this BEMP.

Terminology:

There is often confusion about exactly what car sharing is and how it works. This is compounded by the range of terms used to describe it. Further, in recent years, different forms of car sharing have been introduced. We will thus begin by defining car sharing, the problems it addresses and where it works best in comparison to carpooling, another form of shared car use. We will then differentiate among the three main forms of car sharing that currently exist.

Car sharing vs. carpooling

Carpooling[30] is defined as two or more people travelling together in a car (usually a car owned by the driver of the vehicle) to a shared destination, whereas car sharing allows different people access to the use of a fleet of vehicles (normally owned and maintained by a private company or a cooperative) by booking a vehicle for a defined period of time. Each works best in a different context (urban vs. suburban/rural), addresses different issues (urban space issues vs. pollution and congestion) and serves a different target audience (those who don't need a car for regular daily journeys vs. those who depend on a car for daily use).

[30] Also called ride sharing or lift sharing or sometimes (confusingly!) car sharing

Table 4-5: car sharing vs. carpooling

	Car sharing	Carpooling
Basic description	Cars can be reserved and accessed by individuals at car sharing stations at any time of day	two or more people travelling together in one car to a common destination
Where it works best	Where people don't need a car for regular trips to work, school or shopping	For work journeys that are regular
Key problems it addresses	• urban parking problems • over-filled street space • complements public transport, cycling and walking to reduce the need for car ownership	• congestion • fuel consumption • pollution
Key target groups	• those in urban areas who do not need a car on a daily basis • companies and authorities (for fleet management)	• those in suburbs or the countryside who need a car for their daily trip to work • employees of companies (as part of a mobility management strategy)

Different forms of car sharing[31]

The *Bundesverband Carsharing*, the German national umbrella organisation for car sharing operators, has developed a comprehensive definition of car sharing for its own purposes (see box). The key aspects include 24/7 booking and pick up for all registered users, cars located at a network of decentralised stations and fees based on both distance driven and time.

In recent years, several new car sharing services have started up with involvement of the motor industry (and in one case of the battery manufacturer).[32] These offer cars that are parked randomly on local streets rather than at fixed stations and that are located by potential users through GPS. Users can take a car for as long as they want and park it anywhere within the operating area of the provider. Rates are based solely on time with no cost based on distance.

These "free-floating" operations require no prior reservation and users are not required to register a return time when they take a car. On the other hand, they don't allow early pre-reservation, meaning availability of a vehicle cannot be guaranteed. These systems have no fixed stations, meaning there are no (or in some cities few) reserved parking spots for the return. They generally offer only one (small) car type.

[31] Called car clubs in the UK and Ireland

[32] For example Car2Go by Mercedes, DriveNow by BMW and Autolib' by Bolloré (the producer of the battery)

Another recent development (2011) is one-way car sharing, meaning customers can pick up a car at one station and return it to a different one. Autolib' in Paris pioneered one-way car sharing,[33] which also requires no pre-booking and no pre-defined reservation time. The service offers users the advantage of a guaranteed parking spot at the end of a journey but again, only small cars are available.

Unlike station-based car sharing, the question of what kind of journeys free-floating and one-way car sharing replace has not been clearly established, but studies on Car2Go in Amsterdam (Gemeente Amsterdam, 2013) and Autolib' in Paris (6t – bureau de recherche, 2014) indicate that there is a tendency for them to replace public transport journeys, putting them in competition with the "eco-modes" rather than complementing them. While the impacts of free-floating and/or one-way systems could improve through alliances with station-based systems, and indeed this is being experimented with in some places,[34] no research has yet been carried out.

Further, although accurate data are difficult to find, the existing free-floating and one-way car sharing systems are highly subsidised,[35] whereas most station-based car sharing operations are run on a break even or for-(modest) profit basis.

Bundesverband Carsharing definition of car sharing

Car sharing is the organised, common use of motor vehicles. Car sharing organisations offer the service of car sharing as an integrated component of the group of sustainable modes (rail, bus, bicycle, walking). The result is an individually-organised mobility that complements and supports public transport and reduces impacts on the environment and the local transport system. By reaching a larger market share, providers aim to further increase this effect further. The service of car sharing is defined by the following components:

- Within the limits of liability of the registered user of a car, the service is open to all insofar as the preconditions for participation are met – free of discrimination and transparently operated.
- Use is based on a framework contract; there is no separate contract for each individual journey.
- There is a decentralised network of stations with vehicles available near to residences as well as to public transport stations and stops.
- The vehicles can be booked, picked up and returned 24/7 by customers at unattended stations.
- Use is calculated by time and distance driven (including journey-related operating costs).
- Bookings as short as one hour are possible. The hourly price may not be more than one-eighth of the daily price.

The complete *Bundesverband Carsharing* definition of car sharing can be found (in German) at www.momo-cs.eu.

[33] As Autolib' cars are electric, stations were necessary for recharging. The push for a fully electric car sharing operation was led by Bertrand Delanöe, the mayor of Paris, who based the system on Paris' popular Vélib' bicycle sharing system.

[34] In 2013, *Grünes Auto Göttingen* in Göttingen, Germany made many of its smaller cars available for one-way use in addition to its existing station-based service. In 2014 in Hanover and Mannheim, Germany, the station-based car sharing provider *Stadtmobil* set up a parallel free-floating system called Joe Car.

[35] According to the *Frankfurter Allgemeine Zeitung online*, the investment required for Autolib' was estimated at roughly €200 million, with €60 million coming from Bolloré (the manufacturer of the battery), €35 million from Paris and €50,000 per station from the participating surrounding municipalities.

Table 4-6*: Comparison of station-based, free-floating and one-way car sharing operations*

	Station-based	***Free-floating***	***One-way***[36]
Pre-booking	Yes (can also be done immediately before travel)	No	No
Rental time must be specified	Yes	No	No
Fixed stations	Yes	No	Yes
Reserved parking space	Yes	No	Yes
Payment based on	Time, distance and vehicle size	Time only	Time only
Car types available	Small car to passenger van or transporter	One type (small)	One type (small)
Car return	To the same station	To anywhere within the service area	To any station with a free space
Impact on car ownership	Each vehicle replaces 4-8 privately-owned cars (Loose, 2009a)	Each vehicle replaces roughly 1 privately-owned car (Gemeente Amsterdam, 2013)	Each vehicle replaces 3 privately-owned cars (6t – bureau de recherche, 2014)

Station-based car sharing, with its range of vehicles and tariffs based on both time and distance, has demonstrated a positive effect on mobility patterns and has proved to be an alternative to car ownership. The impacts of the newer free-floating and one-way systems on the environment have yet to be established on a similar scientific basis. For this reason, this report refers to station-based car sharing as defined by the *Bundesverband Carsharing* and any environmental (or other) effects described are limited to this form of car sharing.

Achieved environmental benefits

Car sharing has achieved several measurable (as well as some more difficult to measure) environmental benefits.

Reduced car ownership

A comparison in Switzerland of households before and during car sharing participation shows that the proportion of car-free households grows with car sharing participation and the proportion of personal cars kept in the household drops (Interface Institut für Politikstudien, 2006). With car sharing participation, personal cars become, to a large extent, unnecessary. According to another report (Loose, 2009a), on average, four to eight private cars are replaced by each car sharing vehicle, resulting in reduced parking pressure in the neighbourhoods in which large numbers of car sharing customers are well served. There is potential for a significant space gain through car sharing.

Surveys by the Bremen-based car sharing operator cambio show even more positive results on the impact on car ownership. According to cambio, about 50% of new car sharing customers had a car before they became car sharers but only 13% of them maintained a car. There are statistically 40 users for every cambio car in Bremen, meaning a replacement rate of about 10 cars by every car sharing car. At least in Bremen, a combination of walking, cycling, public transport and car sharing appears to be a full replacement for many for car ownership.

[36] The only full one-way car sharing scheme we're aware of is Autolib' in Paris. Data are based on this service.

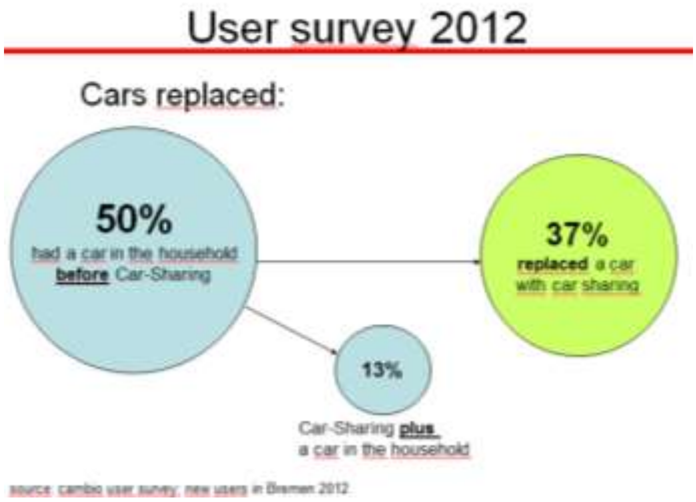

Figure 4-2: Excerpt from the 2012 annual user survey of cambio in Bremen showing car sharers who have got rid of a car since becoming cambio members

Changes in individuals' transport choices

Car sharers have been demonstrated to drive fewer kilometres and to use bicycles and public transport more. A survey carried out in the context of the EU momo project (Muhr, 2009) surveyed cambio customers in Brussels. The results showed that after becoming a car sharer:

- 25% used buses and trams more (10% much more)
- 22% used trains more (5% much more)
- 19% cycled more (7% much more)
- 28% walked more

Similar results were found in a study commissioned by the Swiss Federal Energy Agency (Interface Institut für Politikstudien, 2006) where car sharing users were shown to use public transport considerably more than they did before they began car sharing. They also made use of bicycles, taxis or rental cars much more than they did previously. The Swiss study measured the effect this transport behaviour had in relation to traffic-related CO_2 emissions. In the emission calculations, the study concluded that each active Swiss car sharing user emitted 290 kg of CO_2 less each year because of car sharing participation than he or she would without it.

Lower carbon emissions

The use of car sharing vehicles in fleets with different car types (and different price categories) allows users to select based on need. As many car sharing journeys are taken without large amounts of luggage and without many passengers, compact cars are the predominant vehicles in most car sharing fleets. Users take a large vehicle only if they need to transport something large. This compares favourably to individuals who may purchase a vehicle large enough for an annual family holiday and use it for regular travel. The fuel requirements and the CO_2 emissions of the car sharing vehicles are correspondingly small.

According to the Swiss study (Interface Institut für Politikstudien, 2006) the average carbon dioxide emissions of the fleet of the Swiss car sharing provider, Mobility, in 2005 were approximately 18 percent lower than new cars on the road in Switzerland in the same years and 25 percent lower than the average emissions of all private cars in Switzerland in 2005. Similarly in Germany, in 2009, the cambio fleet in Bremen emitted an average of 129g CO_2/km, in comparison to 169g/km for the average new vehicle in Germany. The current Ford Fiesta, the main vehicle procured by cambio in Germany, emits only 98g/km.

Comparable results were found through a survey carried out by the *Bundesverband Carsharing* (Loose 2009a). Car sharing fleets in Switzerland, Germany, Belgium, and Great Britain all showed lower specific CO_2 emissions for car sharing fleets than for the personal vehicles in the respective countries, with differences ranging between 32 and 61g/km (see Table 4-7). Since car sharing fleet vehicles, on average, are upgraded more frequently than personal cars, they always meet the latest environmental standards.

Table 4-7: Comparison of specific CO2 emissions of car sharing fleets with personal vehicles by country

C-S provider or country	Specific CO_2 emissions of C-S fleet	Number of vehicles in C-S fleet	specific CO_2 emissions of the national vehicle fleet	...% lower consumption	Comparison year	Source
Mobility, Switzerland	151 g/km	2,200	183 g/km (new cars only)	17.5% (total 1,510 t in year)	2008	Mobility 2009
various, Germany	148 g/km	1,042 (included in the study)	176 g/km (new cars only)	16%	2003	Knie, Canzler 2005
cambio, Germany	129 g/km	575	165 g/km (new cars only)	21.2%	2009	cambio Journal 19/2009; German Federal Bureau of Statistics 2009
cambio Belgium, Belgium	117 g/km (Flanders) 120 g/km (Brussels) 122 g/km Wallonia	248	155 g/km (new cars only)	21.3% - 24.5%	2008	Information by e-mail, Taxistop
4 providers, Italy	127 g/km	236			2008	momo survey
various, Great Britain	110 g/km		171 g/km (assuming the replacement of personal cars after 6 years)	36%	2007 (2001 in some cases)	Carplus 2007

Table 1: comparison of specific CO_2 emissions of Car-Sharing fleets with personal vehicles by country

Appropriate environmental indicators

How effective a large-scale car sharing scheme is in terms of its environmental benefits depends on the combination of at least the following main factors. Their combination provides indications not only about a scheme's success but can also be used to monitor its overall performance.

Table 4-8: Appropriate environmental indicators for implementing a car shring scheme

	Indicator	Unit	Example and/or explanation	Data availability
A)	Number of car sharing users per 10,000 inhabitants	Number of users	This indicator provides a quick and clear insight into the number of car sharing users in a city (and its development over time)	From car sharing operator and local population statistics
B)	Number of registered users per car sharing vehicle	People/ vehicle	This indicator can help you assess the use intensity of a car sharing scheme[37]	Available from car sharing operator

[37] This indicator should be used with caution. If an operator adds extra vehicles in new areas of a city to encourage new membership there, it may negatively skew usage figures.

C)	Mileage driven by car sharing users	km driven/ user/year	This will help you compare the amount driven by car sharers to average car owners	May be available from the operator. If not, user surveys would be needed.
D)	Average CO_2 emission/km across the entire car sharing fleet[38]	g/km	Environmental performance of the car sharing fleet	Available from car sharing operator
E)	Number of privately owned vehicles replaced through car sharing schemes	Vehicles	This is an important indicator to assess the impact in terms of street space usage.	Requires a representative survey among car sharing users
F)	How many private cars each car sharing car replaces	Parameter (measured as indicator E above divided by the number of vehicles in the car sharing fleet)	This is an important indicator to assess the space efficiency of car sharing and the potential for the future in terms of space saving.	Calculation based on E above
G)	Reduction in mileage driven by car sharing users as compared to their mileage pre-car sharing	km driven/year	This indicates how much car sharers reduce their car use through car sharing participation.	To gather data, user travel diaries would be needed, likely as part of a research study.

The studies cited above demonstrate that use of station-based car sharing in itself is a good indicator of reduced driving. Nonetheless, it is important for a car sharing provider to demonstrate (for example through annual user surveys) that users have indeed reduced their car ownership and mileage driven as opposed to simply declaring an intention to do so. For a newly-established car sharing operation, data from a comparable operator in a similar sized city should be accepted until the operation is established and can provide data of its own.

For a look at an established standard, the German environmental label, *Blauer Engel* (Blue Angel) has been evaluating and labelling products and services since 1978 for their ability to protect the environment. In 1995, the city of Bremen initiated a request for the introduction of a Blue Angel category for car sharing. The category and criteria were established and the first car sharing Blue Angel was awarded by the Blue Angel jury in 1999.

In brief, the criteria established to become a Blue Angel certified car sharing provider (RAL gGmbH, 2010) include:

- Access to all (within reasonable legal limits)
- Minimum service including short-term use for periods as short as an hour; charging on the basis of time and kilometres driven (no free kms) with all costs accounted for; tips for fuel-efficient and low-noise driving; and reduced rates for public transport season ticket holders and/or for Deutsche Bahn *Bahncard* holders
- Minimum requirement of 10 registered driver customers per vehicle for a fleet of up to five vehicles and 15 registered driver customers per vehicle for agencies with more than 5 vehicles.

[38] This should be measured on a fleet-wide level rather than vehicle by vehicle as car sharing fleets must also include vans and larger cargo vehicles to meet the various needs of their customers. Similarly for noise pollution, a threshold should be set as opposed to an absolute level, as some large luxury cars are quieter than some smaller economical ones.

- Technical requirements including the green environmental sticker that allows access to most German city centers; no vehicle purchased during the contract may emit more than 230g CO_2/km (based on standard fuel consumption); CO_2 emission requirements for a car sharing fleet are based on the adopted EU CO_2 legislation, which defines an average fleet limit of 130g CO_2/km. Eco-label light-duty vehicles (vans) are dealt with under the same procedure.[39]

Figure 4-3**:** The Blue Angel Jury Environment Label – protects people and the

Cross-media effects

There are no identifiable negative side effects of (station-based) car sharing. To the contrary, it has been demonstrated that car sharers use more public transport, cycle more and own fewer cars than non-car sharers. Car sharing serves as a complement to walking, cycling and public transport, allowing customers access to a car when they need it, otherwise allowing them to select the most appropriate mode from the range available to them for each journey.

As noted above, free-floating and one-way car sharing may tend to induce car travel by attracting users away from public transit or cycling.

Operational data

Car sharing services are not generally run by the city in which they operate. But while a private operator runs the service, there are significant actions that a city can take to create a supportive atmosphere that encourages and increases car sharing. These include:

- Setting up supportive infrastructure
- Establishing policy and legislation to integrate car sharing into the city fabric
- Integrating car sharing with public transport
- Becoming a business customer of the service
- Creating public awareness of the service
- Setting standards that a provider must meet in order to be able take advantage of the supportive infrastructure
- Subsiding an operator to accelerate the rate of growth

Supportive infrastructure includes providing space for on-street car sharing stations so that the car sharing vehicles are visible and accessible. This means making space available where there is demand (i.e. parking problems) both by private users as well as businesses. Space for car sharing vehicles is also needed near public transport stations and stops.

Paris is a good example of a city that has reallocated [40] a significant amount of space previously used for general parking (and other purposes) to the use of shared cars, with its dense network of 4000 reserved parking spaces.

[39] Blue Angel calculations do not include plug-in-hybrid cars and full-electric vehicles since, without being able to verify the source of the electricity, it is impossible to achieve a valid calculation of CO_2 emissions.

[40] As noted above, the Autolib' plan was initiated by the mayor of Paris. Such a bold reallocation of space would not be possible without strong political leadership.

Such decisions are not always possible at the local level and legislative frameworks are different from country to country (Loose, 2009b). In Germany, legislation currently does not exist that would allow cities to allocate street space to car sharing, creating a challenge to further development. Without a uniform legal foundation, some cities have permitted individual stations based on grounds which are currently in legal grey areas. In Italy, national legislation allows reserved parking in public street space only for public transport and for disabled people. Cities may, however, keep certain areas free from regular traffic (such as commercial zones). Car sharing may be counted in this category. At the other extreme, national lawmakers in Belgium have given cities responsibility for deciding which transport services receive reserved land in public street space. Brussels has used this option to establish a clear set of guidelines for car sharing operators (see below).

Legislation and policy (at the local level) include embedding car sharing into the city's overall transport and urban development strategy including integrating it into neighbourhood parking management. This can be done by lowering minimum parking standards in new developments if car sharing is provided to new residents by the developer. In 2009, the city of Bremen was the first to politically pass a car sharing action plan (Stadt Bremen 2009), which set a goal of quadrupling its car sharing membership from the 2009 level of 5,100 users to 20,000 by 2020. The action plan identified a series of actions to take to achieve this goal, including all of the ones named here. By 2014, the number of customers had increased to almost 10,000.

Integration with public transport can include mutual discounts for users of both car sharing and public transport, the integration of car sharing stations with public transport stations and stops,[41] advertising car sharing services to public transport users and including car sharing stations on all local public transport maps.

A city can also **become a business customer** of the local car sharing operation. This allows the city to lead by example, to make its own fleet management more efficient and to make its employees familiar with the service, which they may also choose to use as private customers. The city of Munster, Germany has taken this one step further by incorporating its own fleet into that of the car sharing provider (Loose, 2009c). On weekends and after 4 pm on weekdays, 13 vehicles stationed at a local authority building become part of the *Stadtteilauto* fleet and are available to the operator's customers.

[41] This may also be the role of the public transport operator, depending on how the services are operated in each city.

A city can provide **public relations and awareness-raising** of car sharing (as an activity; not specifically of an operator), explaining how car sharing works and its benefits both to the customer and to the local environment. Bremen is a good example of this. In recent years, it has run several creative campaigns including postcards asking if you "would buy a cow for a glass of milk?" and a series of short videos to demonstrate other ways urban space could be used if there were fewer cars. It also set up a promotion with a cartoon character called Udo, who encourages people to "Use it. Don't own it" (Stadt Bremen 2013a).

Figure 4-4: Car sharing promotion used by the city of Bremen

Quality standards are another way that cities can encourage high-quality car sharing activities. This can mean offering support to car sharing providers that meet standards such as those set by the German Blue Angel (see above) or establishing a set of standards such as those set by the city of Brussels (Ville de Bruxelles, no date) in order for car sharing operators to be allowed to station their vehicles in public space. In Brussels, to be accepted as a car sharing operator, a strict set of conditions must be met (see box).

Further, car sharing operators in Brussels must report twice annually with statistics of use (subscribers, hours of vehicle use, kms driven by station, age and environmental standards of the vehicles, percentage of demand satisfied, number of stations and vehicles). The city may suspend or withdraw the agreement at any time if the operator does not fulfil the conditions and the operator must apply for renewal every two years, with the renewal application accompanied by a declaration confirming that they continue to meet the criteria and a report summarising their plans for new stations foreseen for the coming two years with justification for these based on mobility needs and the interests of residents.

Conditions for use of public street space for car sharing stations in Brussels

1. 24/7 availability
2. Mutual tariff advantages with a public transport provide, a taxi company or the Belgian national train operator
3. Reservation centre and internet site with all relevant information
4. Simple and efficient service for clients (PIN access, a fuel card, option to reserve 15 minutes before use)
5. Tariffs based on time and distance driven and taking into account all the costs of use
6. Tariff rates based on distance and time, adapted to several types of use (limited, medium or frequent use)
7. Vehicles replaced every four years
8. Easily recognised vehicles (e.g. logo)
9. Equality of access
10. Minimum of 10 stations and a minimum of 30 vehicles in service
11. Availability guarantee

Car sharing is often run as a for-profit business. In such cases, operators cannot be expected to set up stations where demand does not warrant it. On the other hand, it may nonetheless be desirable from the city's perspective that car sharing be offered in order to encourage the increased use of the service. In such cases, a city may choose to **subsidise the establishment of new car sharing stations** in neighbourhoods where demand does not (yet) make them financially viable. A contract can be established with the operator whereby the subsidy is in effect for (for example) five years, with the amount decreasing each year. At the end of the subsidy period, the station costs are fully the responsibility of the operator.

Applicability

Car sharing is generally more successful in urban settings than suburban or rural areas, although there are examples in all three settings. While no minimum city size should be dictated, some indicators of potential success include:

- A reasonably high population density so that there is a market for the service
- Well-developed public transport and/or cycling infrastructure so that a good number of people can meet their daily needs without a car

Given these basic criteria, car sharing should be applicable in almost any city in Europe of at least 200,000 inhabitants.

However, it is possible to implement the service even in smaller towns and cities. For example, most of the places where the Swiss operator, Mobility, has its cars located are towns of fewer than 20,000. It must be noted, however, that Mobility is a cooperative, meaning decisions can be made based on factors other than pure economics. Switzerland also has an excellent public transport network, even in small towns, meaning that many people in smaller centres are indeed able to meet their daily needs without a personal car.

Car sharing can also be applicable in small towns where there is a solid base of volunteers to run the organisation. This is the case in Vatterstetten, near Munich in Germany. The town of 21,000 has had a thriving volunteer-run car sharing organisation since 1992, and supports other volunteer-run groups in Germany in setting up their own car sharing organisations.[42]

In Ansbach, Germany, a strategic alliance between a citizens' initiative, the city, the municipal utility and a local car rental company managed to establish a successful car sharing scheme for its 40,000 inhabitants.

A third option for smaller centres is to collaborate with a car sharing provider in a nearby larger city, as is done by *Stadtmobil* in the Hanover, Karlsruhe and Rhine-Neckar areas of Germany. The smaller town can procure the vehicles for use in its local area but make them part of the larger city's booking system. Depending on the distance, the smaller town may also provide (or contract) the maintenance of the local vehicles so that the car sharing operator does not need to travel to the smaller town to deal with minor issues.

Economics

While this document is intended to address actions that cities can take with regard to car sharing, it is important to understand the economic aspects important to a city, a car sharing provider and to (potential) car sharing users.

<u>*City perspective*</u>

From the perspective of a city, parking management is a major financial incentive to support car sharing, assuming the choice is between continuing to provide parking for every new car or making efficient use of both space and vehicles.

A single off-street parking space costs €20,000-€30,000 to build and roughly €20/month to operate and maintain. Again using numbers from cambio in Bremen, the 9,000 current car sharing users have done away with more than 2,000 cars. In order to accommodate that number of vehicles using parking garages, the city of Bremen estimates an investment of approximately €40,000,000-€60,000,000, plus €480,000 annually for maintenance. Some of these costs savings are realised by developers, who are able to build housing with less car parking than a comparable development without car sharing.

Another economic factor from the perspective of a city is fleet management. If the city becomes a car sharing customer, the efficiency gain in booking and optimised use of vehicles create a cost saving. It also allows the city to allocate journeys to specific departments or drivers, offering transparent pricing and full-cost accounting of work-related travel.

[42] It should be noted that there is often less interest in car sharing in smaller towns and cities than in larger cities because the pressure on parking space is less extreme. In such cases, other driving forces (e.g. environmental ones) must be stronger in order for such an initiative to be successful.

Costs incurred by a local authority can range from nothing (i.e. allow the for-profit business to run its operation in the city without any interaction) to the thousands, depending on how they choose to support the activity (e.g. setting up supportive infrastructure, integrating car sharing with public transport, creating public awareness or subsiding an operator to accelerate the rate of growth as described under Operational Data above).

A city may decide whether a car sharing operator should pay rent for the use of land for stations on public space. Examples of both exist: in Bremen, the operator pays for the space, whereas in Rome, it may use the space free of charge.

If a city is interested in its local car sharing fleet offering electric cars, this may require further subsidy (which could come, for example, in the form of supplying charging stations). While the situation may change in the future – and many car sharing operators are already experimenting with electric vehicles (Rupprecht Consult, 2013) – with charging time and higher purchase costs, no car sharing operator to date has been able to develop a cost-recovery model for electric cars.

Operator perspective:

From the perspective of a car sharing operator, the business case has been demonstrated for station-based car sharing. For-profit operations and cooperatives exist in many European cities that do not require subsidies from the cities in which they operate. As noted above, one-way and free-floating car sharing operations are financed by the corresponding car (or battery) manufacturer.

Customer perspective

From the perspective of the user, car sharing has an influence on travel choices, and choices made based on finances (e.g. take a bike rather than booking a car for a short journey) serve to enforce the environmental benefit of car sharing. Once a person has purchased a private vehicle, the cost of the car and road tax are typically paid for, so there is no disincentive to use the car less. In contrast, car sharers sees the cost of each individual journey, which leads them to reassess the best transport option available for each journey, whether it be a bus, bike, compact car or a transporter.

Driving force for implementation

Because car sharing is not necessarily the first solution cities think about (or perhaps they aren't aware of the potential benefits of the service), awareness may be the first requirement before implementation can occur.

For cities that already have a well-established car sharing operation, the demand by operators for more space for additional stations can be one driving force.

In cities that currently have no car sharing, factors that could serve as driving forces are connected to space, access, quality of life and the environment. These include:

- A mismatch between the number of cars and the amount of street space available, considering that space is also needed for pedestrians and cyclists
- A lack of off-street parking space and the high cost of building parking garages (see economics above)
- Safety and access issues for emergency vehicles and waste collection vehicles[43]
- Quality of urban life
- CO_2 reduction (based on an assumption of less car use and car ownership resulting from car sharing)

In any city where any of these factors create challenges, it is possible for a city to create its own driving force by establishing a car sharing action plan with concrete goals and timelines to achieve them, as has been demonstrated through the ongoing implementation of the city of Bremen's car sharing action plan (Stadt Bremen 2009; Stadt Bremen 2013).

[43] The city of Bremen has found allies among fire fighters and waste collectors by consulting them on particularly tight neighbourhoods and having them test drive streets that have been redesigned to prevent illegal parking and create car sharing stations.

Reference organisations

As noted above, it is not generally seen as the responsibility of cities to establish a car sharing operation. This would normally be done by a private operator. However, cities that have been exemplary in creating positive conditions for car sharing to grow include:
City of Bremen

- Embedding car sharing into its development plans
- Establishing *mobil.punkte* (mobility points) in public space including car sharing stations near public transport stops
- Establishing a car sharing action plan
- Becoming a business customer of the local car sharing provider
- Creating a series of promotional videos on car sharing (see: https://www.youtube.com/user/GlotzRichter)
- Creating a public campaign to "Use it. Don't own it" for car sharing (see: http://mobilpunkt-bremen.de/index.php?/)

City of Brussels

- Creating rules for the use of public street space that support and encourage high-quality car sharing operation and lead to increased use of sustainable modes of transport.
- Integrating car sharing with public transport (car sharing stations marked on public transport maps, advertising in buses and metro, discounted prices for those who use both services)

City of Paris

- Providing large amounts of public street space for car sharing stations

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4.4 Integrated ticketing for public transport

Description

A transport ticketing system is "integrated" if it allows travellers to pay for all legs of a journey on different public transport modes, typically including buses, trams, subways, light rail and in some cases even taxis, ferries, shared cars and bicycles. The environmental benefits of integrated ticketing schemes are primarily related to the increased ease and convenience of using public transport by eliminating the hassle of paying for each individual journey and thus contributing to wider modal shift strategies. Puhe et al. (2014) argue indeed that "the integration of tariffs, operators and modes is proved to have a positive impact on transport demand" (2014, p. 1). The benefits of a shift from private motorized transport to public transport are undisputed in terms of air quality, use of valuable urban space, noise reduction etc. (see section "Achieved environmental benefits" below for further information).

Integrated ticketing is not a radically new concept; it has existed in many cities for several decades. It comes in a variety of forms with varying technological requirements, covering different combinations of transport modes within specified zones and timeframes; each integrated ticketing scheme has its own set of advantages and disadvantages. Sometimes integrated ticketing is understood as some form of proof of payment (e.g. a paper ticket or a magnetic stripe card) for a lump sum, which allows travellers to use different public transport modes for a certain time. This approach is very easy to implement and therefore widely deployed. In Cologne, Germany, for example, a "1b" paper ticket allows people to use buses, trams and inter-urban trains within a certain geographical zone for up to 90 minutes. This low-tech approach is rather crude, however, because it penalises people, who only want to take rides that are just a little longer than the cheaper "1a" short-distance ticket. Generally speaking, the large increments between price steps are often perceived as unfair. Puhe et al. (2014, p. 9) conclude that "magnetic stripe cards are … technologically simple and cheap to produce. However, they are easy to copy and only able to save very little information." Due to these and other disadvantages, such systems are not the avant-garde in the area of integrated ticketing.

Because BEMPs are to be based on a "frontrunner" approach (Schoenberger et al., 2014), this document is primarily based on a notion of integrated ticketing as a smart system with the capability of identifying and charging trips which use multiple modes. In most cases, the charging method is a deduction from a pre-paid amount. Different systems exist for the storage of pre-paid monies (or the remote information about the remaining amount): This can be recorded on a magnetic strip on the back of a paper ticket or on a central server, with which a chip inside a so-called "smart card" can communicate. For an overview of the different approaches see section 2.2 in Puhe et al. (2014). These different systems require different types of cards and different technical infrastructure. The most advanced systems also allow the use of smartphones for this purpose – for examples see Clarion (2014).

The practical usability of a product or service like public transport is not the only factor for its acceptance; it also has to have a positive "image" (Shove, 2010). It is therefore noteworthy that the introduction of an integrated ticketing system can boost the reputation of public transport as a modern and respectable way to move about. Pricing matters too – both in terms of actual money spent as well as in the subjectively perceived price. This is important because the use of integrated tickets is often rewarded with some form of discount. In the smarter versions of such systems the user can even rest assured to get retroactively and automatically charged the most advantageous fare (known as "capping"). This significant psychological effect eliminates the worry one would otherwise face of choosing the best ticket type out of an often confusing array of options. Such benefits seem at least as important as the actual economic savings because most travellers could not actually specify their exact saving.

The integration across various modes of public transport requires the coordination of various stakeholders, operators, authorities, financial service providers, telecommunication operators and suppliers (Puhe et al., 2014. p. 2-3), the exchange of data, automated financial transactions and so forth. It is therefore not surprising that various political, technical and managerial problems caused long delays in cases such as Sydney, Dublin or Stockholm. The Hungarian capital managed to tackle related issues and to replace the fragmented management structure of urban mobility with the establishment of the Budapest Transport Centre (Heves, 2012). Despite some undeniable challenges, a large number of cities have managed to introduce various forms of integrated ticketing. A reasonably comprehensive list (of transport smart cards) is maintained at Wikipedia (Wikipedia, 2014). It shows that not only large cities managed to establish such a system but also medium and smaller municipalities and even semi-rural authorities like counties.

Where the city itself acts as a public transport operator (e.g. through a city-owned subsidiary company) it can implement related initiatives itself. In cases where the municipality awards public transport services to private companies in a tendering process they can at least spearhead related efforts by stipulating integrated ticketing solutions into the tender document (RAL gGmbH, 2014). In a third case, where public transport is provided through multiple competing private companies, related coordination efforts can be particularly challenging. But even there, public administrations can bring these actors together and facilitate their cooperation as neutral broker.

A well-known frontrunner in the area of integrated ticketing for public transport is London's Oyster card, which was introduced in 2003. It is made of plastic, the size of a credit card with an incorporated chip and is therefore rechargeable and reusable without a predetermined end. Oyster is supported by Transport for London (TfL) and can be used across most modes of public transport in the Greater London network. As a contactless smart card, it can hold various ticket types (subscription, single journeys …) and money can be added to the card via ticket machines, online or at some credit card terminals. Passengers must 'touch in' at the beginning of their journey and 'touch out' when they reach their final destination. This means that users have to hold their card near a card reader device at public transport entrances and exits.

Achieved environmental benefits

Environmental benefits of integrated ticketing systems mostly accrue from the increased ease and convenience of using public transport, the reduction of queues, faster boarding times and, as a consequence, an overall increase of travel speed due to the reduced times needed for cash transactions, primarily on buses. Such systems therefore contribute to wider modal shift strategies. The benefits of a shift from private motorized transport to public transport are undisputed in terms of air quality, use of valuable urban space, noise reduction, lower levels of atmospheric pollutants and greenhouse gas emissions, greater biodiversity and improved mobility and access for citizens.

However, such effects are very difficult to trace in a direct chain of causes to a modal shift triggered by an integrated ticketing system. This would require precise knowledge about how many people made how many journeys by public transport instead of by car simply because of an integrated ticketing system. Nevertheless, related causal claims are widely considered plausible.

What could be called secondary effects are also being reported. These can result from the data about people's travel patterns (e.g. timing and sequencing of trips, travel origins and destinations) that many such systems allow to collect and therefore facilitate efficiency gains for the operator such as a better degree of capacity utilisation (Blaum, 2013) and others (Pelletier, Trépanier, & Morency, 2011).

In cases where such a system is implemented with reusable smart cards, additional environmental benefits stem from the reduction of paper usage. In the case of London, where currently 85% of all rail and bus trips are being paid for using an Oyster card, an estimated 1542 tons of paper are saved per year, equivalent to 38 heavy 40t trucks[44]. Also the reduced amount

[44] Own calculation based on the following data and assumptions: Number of trips per year on buses, underground, Dockland Light Railway, tramlink, overground and Emirates Air Line: 3820.7 million (Transport for London, 2013, p. 7). Plus 500 million estimated trips on eligible National Rail services within the London fare zones. Estimate of 60% return trip tickets

of rubbish from discarded paper tickets deserves mention in this context. The scale of such benefits is of course much less impressive for smaller systems in less populous areas.

Appropriate environmental indicators

Suitable environmental indicators for Best Environmental Management Practices have to be

- valid (tell you what you actually want to know),
- practical in terms of data procurement and analysis,
- meaningful in internal and external communication (non-experts should understand it)
- and should allow relevant actors to monitor a BEMP's performance over time.

The validity criterion is the hardest to meet in the case of integrated ticketing systems because their direct causal effects on the environment are nearly impossible to measure. A reasonably valid indicator would be the following:

Table 4-9: Appropriate environmental indicator for integrating ticketing for public transport

	Indicator	Unit	Example and/or explanation	Data availability
A)	Number of public transport users who would have used private motorised transportation in the absence of an integrated ticketing system (ideally normalised by total population in the catchment area)	%	Methodically very difficult to measure. A time series comparison (before & after) could provide useful data for this indicator; but this is very difficult in practice.	Requires representative survey

In a survey from 2011, 66% of car users in Europe answered "Yes, definitively" or "Yes, maybe" to the question whether they would "consider using public transport more frequently if it would be possible to buy a single ticket covering all possible transport modes" (European Commission, 2011, p. 23). Actual and locally specific data for the above indicator is however very difficult to obtain. Although a representative time series survey (before & after comparison) could provide reasonably robust data, the trustworthiness of people's statements is as much an issue as the practical implementation and cost of such a survey. This and similar theoretically valid indicators thus struggle with the practicability criterion.
Therefore, in most cases, the success and intensity of use of such a system has to stand in as proxy of environmental indicators under the general assumption that integrated ticketing solutions provide some environmental benefits via a lengthy chain of causes and effects. The most important "link" of such chains is always the modal shift from individual cars to public transport. The following proposed indicators are therefore a compromise between the above mentioned ideal criteria.

Table 4-10: Further appropriate environmental indicator for integrating ticketing for public transport

	Indicator	Unit	Example and/or explanation	Data availability
B)	Number of trips paid for by the integrated ticket	No.	Reasonably valid under the assumption that a (relatively constant) percentage of such trips is the result of a modal shift from individual cars to public transport. Good to measure performance over time.	Obtainable from operational data
C)	Percentage of trips paid for by the integrated ticket	%	"Over 85 percent of all rail and bus travel in London is paid for using Oyster. The number of people paying cash has dropped to less than one percent" (ELTIS, 2013).	Obtainable from operational

(only one ticket for two trips). This results in a total number of trips per year of 4320.7 million. Assumed weight per paper ticket: 0,7 g.

			More an operational success factor (good to measure performance over time) than an environmental indicator.	data
D)	Number of person-kilometres travelled on the integrated ticket	Person-km	Using some standard assumptions (e.g. average occupancy rate per car) this data can be used to calculate environmental benefits of public transport in general. Difficult to draw conclusions about the environmental impact of integrated ticketing per se.	Obtainable from operational data in tap-in/tap-out systems

Although the indicators B), C) and D) provide relevant information about the performance of an integrated ticketing system, they do not directly relate to environmental benefits. Such benefits like space usage (lowered demand for parking), air pollution (tropospheric and stratospheric), noise, CO_2 emissions, energy and material efficiency, biodiversity are always derived from indicator A). The latter therefore remains critical despite its practicability problems. Efforts should thus be made to collect related data at least every few years. This would allow an environmentally meaningful calibration of indicators B), C) and D). In other words, if base-line data about indicator A) could be obtained at least from time to time, the environmental significance of the other indicators could be greatly enhanced.
Other indicators are still interesting to gauge the success of the integrated ticketing scheme as such but do not deserve the status of obligatory indicators of a BEMP on integrated ticketing:

Table 4-11: Extra appropriate environmental indicator for integrating ticketing for public transport

	Indicator	Unit	Example and/or explanation	Data availability
E)	Number of cards issued as percentage of population in the catchment area	%	"Since its launch … around 60 million Oyster cards have been issued" (ELTIS, 2013) at a total population of London of 8.3 million ➔ 722% of the population. More an operational success factor than an environmental indicator. Plus, the significance of this indicator can be distorted in areas with many tourists and in-commuters.	Easily obtainable from operational data
F)	Ratio of cards issued 12 months after the initial introduction compared to all non-single-trip-tickets sold per annum before	%	AltoAdige Pass: "In the first year of operation of the new ticketing system over 120,000 Passes were distributed, with an increase in 'season tickets' of 75%" (Di Bartolo, 2013)	Easily obtainable from operational data
G)	Subjective satisfaction level among users	%	"Customers are in general very satisfied with their 'Oyster'. Survey results from late 2013 show that overall satisfaction among users continues to track at a high level of 80 out of 100" (ELTIS, 2013)	Representative survey
H)	Trust in data protection adherence	%	"A report by the UK's independent passenger watchdog, London TravelWatch … reported that passengers are still wary and unconvinced by the possibilities of contactless and mobile payment technology regarded by them as too recent and not fully tested" (Andrews, 2013).	Representative survey

Cross-media effects

As with all initiatives to increase ridership numbers of public transport, integrated ticketing aims to attract new users from individual cars. However, there is no guarantee that an increase of public transport's attractiveness might not also induce cyclists and pedestrians to shift to public transport. Similar and even inverse unintended side effects have been reported from various modal shift strategies (Cachia Marsh & Ritzau-Kjaerulff, 2012). The absolute environmental effect is still mostly positive though. This phenomenon therefore underlines the importance of considering mobility as a complex system whose various elements have to be tackled in an integrated manner. The approach of *Sustainable Urban Mobility Planning* (www.mobility-plans.eu) provides such a holistic strategy that can help to avoid the cannibalisation across different sustainable modes of travel.

In almost all existing cases and presumably in all future applications of integrated ticketing, so-called smart cards will play a prominent role. At the most general technical level, an integrated circuit (chip) on board such a card can communicate with a card reader through some form of Near Field Communication (NFC) technology. The production of these chips, readers and cards requires material and energy resources. The cards themselves are typically made of plastic, generally polyvinyl chloride or other (often polyester-based) materials. A lifecycle assessment for these materials should be considered in principle but in practice is very time consuming and, considering the magnitude of mobility related resource usage, not hugely significant. In addition, smart cards from paper with a smaller environmental footprint are readily available on the market anyway and should be considered.

During the operation of a smart card-based integrated ticketing system, significant amounts of electricity are being consumed for the reader equipment, vending and top-up machines, website and central processing servers. However, their combined environmental impact is assumed to be marginal compared to the expected benefits of more and more frequent public transport usage. Quantitative data about these effects is very hard to come by.

Operational data

Technology matters greatly for integrated ticketing systems and all e-ticketing solutions rely on recent advances with Radio Frequency Identification (RFID) and/or Near Field Communication (NFC) technologies. Related information about these technologies is readily available online and a concise yet very informative overview of e-ticketing technologies is provided by Puhe et al. (2014, chapter 3).

Out of these various technical options different cities have adopted different combinations and no approach has yet emerged as distinctly dominant. What influences the choices in operational terms are the maximum possible distance between card and reader, the ability to store different types of data on a card, the robustness of the devices, ease-of-use, maintenance efforts, on-board CPU capabilities etc.

The definition of integrated ticketing is the possibility to pay for different transport modes with one ticket. In most cases, this includes buses, trams, light-rail, underground and other forms of public transport. Whereas the integration of these modes is relatively common practice, it is yet very advanced to also include semi-public modes of travel such as car-sharing and bike-sharing. Gijon's Citizen Card in Spain is one of the few cases where the use of rental bikes has been incorporated. It also grants access to electric vehicle charging points and many other local amenities, from museums to swimming pools. Also the Urbana card in Ljubljana (Slovenja) includes the option to pay for the local rental bikes "Bicikelj" and allows users to pay for parking spaces with the same payment method (Clarion, 2014). In Lund, the JoJo Card for public transport and the Lundahoj card for public bicycles can be linked up.

An interesting hybrid case is the "VSS-Mobilpass" in Stuttgart, Germany. This is a plastic smart card which is issued by the association of public transport providers in the metropolitan area only for owners of an annual public transport subscription; in this sense it is proof of a lump sum pre-payment. The card cannot be used to pay for individual journeys on buses or trams but (upon separate registration) as a card-key to open the vehicles of three CarSharing operators and to unlock bikes of a bike-sharing schemes. Mobilpass owners benefit from reduced rates for these shared bikes and can use it at a secure eBike charging station. A more advanced smart card with the ability to identify and charge for each individual journey as well with on-board payment functionalities is planned for the future (Maiolo, 2014).

The German city of Bremen used to offer a joint card that allowed to open and pay for CarSharing vehicles as well as to prepay public transport tickets (Der Senator für Bau und Umwelt, 1998). This "jack of all trades device" also came with disadvantages though. A key problem was the fact that the public transport card should be transferable to other users, the CarSharing card, however, should not. In addition, an inevitable problem for an integrated payment functionality is always the need for a clearing house, which handles the financial transactions from the various users to the various providers. This service costs money in the form of a commission and thus increases the price for the end-user (Glotz-Richter, 2014).

But technical and financial challenges are not the only aspects that need attention during the design and implementation of an integrated ticketing system. As Di Bartolo (2013) highlights, user concerns also have to be addressed with public explanations, a telephone hotline, clear online information, transparent complaints procedures and so forth and friendly staff helping customers in the early phases.

A particularly interesting approach for the actual operation of an integrated ticketing system has been chosen for the pricing scheme of the Alto Adige Pass: It has been conceived as an awarding mechanism where the fare per kilometre decreases with the cumulative distance travelled. The first 1.000 km cost 8 €Cent/km. This price reduces to 6 €Cent/km for up to 10.000 km, 2 €Cent/km for up to 20.000 km and every km travelled beyond 20.000 km is completely free of charge (SAD Nahverkehr A.G., 2014). Other discounts are also built into the tariff system for commuters, families, the elderly, pupils and handicapped people (Di Bartolo, 2013).

Applicability

Integrated ticketing approaches have successfully been implemented in a variety of cities and regions, on every continent, from megacities to more peripheral areas, in highly developed as well as underdeveloped countries. This indicates a considerable degree of freedom from contextual constraints. It does not imply universal applicability and frictionless transferability however.

One potential obstacle to the implementation of an integrated ticketing system is the size of a public transport system. Below a certain critical mass of users and annual transactions it can be challenging to recoup the initial investments in terms of time and finances. Direct financial investments refer to the installation of the necessary technical infrastructure, which do not necessarily have to be borne by public authorities. In any case, these costs have decreased dramatically over the last one and a half decades, during which integrated ticketing systems have become more mainstream and the number of suppliers has increased.

Time investments are primarily related to the coordination efforts among the various actors that need to cooperate in an integrated ticketing system. Here, public authorities can play a particularly prominent role. In fact, Puhe et al. (2014, p. 45) argue that "strong governmental support has proved to be important for institutional coordination of integrated ticketing schemes in the Netherlands and the UK." Under rigorous economic constraints (i.e. shortage of staff), such initiatives can obviously struggle to develop sufficient momentum. What can also hinder such activities are institutional and policy barriers within a public administration. In well organised administrations, however, these problems should not be insurmountable.

Regardless of the size of a public transport area, what can be a significant hurdle to the introduction of an integrated ticketing system is a highly disintegrated landscape of public transport operators. This increases the coordination effort and the risk of ending up with a non-comprehensive system. Nevertheless, examples exist where such challenges have been successfully overcome (Heves, 2012).

Locally specific factors can also include social and cultural barriers with regards to the willingness of various actors to engage in related discussions and cooperation agreements. Puhe et al. (2014, p. 9) refer to a similar problem as a "lack of political and entrepreneurial vision." Likewise, the legal context and related liability issues, data protection regulations etc. also differ between countries but in few cases to such a degree that it would thwart integrated ticketing initiatives completely.

A strong factor that can boost the wider application of such systems is the wealth of experience from existing cases so that no one has to re-invent the wheel. The pioneer investment of cities such as London can now be avoided almost completely by follower cities.

Economics

Economic aspects of integrated ticketing can be differentiated into three basic categories as in the table below.

Table 4-12: Three basic categories which can differentiate aspects of integrated ticketing

Expenses	Savings	Revenues
- Research and development - Procurement of equipment - Marketing / customer support - Overhead and management - Maintenance	- Reduction of fare evasion - Staff savings (driver time / ticket offices) - Reduced managerial effort - Increased expertise in ICT which can be applied to other sectors (Cheung, 2006)	- Increased customer base - Increased usage intensity - Revenue from applications beyond transport - Sale of know-how and intellectual property (rare)

The price of e-ticketing technologies has steadily decreased in recent years. Early implementers, however, such as Hong Kong or London had significant research and development costs to bear. The total cost of the Oyster card from the initial scheme development until and including the forecast costs to the end of 2015 was £1.1 billion (TRANSFORuM, 2014). It is important to note, however, that due to the widespread use of similar systems nowadays, integrated ticketing solutions can be purchased "off the shelf" with close to no research and development costs. But even in London with its expensive early adopter situation "the business case was quite clear" argues Matthew Hudson, Head of Business Development at Transport for London (cited in Andrews, 2013). The old paper ticket system would not have been able to handle the amount of passengers. An extension of the gatelines would have solved this problem but this would have been even more expensive and less sustainable than this new technological solution.

In most other cities an onrush of public transport users is probably not the most pressing problem. Other business cases are therefore required and will always include a bundle of factors such as the following:

Most important among all revenue generating aspects is the plausible assumption that the convenience of such a system increases public transport ridership overall. This is seen as a combination of an increased customer base (non-users becoming users) and usage intensity (infrequent to regular usage). Fewer vending machine transactions mean reduced investment in such machines and in their maintenance. Bus drivers lose less time to fare collection; also their job satisfaction and retention might increase. Faster boarding can translate to faster trip times overall, i.e. same number of passengers moved in less (driver) time while customer satisfaction increases. Also the problem of fare evasion and irregular ticket usage can be reduced. London's public transport companies have seen their income losses due to such problems "cut from 4.5 percent in 2003 to 1.5 percent in 2007, which translates into additional proceeds of nearly € 47 million" (Blaum, 2013).

Another important advantage of smartcards plays out its strength in situations where public transport services are provided by multiple operators. Here, the data which is continually and automatically generated allows to control the distribution of revenue between the operators (ELTIS, 2013). In addition, the running of an integrated ticketing system can, in itself, be managed in all cases at lean costs. The cost of card sales can be optimised, taking into account the experience of various frontrunners (drop from 14% to 10% in London), "reducing commissions paid to agents for Oyster sales, lowering the number of cards that are issued, and a drive to encourage customer self-service" (ELTIS, 2013, p. 2).

Additional possibilities to even generate extra revenue are being used in some cases where the card's commercial potentials are being reaped. Hong Kong is a typical case where top-ups can be arranged in retail shops and through automated links to bank accounts. This application eventually led to a widening of the payment function to non-transport related services and products and generates some revenue through commissions. Such applications are said to have particular potential in touristic destinations (Puhe et al., 2014). Interestingly, London chose the opposite direction and updated its reading devices to accept contactless debit and credit cards for small amounts under £20 without PIN (Andrews, 2013).

Driving force for implementation

The main motivation for the introduction of an integrated ticketing scheme is typically a robust business case that promises at least an acceptable return on investment within the foreseeable future. An increased revenue stream, avoided other investments and direct savings all play a role in such plans. But even if the outlook does not promise a significant profit, public authorities have still chosen this approach because of its non-monetary benefits to their citizens in terms of environmental advantages, quality of life and the sheer convenience for public transport users.
In fact, the main aim of the introduction of the AltoAdige Pass was “to incentive[ise] citizens, commuters, and leisure travellers to increase the use public transport and to attract new passengers … and that is what has actually happened” (Di Bartolo, 2013).
The situation in London is a bit more complex: As ridership numbers rose in the 1990s, the existing subway infrastructure dating back to 1850 was no longer fit for its purpose. In particular the gate lines were too small to handle the huge numbers of daily travellers. Station entrances could not be widened, though, because of the prohibitively high cost of real estate in London, which would have been required for such an approach. The Oyster card solved this problem in a different way by increasing the passenger throughput per time.
London’s smart card also addressed another problem, the “lack of integration between the transport modes in the London public transport network” (TRANSFORuM, 2014, p. 130). The increased convenience of the system was expected to further attract more people to public transport, thus increasing the revenue stream. What also played a role was London’s overall ambition to keep step in the race for global competitiveness with locations such as Singapore and Hong Kong who had introduced a similar system before. An analogous rationale is often also at play in most other cases where a city’s reputation as an innovative home for modern citizens and businesses is seen as very important.

Reference organisations

Selection of widely used contactless smart cards in cities, metropolitan areas and larger areas (in chronological order of their introduction):

- Hong Kong’s Octopus Card (1997)
- Singapore’s EZ-Link (2001)
- Tokyo’s Suica (2001)
- Navigo, Paris (2001)
- London's Oyster card (2003)
- Dutch OV-chipkaart (starting in 2005)
- Mi Muovo. Mobility integrated fare system in the Emilia-Romagna Region (2008)
- Stockholm's Access card (2008)
- Lagos’ ETC Card (2010)
- Dublin’s Leap Card (2011)

For a comprehensive list see List of smart cards (n.d.). Puhe et al. (2014) also provide an detailed overview of 12 integrated e-ticketing systems.

Integrated ticketing projects in regions and smaller cities (selection only):

- **AltoAdige Pass**. Italy.
  - Very interesting fee structure: “The more you ride the less you pay.”

    - Di Bartolo (2013)
- VSS-Mobilpass. Stuttgart, Germany
    - Interesting integration with CarSharing providers
    -
- **The Key**. North West England.
    - In the process of also introducing smartphone tickets.
    - Carreno (2012)
- **Maribor**, Slovenia.
    - Single ticket system between local bus services and to a cable car in the ski resort.
    - Toplak (2011)
- **oMnibus Card** in Brescia, Italy
    - Valid on buses, the local bike-sharing system and even for carparks.
    - CIVITAS (n.d.)
- **Resplusticket**. Sweden
    - Integrates regional trains, commuter trains, express busses, regional busses, local busses, underground, trolley across multiple provider companies.
    - Králíček (2010)
- **Urbana City Card**, Ljubljana, Slovenia.
    - Payment of city buses and funicular railway, public bike network and parking.
    - Category winner of MasterCard Transport Ticketing Awards 2014.
    - ELTIS (2014)
    - Mestna občina Ljubljana (2014)

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4.5 Improving the uptake of electric vehicles in urban areas

Description

The environmental and health impact of conventional private vehicles coupled with annually increasing maintenance and fuel costs has led many cities to turn away from the internal combustion engine and search for a more environmentally friendly replacement. Electric vehicles (EVs) are the frontrunner sustainable alternative, providing tangible environmental benefits as well as energy security and health benefits.

Instead of an internal combustion engine, which converts refined fossil fuels to mechanical energy, electric cars store energy in a rechargeable battery. These batteries can be charged at any electric outlet plug.

Electric vehicles have improved rapidly over the last number of years, and new-generation electric vehicles offer similar comforts to their fossil fuel counterparts. Thanks to both legislation and increased consumer demand, motor vehicle manufacturers are increasing their efforts within the electric vehicle market. As the number of manufacturers grows and EU and national legislation enforces stricter emissions standards, the availability and choice of electric vehicles is set to increase. This coupled with improvements in battery technology will see the price of the vehicles fall. Already the vehicles are far more cost effective than traditional vehicles when considered in terms of their life cycle.

Public administrations can directly purchase electric vehicles for the mobility needs of their staff, additionally, schemes that support the purchase of electric vehicles by residents can also be put in place, devoting some budget or reaching agreements with local banks at reduced interest rates. Moreover, public administration can support the uptake of electric vehicles allowing their circulation in restricted traffic areas or on preferential lanes, increasing the number of public charging points, reducing EV taxation, introducing or supporting private EV carsharing schemes and finally advertising to residents the support measures for EVs.

Achieved environmental benefit

Electric cars hold significant environmental benefits over their fossil-fuel counterparts. The only emissions caused by the vehicles are generated in the production of electricity - the cars themselves emit nothing. As electricity generation from clean sources increases, the carbon footprint of electric cars correlatively drops. As such the vehicles play a role in curbing GHG emissions. It is important to emphasise that the emission benefits of electric vehicles are only fully applicable if the energy being generated is from renewable sources.

EVs are far more efficient than internal combustion engine vehicles in terms of energy use. 75% of the chemical energy from the batteries in EVs is converted to power the wheels, while internal combustion engines convert only 20% of the energy stored in gasoline. EVs do not consume any power when stopped in traffic and have the ability to recover energy normally lost during braking (the kinetic energy used in breaking further charges the car's battery).

As a result of the increased efficiency, EVs are far quieter than internal combustion engine vehicles and contribute significantly to reducing noise pollution, particularly in congested urban areas. This however has been cited as a safety concern for pedestrians, cyclists and the site impaired, and may lead to an increase in collisions.

When used in place of conventional vehicles, EV's have the potential to greatly improve air quality. A wide-scale changeover to electric vehicle use would reduce atmospheric pollutants such as NO_x, CO and Particulate matter, which can be harmful to human health, overtime causing respiratory illness and heart disease.

Appropriate environmental indicators

Table 4-13: Appropriate Environmental Indicator – Electric Vehicles

Name	Unit of measure	Description
Electric vehicles on the road compared to total vehicles	%	Number of electric vehicles (divided into fully electric and Hybrid) circulating on the road. Electric vehicles could be disaggregated into the following categories: cars bikes and scooters commercial vehicles
Electric public fleet compared to total public vehicles	%	Number of electric vehicles (divided into fully electric and Hybrid) which are part of the public fleets owned or managed by the public authority.
Public charging points per inhabitants	%	Number of public charging points available in the city.

Cross-media effects

E-mobility retains some of the drawbacks associated with conventional private vehicles. Land use is a “non-achieved” benefit, as e-mobility does not reduce pressure on land-use for transportation infrastructure. Electric cars also facilitate urban sprawl in the same manner as conventional vehicles and do not address congestion and other traffic problems.

Operational data

Case study 1: Stimulating e-mobility, London, United Kingdom

The city of London is facilitating the future of environmentally-friendly private vehicle ownership by ensuring the uptake and viability of electric cars. Through enacting its EV plans London is hoping to become the electric car capital of the world.

To achieve this, London has drawn up the Electric Vehicle Delivery Plan. The British capital aims to have 100,000 electric vehicles on the road with 25,000 battery charging points by 2015. The city also aims to convert 1,000 Greater London Authority fleet vehicles to electric by the same year.

Tackling the level of emissions caused by private vehicles is a priority for London authorities. It is estimated that poor air quality is responsible for 1,000 premature deaths and 1,000 hospital admissions per year in the city. Transport accounts for 22% of the cities total CO_2 emissions, with motorbikes and cars accounting for 16% of the total CO_2 emissions, 46% of its NO_X emissions of and 83% of its PM_{10} emissions. Car transport is also the leading source of CO_2 emissions amongst transport in the city. Figure 4-5 breaks down CO_2 emissions from London’s transport by transport mode.

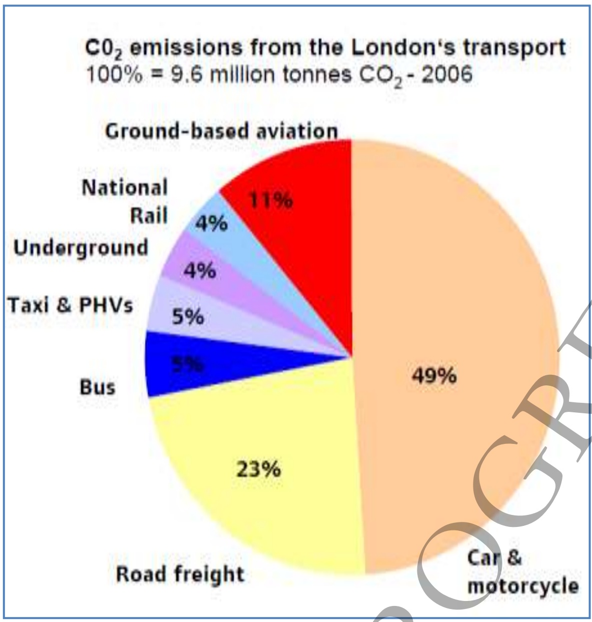

Figure 4-5: CO2 emissions from London Transport by transport mode. Source: Office of the Mayor of London, 2009

After examining possible candidates for a low-emission alternative to fossil-fuel based car transportation, the city agreed that electric vehicles presented the most effective option. Taking into account the UK's current electricity mix, which includes electricity generated by carbon-heavy energy sources, electric cars are still around 30% to 40% less pollutant than combustion engine vehicles.

The Electric Vehicle Delivery Plan sets out a strategy to stimulate the market for electric vehicles within London. It is separated into three sections.

1. Infrastructure

This aspect focuses on the roll out of charge points across the city. The city will work with the boroughs and other partners to deliver 25,000 charge points by 2015, including a network of fast charge sites. 500 charge stations will be on-street, while 2,000 will be off-street in areas such as car parks. 22,500 will be provided in partnership with businesses. Under city policy, all new developments will be required to provide charging facilities. The city is trialling wireless charge points, in which cars drive over an electric charge pad.

2. Vehicles

The public vehicle fleet will be electrified, with a target of 1,000 electrified vehicles in the Greater London Authority (GLA) Fleet by 2015. The GLA comprises Transport for London, the Metropolitan Police Service, the London Fire Brigade, and the Greater London Authority. After a detailed analysis of the operational requirements of the GLA fleet, a procurement framework was established to purchase 1,000 new electric vehicles, with funding support sought from the national government. Support is also being provided to the boroughs and central government to increase their electric vehicle numbers.

The GLA is working with companies to expand the use of electric vehicles, and has established the "Electric 20" partnership. The city is working with twenty companies that already use electric vehicles on a daily basis, such as Sainsbury's, Tesco's, Marks and Spencer, and Royal Mail, to learn from their experiences and encourage other companies to copy their example.

Manufacturers are striving to create a cost model that ensures purchasing an electric car is more cost effective than purchasing a car run on fossil fuels over a four or five year period. The higher initial cost of purchasing (caused by the expense of the battery) is offset by lower maintenance and fuel costs. Costs saved through owning an EV in London include:

- Exemption from the congestion charge
- Lower fuel costs
- No road tax
- Reduced rate parking

3. Incentives, marketing and communications

Marketing is important to the success of the scheme – for it to work, customer benefits must be adequately communicated to the public.

As mentioned above, in order to incentivise potential customers the city is abolishing the Congestion Charge for electric vehicles, abolishing road tax and is working with the borough to develop parking incentives. Car clubs are also being encouraged to increase their percentage of electric vehicles.

To further make owning an electric vehicle easier, the city has developed a London-wide membership scheme for users, which provides access to the charge point network and the congestion charge discount. The scheme, named Source London, provides this for a fee of £10, which was recently reduced from £100. As the fee was intended to be nominal and not to generate revenue, authorities felt that £10 provided more of an incentive to potential users. Source is consolidating all charging points, originally managed by separate borough authorities. By 2015 the scheme hopes to create a system in which no Londoner is more than one mile from a publicly accessible charging point.

On of the drawbacks of city run-schemes is that they stay within the jurisdiction of the city. The difficulty of linking the city scheme with other schemes is that other regions might not be using the same charging points, leading to compatibility issues. National schemes can lead to a larger uptake in the short term and increase user confidence, solidifying the concept as a viable alternative to fossil-fuel based cars in the minds of the public.

Source: City of London, available from New York City Global Partners Innovative Exchange, http://www.nyc.gov/html/unccp/gprb/downloads/pdf/London_ElectricVehicles.pdf

City example: Promoting electric vehicle uptake, Rotterdam, The Netherlands

With the Project Power Surge the city has been installing charging points and provide funding for individuals, organizations and companies. Electric transport will significantly contribute to achieving the objective of reducing CO2 emissions by 50% by 2025, in comparison to 1990 levels.
The Rotterdam Climate Initiative (RCI) is Rotterdam's response to the challenges the Rijnmond region will face in the coming decades, and the economic opportunities this offers. RCI is a public-private partnership and serves as executive climate committee. It is an initiative of the city of Rotterdam, The Port of Rotterdam, Deltalinqs (as representative of the industrial companies in Rotterdam) and DCMR Environmental Protection Agency Rijnmond. The partners join forces with their associates to create a unique movement in which government, companies, knowledge institutes, other organizations, and citizens collaborate. For Project Power Surge, RCI works together with different Dutch organisations and companies such as the postal service TNT, energy company ENECO, financial parties and ministries. Rotterdam has the ambition to become a leading city in electric transport. This will improve air quality and reduce traffic noise, significantly improving the quality of life of Rotterdam's citizens. By 2025, the number of EVs should rise to as many as 200,000. 15% of all electric vehicles in the Netherlands will then be cruising around the Rotterdam region.
During the last years, there has been a significant increase in the number of electric bikes, scooters, cars, and even delivery vans and refuse collection vehicles in Rotterdam. Project Power Surge has been boosting these numbers, creating the right conditions to dramatically accelerate the introduction of electric transport. Furthermore, electric transport will significantly contribute to achieving the objective of reducing CO_2 emissions by 50% by 2025, in comparison to 1990 levels.
The RCI participates in the C40 Climate Leadership Group, an alliance of 40 large cities from all over the world which collaborate on climate change issues.
Project Power Surge is part of the city's plan to dedicate resources to the installation of sufficient charging points in the city. In addition, Rotterdam provides funding for the installation of the first 1,000 charging points for the benefit of private individuals, organizations, and companies that will purchase an electric vehicle. In order to make electric driving even more attractive, the city will offer an extra 1,000 free parking permits to store these vehicles for one year.
Project Power Surge boosts further development of electric transport. Initiators of innovative projects are encouraged and supported in many ways, for instance through support for experiments, the set-up of regulation-free zones, and the moral support of knowing that the municipal government itself actively participates in innovations and experiments.

Source: LG Action (n.d.) ROTTERDAM, The Netherlands: Surging ahead with electric vehicles. Retrieved from: http://www.lg-action.eu/fileadmin/template/projects/lg-action/files/it/Country_Profiles/LG_Action_case_Rotterdam.pdf

Applicability
EV's are suited to city mobility patterns, as traffic congestion requires frequent stopping and starting. Therefore EV schemes are most successful in cities in which short driving distances are the norm. As EVs can be charged by any source of electricity, an electric vehicle scheme is replicable in almost all European urban settings.
When implementing an electric vehicle scheme, a strong communications strategy is necessary. Dissemination means include a dedicated website, citizen workshops, broadcast advertisements, brochures, etc. Without this citizens may not be aware of the strong benefits that EV's possess.
Public authorities incorporating electric vehicles into their public fleet is a good way for authorities to boost uptake immediately. As stated above, London aims to have 1,000 EVs in its

public fleet by 2015. Adjusting procurement policy to favour electric vehicles is a positive step in realising a functioning EV scheme.

Economics

It is estimated in London that the plan has required £60 million. This includes installation of the 25,000 charging points and conversion of the GLA fleet. The GLA, central Government and private sector will each contribute equally. The funding breaks down as 50% from the government sector and 50% from the private sector. The payback period for the scheme is hard to estimate, though in London it is envisaged that once fully operational the scheme will be transferred to the private sector, or be run through a public-private partnership. Market forces will then set the price of the scheme for consumers.

In the case of London, the city has been criticised for using public money to fund a means of transport that is not public but rather individual. However this can be justified as the scheme provides benefits in terms of the wider public good.

Backing from the private sector is a good way to reduce the financial burden on local authorities. Many private companies see this as a good public relations exercise and so are willing to provide time and funding.

Driving force for implementation

As electricity can be generated by numerous sources, electric cars bypass concerns associated with fossil-fuels, such as peak oil availability and major price fluctuations.
As well as environmental and consumer cost benefits (over an extended period), the energy required for electric vehicles can be produced domestically, stimulating the domestic economy.

Electric vehicles are also much quieter than internal combustion engine vehicles. A large scale changeover would significantly reduce noise pollution.

Another major driving force is electric vehicles ability to improve the economy. As well as the obvious jobs created in construction by internal infrastructure projects, electric vehicles can also support a low carbon economy and economic growth through stimulating the car manufacturing industry.

Reference organisations

- City of London, UK
- Rotterdam, the Netherlands

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4.6 Fostering passenger intermodality

Description

The tendency over the past several decades has been for many people to view car-based travel as the best mode of transport from the origin to the final destination due to its high level of comfort and convenience. There is also the perception that it affords the greatest freedom of mobility. However, the environmental problems caused by this practice have become ever more pressing: Traffic congestion, increased air and noise pollution, inefficient use of valuable space and an overall reduced efficiency of the transport system are only few of the most prominent ones. The solution is for public authorities to encourage the development of convenient, safe, fast and seamless connections between more sustainable modes of transport; in short: fostering intermodality.

In a smoothly integrated intermodal system people might start their journey as a pedestrian, and then become a driver or a cyclist, then a passenger, and then a pedestrian again for the final metres. Through a clever combination of modes they would avoid each mode’s specific and often inevitable weakness while at the same time utilise their various strengths.

In practice, however, intermodality can never compete with the “one-seat ride” characteristic of the private car. Interchange points often contribute to feelings of uncertainty for the traveller due to unclear signage or pathways at the point of transfer and the potential for delays. Therefore, where, when and how sustainable modes are interconnected plays a large role in their total attractiveness when compared to relying only (or mostly) on the passenger car. The extent to which the connections between modes are quick, easy, safe, reliable (in the sense “as planned”) at the designated modal choice nodes ultimately determines the attractiveness of the more sustainable journey option(s).

Intermodality is achieved through the effective intersection between urban land use planning and transport planning in order to make better use of the existing transport infrastructure. Public administrations have an important role to play in this context, as transport infrastructure providers, as facilitators, owners of land space for intermodal hubs, providers of information and as a broker who brings representatives of different modes together. Public administrations can therefore foster passenger intermodality by cooperating with various public transport operators, bike- and car-sharing companies to ensure smart and seamless connections between modes. Intermodal transport systems link together the infrastructure and services for public transport (buses, trams/light rail and commuter rail), walking, biking, bike sharing, and car sharing.

When implementing measures which foster passenger intermodality, public authorities need to consider the interoperability of different transport systems and modes and how they can best collaborate with providers of both ‘hardware’ (e.g. infrastructure) and ‘software’ (e.g. ITS, ticketing). First, the existing structure of the transport network plays a large role in identifying the location and configuration of modal choice nodes, which has an influence on the nodes’ attractive capacity and ultimately the intermodality of the transport system (Ambrosino & Sciomachen, 2006). In short, this means that it is important to first work with the existing transport infrastructure by creating smarter links between modes wherever possible. This is the most cost-effective solution which can produce quick wins. Therefore, this BEMP sets five key measures to be implemented for an effective intermodal transport system:

- <u>Modal choice nodes:</u> Conveniently placed multimodal transport hubs, also referred to as “modal choice nodes” (Ambrosino & Sciomachen, 2006) which are typically formed around existing public transport stops or stations and which have clear signage and information;
- <u>Infrastructure network:</u> A comprehensive network of infrastructure for public transport (e.g. established bus routes, tram or rail lines), bike lanes on existing roads and separated paths for walking and cycling built with safety and accessibility in mind, including the ability to bring bikes onto transit;
- <u>Intermodal journey planning software:</u> Provision of real-time intermodal journey planning information tailored to individuals’ travel needs, e.g. through the use of

intelligent transport systems (ITS) for apps and a website, ideally also considering cycling and walking as well as available car sharing and bike sharing schemes.;

- Integrated ticketing and e-ticketing;
- Pricing and demand management schemes: e.g. congestion charging.

The EU-funded SYNAPTIC project (2012) provides a clear conceptual overview of the various aspects which need to be considered for intermodal trips. Figure 4-6 provides a representation of a typical multimodal journey, while the following list comprises the main factors which need to be considered when planning measures that foster intermodality:

1. Journey planning at the 'home hub'
2. 'First mile' connections, from origin to local interchange
3. The local interchange experience
4. Feeder access to major interchange
5. The major interchange
6. 'Hub-to-hub' services
7. The destination interchange
8. 'Last mile' connections, from final interchange to destination

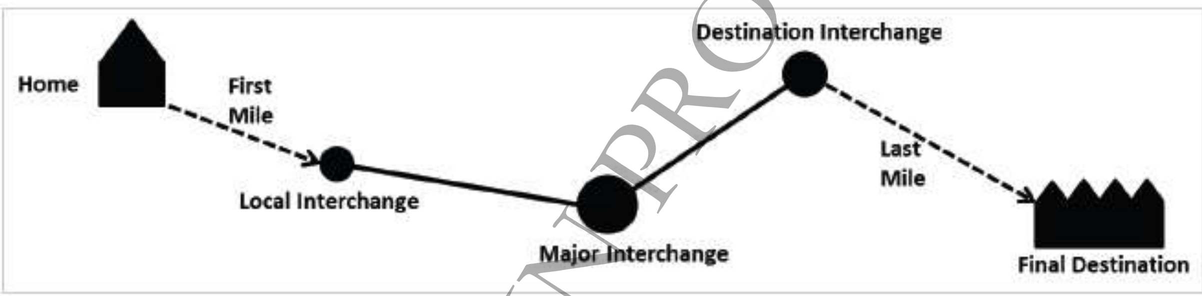

Figure 4-6: Diagram of a typical multimodal journey (*Source: SYNAPTIC, 2012)*

In essence, fostering intermodality means thinking of mobility as a service which should be made available to all citizens. Sampo Hietanen, CEO of ITS-Finland, a not-for-profit public/private sector association, defines the concept of Mobility as a Service (MaaS):
"The vision is to see the whole transport sector as a cooperative, interconnected ecosystem, providing service reflecting the needs of customers. (…) The ecosystem consists of transport infrastructure, transport services, transport information and payment services" (Hietanen, 2014).
One of the main findings of the EU-funded INTERCONNECT project was that fostering intermodality requires "co-operation between a range of authorities and providers in the public and private sectors and may necessitate a wider vision than might otherwise prevail", and that organisational issues relating to this wider vision heavily influence the development of intermodal systems (Bak, Pawlowska, & Borkowski, 2012). Further, Bak et al. (2012) cite institutional barriers, lack of investment and failure to innovate as the main institutional challenges for effective interconnection of modes. It is therefore important for public authorities to act as an effective broker who brings representatives of different modes and sectors together to reach a common vision for a coherent intermodal transport system.
Policies which aim to solve mobility challenges and create a more integrated, sustainable transport system require a holistic approach of multi-sectoral (horizontal), multi-level (vertical) and cross-territorial cooperation. Public authorities need to consider the interoperability of different transport modes and how they can best collaborate with providers of both 'hardware' (e.g. infrastructure) and 'software' (e.g. ITS, ticketing). As previously mentioned, intermodality is achieved through the effective intersection between urban land use planning and transport planning in order to make better use of the existing transport infrastructure. Therefore, public authorities should involve all relevant internal departments (e.g. building and land use, urban planning, transport, environment, energy, etc.) and may need to cooperate with neighbouring authorities (e.g. municipalities, local authorities, communities, districts, etc.) in order to determine the best locations and configurations for modal choice nodes and additional infrastructure. Cooperation with the private sector may also be needed for features such as car sharing, bike sharing and creating intermodal journey planning software. The end result should

be an interconnected, coherent transport system which meets citizens' mobility needs while enabling them to travel more sustainably.
To illustrate this BEMP, three cities have been chosen as frontrunners: London (UK), Bremen (Germany) and Lund (Sweden). These three cities represent good practice for fostering passenger intermodality in large, medium and small cities respectively. While the number of modes and their interchange points vary between London, Bremen and Lund, each city's approach is appropriate to scale, striving to make the smartest use of its transport system. The result is a modal share of sustainable modes of about 60% in all three cities (see Figure 2). Together, these three cities will demonstrate how public authorities' approaches to fostering passenger intermodality differ across scales, and will therefore help to identify benchmarks of excellence which are widely applicable to cities across Europe.

Achieved environmental benefits

The actual effects of a smooth integration of multiple transport modes are hard to predict and so are the related environmental benefits. After all, the convenience of combining the private car with cycling, public transport and walking could – theoretically – prompt a bicycle commuter to switch to a combination of motorised and non-motorised vehicles. In the majority of cases, however, the opposite shift is likely to materialise: people who typically use their private car from their origin to their final destination might discover that a clever combination of modes (all of which being at least to some degree more energy- and space efficient) does not cause more hassle, does not cost more money, does not take longer, is not less safe and overall not less convenient than the option with a private car. Ideally, a well-integrated multi-modal system is not only *not worse* but *better* than the car-bound alternative.
The cumulative environmental effects of successful efforts to turn multi-modal trips into a realistic and convenient proposition are identical to those accruing from less complex modal shift strategies. Related key benefits are therefore also mentioned in the BEMP on "Fostering walking and cycling." The most important ones are related to a reduction of air pollution, through lower levels of NO_x, PM, SO_2, as well as to lower levels of CO_2-emissions. In cases where walking and cycling replaces motorised traffic, good intermodal systems further can cause a reduction of noise levels, which currently causes severe stress (exceeding 55Lden) for affects almost 67 million people, that is, 55% of the population living in agglomerations with more than 250,000 inhabitants (European Environment Agency, 2009).
Less exclusive and less intensive use of private cars also has positive effects on congestion levels and land use. These are environmental benefits that would not accrue from a strategy that focuses purely on the technical substitution of fossil with renewable fuels or with electricity. A relaxation of spatial pressures due to a reduced number of cars requiring parking space in a city, for example, can open possibilities to rededicated space to public parks and other convivial spaces as well as to habitats for wildlife, thereby increasing urban biodiversity. Of course, social and health-related benefits are also worth mentioning in local discussions about the benefits of a well-integrated multimodal transport system. Prominent among them are improved health levels due to more active transport and greater access to mobility for women, lower socio-economic groups and other marginalised groups.
Apart from these effects that stem from the *results* of intermodal integration initiatives it is also important to note that related *measures* can have positive environmental effects in themselves. The main ones are related to the increase of urban density, which is an integral component of any effort to foster non-car-bound modes of travel. A higher concentration of people living within walking distance of transit stops, for example, does not only help to make public transport more financially viable but also typically reduces distances overall and can help to preserve valuable land for other uses. This is, again, very similar to nearly all modal shift strategies.

Appropriate environmental indicators

An ideal indicator to assess the effectiveness of intermodality-measures would be the:
increase in the percentage of people who use more than one mode in their daily commute.

However it requires a representative survey among the wider population – surely possible but at least not unproblematic in terms of data gathering. Its usefulness for monitoring purposes is also limited because there is surely a degree of saturation beyond which intermodality does not yield further benefits. After all, mixing modes is not an end in itself.
Some more pragmatic alternatives are presented in Table 3. Indicators A, D and E are the most important among all the others, as they cover a wider range of travellers and are more directly representative of the transport system's overall intermodality.

Table 4-14: Environmental performance indicators

	Indicator	Unit	Example and/or explanation	Data availability
A)	Average number of bicycle rack spaces at public transport stops per average daily passenger throughput	Spaces per passenger	This indicator should include data from all public transport stops in a given catchment area. The normalisation by the stop's throughput is important to account for the fact that large interchanges obviously require more racks than an individual bus stop. Ideally, only those bicycle racks should be counted that meet certain quality criteria (for example certified by the national cycling association).	Can be derived from standard operational data
B)	Percentage of riders on local trains who take their bicycle on board	%	Values of this indicator would also be interesting for other modes of public transport like buses, trams etc. A sophisticated version of this indicator would take the times of the days into account.	In most cases part of the existing data set
C)	Ratio between ticket price for carrying one bicycle on public transport out of the ticket price for one adult person for the same distance	Ratio	The closest this ratio is to zero, the lowest is the price for carrying the bicycle on public transport. Experience from Denmark shows that the number of passengers on Copenhagen's S-train with bicycle has more than tripled from 2.1 mio to 7.3 mio (annually) since 2009 when bicycle carriage was made free of charge (European Cyclists' Federation, 2010, p. 2).	Easily obtainable
D)	Percentage of people who live within a reasonable radius from high-frequency public transport stops that combine walking/cycling with public transport.	%	"Reasonable radius" should be defined as 800m (for walking) and 3 km (for cycling) (European Cyclists' Federation, 2010, p. 1) "high-frequency" to be defined as served at least twice per hour during morning and evening rush hours.	Requires standard survey data with moderately sophisticated GIS modelling
E)	Intermodal journey planning software includes walkable and cyclable journey legs	Yes / No	The intermodal journey planner includes walking and cycling wherever possible/desirable so that they are clearly linked together with public transport.	Easily obtainable
F)	Structural cooperation between public administration and CarSharing providers	Yes / No	Public administration and CarSharing providers work together to identify modal choice nodes where CarSharing could be integrated, and develop a strategy for implementation.	Easily obtainable

Although it has been argued above that an indicator like the "increase in the percentage of people who use more than one mode on their daily commute" is problematic in terms of data gathering, it is still advisable to conduct some kind of qualitative review at regular intervals.

This is important to understand the reasons why some people allowed themselves to be "induced" towards more intermodal travel patterns – and why others resist such a change. Such insights enable local decision makers to amend, adjust and improve their efforts with targeted measures in the next round of their systemic intermodality approach.

Cross-media effects

The creation of improvement of "intermodality-facilitating" infrastructure often requires additional space in dense urban settings. Therefore, one of the first areas of potential impact is the additional land area needed to construct modal choice nodes and additional transport infrastructure (e.g. cycling paths, tram lines, etc.). This might even encroach on existing green spaces. Bicycle parking is one such example which takes up a certain amount of space – often in the very core of a city. However, car parking takes up even more space, so it could also be argued that the increased land use needs for fostering sustainable passenger intermodality would be offset by the reduced need for car parking spaces. This of course assumes that as part of its plan to foster intermodality, the public authority would in fact actively reduce the available car parking spaces, which is highly recommended indeed.

It is also important to be aware of the possibility for an unfavourable "cannibalisation across different sustainable modes of travel" when intermodality measures are implemented. As public transport becomes faster and more convenient, some cyclists and pedestrians (i.e. the modes with the least environmental impact) might decide to switch to public transport more often. While public transport is considered a relatively sustainable mode of transport – particularly when compared to only using a car – it still uses energy which typically results in GHG emissions. However, ideally the convenience of intermodal journeys using mostly sustainable modes would reduce the likelihood that people would switch to mostly relying on a car.

Sometimes policies with the best intentions to improve intermodality result in unforeseen consequences for the city's modal split. For example, Munich's efforts to create 'bike-friendly legislation' in its *Radlhauptstadt* initiative resulted in a successful increase in the share of cycling, from 8.1% to 14% between 2000 and 2008. However, this came at the expense of walking and public transport, which decreased by 7% and 11% respectively (Marsh & Ritzau-Kjaerulff, 2012). At the same time, the car modal share increased by 13%. This result in Munich highlights the need for holistic approaches to fostering intermodality which cover more than just one mode at a time.

Operational data

The City of London's holistic and comprehensive approach to fostering passenger intermodality has been identified as a frontrunner. London's efforts have been led by its transport authority and mobility provider, Transport for London (TfL). As a city of 8.3 million inhabitants, London has 600 multimodal stations and a designated Interchange team tasked with monitoring and optimising the coordination of intermodal interchanges. TfL has successfully created a coherent and integrated transport system while minimising barriers to intermodal journeys.

Two other European cities have been selected as supporting frontrunners to fill in gaps in the London case and to represent their size class: Bremen (Germany) as a mid-sized city, and Lund (Sweden) as a small city (see Table 4-15). Bremen is known for its integration of both cycling and car sharing together with public transport in order to optimise residents' and visitors' freedom of mobility. Its *Mobil.punkt* hubs integrate train, tram, bus, cycling, car sharing, taxis and walking. Lund is a compact and highly walkable city which is also known for its strong cycling culture. Through its sustainable transport plan, *LundaMaTs II*, it has created an intermodal transport system which seamlessly integrates rail, bus, cycling and walking.

As previously mentioned, London, Bremen and Lund all have a modal split of approximately 60% sustainable modes (see Figure 4-7). For an overview of the measures taken by each city which support the use of these sustainable modes, see Table 4-15.

Table 4-15: Basic city data on London, Bremen and Lund

	London	Bremen	Lund
Population	8,308,000 (2013)	548,319 (2012)	82,800 (2010)
Land area	1,572 km2	408 km2	25.75 km2
Density	5,285 hab/km2	1,344 hab/km2	3,215 hab/km2

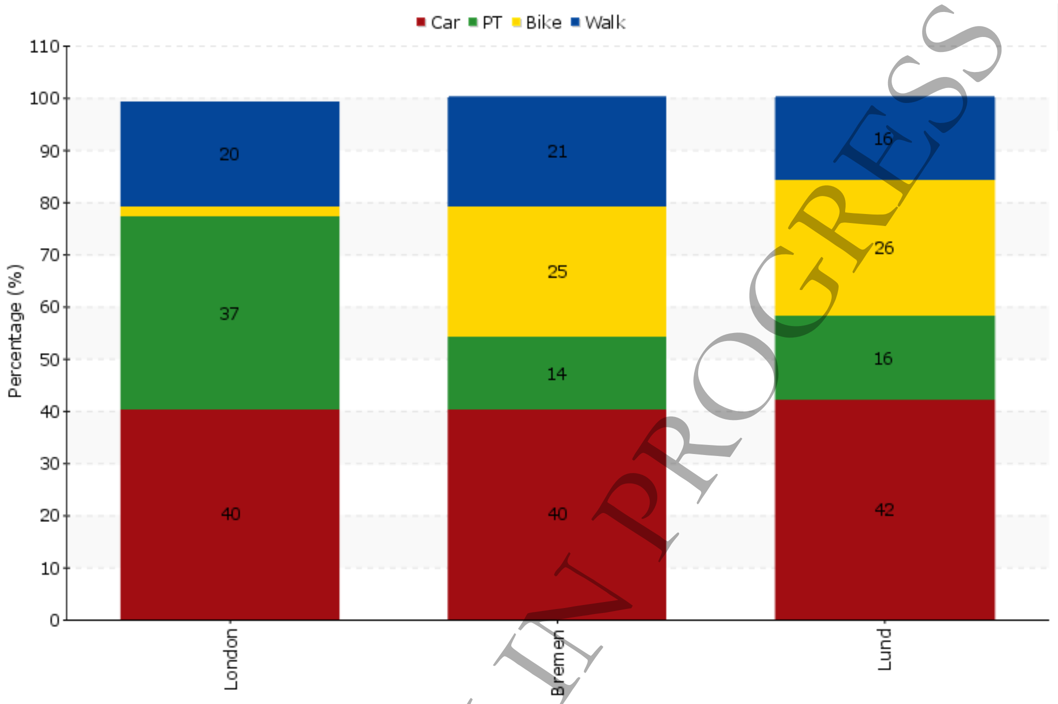

Figure 4-7: Comparison of modal split between London, Bremen and Lund. Source: EPOMM Modal Split Tool, http://www.epomm.eu/tems/index.phtml

When fostering passenger intermodality, an overall approach which relies on cooperation between a range of authorities and providers is essential. Throughout the process, the public authority plays a central role in bringing stakeholders together and facilitating their participation in the development of policies and measures which foster intermodality. Cross-sectoral and participatory approaches are hallmarks of Lund and Bremen's approaches measures to fostering passenger intermodality. Lund consulted with a variety of groups when creating its successful LundaMaTs plan, and later the LundaMaTs II plan. The city recognized the need for a holistic approach and actively facilitated cooperation within the municipality: in addition to carrying out a thorough participatory process with public and private stakeholders, several cross-sectoral working groups were formed such as a political steering group and an expert group. In Bremen, the improvement in its intermodality "have come about primarily when a person or a group with an idea has found someone with decision making power and convinced them to try something new. This is a matter of communication more than anything else" (Glotz-Richter 2004).
Now that the value of a participatory approach has been identified, this BEMP will go on to discuss operational data specific to each of the five key characteristics of an intermodal transport system. Table 4-16 page provides an overview of the key features of each city's intermodal transport system, which is followed by more detailed descriptions of the operational data.

Table 4-16: Overview of passenger intermodality in London, Bremen and Lund

		London	Bremen	Lund
Modal choice nodes	General	600 multimodal stations for walking, cycling, buses, taxis, tube, rail, light rail, tram and cars	Mobil.punkt hubs throughout the city integrate train, tram, bus, cycling, carsharing, taxis and walking; bike-and-ride facilities with 1,500 guarded storage spaces at the central station	Central train station is the main node for rail (international, national, and regional), bus (regional and local), cycling and walking; bus stops throughout city located along cycle/walking paths, many with cycle parking
	Signage & info	'Legible London' signage system of 1,300 signs throughout almost all boroughs (maps, directions); fosters intermodality between walking and other modes	Electronic kiosks at Mobil.punkte hubs provide transport information and allow carshare reservations; real-time information on electronic signs at bus and tram stops	Real-time arrival/departure info at train station and most bus stops; user-friendly signage and timetables at all bus stops
Infrastructure network	Bus	Yes	Yes	Yes
	Tram / underground	Yes (tram and underground)	Yes (tram)	Not yet (one line planned for 2018)
	Rail	Yes	Yes	Yes
	Bike paths	Yes	Yes	Yes
	Car share	Info on Car clubs on the TfL website	200 cars across 50 car sharing locations, also at mobil.punkt hubs	No
	Bike share	Barclay's Cycle Hire (PPP between several boroughs and Barclays bank)	ADFC Cycle Centre at the central station with maintenance and information services; E-bike hire in the city centre, with charging facilities for private e-bikes	Lundahoj (seasonal passes can be integrated into the Jojo smart card)
Intermodal journey planning software	ITS	TfL journey planner	VBN trip planner & app	Skånetrafiken Travel Planner
	Modes included	Bus, tram, rail, biking (including Barclays Cycle Hire and bringing on transit), walking	Bus, tram, train and dial-a-ride taxi; option to add an intermediate station or plan your onward journey	Train (regional, national and international), bus (local, regional), biking (including bringing on transit), walking
Integrated ticketing	General	Oyster card (Greater London area, covers bus, tube, tram, DLR, London Overground and most National Rail services in London)	e-ticketing and Smart card "eierlegendewollmilchsau" (combines transit, carsharing and banking), made possible due to umbrella organisation which oversees 35 PT operators in the region	Jojo card (regional bus and rail coverage of Skåne province)
Pricing & demand management	Congestion charge	11.50 GBP daily charge for driving within the charging zone Mon-Fri 7a-6p; Congestion Charge Auto Pay option, flexible pricing options	No	No

Modal choice nodes

Modal choice nodes are the central focal point of efforts to foster intermodality. It is at these nodes where modes converge in dynamic and efficient ways. The ability of sustainable modes to match or surpass the convenience of car-only travel relies largely on modal choice nodes' user-friendliness.

Transport for London's (TfL's) goal is to "ensure that by minimising the barriers experienced by a passenger transferring between services and modes, the transport network is perceived as a coherent and integrated system" (Transport for London, 2014a). TfL Interchange is a team within TfL which monitors interchanges and identifies those which may need better coordination due to changes in transport and land-use. Based on these observations, interchanges are prioritised and recommended to TfL's Interchange Programme Board (IPB) for further action. From there, a collaborative approach is taken to address the interchanges' deficiencies by involving key stakeholders and sponsors within the local boroughs. The overall aim of TfL Interchange is to treat all transport modes and their users equally. Its Interchange Best Practice Guidelines list four aspects to strive towards:

- Efficiency (operations, movement to and within the interchange, sustainability);
- Usability (accessibility, safety and accident prevention, personal security, protection);
- Understanding (legibility, permeability, wayfinding, information);
- Quality (perception, built design, spaces, sense of place)

Transport for London has very useful Interchange Best Practice Guidelines, which can provide much more in-depth information about creating smarter links between modes in terms of the above four design principles. In this document (Transport for London, 2014a), TfL cites two concepts underlying their approach to interchange design:

- "Understanding how an interchange zone is perceived by all those with an interest in it - passengers, non-users, transport operators, regulatory authorities, providers or developers of facilities and services and
- The flows and movements of people and services within the interchange zone and between the interchange zone and its surrounding area"

In terms of horizontal and territorial policy integration, London engages in network wide cooperation which includes "network and service planning, ticketing, journey planning information, service disruptions and marketing" (Transport for London, 2014a). In cases where an interchange is owned, managed or served by more than one organisation, an Interchange Facility Management Agreement is created between the parties which sets out procedures for their coordination and cooperation. These Interchange Facility Management Agreements are reviewed by the interchange operators once a year.

Bremen and Lund each have examples of modal choice nodes which successfully abide by the above two interchange design concepts. Bremen's mobil.punkt hubs innovatively integrate car sharing along with transit, taxis, walking and cycling. This approach is discussed further in the section below titled *Sharing schemes (car and bike share).* Lund has also made sure that people entering the city via the central train station (its major interchange) have clear information and pathways as they move from train to bus or bike. The central train station also tends to be the best place to provide a hub for cycling-related services to encourage people to bridge the 'last mile' of their journeys to the city centre using a fast and low-impact mode. Both Bremen and Lund have large bicycle parking facilities, both guarded and unguarded. For example, Bremen's ADFC Cycle Centre provides bike-and-ride facilities with 1,500 guarded storage spaces, as well as bicycle maintenance services and information on cycling in the city.

Signage and information

Signage and information make changing between modes more efficient and convenient, thereby increasing travellers' confidence in navigating the intermodal system. Real-time information about arrivals and departures via electronic signs at bus, tram and train stops are ubiquitous amongst cities which successfully foster intermodality. London's 'Legible London' signage system aids pedestrians in navigating the city using maps and directions to landmarks, with 1,300 signs placed throughout almost all boroughs. In Bremen, electronic kiosks provide pricing and timetable information for public transport as well as enabling reservations for a car share or and taxi.

The layout of a modal choice node has direct impacts on its usefulness and the clarity of information being provided. London's modal choice nodes are comprised of decision spaces, movement spaces and opportunity spaces. In decision spaces, there is clear signage or transport information which helps travellers to decide how to proceed with their onward journey. Movement spaces are clear pathways which connect the areas between decision spaces so that passengers can move with ease towards their next mode of choice. Opportunity spaces are areas next to (but out of the way from) the main flow of foot traffic. They present the opportunity to offer some additional value or service at the modal choice node (e.g. street furniture, cafes, retail display, landscaping).

Infrastructure network

London has a comprehensive public transport system which makes use of a wide variety of modes, including buses, taxis, tube, rail, light rail, tram. The city has also prioritised measures to increase cycling and walkability, and includes these modes in its journey planning website and smartphone app.

In Bremen, cooperation amongst transport providers is made possible due to one umbrella organization which covers all 35 transit operators in the region (Verkehrsgemeinschaft Bremen-Niedersachsen VBN). In terms of the city's overall integration strategy, this is coordinated by the Department for Construction, Environment and Transport. According to a high-level representative of the city of Bremen, "lessons learned in the process emphasize the importance of communication and building links between different partners. Integrating modes is not primarily a question of technology, although technology does offer useful tools. Integration is rather a question of bringing people together and several suggestions are made as to how to do so successfully" (Glotz-Richter, 2004).

In Lund, the LundaMaTs II transport plan provides the political direction for intermodality in terms of infrastructure, with clear goals and targets set:

- The length of walkways and cycleways will increase 30% by 2030.
- The proportion of safe crossings for pedestrians and cyclists will be 100% by 2030.
- Walking trips per resident will increase.
- Cycling trips per resident will increase 10% by 2030.
- Travel by public transport per resident will increase continuously.
- Motor vehicle transport per resident on national and municipal road networks will decrease.
- Motor vehicle transport per resident on the municipal road network will decrease 5% by 2030.
- By 2030 all properties exposed to noise levels above 54 dBA will have been offered grants.

Lund has also integrated intermodality into its vision for any future land use developments. The LundaMaTs II plan states that "The public transport/car travel-time ratio for new developments will be less than 2.0 for travel to city and district centres (covers housing and workplaces)" (Lunds kommun, 2007).

In 2014, Lund performed a preliminary review of the goals set for 2013 to see if they were met[45]. The results were that all targets were met or exceeded except for walking and cycling (Lunds kommun, 2014b). Instead, there was a 50% increase in public transport use. This is due to an increase in population within the city in recent years, which makes it difficult for the large university student population to find housing. Therefore, students tend to live further from the city centre and commute by bus or train instead of walking or cycling.

The clearest example of fostering intermodality through infrastructural measures in Lund is at the central train station (see Figure 4-8). There, the four main modes of transport are combined: walking, cycling, bus (local and regional) and rail (regional, national and international). At the exits of each train platform, real-time bus arrival information is displayed on a screen. Real-time arrivals and departures are also displayed for trains. Local and regional buses stop directly in front of the train station, and plenty of bicycle parking is provided within close proximity. Lund

[45] The city's full annual report, set to be released in October 2014, will include more detailed information on the LundaMaTs II 2013 results.

is also quite compact and walkable, so journeys to the main business and shopping areas are within reach of the central station. In order to accommodate the rapid increase in public transport use, Lund is currently in the early stages of planning for its first tram line which would run along a main route currently served by comparatively lower-capacity bus service (Lunds kommun, 2014a). The tram line is anticipated to be up and running as early as 2018.

Figure 4-8: Ample bicycle parking in Lund next to a bus stop, which is directly in front of the main train station. ***Source: Lunds kommun, 2007***

<u>Sharing schemes (car and bike share)</u>

Car sharing and bike sharing allow greater intermodal flexibility, with pick-up and drop-off locations located at or near public transport stops. Bremen is a frontrunner for car sharing.
Today, 200 cars are spread across 50 car sharing locations in Bremen, and they are a key feature of the city's mobil.punkt hubs. Car sharing has even been integrated into the integrated smart card ticketing system called "eierlegendewollmilchsau". Car sharing has even been integrated into the city's municipal fleet: Bremen City Department for Construction, Environment and Transport replaced part of its fleet with carshare services. Several residential developments also feature built-in car sharing stations, thereby reducing the parking spaces needed.
(Glotz-Richter, 2004) lists two important factors to keep in mind when establishing links between potential partners, such as car share operators and developers:

- Having a clear vision of the roles of the partners;
- Understanding the forces that motivate the partners

For example, if economic interests are what motivate a potential partner, then the public authority should frame its proposal for cooperation from an economic standpoint. This was successfully accomplished in London for its public-private partnership (PPP) with Barclays Bank for the establishment of a sponsored bike rental scheme. Barclays Cycle Hire (known colloquially as Barclay Bikes), has more than 10,000 bikes at over 700 docking stations located every 300 to 500 metres. The partnership is also engaged in planning and implementing "cycle superhighways" throughout the city to improve access for cyclists.
Lundahoj is Lund's bike sharing scheme which was launched on August 20, 2014. The system has 250 bikes across 17 bike stations, many of which are located at public transport stops. Lundahoj has integrated its ticketing with the region's public transport smart card, Jojo. The Lundahoj season pass can be connected to the Jojo card so that one card can be used for both bike sharing and public transport.

<u>Intermodal journey planning software</u>

Intermodal journey planning software (e.g. websites and apps) are the virtual equivalent of modal choice nodes: they help travellers link modes together so they can move in the most efficient way along their journey. Traditional journey planning websites and apps only link together public transport modes and sometimes walking. However, truly intermodal journey

planning software includes cycling, car share, bike share, taxi, and the ability to bring your bike onto public transport.
Integrating bike sharing into journey planning software further promotes the use of sustainable modes, but it is not yet that common. One example comes from the Rhine-Ruhr area of Germany, where the 'metropolradruhr' bike rental service is integrated into the local transport association's (VRR) trip planner (Stadt Bochum, 2012).

Integrated ticketing and e-ticketing
Integrated ticketing is the traveller's passport across fee-charing sustainable transport modes (e.g. public transport, bike sharing and car sharing); it allows for greater freedom of movement and seamless transfers, thus saving time. All three of the frontrunners' integrated ticketing schemes cover regional travel. For more detailed information on e-ticketing see the separate BEMP about this topic.

Pricing and demand management schemes
All of the measures discussed in this paper have so far been "pull" measures designed to provide more efficient access to sustainable modes of transport in an effort to draw people out of their cars. However, it does not always follow that if a public authority creates opportunities for easier access to sustainable modes, people will automatically begin using them. UITP (2011) argues that "mainly the fixed costs incurred lead car owners to spontaneously use their vehicles for every trip. The main challenge facing authorities is thus to decrease significantly the number of private cars". Therefore, it bears mentioning that demand management and pricing schemes such as congestion charging and parking pricing can act as complementary "push" measures which reduce the number of cars on the road and encourage people to switch to more sustainable modes. As the largest and most densely populated of the three frontrunner cities, London is the only one with a congestion charge. Implemented in 2003, London has seen a 12% reduction in CO_2, PM and NO_x as well as a 21% reduction in vehicles entering the congestion charging area and a 38% increase in bus ridership as a result of the congestion charge (see the separate BEMP on this topic).

Applicability

All cities can benefit from measures which foster intermodality. The question which public authorities should ask is which of the five aspects from the intermodality 'menu' it should choose to focus most of its attention on. This depends on a number of factors, from current environmental and social challenges, to the degree to which the city is already intermodal.

Modal choice nodes
The size and quantity of modal choice nodes should correlate to the size of the city in terms of population and density. For example, London is a megacity with many dense "centres" which call for large interchanges. It also offers the widest variety of modes. One example is the Vauxhall Interchange is a large complex which links the London Underground with bus as well as cycling and Barclays Cycle Hire points. Bremen, as a medium-sized city which also happens to be the least dense of the three frontrunners, has a large interchange at the central station and several mobil.punkt hubs throughout the city which integrate car sharing. The smallest city on the list, Lund, is quite dense and takes up less land area. It also only has two forms of public transport: rail and bus. Therefore, its main modal choice node is the central station, and its multiple bus interchanges integrate walking and cycling.

Infrastructure network
The existing infrastructure is the first thing that a public authority should analyse, because there may already be very quick and simple solutions for improved integration which could have a big impact. For example, there already may be a comprehensive network of cycling paths and many well-placed bus stops, but no bike parking and a lack of timetable information and maps at the bus stops. Bike parking and paper maps are a first step towards a more intermodal transport system which attracts more users, and the costs are relatively low.

It can also help to look at the modes already in use, and their modal share. This may provide further insight into trends and disconnects between modes. For example, if there is a strong cycling culture, but a low share for public transport and a high share for car use, then focusing on integrating cycling and public transport could draw car users to these more sustainable modes.

Intermodal journey planning software
Journey planning software is often the point of entry for attracting potential new users, and it is applicable in all local contexts. It has the potential to showcase all available modes in a city and their connectivity for different journey types. Most public transport providers already offer a journey planning tool, although many only incorporate public transport and walking. Public authorities can therefore engage with the public transport providers and other potential partners to incorporate data from other modes into the journey planning software. This usually does not cost very much, and is another "quick win" for a public authority to explore.

Integrated ticketing
Much like intermodal journey planning software, integrated ticketing is also applicable in any urban context with multiple modes. The main issue is with the cost of implementing an integrated ticketing scheme. There would also need to be enough users of the system to justify the scheme. For further insights on the applicability of integrated ticketing, see the separate BEMP on this topic.

Pricing and demand management
Congestion charging is perhaps the most controversial and least transferrable characteristic of an intermodal transport system. It tends to work best in large cities which have severe traffic congestion. In order for such pricing and demand management schemes to work as "push" measures, there also needs to be adequate access to sustainable modes that will do an effective job of "pulling in" users. For further details on the applicability of congestion charging, see the BEMP on congestion charging.

Economics

As set out in the description section, enhancing the intermodality of a transport system relies on the implementation of a series of measures such as improving interchanges, providing safe and attractive walking and cycling infrastructure and the introduction of integrated ticketing. The costs of delivering individual measures do of course vary significantly, while the benefits to travellers could be expected to increase cumulatively as more and more improvements are made across the network – i.e. the overall improvement to the journey experience for a person making a multi-modal trip would be greater than the sum of individual parts.
In the case of Lund, the total costs of running and implementing the project proposals is estimated at SEK 75-80 million (8.1-8.7 million EUR), while investment costs are estimated at SEK 1-3 billion (100-330 million EUR). To this must be added increased operational costs of SEK 5-10 million (550,000 to 1 million EUR) per year as a result of investment or new services" (Lunds kommun, 2007). Undertaking a cost-benefit analysis of a full package of intermodality measures such as this would be immensely challenging, with results relying on many informed assumptions. Nevertheless, a review of some of the Cost Benefit Analyses (CBA) tools developed by mobility practitioners provides a means for identifying the key factors that can be taken into account from the perspective of transport users, operators and providers.
The KITE European knowledge base for intermodal transport CBA tool and UK Department for Transport TUBA (Transport Users Based Assessment) tool identify costs and benefits including the following (Department for Transport, 2014; Rodrigues, 2009; Transport for London, 2014b):

- Intermodal transport scheme cost
- Overall speed of the journey – values of time are input to TUBA as perceived costs.
- Levels of walking and waiting time at interchanges

- Comfort of the journey – points for consideration include number of seats in waiting areas, cleanliness, weather protection and provision of cafes or shops. In relation to this, it is worth drawing attention to TfL guidance that advises "an interchange can become an identifiable place, with its own character and with potential to become a destination in its own right. This means that an upgrade is likely to boost real estate values and retailers' turnover. In some cases (e.g. Hong Kong) the city benefits economically from such measures by means of a special policy that allows them to skim some of this value increase for their municipal purse" (Transport for London, 2014b). The cost of interchange improvements may therefore be partly funded by commercial interests, and the ability of travellers to undertake additional tasks such as shopping can be factored as a further benefit.
- Safety and security
- Cost of the journey, such as vehicle operating costs and fuel costs

The environmental benefits of intermodality should also be factored into any assessment of proposals, along with the proven health benefits of walking and cycling.

Clearly different cities have different starting points, in terms of which aspects of intermodality can be improved, and different budgets available. Some cities may need extensive retrofits or expansion of the infrastructure for public transport, cycling or walking which are costly upfront, but which would reap great environmental, social and economic benefits in the long-term. Other cities may only need to do minor adjustments to existing transport hubs to make them more user-friendly. Cheaper options include: improving information/signage, introducing an ITS trip planning website and app, and providing bicycle parking.

The financial and economic issues of intermodality issues have often been found to interact with organisational issues, creating barriers to improving the transport network overall (Bak et al., 2012). For instance, those stakeholders experiencing the greatest benefits of transport network improvements may not be the same as those financing the improvements. The EU-funded EVIDENCE project, which runs from March 2014 until February 2017, seeks to provide advice to decision-makers about the proven economic benefits of sustainable transport initiatives which foster intermodality (EVIDENCE, 2014). It could therefore provide proof for public authorities seeking to promote and implement intermodality programmes.

Driving force for implementation

Fostering passenger intermodality requires a holistic approach to transport planning and management, meaning that all three pillars of sustainability are taken into account: environmental, social and economic. Because of this, the driving forces for implementation are often three-pronged. London's drive for implementing measures which foster passenger intermodailty are to "mak[e] public transport more attractive to existing and potential passengers" and so that "the transport system, including interchanges, can contribute to the achievement of broader economic, social, and environmental objectives" (Transport for London, 2014a). Lund was motivated to improve intermodality so that "the city and its transport system will be jointly developed to create a sustainable, attractive place that people will want to visit and live in" (Lunds kommun, 2007). The LundaMaTs II plan also states that its goal is to reduce CO2 emissions from transport per resident by 40% by 2030. Bremen was motivated to improve the urban quality of life by using public space more efficiently and recovering areas for social and ecological functions (WerkstattStadt, 2011).

The immediate and overall goal is to make the most efficient use of the existing transport system. The following factors are the main drivers for a public authority to take a closer look at its overall sustainable mobility strategy:

- Car traffic congestion is a problem which is remaining the same or increasing over time
- The city's modal split is out of balance (e.g. large share of car use, very little public transport, cycling and walking)
- Adequate transport infrastructure is currently available yet underused

- Increasing environmental concerns (e.g. GHG emissions) and rising petrol prices are often cited as driving forces in the implementation of solutions which foster intermodality (Burckhart & Blair, 2009).

Reference organisations

Table 4-17: Refernce organisations in fostereing passengers' intermodality

Location	Link/Project title	Intermodality component(s)
Strasbourg, France	http://www.carto.strasbourg.eu/Home	Comprehensive trip planner including multiple modes
Almada, Portugal	http://www.eltis.org/index.php?id=13&study_id=2888	Tram filled the gaps between PT networks; intermodal info guide (online and paper) + examples of multimodal trips
Region of Basse-Normandie, France	Comment j'y vais in France: http://www.commentjyvais.fr/	Promotes carpooling for locations >5km from PT stop, and walking or cycling for <5km
The Netherlands	PT-bike http://www.ov-fiets.nl/	Promotes the multimodal trip using public transport and cycling
Department of Finistère, France	http://www.covoiturage-finistere.fr/ http://www.viaoo29.fr/	Stimulates carpooling through a matching website and through the PT provider's online route planner, complemented by parking near bus stops equipped with bicycle racks.
Bremen, Germany	mobil.punkte: http://www.360cities.net/search/mobilpunkt	Ten car sharing stations located near PT stops which also have bicycle racks and multimodal travel information.
Amsterdam, The Netherlands	OV-Chipkaart (OV-Chipcard)	Ferry services are integrated with the city's public transport system; smart card system
Utretch, The Netherlands	Utrecth Zuilen (suburban station opened in June 2007)	Intermodality between walking, biking and train, with bicycle lanes, bike storage lockers, touch point for O-V Chipcard and clear signage and timetable information. (See SYNAPTIC 2012).
Amsterdam, The Netherlands	Amsterdam Biljmer ArenA (suburban station)	Integration of bus/tram, metro, suburban rail and intercity rail within one clearly marked station complex.
Newcastle upon Tyne, UK	GoSmarter (Schools Go Smarter and Go Smarter to Work) – partnered with neighbouring local authorities; Co-wheels car club (car sharing); one of the largest electric vehicle charge point networks in Europe; Go Zero	The GoSmarter campaign helps students and working adults to plan their routes to school and work using sustainable modes. GoSmarter offers a Personalised Journey Plan as well as a variety of activities and support. Co-wheels car club is a car sharing scheme which has a presence at the central railway station. The Go Zero campaign aims to reduce the city's GHG emissions, and includes a route planning app which includes information on car sharing and EV charging. In addition, Newcastle has one of the largest electric vehicle charge point networks in Europe. People can charge their EVs for free, and can also park for free as long as they are charging their vehicle.

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4.7 Implementing a congestion charge

Description

Experiences from frontrunner cities such as London, Milan and Stockholm show that congestion charges can be an effective means for achieving multiple policy objectives. Benefits can include: reducing traffic volumes in a specified area; increasing the efficiency of the transport system as a whole; encouraging people to use public transport, walk and cycle; and raising finance for a city. From an environmental perspective, this translates to environmental benefits such as reductions in air and noise pollution, as well as opportunities to improve the quality and attractiveness of the city centre. When planning a congestion charging scheme it is important to be informed about the links between traffic congestion and environmental issues, as well as the different aims, achievements and lessons learnt from existing congestion charging schemes.
Traffic congestion is a problem experienced in many European cities and, in simple terms, can be described as the situation where the addition of a vehicle to the traffic flow on a road network increases the journey time for others (Thompson and Bull 2001 cited in Bull 2003 and Jarl 2009). Congestion leads to higher operational costs for road users, including both private vehicles and public bus operators. It also causes externalities that are more difficult to quantify in terms of wasted time and increased environmental pollution (Button 1993 cited by Jarl 2009). When motor vehicles are forced to stop and then accelerate again in heavy traffic, this results in greater emissions than when traffic moves at more consistent speeds (Barth & Boriboonsomsin 2008). Table 4-18 records congestion levels in ten of the most congested cities in Europe, as recorded in the TomTom European Traffic Index, which aims to provide policy makers with unique and unbiased information. The figures for delays per hour during peak periods illustrate powerfully the inefficiency of congested road networks.

Table 4-18: Congestion levels in European cities

City and country	Rank[46]	Congestion level	Delay per hour in peak period	Delay per year with a 30min commute
Palermo, Italy	1	39%	37mins	87hrs
Warsaw, Poland	2	39%	43mins	96hrs
Rome, Italy	3	37%	40mins	92hrs
Dublin, Ireland	4	35%	43mins	96hrs
Marseille, France	5	35%	38mins	89hrs
Paris, France	6	35%	38mins	89hrs
London, UK	7	34%	36mins	86hrs
Athens, Greece	8	34%	30mins	76hrs
Brussels, Belgium	9	34%	45mins	98hrs
Stockholm, Sweden	10			

Sources: TomTom European Traffic Index 2014

Cities can seek to reduce congestion by providing more road capacity or public transport (supply-side measures); and by seeking to influence travel demand and behaviour through measures such as congestion charging (a demand-side measure)(Jarl 2009). Based on the experience of congestion charging in London, Milan, Singapore and Stockholm, experts emphasize that a charge should be implemented as part of a package of transport measures. An important lesson is that a congestion charge must be accompanied by complementary services that provide a valid alternative to the car (Santos 2005 cited by Givoni 2011).
At a theoretical level, a congestion charge is different from road pricing (road tolls), even though they may be perceived by some highway users in the same way. Road pricing is typically implemented as a way of paying back the cost of a debt financed road – i.e. the road pricing toll is paid whether the road is congested or not. In comparison, congestion charges are

[46] Rank 1 refers to most congested city. Table ranks amended to show only cities within the EU. Moscow and Istanbul rank highest in the TomTom European Traffic Index.

targeted at providing economic disincentives for the use of congested roads at congested times (see the charging times for London, Milan and Stockholm in Table 4-19).

Drivers that used the congested road network prior to the implementation of the charge are presented with a number of choices. They can: use alternative roads; travel at times outside the peak hours; use other modes of transport; or decide that the trip is not necessary (TIDE, 2014; Jarl 2009). For each of these travel choices, environmental benefits can be realized as a result of: the decision not to use a private motorized car; or the reduced level of congestion (as summarized inTable 4-20).

Table 4-19: Overview of the London, Milan and Stockholm congestion charges

	London	**Milan**	**Stockholm**
Name	Congestion Charge	Area C	Congestion Tax
Date introduced and changes	Introduced 2003; a western extension was introduced in 2007, but this extension was removed at the end of 2010.	Ecopass in 2008, with upgrade to Area C scheme confirmed in 2013.	Introduced in 2007, following a referendum and 6 month trial in 2006.
Area covered	Central city area of 21km^2 bounded by the inner ring road (1.3% of total Greater London area)	City centre 'Cerchia dei Bastioni' Limited Traffic Zone (LTZ) of 8.2km^2 (4.5% of municipality)	Central area of 34km^2 (18% of the city area)
Charging times	07.00 – 18.00 (Mon to Fri)	07.30 – 19.30 (Mon to Wed & Fri) 07.30 – 18.00 (Thurs)	06.30 – 18.30 (Mon to Fri)
Charge cost[47]	£5 (€6.28) in 2003, increasing to £11.50 (€14.45) by 2014. Cost reduced by £1 if registered for Auto Pay. Residents and Ultra Low Emission vehicle Discounts (ULED) available.	€5 Residents have 40 free accesses per annum and reduced rate of €2 from 41st access.	5 to 20 Swedish kronor depending on time of day (€0.54 to €2.18). Maximum price for a day limited to 60 kronor (€6.53).
Exemptions from charge	Mopeds, motorcycles, emergency service vehicles, health service vehicles, vehicles for disabled people, other public utility vehicles.	Mopeds, motorcycles, electric cars, vehicles for disabled people, public utility vehicles, public transport vehicles and taxis. Hybrid, methane, lpg and biofuel vehicles exempt until 31/12/2016.	Emergency vehicles, buses >14 tonnes, fuel blend primarily consisting of alchohol, diplomatic cars, motorcycles, vehicles registered abroad, military vehicles. And vehicles with a permit: vehicles for disabled people, vehicles running partly or completely on electricity, gas (not LPG), and transportation vehicles <10 tonnes.

Sources: TfL 2014a, GLA (not dated), Jarl 2009

[47] Curreny conversions undertaken on 12 August 2014 utilizing www.x-rates.com

Table 4-20: Environmental benefits resulting from travel choices when a congestion charge is implemented

Travel choice	Reduced use of private motorized vehicles	Reduced pollution due to reduced congestion / traffic queuing
Use alternative roads		X
Travel at times outside peak hours		X
Use other modes of transport	X	
Decide the trip is not necessary	X	

Tackling congestion is an important goal of all congestion charges, but the emphasis given to associated environmental impacts by cities varies. For instance, in the case of Milan, environmental objectives were a primary driver for the implementation of the Area C scheme (ITF 2014, Mattioli et al. 2012). Widespread public concern about high levels of air pollution in the city led to the implementation of the Ecopass charge for access to the city in 2008. This was not found to be effective enough in reducing PM10 levels, so, during a city-wide referendum during 2012, 79.1% of voters supported an upgrade and geographical extension of the Ecopass scheme. The result was the implementation of the Area C congestion charge. As set out in Table 4-21, the explicit objectives of the Area C scheme covers a broad range of environmental and socio-economic objectives.

In contrast, the explicit focus of the London Congestion Charge scheme has been on the efficient operation of the transport system. The Congestion Charge was successfully introduced in 2003 with the following four stated priorities:

- to reduce congestion;
- to make radical improvements to bus services;
- to improve journey time reliability for car users; and
- to make the distribution of goods and services more efficient.

While the overall efficiency of the transport system is emphasized in the scheme objectives, a Transport for London (TfL) evaluation report states that the London Congestion Charge has also led to environmental and safety improvements. In addition, the charge has been successful in generating revenues to support implementation of the Mayor’s Transport Strategy (TfL 2007).

In the case of Stockholm, the main goal of the congestion charge was to reduce congestion. A “better environment” was also considered a goal, but proponents were careful not to overemphasize this purpose or to promise too many environmental benefits. The project was never promoted as a way to raise money (Swanson 2009).

Table 4-21 provides a comparison of the explicit objectives of the London, Milan and Stockholm congestion charging schemes. This shows that reducing noise pollution has not been an explicit objective for any of these three congestion charging examples, although this may be captured in the objectives to improve the quality and attractiveness of the urban environment.

Table 4-21: Comparison of stated congestion charge objectives for London, Milan and the Stockholm congestion charging trial (see section 8 for more information on the Stockholm Trial).

London	Milan	Stockholm (trial)
-	Reduced air pollutant emissions: Total & Exhaust PM10; Ammonia; Nitrogen Oxides; Carbon Dioxide	Emissions of carbon dioxide, nitrogen oxides and particles in inner city air should be reduced
-	Reducing health risk relating to air pollution: less Black Carbon	
-	Decreased demand for use of public space for on-street parking	
-	Improving the quality and	People residing or staying in

London	Milan	Stockholm (trial)
	attractiveness of the urban centre	the inner city should experience an improvement in the urban environment
-	Reduced vehicular access to Area C	
Reduced traffic congestion	Reduced traffic congestion	The number of vehicles in the congestion-charging zone during the peak periods of the morning and afternoon should be reduced by 10% to 15%
Improve journey time reliability for car users	Increased speed of private transport	Traffic flows should improve on the most heavily trafficked roads in Stockholm
Make radical improvements to bus services	Increased speed of public transport	
	Increasing the share of sustainable modes of travel	
-	Reduced road accidents	
To make the distribution of goods and services more efficient	-	
-	Raising funds for the development of mobility infrastructures: cycle lanes; pedestrian zones; 30kph zones.	More resources to be provided for public transport.

Sources: TfL 2014a, ITF 2014, SLB Analys 2006

Achieved environmental benefits

The London, Milan and Stockholm congestion charging schemes can all be considered successful in achieving their stated aims. In broad terms, each of these congestion charging schemes reduced the numbers of private vehicles entering the charging area by around 20-30% (ranging from 21% in London, to 28.5% in Milan and 29% in Stockholm) . Increases in the reliability and efficiency of public transport were also achieved.

As a result, the congestion charging schemes contributed to achieving the following primary environmental benefits:

- Reduction in CO_2 emissions and other air pollutants responsible for global climate change. CO_2 emissions reductions of 12% are recorded for London, increasing to as much as a 35% reduction for Milan.
- Reduction in air pollution, such as NO_x and PM10, that can cause health problems at a local or regional scale. For example, London recorded a 12% reduction in PM10 levels, with 15% and 18% reductions achieved in Milan and Stockholm respectively.
- Reduction in road and parking capacity requirements, creating space for other land uses such as public open space. Associated benefits could include the introduction of green infrastructure such as parks, street trees and planting, helping to protect and enhance local biodiversity and reduce stormwater runoff.
- Potential for reduced noise pollution, although this will depend on the travel alternatives available and the comparative noise profiles of cars, buses and motorcycles etc.

Further information on the achieved environmental benefits of congestion charging schemes is provided in the section 'Operational Data'.

Achieved environmental benefits over time

It is clear that congestion charging can have a significant and immediate effect on traffic levels, but consideration also needs to be given to long term goals and measures that could be taken to maintain environmental benefits. In the case of London, the average excess delay on roads inside the Congestion Charge zone was 2.3min/km in 2002 – the base congestion level before the scheme was introduced. This fell to 1.6min/km in 2003 when the Congestion Charge was implemented (a 30% reduction in congestion). The level of congestion remained the same in the following year, but started to increase thereafter. In 2005 and 2006 it increased to 1.8 and 2.1 min/km respectively, so congestion had almost returned to its pre-charging level in 2006 (Givoni, 2011). It is notable that London remains one of the more congested cities in Europe in 2014, featuring within the ten most congested cities in the TomTom traffic index (see Table 4-18 – Stockholm also continues to feature in this list).

Givoni (2011) advises that this is not itself a sign that the London Congestion Charge failed, as background travel demand is increasing and congestion levels could have been worse without it. Yet this situation does raise theoretical and practical questions for cities considering a congestion charge:

- Congestion charges can deter some drivers, but as congestion levels are reduced, others may find driving into the city more attractive. From an economic perspective this can be viewed as an optimal allocation of the available road capacity, however the environmental benefits of the scheme are compromised. Cities should therefore seek to identify supplementary measures that reinforce the attractiveness of alternative transport modes, with these being implemented in phases as congestion levels are reduced.
- It is possible that the effect of implementing a congestion charge could be offset by other organisations that decide to reduce parking fees inside the charging zone in response, especially for cities where a high percentage of car parking is provided by private companies rather than the public authority.

When compared to London, a similar initial impact was achieved with the Stockholm Congestion Tax, but this effect was maintained over time. The Stockholm example could therefore offer insights into how long term benefits can be realised.

Combined effects of congestion charging with other measures

Congestion charging is best implemented as one component of a package of sustainable mobility measures, which can make it difficult to differentiate between the environmental benefits attributable to each measure. For instance, in the example of the London Congestion Charge it is estimated that around 30,000 car users switched to bus transport during the period 2002 to 2003. What is not clear is what proportion of this success relates to the improvements to bus services implemented during this period, or the introduction of the Congestion Charge (Givoni, 2006). While this can make evaluation of congestion charging measures more challenging, this example reinforces the message that a charge should be designed to complement other transport initiatives.

Reducing levels of Air Pollution

It is reasonable to expect that congestion charging will result in some indirect environmental benefits, particularly relating to air pollution, although this remains an area of controversy. Studies which have looked in detail at air pollutant concentration data and estimated the environmental effect of congestion charges show mixed results (Givoni, 2006 referring to Carnovale & Gibson 2013 and Atkinson et al., 2009). Mattioli et al. (2012) advise that both supporters and opponents of congestion charging therefore sought to utilize the available evidence on this subject in Milan. In the run up to the Area C referendum, it is suggested that city officials in Milan sought to de-couple the proposed congestion charge from tackling levels of PM10 in the city, given the level of uncertainty on benefits. Nevertheless, the question of congestion charging has remained framed in terms of air pollution amongst the general public as well as in the media.

A study by Carnovale & Gibson (2013) took advantage of an 8 week suspension of the Area C scheme48 to assess the effects on air pollution with and without congestion charging. They concluded that Area C reduces traffic and improves air quality, but that the effectiveness of the scheme is undermined by certain driver responses. The effect of suspending the charge was that concentrations of CO_2 increased by 5.5%, ozone by 12% and total suspended particulates (TSP)

[48] In late July 2012, an Italien court unexpectedly suspended the Area C charge and reinstated it again approximately 8 weeks later (Carnovale & Gibson 2013)

by 16%, a significant change in air quality given that Area C represents only 5% of the city. It was found that drivers' responses to implementation of the charge were:

- Changing the time of travel to avoid the priced period.
- Using vehicles exempt from the charge, such as motorcycles and mopeds, for which exhaust emissions standards are currently less stringent than for cars (Europa, 2010)
- Use of roads outside the charging area.

If a congestion charge is to have greater environmental benefits, in particular reducing air pollution, it is necessary to carefully consider complementary measures. For example, careful definition of "exempt vehicles" and implementation of a Low Emission Zone (LEZ) alongside the congestion charge could prevent drivers switching to motorcycles and mopeds that can have poor emissions standards.

Appropriate environmental indicators

It is recommended that indicators are selected that allow monitoring of direct environmental benefits, such as reductions in air pollution, as well as indicators that enable public administrations to gauge levels of congestion and beneficial changes in travel behaviour. The following three key indicators are recommended:

- Reduction in air pollution, including reduction of Greenhouse Gas Emissions.
- Reduction in vehicular access to the congestion charging area.
- Increased average speed of private cars and punctuality of public transport vehicles in the congestion area.
- Increased trip share of sustainable modes of travel (i.e. public transport, cycling and walking).

Table 4-22 provides additional information on indicators that have been utilized by frontrunner cities, together with some references for further reading. When selecting indicators, public authorities should seek to align these with existing indicator sets developed at a European level, such as the European Green Capital Award, Reference Framework for Sustainable Cities (RFSC), Covenant of Mayors and European Green Cities Index. This can help to facilitate research at national and international levels on the effectiveness of different measures in the future, as well as benchmarking in relation to other cities.

Table 4-22: Recommended environmental indicators for a congestion charge

Indicator		Unit	Additional information	Existing European Indicators
Air pollution reduction	CO_2 Emissions	Tonnes CO_2	Four key air pollution measures are identified here. The European Union has developed an extensive body of legislation which established further health based standards and objectives for air pollutants. A full list of the standards is available at: http://ec.europa.eu/environment/air/quality/standards.htm See also: http://www.airqualitynow.eu/comparing_smi.php#parag4	Green Capital Award – Climate Change Mitigation and Ambient Air Quality are indicator areas assessed. RFSC Key Indicators are: K15 Greenhouse Gas Emissions in tons per capita; K18 number of times European Directive PM10 limit exceeded. Covenant of Mayors: CO_2 emissions per capita; and reduction target by 2020 by sector/field of action. Green Cities Index: CO_2 emissions, intensity and reduction strategy; and annual daily mean of other pollutants.
	Fine particles (PM2.5)	μg/m^3		
	PM10	μg/m^3		
	Nitrogen dioxide (NO_2)	μg/m^3		

Indicator		Unit	Additional information	Existing European Indicators
Noise pollution reduction	Day – evening – night equivalent level	L_{den}	The Environmental Noise Directive (2002/49/EC) aims to define a common approach intended to avoid, prevent or reduce on a prioritised basis the harmful effects, including annoyance, due to the exposure to environmental noise. Harmonized indicators for developing strategic noise maps are recommended.	Green Capital Award – Quality of the acoustic environment is an indicator area assessed.
	Night equivalent level	L_{night}		
Land use	Reduction in public space used for roads and parking	ha		Green Capital Award – Green urban areas is an indicator area assessed. RFSC Key Indicators include: K20 Satisfaction with public spaces
Changes in congestion levels and travel behaviour	Reduced vehicular access to congestion charging area	Vehicles / hour or day	Ideally types of vehicles should be recorded for analysis: motorcycle, car, heavy goods vehicle, taxis etc. Authorities should also consider recording useage of exempt and Low Emissions Vehicles (LEV).	RFSC Key Indicators include: K7 - Percentage of trips by private motorised transport Green Cities Index: congestion reduction policies
	Increased average speed of private vehicles	km / hour	In London, a comparison is made between the free-flow speed of traffic (recorded at night time) and average speeds achieved during the day.	
	Increased average speed of public transport vehicles	km / hour		
	Increase in area dedicated to sustainable modes of travel	km^2 or % of total transport network		Green Cities Index: size of non-car transport network
	Increased trip share of sustainable modes of travel	Expressed as %	Sustainable modes of travel comprise use of public transport, cycling and walking.	Green Capital Award – Local transport is an indicator area assessed. Green Cities Index: use of non-car transport
	Finance raised for investment in sustainable modes of transport	€ / % of net revenue from the scheme	Figure should exclude cost of implementing congestion charge scheme.	

Sources: EC Air Quality Standards; EC Environmental Noise Directive (2002)

<u>*Monitoring of Black Carbon*</u>

A growing number of studies have focussed on Black Carbon (BC) as an alternative (or complementary) measure for air pollution and demonstrating the environmental and health impacts of transport policy (Mattioli et al. 2012 citing Wang et al. 2009, Westerdahl et al. 2009, Bruckmann, 2011, Reche et al. 2011 and Invernizzi et al 2011). BC is the sooty part of

Particulate Matter (PM) formed by the incomplete combustion of fossil fuels and biomass. It is mostly emitted by vehicles, ships, coal and wood burning stoves. Of all air pollutants, PM is the most harmful to health and the black carbon part of PM is particularly harmful as it comprises a mixture of very fine, partly carcinogenic particles, small enough to enter the bloodstream. There is currently also a lively debate about whether reducing this pollutant could have significant gains in reducing climate change (EEA, 2013). When implementing a monitoring system for a congestion charge, city administrations should therefore consider including a BC Indicator, taking into account the most up to date guidance available.

Financing of sustainable mobility infrastructure
An important indirect benefit of congestion charging is that a city administration can raise finance, allowing it to invest in infrastructure for sustainable mobility modes such as public transport, walking and cycling. For instance, in Milan a total of €13mil has been raised for investment in public transport and cycle sharing schemes through the Area C scheme. In contrast, a proportion of the revenue from the congestion charge in Stockholm has been directed towards a city bypass road project. Swanson (2009) quotes Karlina Isaksson from Sweden's Royal Institute of Technology, who explained: "It was such a big effort to make it [the congestion charge] happen and people think of it as such an environmentally progressive thing. But this perception is illusory…The real struggle is not whether to have a congestion charge, but how to use the revenues."

Cross-media effects
The implementation of a congestion charge can result in a variety of travel behaviour responses, with the result that some localised environmental impacts may shift from within the charging zone to the area nearby. Carnovale & Gibson (2013) report that some drivers responded to the Milan Area C scheme by driving around the city centre. For drivers seeking to avoid Area C, the natural route typically involves the Circonvallzione Esterna, a ring of larger roads located 0.6km – 2km from the Area C boundary.
As noted above, it has also been suggested that some drivers switched to travelling by motorcycle or moped in Milan, thereby avoiding the charge (a marginally significant increase in motorcycle use was detected by Carnovale & Gibson, 2013). While this shift to motorcycle use is beneficial in terms of easing congestion, as the vehicle takes up less road space than a car, the environmental benefits with respect to air and noise pollution can be limited (vehicle emissions standards for motorcycles are less stringent than those for cars).
If the greatest environmental benefits from a congestion charge are to be achieved, it is important that city administrations seek to predict the most likely travel responses and put in place complementary measures to mitigate potentially damaging cross-media effects.

Operational data
Information on achieved environmental benefits and operational data in Table 4-23 suggests that the Milan Area C scheme recorded higher reductions of air pollutants than the London or Stockholm schemes. However, the different contexts for each scheme, and likelihood of differences in the monitoring and evaluation methodologies pursued, make direct comparisons difficult and potentially misleading. For instance, Milan had a much higher modal share of car use than either London or Stockholm when it implemented Area C, increasing the likelihood that larger reductions in car use and associated air pollutants could be achieved. As discussed above, the full extent of achieved environmental benefits with respect to air pollution have been the subject of debate in Milan.

Table 4-23: Achieved environmental benefits – examples of London, Milan, Stockholm

Environmental benefit	London	Milan	Stockholm
Reduced air pollutant emissions: Carbon Dioxide; Total & Exhaust PM10;	12% reduction in Carbon Dioxide 12% reduction in Fine Particulate Matter	35% reduction in Carbon Dioxide 18% reduction in PM10	15% reduction in PM10 (2007 & 2008) 10% reduction in Nitrogen Oxide (2007

Environmental benefit	London	Milan	Stockholm
Ammonia; Nitrogen Oxides	(PM10) 12% reduction in Nitrogen Oxide emissions	42% reduction in Ammonia 18% reduction in Nitrogen Oxide	& 2008)
Reducing health risk relating to air pollution: less Black Carbon	-	52% reduction (Sep 2013) and 32% reduction (Oct 2013)	-
Decreased demand for use of public space for on-street parking and improved quality and attractiveness of the urban centre	-	10% reduction and reuse of spaces to provide car and bike sharing mobility systems.	-
Reduced vehicular access to congestion charging area	21% reduction (2006) & 12-17% reduction in vehicle kilometres (2003-2004)	28.5% reduction (2013 – compared to Ecopass)	29% reduction (2011 adjusted for population growth and excluding cars exempt from the charge)
Reduced traffic congestion	30% reduction waiting times in traffic	28% reduction in congestion	-
Increased speed of private transport	-	+1.5km/h in Area C; +0.3km/h throughout city	-
Increased speed of public transport	30% reduction in bus delays (2003/04)	+6.9% for buses; +4.1% for trams	Punctuality of buses at final stop improved (trial)
Increasing the share of sustainable modes of travel	38% bus passenger increase (2003/04)	-	5% increase in passages (trial)
Reduced road accidents	-	23.8% reduction	-
Raising funds for the development of mobility infrastructure. E.g. for Milan: cycle lanes; pedestrian zones; 30kph zones.	By law, all net revenue raised by the charge must be reinvested in improving London's transport network.	€10mil towards public transport and €3mil towards 2nd phase bike sharing scheme	-

Sources: VCÖ (not dated), ITF 2014, Jarl (2009)

With respect to congestion charging scheme design, a number of factors will influence choices on the congestion charging technologies to be utilised and overall cost of the scheme, such as the size of the geographical area covered, the number of entry points and the complexity of the regulations a public administration wishes to apply. Well-designed congestion charging technology can offer greater flexibility in design choices, e.g. by enabling complex charging schemes and exemptions for different types of users. For example, a public administration may wish to encourage use of vehicles with lower emissions, such as hybrid and electric cars, and therefore a system that allows for automatic identification is an advantage. A range of technology options exist, as follows:

- Manual toll collection / automatic coin collection machines
- Paper license: point or area-based
- Automatic Number Plate Recognition (ANPR)
- Dedicated Short Range Communication/Electronic tags (DSRC)
- Global Navigation Satellite Systems (GNSS)

The principal charging options for congestion charging today are DSRC and ANPR, and most schemes use ANPR for enforcement (TIDE 2014). Now that there is significant global experience of designing and implementing systems, follower cities are able to benefit from the technology trialling process undertaken by early adopters.
Of the frontrunner schemes, the Milan Area C charging area is relatively small at $8.2km^2$. The zone is accessible through 43 entrance points which are constantly monitored by ANPR cameras. This smart system recognises the vehicle's category matching the plate to the registered vehicle and charges the correct fee (Cascade, not dated).
The charging areas for London and Stockholm are much larger at $21km^2$ and $34km^2$ respectively and a different approach was taken to applying the charge in the two cities. While London has congestion charging "zone" within which all non-exempted vehicles are charged, Stockholm decided to implement a charged cordon surrounding the central part of the city. This means that vehicles are only charged when crossing the cordon and can still drive within the cordon for free (Jarl 2009). While this approach may assist in removing objection to a scheme from businesses and residents within the charging zone, it may also have the negative effect of encouraging short journeys by car within the city.

Applicability

Implementing a congestion charge is a significant financial and political undertaking and careful consideration needs to be given to whether it is the most appropriate measure for achieving the environmental goals of the public administration. The following questions provide a starting point for considering whether a congestion charging scheme is a transferable measure for a particular city.

- **How bad is traffic congestion in the city?** There needs to be sufficient public recognition and concern about congestion, and/or associated environmental impacts, if a charging scheme is to gain democratic support. In Milan it was the related issue of air pollution that led to the resounding referendum result (79.1% in favour of the scheme). Although this seems an obvious point, commentators have suggested that one reason for the "no vote" in the Manchester congestion charge referendum was that congestion was not considered a priority issue for the city (see section 8 'Driving force for implementation' for more information).
- **What is the current public transport modal share?** – Considering the conditions before implementation of congestion charges, Stockholm and London had high modes shares of public transport and low numbers of car ownership (Jarl, 2009). This means that the effects of a congestion charge would not be as pronounced, although still significant. In comparison, Milan has relatively low levels of public transport usage and therefore required either major public transport investment alongside the congestion charge and/or a congestion charge scheme that is designed to affect fewer road users (Jarl, 2009) by limiting the charge to a smaller part of the city.
- **Is the congestion charging proposal an element of a Sustainable Urban Mobility Plan?** – Experts advise that a congestion charge needs to be one part of a package of measures. If car use is to be restricted there clearly need to be alternative modes of transport in place that provide sufficient capacity, reliability and convenience. The preparation and adoption of a Sustainable Urban Mobility Plan (SUMP) provides the appropriate process for engaging stakeholders and assessing the suitability of complementary or alternative transport measures.
- **Taking into account the size and structure of the city, are there alternative measures that could be more appropriate?** – In smaller cities with a relatively compact, "walkable" city centre, the pedestrianisation of streets and dedication of more road space for public transport and cycling could provide an alternative means for discouraging car use. This approach has the benefit of simultaneously improving infrastructure for sustainable modes of transport. Congestion charging may therefore be most applicable for larger cities where limiting highway options and widespread pedestrianisation is not a practical solution.
- **What are the equity implications of introducing a congestion charge?** A concern previously expressed in relation to congestion charging is that people on lower income or

specific social groups may be unfairly disadvantaged. A study undertaken in relation to the Stockholm trial and morning commuting found no clear pattern of increasing burden for people with either increasing income or decreasing income. It also found no significant difference in either the mode-switching behaviour or the average welfare effect for women versus for men (Karlstöm & Franklin 2009). Nevertheless, when designing a congestion charging scheme the potential equity implications should be taken into account, for instance, could a particular community be disadvantaged due to the boundary location of the congestion charging area and a lack of credible alternative modes of transport?

Economics

Information available for the London, Milan and Stockholm examples reveals wide variations in the cost of implementing and operating a congestion charge scheme (see Table 4-24). This is not so surprising given that the geographical area covered by the schemes ranges from 8.2km^2 in Milan to 34km^2 in Stockholm. There also appear to be variations in terms of what elements of associated infrastructure, such as public transport improvements and parking provision, are included in the costing information.

Table 4-24: Overview of the London, Milan and Stockholm congestion charges49

	London	**Milan (cost info for Ecopass scheme only - unofficial)**	**Stockholm**
Implementation cost	£200million (approx. €250million)	€7million	SEK 1,900million (approx. €207million)
Annual management cost	Implementation and operational costs spread over several years – see Table 7	€0.6million	SEK 220million (approx. €24milion)

Sources: Santos 2008, Rotaris et al. 2009, Eliasson (not dated).

When considering if a congestion charge is an appropriate measure, cost benefit analyses and projections of revenue generation can be utilised as helpful tools. A cost benefit analysis undertaken for the Stockholm scheme showed that the congestion charge yields a large social surplus, great enough to cover both investment and operational costs. Eliasson (not dated) reported that the value of the time gains compared to paid charges is remarkably high compared to most theoretical examples. It should be highlighted that cost benefit analysis techniques typically take a holistic approach, taking into account social factors, as well as the economic and environmental benefits of a scheme.

Reinvesting in sustainable transport modes

The London Congestion Charge provides a well-documented example of a scheme that has achieved revenue for reinvestment in other sustainable mobility infrastructure. Initial capital investment for the Congestion Charge project (excluding the western extension) was approximately £200million at 2002 prices, with the majority of funding provided by the UK central government. Table 4-25 presents costs and revenues for the 2002-07 period. With the exception of the financial year 2002-03, which is different because the Congestion Charge was introduced towards the end of it, the scheme returned significant revenue funding of between £82 and £120 million per annum during this period (Santos 2008). In the case of London, all net revenue from the charge has to be reinvested in improving transport in the city by law, helping to make the charge more politically palatable (TfL 2014b).

[49] Currency conversions undertaken during August 2014 utilizing www.x-rates.com

Table 4-25: Annual Costs and Revenues of the London Congestion Charge project

Costs and revenues	2002-03	2003-04	2004-05	2005-06	2006-07
Total operating costs	£18mil	£98mil	£92mil	£88mil	£88mil
Total revenues	£20mil	£179mil	£197mil	£210mil	£208mil
Charge revenues	£19mil	£122mil	£120mil	£144mil	£154mil
Enforcement revenues	£1mil	£58mil	£77mil	£66mil	£54mil
Net revenues	**£2mil**	**£82mil**	**£105mil**	**£122mil**	**£120mil**

Source: Santos 2008

Given the financial success of the congestion charging scheme presented here, it would be expected that a broader cost-benefit analysis would return even stronger positive results, after factoring in: achieved environmental benefits of the charge; overall social utility (e.g. reduced congestion, road safety); and the additional positive effects from investment in other sustainable transport modes.

Driving force for implementation

In addition to having large up-front capital costs, the implementation of a congestion charge takes tremendous political will. For a public authority to begin charging for use of roads that for decades have been free to access is bound to raise controversy. Along with the environmental benefits of a scheme, a major selling point for congestion charging can be the economic benefits. The EC estimates that congestion costs nearly €100billion or 1% of the EU's GDP annually, with congestion often occurring in and around urban areas (EC Mobility and Transport 2014).

The examples of London, Milan and Stockholm provide examples of how objection to proposed schemes was successfully overcome. In other cases, such as Manchester and Edinburgh in the UK, congestion charging proposals were rejected in public referendums and lessons can be learnt from the way proposals were presented to the population. A major conundrum for public authorities considering congestion charge proposals is that public support tends to increase significantly after the commencement of a scheme (Jarl 2009). The question therefore is, how can support be rallied before key decision-making events?

Popular support for the Stockholm Congestion Tax increased from 36% in 2005, before the introduction of the scheme, to 74% in 2011 (VCÖ, not dated). In order to help foster support for the proposal, a full-scale trial of congestion charging preceded the public referendum held in 2007 (Givoni, 2011), at which a "yes" vote was secured by a narrow margin of 51%. The trial lasted seven months and was costly to implement, as Stockholm's transit system was very keen to prove that it would be up to the challenge of increased useage (Swanson, 2009). Public transport was extended with 197 new buses and 16 new buslines. This provided an effective and fast alternative for travelling at peak hours from the municipalities surrounding Stockholm into the inner city. Where possible existing bus-, underground- and commuter train lines were reinforced with additional departures.

It is clear that a very high level of political commitment was required to justify this level of expenditure for a trial, although this meant the move to a permanent scheme could be undertaken relatively quickly. Eliasson, Director of the Centre for Transport Studies at Sweden's Royal Institute of Technology, has advised that in other cities where congestion pricing would significantly enhance the efficiency of the traffic system, the Stockholm "try before you buy" approach may be the key for voter buy-in. This view is supported by others:

"Modelling results actually showed quite accurately what the effects [of the congestion charge] would be, so I didn't think [the trial] was needed. But then I realized that people didn't actually believe that it would have an effect on congestion. They needed to see it to believe it." (Mattson from the Royal Institute of Technology, quoted in Swanson, 2009b)

The failed referendum in Manchester in 2008 provides an example of where there was both a lack of clarity on congestion charging objectives and these were not perceived to be the highest priority issues by the city's population. The implementation of a congestion charge in Manchester was a pre-condition set out by the UK national government for the city to receive a further £1.5billion pounds of government funding for investment in transport. Swanson (2009) identifies a number of reasons for why 80% of people voted against the congestion charge, which include:

- congestion is not so bad in Manchester, especially compared to London;
- the link between the charge and public transport investment was not clearly explained, or was interpreted as "money grabbing"; and
- resentment for central Government and the imposition of a tax during a downturn in the economy.

Based on a review of the experiences of London, Stockholm and Manchester, Swanson (2009a) usefully identifies four core messages for a congestion charging campaign:

1. Define the problem – If the public are to be persuaded that congestion charging is necessary, it is essential to clearly define and articulate the problem that the scheme is designed to address. For instance, congestion was a recognized problem in London and Stockholm. Leaders in those cities did not need to waste time convincing the public of that fact. In contrast, congestion was not a significant problem in Manchester.
2. Explain the solution – A high level of investment plus a clear, simple message regarding the role of congestion charging in the wider transportation plan for the area is vital to winning public support. Longer-term education is also important. In London, sustained marketing and education has helped to build public understanding and support for the transportation system as an integral part of the cultural and economic identity of the metropolitan region.
3. Show the benefits – The public shouldn't be expected to simply accept radical change without experiencing the benefits. Demonstrating to the public that the new charge will lead directly to tangible transportation-related benefits is a pivotal aspect of gaining support for the scheme. In both London and Stockholm, congestion charging was accompanied by major improvements in public transit.
4. Demonstrate leadership and earn the public's trust – The underlying theme is the importance of cultivating and maintaining the public's trust in the ability of leader's to act efficiently and with integrity.

Reference organisations

In addition to the frontrunner schemes highlighted within this BEMP, a number of other cities within Europe have introduced congestion charging schemes (TIDE, 2014):

1986 Bergen
1990 Oslo
1991 Trondheim
2001 Nord-Jæren, Oslo Package 2, Rome central area
2002 Durham
2003 London
2005 Bologna, Edinburgh referendum rejects charging scheme, Trondheim scheme ends.
2006 Stockholm trial and referendum
2007 Stockholm becomes permanent scheme, London adds westerns extension
2008 Milan Eco Pass
2012 Milan scheme changed into Area C
2013 Gothenburg

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4.8 Limiting free parking spaces in cities

Description

Travel with individually owned automobiles is an enormously space-consuming form of mobility because each car requires a parking space at the place of origin and at the destination. In the general case where street parking is available on publicly-owned land, and therefore managed by the municipality, free parking options (or cheaper parking than private car parks) are often available. Minimum parking requirements, i.e. mandating a minimum number of parking places in office or residential buildings, are also commonplace local regulations. It can therefore be considered that many cities have an over-abundance of under-priced parking considering the overall allocation of this publicly-owned resource compared to other transport modes. When driving to a destination, people rarely have to consider whether parking will be available—chances are it will be available and free, often making driving the most appealing and practical option.

Where parking space is provided free of charge, the cost of car use is effectively subsidised at the expense of the wider public, including people who do not drive. Free parking on public space does not mean parking without cost to anyone; on the contrary, parking costs not paid directly by drivers occupying the parking space are instead subsidized through tax-payers' money and absorbed into the prices of housing, goods, and services. People pay for parking not in their roles as motorists, but rather as consumers, workers, residents, i.e. direct and indirect taxpayers. When the cost of parking is bundled with other costs, no one can save money on parking by using less of it. In effect, under-priced parking skews travel choices towards more cars and away from public transit, cycling and walking at the expense of the general public. Abundant free parking contributes to high demand for cars because it reduces the cost of car ownership. "Free" parking is not a manifestation of the freedom to circulate either, because the space is monopolised by a single car at the expense of other uses by the community. Therefore "limiting free parking", while initially unpopular, is rather a fairer use of public resources.

The use of private cars is therefore subsidised by free / cheap parking and minimum parking policies; assuming that the municipality considers that the externalities generated by car usage are negative (the harmful environmental and space-planning effects of automobile dependency are well-documented), it should aim to reduce this subsidisation and instead correct the balance by increasing the relative costs of car usage (ideally redirecting the revenues towards more environmentally friendly modes) and therefore reap the environmental benefits of successful strategies to limit car usage.

Parking is a key influence in the travel decisions that people make. When parking spaces are limited and provided at a relatively high cost, there will be a disincentive to drive everywhere. When cars are the dominant mode of transportation, many spaces are needed to accommodate them at each destination and minimum parking requirements are often instated to cope with the perceived demand. Parking spaces are spaces that are deprived of other uses. Commercial parking lots may be nearly full during business hours, but vast empty lots of asphalt and wasted space during off-hours. The land used for parking bears an opportunity cost which is not always fully accounted for when the land is managed by public authorities.

Parking availability and parking prices are highly political issues. Quite often, public administrations may feel compelled to ensure plenty of free or low-cost parking as alleged precondition for vibrant commercial activities. In many cases, public authorities embrace the polluter-pays principle in general, but still shy away from applying this logic to the price of parking because of the challenge of adjusting the price flexibly to the permanently fluctuating demand, space availability, and pollution levels.

The City of Los Angeles's Department of Transportation met this challenge with a flexible, demand-responsive pricing system called LA Express Park which was deployed in downtown LA in 2011. The scheme includes a system for detecting and managing the availability of on-street parking with smart parking meters that respond to demand by changing their prices according to location, time of day, and day of the week. The system thus ensures that scarce parking resources are better used. LA Express Park also makes finding a parking spot easier, thus reducing the number of cars circling around the block in search of a free parking space.

Although parking fees may initially be met with some objections, parking meters with revenue that goes towards improving the local community tend to be well-received in the long run. Beyond the obvious benefit of reducing vehicle trips and making it easier to find a parking space, limiting free parking and eliminating minimum parking requirements reduces air pollution, lowers oil consumption, and eases congestion.

Higher prices for on-street parking and the abolishment of minimum parking requirements are two strategies that go hand in hand, producing synergies to improve parking in cities and achieve environmental benefits as a result. The next section will address parking pricing, followed by a section focused on minimum parking requirements.

<u>Parking pricing</u>

On-street parking tends to be free or relatively inexpensive, while off-street parking (generally privately-owned) tends to cost more, which compels drivers to cruise the streets to look for on-street parking, rather than opting to pay for off-street parking. When the difference in fees between on- and off-street parking is so great, on-street parking becomes overcrowded and the roads become congested with cars circling in search of an on-street parking space. According to a study of a 15 block area in Manhattan, finding an on-street space took an average 3.1 minutes with an average cruising distance of 0.37 miles. In a year, cruising for under-priced parking in this 15 block area alone creates about 366,000 excess vehicle miles of travel (equal to 14 trips around the earth) and 325 tons of CO_2 (Shoup, 2011a). Significantly raised on-street parking fees mean that motorists spend less time looking for parking, thus saving fuel and time, and avoiding contributing to congestion as they cruise for a parking spot.

Charging parking fees gives people more accurate economic information to decide whether they want to pay for parking or choose another means of travel, rather than indirectly paying for parking that is bundled with other costs. Reducing the difference in fees for on-street and off-street parking, aiming for a price figure that is the lowest price a city can charge and still have one or two vacant spots per block, will decrease the relative appeal of on-street parking and thus limit the congestion associated with cruising in search of a free spot. Demand-responsive pricing is an effective way to ensure that the fees are neither too low nor too high, but more simple measures that reduce abundance of free parking are also useful. Ideally the fee will, not as a goal but as a by-product, raise revenue to improve the local community, while ensuring that not all parking spaces are occupied at all times. This is further expanded upon in the Operational data and Economics sections.

<u>Parking requirements</u>

To truly limit the negative impacts of parking and the instance of people even choosing to travel by car, minimum parking requirements must be abolished. Minimum parking requirements were instituted to move parked cars off the streets and alleviate the street parking demands that congest and burden neighbourhoods. Underground parking or dedicated parking structures were viewed as a way to mitigate parking demand, but their abundance not only increased demand, but also changed the way people travel, the way cities are built, and how much energy is consumed. Now cities around the world have policies that force developers to designate vast amounts of space for the car; for parking, for roads, et cetera. Local authorities often require developers provide a minimum number of parking spaces per building/development. Such policies lose sight of the needs of people and tend to prioritise space for cars over pleasant environmental ambiance for the people in them, or the people who can choose other means of transport.

Minimum parking requirements displace the question of who should pay for car parking and increase the cost of housing, as well as goods and services. It tends to distort the economic choices made by developers, landlord and tenants of the buildings subject to these regulations. When the developer pays, it means that the costs will be passed on either to those parking, or those using other spaces in the building. If the building is leased out to commercial spaces, the shop owners will pay higher rent, which in turn is passed on to higher costs for customers, regardless of whether they arrive by car or by other means. As an example if the space is used by a restaurant, the cost will be included in the menu prices, and everyone will pay more for their meal regardless of the means by which they travelled to get there.

Minimum parking requirements are not easy to establish and are often arbitrary. They are based on the unreasonable assumption that the demand for parking does not depend on its price (Shoup, 1999). A common miscalculation in urban planning involves calculating the need for parking based on peak hours in a situation in which parking is free, which is inflated and not representative of demand if parking were appropriately priced. This means that such plans are basing projections on the peak demand for free parking. These requirements, supported by little or no empirical evidence, create an oversupply of parking spaces. Though there is little basis for minimum parking requirements, they tend to be rigidly enforced, placing limits on how land and buildings are used. Removing minimum parking requirements is not the same as forcing limits on parking availability; it merely gives housing developers and businesses the flexibility to decide how much parking to provide.

In short, when parking is saturated and there seem to be not enough spaces to meet demand, the solution is to price curb parking rather than to mandate off-street parking. In the long run, cities should therefore adapt their parking management strategy both by managing the on-street parking supply, and removing minimum parking requirements. The environmental benefits will be manifold.

Achieved environmental benefits

Car traffic is a significant source of harmful emissions and pollution. Parking fees and limited parking spaces reduce incentives for driving. A decrease in driving leads to less pollution and congestion, thus improving both environmental health and ambiance. A good parking policy can serve as a powerful tool for improving not only traffic congestion and modal split, but also land use and energy efficiency. Other environmental benefits resulting from driving include less air pollution, oil consumption, and traffic congestion. Environmental benefits from allocating less space for car parking includes reduced pressure on scarce space resources, freeing space for other uses such as parks, which promote better air quality and biodiversity.

The implementation of parking fees can result in a variety of travel behaviour responses, with resulting environmental impacts. Changes in driving behaviour and modal choice can have a profound effect environmental quality, as people drive less and drive differently (e.g. parking farther away from their destination, where parking max be less expensive or more available) when (free) parking is limited.

Implementing metered parking diminishes parking demand. Meanwhile, controlling parking supply by lifting minimum parking requirements diminishes the condition for every building to provide parking and liberates land for other uses. More people travel by car when parking is free, as it can make driving appear to be an inexpensive option. In a UK-based study, doubling parking fees resulted in a 20% reduction in car usage, and cutting the parking supply in half led to a 30% drop in car use (ITDP, 2011b).

Metered parking increases the turnover of parked vehicles by ensuring that drivers will not remain in a parking space for more than a few hours. Professor Donald Shoup (University of California, Los Angeles) calculates that the ideal parking prices will create a turnover that keeps 15% of spaces vacant at any given time, or one or two available on-street parking spaces per block. This level of availability would alleviate the need to cruise for parking, a search that can take several minutes and can be responsible for a significant portion of all street traffic (Shoup, 2011b). The number of vehicle kilometres travelled due to searching for an available space dropped by two-thirds when Vienna introduced parking fees (ITDP, 2011). The decrease in trips taken and kilometres travelled translates to less vehicle emissions.

Some cities have addressed the issue by directly linking emissions to parking policy. For example, several boroughs in London have introduced parking pricing schemes based on vehicle emissions. Vehicles that emit the most CO_2 per mile pay the highest residential parking fees, while electric vehicles may park for free. Such schemes incentivize the replacement of polluting cars with low-emission vehicles as a means to improve air quality and address climate change issues. In France, parking fees are seen as an efficient measure to reduce car traffic and reduce greenhouse gas emissions every year nationwide (ITDP, 2011).

Parking regulation has great potential to serve in improving air quality in urban areas. If measures limiting parking are implemented, car trips to that location will likely decrease over time, as will the incentive to own a car. The demand for parking is not fixed as a universal constant but a function of individual cities' or even neighbourhoods' particular structures and options From this follows that parking requirements are not universal either but can be adjusted to suit a city's (and its citizens') ambition.

Appropriate environmental indicators

The indicators for the effects of limiting (free) parking can be divided into primary environmental indicators that convey the direct environmental benefits, and contributory environmental indicators that convey other related effects that lead to environmental improvements.
The indicators of modal split and the number of people who are induced by changes to a city's parking policy to shift from car to other means of travel are of critical importance. Modal split is linked to and can be useful for gathering many other indicators including air pollution reduction, noise pollution reduction, land use, and parking demand. Determining parking policy's influence in modal split and other indicators is difficult, as travel behaviour is influenced by multiple factors. A reduced burden on parking can also be observed, but attributing the cause to parking policy alone ignores other influential factors that are important to consider (i.e. other transport policies). Though it is very difficult to establish a causal link from parking policies to travel behaviour, measures of public perceptions and reactions can be carried out through surveys.

Table 4-26: Recommended environmental indicators for limiting (free) parking

	Indicator		**Unit**	**Example and/or explanation**
	Primary Environmental Indicators			
A	Air pollution reduction	CO_2 Emissions	Tonnes CO_2	Levels of other air pollutants are often correlated with these, so depending on the resources a city possesses, different pollutants can be measured as "lead-indicators" of air quality.
B		Sulphur dioxide (SO_2)	µg/m^3	
C		Nitrogen dioxide (NO_2)	µg/m^3	
D	Noise pollution reduction	Day – evening – night equivalent level	L_{den}	The Environmental Noise Directive (2002/49/EC) aims to define a common approach intended to avoid, prevent or reduce on a prioritised basis the harmful effects, including annoyance, due to the exposure to environmental noise. Harmonized indicators for developing strategic noise maps are recommended.
E		Night equivalent level	L_{night}	
F	Land use	Reduction in public space used for parking	ha	When off-street parking is reduced, the spaces can serve other functions. If market prices are applied to on-street parking, each parking space is used more efficiently, with more balanced occupancy and turnover of vehicles.
	Contributory indicators			
G	Modal split		Expressed as %	Traffic should respond accordingly, with fewer people opting to travel by car. Ideally it will reflect increased trip share of sustainable modes of travel.
H	Parking demand		Vehicles / hour or day	Amount of available parking spaces at a given time. Can be monitored, especially when smart pricing systems are in place
I	Gap between on- and off-street parking prices		Price difference in local currency	There should not be a great discrepancy between on- and off-street parking prices.
J	Percentage of available parking		Expressed	Indicator whether the price and

	Indicator	Unit	Example and/or explanation
	spaces during business hours	as %	availability of parking is appropriate to avoid both conges-tion, parking-search-traffic etc. and is not scaring away all drivers with exorbitantly high prices (target should be 80-90%).
K	Traffic congestion	Hours of extra travel time due to congestion, or ratio of on-peak to off-peak travel speeds	With reduced incentive to drive and parking more readily available by meters, fewer cars may be on the road and drivers are less likely to need to cruise for parking.

Cross-media effects

Parking policy involves various stakeholders at the local level, including public administrators, experts, industry and commercial organisations, representatives from the transport sector, building developers, and consumers. It is closely linked to land use and has a direct impact on public revenue and traffic congestion. Its intended environmental effects are usually to limit traffic congestion and pollution, or to free up land for more effective uses.

When redesigning an area to have fewer parking spaces, a holistic planning approach is essential. In the process of repurposing land that was previously dedicated for parking, it is important that the impacts of the construction be carefully considered so as not to add further disruption and pollution to the surrounding environment. In addition, the area must be accessible by other means when the parking spaces are removed and replaced, otherwise people will simply go elsewhere and create congestion in other areas.

An unexpected challenge Los Angeles faces with respect to the implementation of LA Express Park is the abuse of disabled parking placards. In California, 11% of drivers have disabled placards. Disabled placards, which are relatively easy to obtain, allow unlimited free parking at all meters. Their owners can park for free all day, thus limiting parking space turnover while not providing any payment for the occupied space. This unanticipated response to higher parking prices counteracted the intended environmental benefits of less pollution from crusing.

To maximise the potential that the aforementioned environmental benefits are achieved, it is important that city administrators consider the most likely travel responses to changes in parking policy and put in place complementary measures to mitigate the potentially damaging cross-media effects.

Operational data

Examples of optimising pricing for parking

Optimising pricing for parking can be approached in a variety of ways. Los Angeles stands as a frontrunner of incorporating technological innovation with an adaptive strategy. The strategy was initially implemented in the downtown area in early 2011 and was fully launched on 21 May 2012. LA Express Park involves using real-time data for on- and off-street parking meters as well as parking garages, with variable pricing based on occupancy. Mobile apps and a website deliver real-time traffic status. The sensor-based parking was implemented to reduce traffic congestion and pollution.

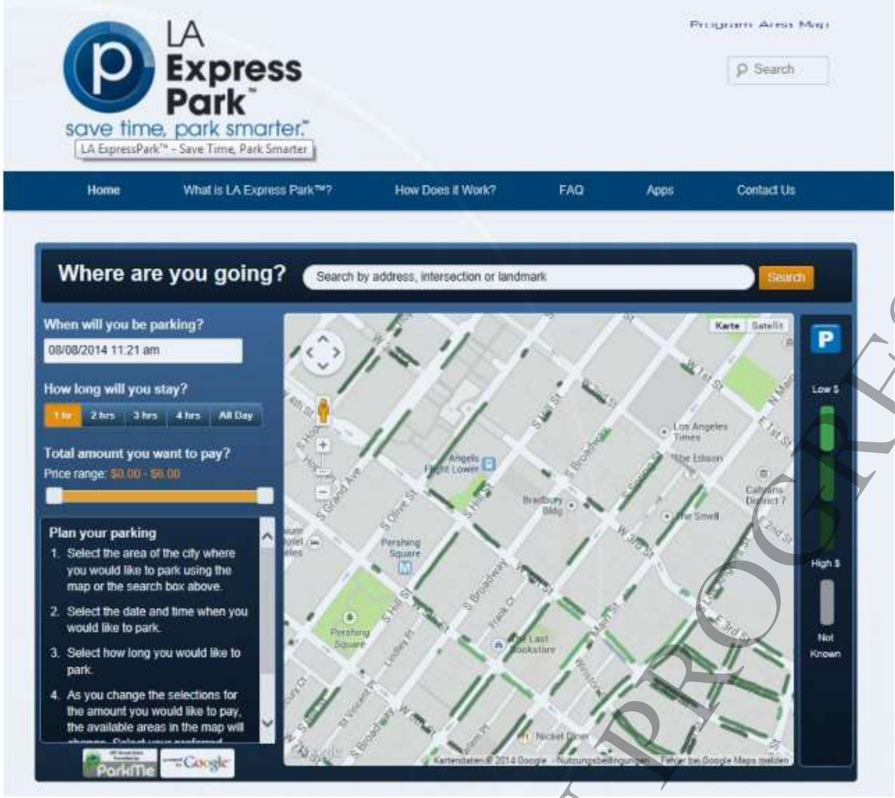

Figure 4-9: LA Express Park website (www.laexpresspark.org)

In its initial phase in spring 2011, the project already encompassed 6000 on-street parking meters, 9500 off-street meters, and 11 city-owned garage facilities. Getting the project off the ground involved $15m from a local US Department of Transportation grant and $3.5m of local funds (LA Express Park, 2014). Further development of the technology included an investment from Xerox to create the Merge system that the meters use. Merge includes a parking enforcement system which displays possible parking violations to officers via an online app. This makes enforcement more efficient, as officers do not have to patrol streets as frequently.

Another special feature, which has also been taken up by other cities, is the parking guidance system which allows drivers to know the closest vacant parking space as well as how to get there with the least traffic. Sophisticated data analytics feed into the hardware and software that help users make sense of parking options. The information is available through a variety of sources, including a website, smart phone app, phone number, an in-vehicle GPS system, and on-street digital signs. Parking systems can serve as a testing-ground for the software and hardware solutions of tomorrow; the system in Los Angeles is an outstanding example.

If parking spaces are removed, people must have another means of reaching their destination. The removal of parking spaces can result in more room for other infrastructure, such as better sidewalks or cycle lanes. It is crucial that other modes are viable options; otherwise negative consequences may include parking violations, fewer people traveling to the destination, and citizen disapproval. University of Graz dealt with this issue by creating a parking permit system in tandem with developing better bicycle parking infrastructure. Individuals opted out of the parking permit received 50% of the cost of the pass in the form of public transport coupons (Kelz, 2013). Measures should not only decrease the incentives to drive, but also increase the attractiveness and accessibility of other modes. The actions of University of Graz led to an increase in cycling and 450 people waiving their parking permits in favour of public transport coupons (Kelz, 2013). Such developments are a boon to social inclusion because they allow an area to be accessible to people who do not own cars.

Though raising revenue is not and should not be the purpose of instituting parking fees, neighbourhoods can benefit from the funds raised. Part of Los Angeles's LA Express Park project involved upgrading meters to accept credit cards. This change alone more than doubled parking revenue from meters. Revenue generated from parking fees often goes toward supporting sustainable mobility goals.

The previously mentioned disabled placard abuse problem in Los Angeles not only had environmental impacts, but also results in foregone revenue for the city. A study in downtown Los Angeles found that cars with disabled placards took up a disproportionate number of parking spaces and remained parked for long stretches of time. Furthermore, many people using the placards are not disabled, but are using the placard of a relative. This amounts to a loss of $25,000-$30,000 a day in parking fees, or $4 million in foregone revenue each year. Enforcement to prevent such abuse of the system is difficult and expensive. A proposed solution has been to stop allowing unlimited free parking for cars with disabled placards.

Years of planning, as well as a substantial pilot phase were integral to the implementation of the project. The result has been a comprehensive parking system that helps keep traffic flowing, reduces time spent and fuel consumed searching for a parking space, and creates more frequent turnover for businesses. Furthermore, it has provided the city with a means to make data-driven decisions. The following sections outline some of the strategies Los Angeles has employed in the city's approach to parking, as well as examples of how other cities have approached the issue.

Using apps and information technology

Advancements in technology have expanded the scope of innovative approaches for managing parking. The London district of Westminster has begun installing smart parking sensors, which detect whether a space is vacant, across its entire road network. Combined with an app that allows drivers to view a real-time map of parking spaces it directs them to an empty space. Prior to implementation, drivers spent an average of 15 minutes looking for a parking space in the area (BBC, 2014).

Parking advantages for low-emission vehicles

Another type of pricing scheme in Madrid involves smart parking meters that charge extra for cars that pollute more, and reduce parking costs for efficient vehicles - with electric cars able to park for free (ELTIS, 2014). As parking fees are one of the best ways to discourage motorists from driving into the packed city centre, the meters in Madrid are also expected to reduce traffic congestion. Similar to the aforementioned systems, the price of parking also varies based on how busy the street is; busy streets with few remaining parking spaces will cost 20% more than emptier streets. The idea is to make people, especially those with cars that pollute, think twice before travelling by car to the city centre. This system, however, emphasizes the age of the car and the motor, so that a large new car that may actually have higher emissions than an older, smaller car, is charged less. The London borough of Hackney has instituted similar parking fee reductions in favour of electric vehicles. The intention of implementing such systems is to lower pollution levels.

Demand-responsive pricing

The inspiration for LA Express Park can partly be attributed to San Francisco's SFpark system for managing the availability of on-street parking. SFpark is a particularly advanced case of what many European cities (e.g. Madrid, Westminster) are implementing or planning to implement. SFpark uses smart parking meters that change their prices according to location, time of day, and day of the week. The pilot evaluation revealed that after implementing SFpark, average parking rates were lower, parking availability improved, ease of finding a parking space improves, greenhouse gas emissions decreased, and vehicle miles travelled decreased (SFpark, 2014). The amount of time that the 60-80% target parking occupancy was achieved increased by 31% in pilot areas, compared to a 6% increase in control areas (SFpark, 2014). Furthermore, the amount of time that blocks were too full to find parking decreased 16% in pilot areas while increasing 51% in control areas (SFpark, 2014).

Parking fees that raise local revenue

Once parking meters are installed, the revenue can be fed back to the local community so that residents see the direct impacts and benefits of what may initially seem like a disagreeable change. Old town Pasadena (USA) thrives on such a system. The introduction of parking fees in

Pasadena has liberated parking spaces in the area, reducing the amount of cars cruising while increasing the attractiveness of the shopping district (Kolozsvari and Shoup, 2003). Revenue from the parking meters has been used to beautify and maintain the district by investing in street furniture, trees, street cleaning, and other maintenance and improvements.

Cities including Barcelona, Strasbourg, and some boroughs of London use the revenue from parking fees in transit projects, as opposed to absorbing the money into a general fund. For instance, all parking revenue in Barcelona goes toward supporting Bicing, the city's bicycle share program (ITDP, 2011). This strengthens bicycling as an alternative option to driving and is a politically savvy strategy, as it shows the public how the money from the increased charges is being spent to benefit them.

Examples of managing the allocation of urban public space to car parking

A person driving to work alone and parking for free is economically and spatially inefficient; a large vehicle transports one person, then sits on the street or in a garage all day, taking up space that could be used by pedestrians (street parking) or as other-purposed space (parking garages). Several European cities have set out to address this issue with parking policies that discourage driving to work. In Nottingham, companies pay a tax of a £250 per year for each parking space they provide for employees if they provide more than 10 parking spaces (ITDP, 2011b). In Hamburg, companies are exempt from minimum parking requirements if they provide a monthly transit pass to their employees (ITDP, 2011b).

Vauban is a neighbourhood in Freiburg that has decoupled parking from housing. The 2000-apartment area has 5000 residents and only 0.5 parking spaces per apartment. Households that own a car in Vauban must buy a parking permit to use one of the parking spaces, which are usually located on the outskirts of the neighbourhood, rather than within minimal walking distance of each apartment. Parking spaces cost between €18,500 and €22,500 and the maintenance costs are about €70 per month. The neighbourhood has a car sharing scheme with free membership and 20% discount for usage for all residents. Residents also receive discount on public transport, and access to a cooperative bike maintenance centre where they can have their bikes repaired free of charge. Car ownership in Vauban is about 160 cars per 1000 residents, compared to Freiburg's overall car ownership of 390 per 1000 residents. The area has a modal split of 16% cars, 64% bike or foot, and 19% public transport (ITDP, 2011a).

The aforementioned example cities have acted upon the realization that high supply and low price of parking reduces the cost of automobile ownership and supports automobile dependent habits and development. Such habits and urban landscapes may never have existed if minimum parking requirements had not been in place. Minimum parking requirements sever the link between the cost of providing parking and the price that automobile drivers pay for it (Shoup, 2011b).

How did they do it?

Though the aforementioned projects vary considerably in scope, goals, and outcomes, their successes can be attributed to a common set of features and strategies.

Develop a holistic strategy. Developing a sensible parking plan is not only about implementing good new policies, but also about eliminating ineffectual existing policies. In some cities this means introducing parking pricing for on-street parking. In other cities it means getting rid of harmful policies such as minimum parking requirements. Usually both of these aspects of parking management must be considered. In order to enable this paradigm shift, the status quo in terms of land use planning, public transportation, bicycle and pedestrian infrastructure, and low-emission zones must be taken into account.

Use responsive pricing. The purpose of fees is not to raise revenue, but to reduce the need to cruise for parking by eliminating the vast discrepancy in price between on and off street parking. Dynamic pricing is a tested and effective way to ensure that fees are high enough to limit full occupancy without being prohibitively expensive. With SFpark, San Francisco installed meters for curb parking that vary in price according to both location and time of day. Prices are adjusted once a month, and never by more than $0.50 per hour, to seek a price structure which yields one or two available parking spaces per block. Successful schemes focus on occupancy rather than revenue, usually with a target of 85% of spaces being occupied at any given time. The price is too high if there are many vacant spaces and too low if there are no vacant spaces.

Do not impose minimum parking requirements. Minimum parking requirements prohibit flexibility and development. Hamburg took even stronger measures to limit parking by freezing the existing parking supply in the city centre in 1976 with positive results. This means that when a new parking space is built off-street in the area, an on-street parking space has to be removed. On-street parking spaces can be replaced by bicycle parking infrastructure or can be transformed into wider sidewalks or bicycle paths. This type of cap-and-trade was also implemented in Zurich as part of its "historic parking compromise" in 1996 (ITDP, 2011b). Outside of the parking cap zone, Zurich only allows developers to build new parking spaces if the surrounding roads can absorb the additional traffic without congestion and the air can absorb the resulting additional pollution without violating the air quality norms (ITDP, 2011b).

Provide alternatives. If arriving to a destination by car is made less convenient, other options should emerge as more convenient. Thus, it is advisable that places where parking is limited be accessible by other means, with good public transport connections and ample walking and cycling infrastructure. Incentives to use hybrid, electric, or shared vehicles could also be invoked, such as charging infrastructure in parking garages and preferential parking for such vehicles. Implementing changes is most effective if the push measures to limit (free) parking are accompanied by measures to pull users toward other modes or benefit them in other ways. For example, if parking is limited or removed entirely from a development, as in the case of Freiburg's Vauban neighbourhood, give the workers or dwellers a monthly public transport ticket. Or turn the former parking area into a useful space with obvious benefits to many people. San Francisco converted on-street parking and unused bits of street space into "parklets," small plazas and seating areas that make the streets more people-friendly. In a busy shopping district in Dublin, an entire level of car parking in a parking garage was turned into free cycle parking with 24-hour CCTV surveillance for safety and security. Sixteen car parking spaces became 192 bicycle parking spaces, providing parking for 12 times the amount of shoppers as previously on the level, and at limited construction costs as an existing facility had been used.

Involve stakeholders. Involving stakeholders goes hand in hand with the aforementioned strategies. A parking policy provides a framework that has been agreed upon by key stakeholders for delivering an improved overall transport system. Furthermore, stakeholder engagement promotes the integration of parking with other policy areas. Goals should be set in advance with meaningful involvement of the local authority involvement and a detailed, applicable plan that can be monitored and evaluated. To arrange that transitions occur smoothly, thorough coordination with directly and indirectly affected stakeholders is in order. For example, when introducing parking meters in the downtown area, as was done in Madrid, it was helpful to coordinate the decisions with industry, city offices, university, and—the most important stakeholders—engaged citizens.

Gain citizen acceptance. Collect public opinions in order to design appropriate implementation strategies and information campaigns. Public authorities must ensure that changes, particularly restrictive measures, are well-explained to the public. Citizen acceptance of changes to parking costs and availability is a crucial element of successfully introducing change. Effective communication and gradual change increase the likelihood that a measure is met with approval. The fees may be obvious, but the positive changes brought about by instituting them may not be. Clearly communicate how the revenue from parking fees is being used, and make sure citizens are aware of positive changes such as greater ease to find a parking spot, better air quality, and improved public spaces. Making the change gradual, as San Francisco exemplifies by only raising parking prices by a maximum $0.50 per month, also diminishes the likelihood of strong opposition to new parking measures. Citizens must also be educated regarding the effects and importance of the parking provisions, and have incentives to use other modes to reach the destinations where they used to go by car.

Be positive. In the process of introducing a parking policy, especially when garnering citizen acceptance, it is important that the focus be not on what is being limited or taken away, but on the reasons for the changes and the benefits that come with implementation. Language and overall message should not take on a restrictive tone that emphasizes the limitations or costs, but rather should highlight the liberation of more space for people/other uses and the potential gains for the area. What some people see as the limiting cars in the city centre, others perceive as improving accessibility for other modes.

Have strong political will. Citizen support for parking measures usually comes after implementation. Because driving is considered to be an important mode, an overwhelming share of budget and space are allocated to meet the needs and perceived demands for parking. Such allocations and political support for driving send the message that driving is of paramount importance as a mode of travel. Meanwhile, a relative lack of political support for other modes can be a major barrier for their full implementation, effective functioning, and use.

Evaluate. An initial evaluation of applicability is necessary to determine what measures to include in a parking policy. Throughout and after implementation, progress should be evaluated regularly.

Applicability

The following points are indications of conditions under which parking regulations are applicable:

- **A parking problem exists:** If parking spaces are frequently vacant or constantly occupied, this is a good indication that a re-evaluation of pricing is in order. Parking "spillover" is a problem that is erroneously addressed by increasing supply. More likely, a necessary course of action requires the removal of some parking spaces or areas altogether. Minimum parking requirements respond to demand without controlling supply. If minimum parking requirements are in place, this is a good indication that a city needs to reconsider and improve its parking management.
- **Traffic congestion and pollution are significant problems:** Drivers tend to circle in search of parking in the limited vicinity of high-demand. This extra cruising in search of parking accumulates to have a noteworthy impact on traffic congestion and air pollution. Congestion can be significantly reduced by reducing incentives to drive and by taking up parking pricing as a measure to even out the spread of parking demand.
- **There is existing or potential infrastructure to support other modes:** If parking is limited, the effects of the measure will be much greater if other modes cannot absorb some of the people who no longer travel by car. For this reason, it is recommended that a parking management plan be part of a package of mobility measures. If parking is to be limited, there must be clear alternatives modes of transport in place that provide sufficient capacity, reliability and convenience. The preparation and adoption of a Sustainable Urban Mobility Plan (SUMP) provides the appropriate process for engaging stakeholders and assessing the suitability of complementary or alternative transport measures.
- **Land values and parking facility costs are high**: As space in downtown areas is often limited and highly valued, the allocation of a significant portion of that space to serve as parking lots is a loss of space for other uses. Eliminating minimum parking requirements allows compact development and is helpful in eliminating sprawl. Property prices will also be more affordable when parking costs are unbundled from housing. Saturation of the reduced number of parking spaces can be avoided by a pricing scheme.

Economics

Economic aspects of managing the allocation of urban public space to car parking and optimising pricing for parking can be differentiated into three basic categories:

Table 4-27: Economic aspects of managing the allocation of urban public space to car parking

Expenses	Savings	Revenues
- Research and development - Infrastructure costs associated with repurposing parking spaces - Overhead and management	- Parking prices no longer bundled or hidden in other costs (for renters / customers) - Parking lot maintenance no longer required - Limit construction costs of repurposed spaces as they make use of an existing facility	- Increased usage intensity of remaining parking spaces, which creates revenue if parking is priced - Potential revenue from new rental units/commerce spaces in place of former parking structure/lot

There are numerous benefits (savings and revenue) that balance and often outweigh expenses. Providing parking spaces is expensive. The cost of building a single car parking space can range between €10,000 and €40,000. A high minimum parking requirement can thus make new developments more expensive, which in turn raises the costs for property owners and renters. Property developers can easily save hundreds of thousands of euros if they are not required to build car parking spaces.

Eliminating minimum requirements frees up space for other uses, such as more bicycle parking, which in turn can also draw more customers to areas of commerce. A study in Melbourne indicates that removing parking spaces to allow better accessibility for other modes is beneficial to business. On a shopping street in Melbourne, the average cyclists' expenditure was measured to be 73% of a car user's, however the space required to for bicycle parking was only 12% of the space required for car parking. Thus, each square metre of space allocated to cars brought $6 per hour in expenditure, whereas each square metre designated for bicycle parking brought $31 per hour; five times as much. (Lee, 2008)

Table 4-28: Measures for optimising pricing for parking

Expenses	Savings	Revenues
- Research and development - Procurement of equipment for parking meters - Customer support - Overhead and management - Maintenance	- Reduction of driving time / time spent cruising for parking - Parking prices no longer bundled or hidden in other costs (for renters/customers)	- Revenue from parking meters - Increased usage intensity and revenue per space - Higher turnover of customers to commerce districts, more purchases made

Many of the imagined costs of abolishing free parking turn out to be exactly that: imagined. For example, when higher parking prices are instituted, local businesses may fear a drop in commerce. On the contrary, eliminating free parking as an option will increase the turnover of people coming by car, since they will be paying for the time they spend parked. Introducing or raising fees for parking will not scare away customers, and the benefit to having demand-responsive pricing is that if the price is prohibitively high, it will automatically be adjusted until it is low enough that people are willing to pay again. When LA Express Park was implemented, the average price of parking decreased by 11%, while the income from meters went up by 3% and paid hours for parking meters increased by 16% due to an increase in demand in previously low-demand areas (Ghent, 2014).

Innovative pricing measures are especially beneficial from an economic perspective because they always respond to demand. During a recession, prices may go down to keep customers coming. When demand rises and spaces become too routinely occupied, prices will go up, ensuring that a turnover of customers continues. This will help businesses survive and prevent job losses.

Empirical research shows that performance-based prices will promote a faster turnover of vehicles because drivers will pay for the duration of their parking time. Furthermore, occupancy-based on-street parking prices will motivate more people to carpool. Both of these are good for businesses, as it will deliver more people to restaurants, shops, and other places of commerce. (Shoup, 2011a).

Driving force for implementation

While parking management is usually implemented to achieve many goals, the primary driving force tends to be to make finding a parking space easier. The consequences of such an achievement are reduced pollution and reduced congestion, two major priorities of cities. Good parking management increases the availability, but not the amount, of parking.

The typical UK driver spends 106 days of their life searching for a parking space (The Telegraph, 2013). The amount of congestion and pollution caused by cars in search of a parking spot is staggering. In most cities the need for parking spaces exceeds the available space. Parked cars dominate the appearance of streets and impair their ability to function.

Not only does instituting demand-responsive pricing limit the amount of car traffic and thus, the amount of congestion and pollution, it also raises funds the benefit the local community. Meanwhile, limiting the abundance of parking in general encourages the development of people-friendly public spaces as people become less inclined to arrive to destinations by car, and rather travel via other means.

Cities are interested in enhancing the quality of life of their citizens and offering them a pleasant environment in which to live. If cities are committed to providing affordable housing, unbundling parking from housing is mandatory. Bundling parking with living space significantly raises the cost of urban life. Adjusting land and building codes to eliminate minimum parking requirements will significantly affect the overall cost of a unit (Hurd, 2014).

When cities are faced with traffic congestion problems—and most cities are—it is important that local authorities play an active role in improving the situation. The effects of limiting (free) parking spaces make an urban area a more attractive place in which to live and work.

In the case of Los Angeles, the main driving force for introducing LA Express Park was the award of a $290 million grant to the city, with $15 million toward parking, and a heavy commitment to new technology by the city management (Ghent, 2014). The availability of funds facilitated the city's pursuit of acquiring the innovative technology necessary to achieve the vision of an efficient, functional, demand-responsive parking scheme. Such an undertaking is applicable in any city where parking is free, where parking spaces are abundant, and where automobile congestion is a problem. Where many people want to use a scarce public resource, self-restraint does not produce any individual reward.

Parking is not at the forefront of the public's, or even planners' minds when it comes to addressing traffic problems and urban sustainability issues. As a result, it is not sufficiently recognized nor prioritized as a way to limit automobile dependence and the resulting traffic congestion problems. Nonetheless, limiting free parking spaces should be seen as an essential step in developing a sustainable urban mobility plan. Transport is one of the main sectors responsible for air pollution in many cities. Proper parking policy is one fundamental step toward solving pollution issues in cities.

Reference organisations

Cities optimising parking pricing:

- Budapest - http://www.budapest.com/travel/getting_around/parking_in_budapest.en.html
- Burgos - http://www.civitas.eu/content/parking-strategy-and-management-burgos
- Calgary - https://www.calgaryparking.com/web/guest/cpa_secure/parkplus
- London - http://www.cityoflondon.gov.uk/services/transport-and-streets/parking/where-to-park/Pages/Where-to-park.aspx
- Los Angeles - http://www.laexpresspark.org/
- Madrid - http://www.civitas.eu/content/madrid
- San Francisco – http://sfpark.org/

Cities efficiently managing the allocation of urban space for parking:

- Berlin - http://www.tdm-beijing.org/files/news/Parking%20Workshop/3---HeinrichsParking_problems_and_solutions_in_Germany.pdf
- Birmingham - http://www.birmingham.gov.uk/carparkingspd
- Graz - http://www.parken.graz.at/
- Hamburg - http://www.itdp.org/europes-parking-u-turn-from-accommodation-to-regulation/
- London - http://www.london.gov.uk/priorities/planning/publications/the-london-plan
- Paris - http://www.itdp.org/europes-parking-u-turn-from-accommodation-to-regulation/
- Tokyo - http://cleanairinstitute.org/download/rosario/gp1_2_03_paul_barter.pdf
- Toulouse - http://www.civitas.eu/content/toulouse
- Zurich - www.stadt-zuerich.ch/parkplatzkompromiss

Technology and projects

Merge: Xerox developed this award-winning parking bay sensor system for Los Angeles and now offers the technology to cities around the world. The system uses parking occupancy data it collects to obtain and respond to a complete view of parking demand and behaviour. The algorithm-driven pricing model sets prices based on this supply and demand data. Further information: http://www.acs-inc.com/br-tsg-merge-parking-management-system.pdf

SchlauerParken: an effective, low-cost system that gives an overview of inner-city parking spaces in real time. Thomas Hohenacker developed this parking sensor system and an app to match. Its special feature is that the sensors are above the road, attached to street lights for example, and are not placed in the parking bays. Further information: http://www.schlauerparken.com/SchlauerParken.html

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4.9 Implementation of logistic service centres

Description

Urban freight logistics is a large yet often overlooked aspect of a city's sustainable urban mobility. Urban areas attract large quantities of goods and materials flows which originate from far beyond the city's borders. In the absence of measures to restrict or consolidate these flows at the local level, this invariably results in increased urban road freight traffic as deliveries reach the 'last mile' of their journeys (see Figure 4-10). Over the past two decades, freight deliveries to cities have tended towards more frequent, smaller deliveries which travel over longer distances, resulting in reduced load factors and an increase in the number of large delivery vehicles in urban areas (European Environment Agency, 2013; Karrer & Ruesch, 2004).

While this fragmented approach to deliveries satisfies individual customers' needs for reduced times between order and supply, its inefficiencies contribute significantly to a city's GHG emissions, air pollution and noise pollution. According to Behrends (2008), in the EU "goods movement represents between 20 and 30% of vehicle kilometres corresponding to 16-50% of the emissions of air pollutants, depending on the pollutant considered, by transport activities in a city". In order to address these environmental challenges, several cities have successfully implemented city logistics service centres (LSCs). This BEMP posits that the more comprehensive LSC model which provides multiple urban freight services (in contrast with the single-purpose urban consolidation centres model) represents the best environmental management practices when it comes to urban logistics management. With the right physical and economic configuration, LSCs make the first and last mile for deliveries within a dense urban area more efficient and less intrusive environmentally and socially.

An LSC is "a logistics facility that is situated in relatively close proximity to the geographic area that it serves a city centre, an entire town or a specific site (e.g. shopping centre), from which consolidated deliveries are carried out within that area" (Huschebeck & Allen, 2005). LSCs are most often started to address the public authority's aims to reduce CO_2 emissions resulting from freight transport, to alleviate traffic congestion and to reduce environmental problems such as air and noise pollution. Many LSCs make use of electric delivery vehicles to further reduce noise pollution and to make out of hours deliveries a viable option.

LSCs facilitate more efficient use of the existing transport infrastructure for goods distribution within and outside the city by promoting cooperation among local freight actors (freight forwarders, wholesalers, production companies, retailers, etc.). Hendriks (2014a) describes the resulting urban freight management operations as "dynamic, zero-emission, efficient distribution and collection on the 'inside' of the city". In addition to delivery services, LSCs offer storage, waste and packaging material management which can attract new customers and therefore additional income for sustaining the LSC.

LSCs are created for a variety of purposes and can take various forms. Huschebeck & Allen (2005) identify three categories of LSCs:

1. Special project LSCs: used for non-retail purposes (e.g. construction material).
2. LSCs on single sites with one landlord: usually for retail areas and shopping centres.
3. LSCs serving a town/city: part of city logistics schemes, and can vary in terms of the geographic area they serve and the number of partners operating the LSC.

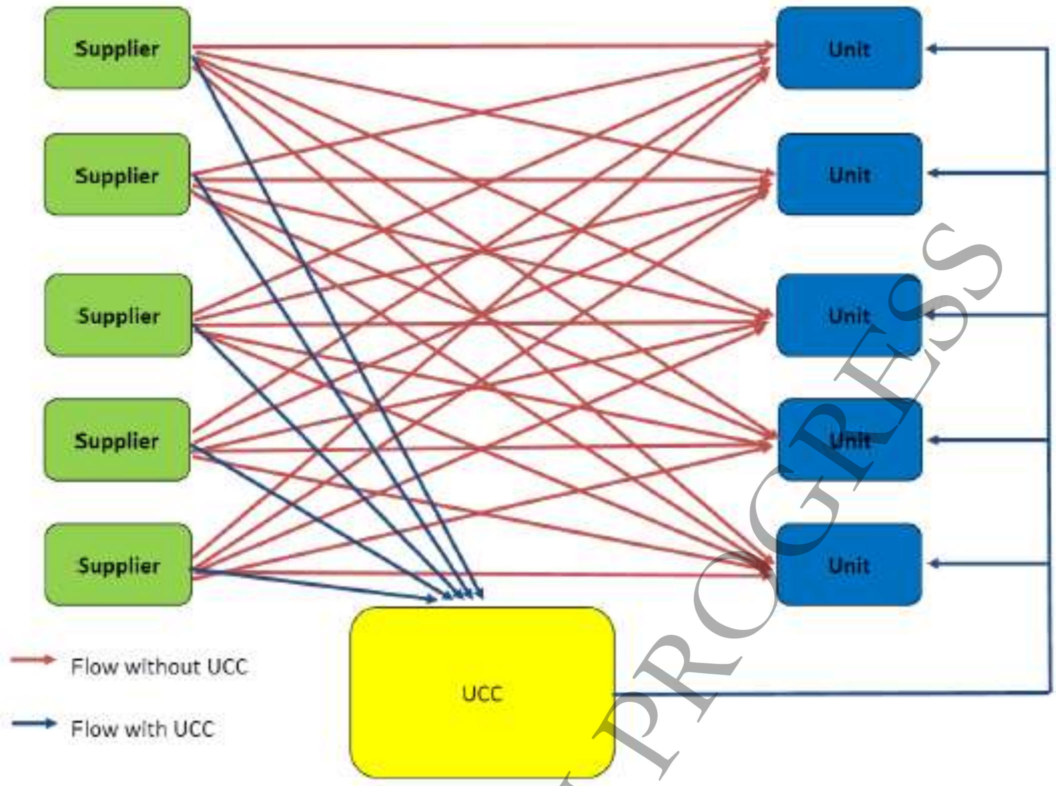

Figure 4-10: Flow with/without an urban freight consolidation scheme[50] ***Source: (Nord, 2013)***

Regardless of the type of LSC, the most successful ones have been initiated by public authorities which brought stakeholders together and financed the start-up phase; in fact, the central role of public authorities is often cited as essential during the start-up of an LSC, and is highly influential for its continuation (Campbell, MacPhail, & Cornelis, 2010; Danielis & Marcucci, 2007; Gonzalez-Feliu, 2011; Lewis, Fell, & Palmer, 2010; Ottosson, 2005). This BEMP looks at the implementation of city Logistics Service Centres (LSCs) and assess their environmental and transport-related benefits as well as highlight what public authorities can do to support successful measure implementation and facilitate good delivery for and with local freight actors. Three frontrunners in the implementation of LSCs are Stockholm (SE), Bristol (UK) and Växjö (SE). Each frontrunner represents one of the three categories of LSCs, and serves to illustrate the BEMP's elements while showcasing how both medium-sized and larger local authorities can encourage and assist in establishing freight distribution centres for various purposes. Table 1 provides an overview of each of the three frontrunners' LSCs and the public authorities' approaches to implementation.

Special project LSC

In 2001, the City of Stockholm (about 850,000 inhabitants) introduced a special project LSC for the construction site of the city's large-scale housing project "Hammarby Sjöstad". The high number of deliveries and heavy vehicle movements led to the idea of implementing a logistic centre where all goods were consolidated and stored (including consolidated transport of construction material, temporary storage, co-transportation of goods from the logistic centre to building sites and smart traffic control).

In addition to delivery services, the LSC offered temporary storage of material. There was also smart traffic control for vehicles entering the construction yard which included SMS-based variable smart traffic signs and a smart computer system was used for the distribution of goods.

[50] In Figure 4-10, the commonly used acronym 'UCC' (urban consolidation centre) is used. UCCs typically serve the sole function of consolidating and distributing goods. For this BEMP, however, LSC is preferred because it encompasses a broader range of city logistic services.

It was reported that congestion levels decreased considerably and so did the number of trucks in the construction site area; CO_2 emissions were reduced by about 100 tons per year; noise levels were lowered significantly.

LSC on a single site with one landlord

The City of Bristol (about 400,000 inhabitants) introduced a city logistics service centre scheme in 2004 which is located about 11 km outside the city centre for its local retailers. Initially planned as a pilot project, the scheme was turned into a permanent logistic centre. It focused on the core retail area Broadmead having more than 300 retail stores. Before actual implementation, thorough analyses of freight distribution patterns and of retailers were made. As a result of the implementation of the urban consolidation centre, delivery trips to the 55 participating retail organisations were reduced by 76%, and significant emissions reductions were achieved. Due to the scheme's success it was extended to also including waste and packaging material management.

LSC serving a town/city

The City of Växjö, Sweden (about 85,000 inhabitants) implemented an LSC in 2010 which serves the city's 450 municipal units, which include local government owned buildings which house offices, schools and other public services. Following a thorough simulation study, the LSC's distribution started small-scale with office supplies but was soon up-scaled to including also food supplies. The centre established an e-purchasing system and introduced an optimised delivery plan on predetermined routes. The City of Växjö achieved a reduction of deliveries to the 450 municipal units by 82% per week (decrease from 1,900 deliveries to 350 deliveries per week).

Table 4-29: Overview of the Stockholm, Bristol and Växjö LSC schemes

	Stockholm	**Bristol**	**Växjö**
Name	Hammarby Sjöstad Logistics Centre	Broadmead Freight Consolidation Scheme	--
Date introduced	2001	2004	2010
LSC type	Special project LSC (construction site)	LSC on a single site with one landlord (retail area)	LSC serving a city (public buildings)
Initiated by	City of Stockholm	Bristol City Council	City of Växjö
Operator	Subcontracted by the City of Stockholm	DHL	Alwex transport AB
Financing	2001: 95% public funds 2004: 40% public funds 2005: 0% public funds	2002-2006: 100% publicly funded (support from EC VIVALDI project), 2006-present: 45% public funds	100% publicly funded
Pilot study	3-year project (2001-2004), reopened in 2005 as fully self-sustaining	Initial survey and 8-month pilot study	Simulation only, based on survey results and other data
No. customers	10 contractors of the housing project	55 retail organisations	450 municipal units
Technology used	SMS-based smart traffic signs, smart computer system for goods distribution	'Styleflow' freight consolidation tracking system	e-purchasing system

Distance from area served	Entrance of construction site	11 km	7 km

Achieved environmental benefits

The environmental benefits derived from implementing an LSC mostly come from a reduction in the number of heavy delivery vehicles entering the city. By consolidating goods and delivering them along more efficient routes, deliveries can make maximum use of smaller vehicles, thereby reducing emissions and noise pollution. LSCs which use electric delivery vehicles, such as Bristol's Broadmead Freight Consolidation Scheme, further reduce emissions and practically eliminate their contribution to noise pollution, making out of hours deliveries possible. This further reduces urban freight deliveries' contribution to traffic congestion during peak hours of the day.

Better coordination and efficiency of freight movement within urban areas leads directly to a number of environmental benefits that are typically associated with sustainable urban transport systems in general. Behrends et al. (2008) identify these environmental benefits as "reducing air pollution and noise emissions, greenhouse gas emissions and energy consumption (including contributing to meeting legislative requirements on air quality and environmental noise e.g. EU directive 2002/49/EC)".

Table 4-30 provides a summary of the environmental benefits achieved from the three frontrunner cities. All of the schemes resulted in a marked reduction in the number of delivery trips per day and, consequently, reductions in vehicles miles travelled and fuel usage. As a result, the LSCs contributed to the following environmental benefits:

- CO_2 emissions reductions, which reduces the city's contribution to climate change
- Reductions in the air pollutants NO_x and PM, which reduces the possible negative health impacts for people and animals
- Reductions in urban freight's contribution to noise levels exceeding the maximum levels of 55 dB(A), which also has impacts on humans' health and quality of life

Table 4-30: Summary of environmental benefits achieved from Stockholm, Bristol and Växjö LSCs[51]

Indicator	**Stockholm[52]**	**Bristol[53]**	**Växjö[54]**
Emission of CO_2	Reduced by 100 tonnes/year (90%)	Reduced by 70 tonnes	Reduced by 40%
Emission of NO_x	--	Reduced by 2,281 kg	--
Reduction of exceeded maximum noise levels of 55 dB(A)	Reduced by 62%	--	--
Number of delivery trips per day	Reduced by 20 trips per day	Reduced by 76%	Reduced by 82% (from 271 dow to 50 per day)
Vehicle km (Vkm) by vehicles type (EV, conventionally fuelled)	Reduced by 38 km per day overall	Reduced by 264,000 Vkm	Reduced by 33%
Fuel usage	--	Reduced by 26,000 litres	Reduced by 68%

[51] Values are listed as provided in reports, therefore the units may vary. Some reports did not specify a time component.

[52] (Ottosson, 2005)

[53] (TRAILBLAZER, 2010)

[54] (Nord, 2013)

Combining LSCs with other measures

There is also the potential to link LSCs together with wider regulations and policy measures relating to emissions reduction and congestion management. For example, London's Low Emission Zone (LEZ) charges heavy diesel vehicles which enter the Greater London. This is done in an effort to encourage the most polluting vehicles to become cleaner (TfL, 2014). Schemes such as these are effective when paired with the creation of an LSC that is not mandatory for all delivery providers to use.

Appropriate environmental indicators

In order to do a proper evaluation of an LSC's environmental impacts and performance, it is important to first gather data on the appropriate environmental indicators so that the base (current) situation is clear. Some of the data for the following indicators may already be available to the public authority, but as a first step it is important to identify data gaps and attempt to fill them in with the most up-to-date information available. Once gathered, these indicators provide valuable insights for the creation of a simulation or pilot study. This will ensure that the LSC's impacts can later be measured and evaluated properly during the pilot study and later after full implementation.

It is important to note, however, that "with the wide range of variables to be measured, there are clearly many ways in which LSC s can potentially be evaluated, with no one single method appropriate to all circumstances" (Browne, Woodburn, & Allen, 2007). Therefore it is important for public authorities to measure the most relevant environmental indicators for their local context.

Appropriate environmental indicators for evaluating progress and success of a freight consolidation centre include emissions in the target area compared to former emissions while making the same deliveries (CO_2, NO_x, PM), reduction of exceeded maximum noise levels above 55 dB(A), number of delivery trips per day before and after measure implementation, vehicle kms by vehicle type (e.g. EV vs conventionally fuelled) and fuel consumption in the target area compared to the previous consumption. The units for these indicators are listed in **Table 4-31**, with further explanations of the indicators where necessary.

Table 4-31: Appropriate environmental indicators to monitor the implementation of an LSC

	Indicator	Unit	Explanation
A)	Emission of CO_2	tonnes/year	
B)	Emission of NO_x	tonnes/year	
C)	Emission of PM	kg/year	
D)	Reduction of exceeded maximum noise levels of 55 dB(A)	times/day	Mostly applicable in confined areas with little outside noise, such as construction sites and possibly some shopping centres. Otherwise, too many other variables could influence noise levels.
E)	Number of delivery trips per day	No./day	Delivery trips should decrease as delivery schedules and route planning are made more efficient.
F)	Vehicle km (Vkm) by vehicles type (EV, conventionally fuelled)	Vkm/day	EVs not only contribute to reduced CO_2, NO_x and PM emissions, but they also reduce noise levels and can make night deliveries a viable option.
G)	Fuel usage	litres	

Cross-media effects

A correctly implemented LSC should have no negative environmental impacts. However, if an LSC is not configured properly in terms of location, scope and organisation, it may not deliver sufficient environmental benefits, and may in fact create new problems and environmental challenges. Negative impacts could result from the following factors:

- **Inappropriate location:** The location of an LSC has a direct impact on the efficiency of delivery routes. Not only do existing (interested) customers need to be taken into account when choosing a spot for the LSC, but potential future customers should also be located.
- **Resource use of the LSC facility**: Factors such as energy use and packaging material recycling and/or disposal methods determine the LSC facility's related CO_2 emissions and overall environmental impact. These factors need to be considered with sustainability in mind so that their related effects are mitigated.
- **Land use impacts of the LSC facility**: Preferably, LSCs should be built on brownfield sites such as previously developed industrial areas. However, in cases where such land is unavailable or undesirable in terms of location, the LSC might be built partly or entirely on greenfield or undeveloped land. This has a direct impact on the habitats of plants and animals, which if planned incorrectly can have a ripple effect of negative consequences for the local ecosystem. In such cases the LSC facility should be designed to be compact and cognisant of the existing natural environment, particularly with regard to wetlands and forested areas.
- **Scope is too small:** If the scope of an LSC is too small, it will quickly run at full capacity and deliveries which might have otherwise been able to be serviced by the LSC are forced to be delivered. Wherever possible and desirable, the LSC should be scaled up to accommodate as many customers as it can attract. This may require moving the LSC to a new location.
- **Ineffective organisation:** Many companies already efficiently consolidate their freight themselves or with parcels carriers, so there are potentially negative consequences for trying to re-channel the flow of goods through an LSC. This is mostly relevant for regulations which require all deliveries coming into the city to use the LSC; however, public authorities which implement LSCs under such regulations are often unsuccessful and cease operations.

Operational data

The factors influencing the implementation of an LSC vary according to its type. "Knowing the current state and improvement potential of the urban freight transport system are prerequisites for defining successful strategies and implementing effective actions" (Behrends et al., 2008). Therefore, the area covered by the LSC as well as the customers to be served form the basis for a public authority's strategy. This is why the first step for a public authority, after identifying the reasons why they want a LSC in their city and who may possibly run it, is to conduct a pilot study or a simulation. In Växjö, the municipality's 108 units answered a questionnaire during a certain time period where they filled in data about the deliveries they received. This data was used for a simulation which focused on the economy, environment and working environment in order to identify synergies which the LSC could realise. Bristol also conducted an eight-month pilot study prior to full implementation. In both of these cases, the pilot study was essential so that the public authority could show stakeholders that it has conducted research on the applicability of the LSC in the local context and was then better informed to suggest a fair and mutually beneficial allocation of costs and benefits.
While public funds are useful (if not essential) for the trial period, BESTUFS (2005) advises against publicly-organised LSCs. Therefore, the public authority should play more of a supporting role in the implementation and operation of an LSC, while one or more key commercial stakeholders that are aware of the benefits of an LSC take the leading role.

Location of the LSC
The location of the LSC depends on the purpose the facility is meant to fulfil. For special projects, such as the Hammarby Sjöstad Logistics Centre, it is ideal to have the LSC onsite (in this case, directly at the entrance of the construction site). However, for LSCs which serve the city or a specific retail area, the facilities are usually located just outside of the city area which it serves, usually with access to the main motorway. For example, Bristol's LSC is 11 km from the city centre, and Växjö's is 7 km away.

Political commitment and support

According to Birgit Hendriks of Eco2city, which developed the concept of the ‘binnenstadservice’ in the Netherlands, it is essential for the local government to “be clear and outspoken about their ambitions on air quality, energy use and sustainability as a whole, and to live it” (Hendriks, 2014b). According to Binnenstadservice (2014), this requires "constructive and effective cooperation between the wide range of stakeholders in the logistical chain (which is a highly competitive market) to reconfigure transport movements based on the use of the service centres". However, there currently is a 'lack of scale' for LSCs in Europe. This means that there are currently very few LSCs in operation, so there is no LSC 'network' as such which would encourage long-distance freight operators to use these services. This is a challenge which requires regional and EU-wide political support. However, it can be said that at the local level, political commitment and clear operating procedures for all involved stakeholders were key to the LSC’s success in Stockholm, Bristol and Växjö.

Bristol’s simple, straightforward Standard Operating Procedures helps the LSC to continue to run smoothly today. It also has a customer services team available to answer questions. In an effort to facilitate further cooperation, Bristol has also formed a Freight Quality Partnership together with three neighbouring local authorities and the freight sector, which provides a forum for discussing innovative freight solutions.

A further insight from the Växjö frontrunner case is that all personnel affected by the change in logistics should be informed about the changes and its benefits in such a way that fosters support for the scheme. Political commitment in Växjö transcended party lines, with both centre and right-wing parties supporting the LSC. This highlights the value for fostering nonpartisan support for LSCs and other urban freight management measures.

Technology and additional services

Once these basic elements are in place, additional technology can enhance the scheme’s efficiency. The use of freight consolidation tracking systems, such as the Styleflow System used by DHL in Bristol’s Broadmead Freight Consolidation Scheme, help to increase customers’ confidence in the LSC’s services by reducing errors and providing a more accurate time window for the arrival of deliveries. For Stockholm’s special project LSC in a construction area, SMS-based smart traffic signs directed delivery vehicles to the best available routes. All of these measures ensure that LSCs are at least as good, if not better, than traditional delivery methods in terms of ensuring timely deliveries. This, in turn, can help to improve customers’ acceptance and support for using the LSC.

Particularly in cities where no mandatory enforcement is in place for using the LSC, it is important for public authorities to attract new users. One way is to increase the flexibility and attractiveness of the LSC by offering additional services such as ticketing, boxing, tagging, waste management and providing overflow storage space for peak or seasonal needs (TRAILBLAZER, 2010). Another key finding from the frontrunner case in Bristol is that when it comes to marketing the LSC, “it is vital that the contractor works hand-in-hand with the Council to encourage participation across the city” (TRAILBLAZER, 2010).

Additional operational data

For further information about developing and implementing an LSC, Lewis et al. (2010) lays out a comprehensive decision tree for implementing an LSC for a shopping centre. The decision tree involves identifying the policy driver, gathering the necessary evidence base, identifying related and supportive strategies at the local, regional, national and EU levels, engaging in a consultation process with all stakeholders, and considering possible individual measures or measure packages.

Applicability

Relatively few LSCs in the world have been implemented successfully. A large proportion of LSCs are not successful due to a lack of support from the private sector and consequently a lack of customer base and income to sustain operations. LSCs tend to be controversial among delivery service providers as well as the clients they would serve due to the additional fees and the need for them to relinquish control over merchandise and transport chain (Karrer & Ruesch, 2004). Therefore, it is important for public authorities to analyse the local context in which the LSC would operate.

LSCs are primarily implemented in cities which are already struggling with traffic congestion, and which receive a high volume of deliveries via heavy delivery vehicles. It has been found that LSCs are mostly beneficial for deliveries in areas which have physical constraints such as historic cities with narrow streets where access can be difficult and results in traffic congestion (Lewis et al., 2010). It also helps to a larger extent the small, independent retailers and operators making small deliveries to multiple stops.

As a starting point, a case study done on the Bristol frontrunner which states that the Bristol model can be implemented in almost any urban area stipulates that the following basic requirements are critical for implementing a successful LSC:

- Support from the stakeholder groups and willingness for the project to succeed – Local Authority, the Contractor, the Retailers and wider User Groups, Suppliers and the Public
- An electric / low emissions vehicle fleet
- A suitable secure warehousing facility located on the edge of the urban area
- A management team experienced in logistics consolidation.

According to Browne et al. (2007) "the likelihood of an LSC being successful depends considerably upon the legal and planning frameworks in the locality or country involved". Both the Stockholm and Växjö cases cited political support as essential to the project's success. LSCs can even find support across party lines, as demonstrated in Växjö's LSC, which was pushed by centre and right wing parties.

If the physical and political situations have been analysed and it is determined that a LSC is an appropriate and desirable solution, the next step is to identify willing customers. The public authority should investigate whether there is a large enough base of providers and customers who are interested in participating in the LSC to warrant the investment. Reports on both the Stockholm and Bristol frontrunner cases state that these models are highly transferrable, but that it will only work if the public authority is able to attract enough interest to do a large number of deliveries (Lewis et al., 2010; Ottosson, 2005). This ensures a more favourable cost-benefit ratio, and ultimately determines the ability of the LSC to be self-sustaining.

Finally, a pilot study or simulation can provide a public authority with further practical insights into the feasibility of sustaining an LSC in the local context. However, it should be noted that "most solutions have shown interesting results in the pilot and test phases but could not survive once the strong public funding support was stopped" (Gonzalez-Feliu, 2011). Therefore, the most important factor for successfully implementing an LSC is for the public authority to have adequate funds available to sponsor the scheme until enough effort and time has gone into helping all of its users realise the benefits so that they are more willing to pay for it themselves.

Economics

The allocation of an LSC's anticipated costs and benefits is a key economic consideration during planning and set-up. Potential LSC partners and customers are usually more acutely aware of potential costs and not as aware of the benefits in economic terms (Huschebeck & Allen, 2005). An LSC can be considered successful in economic terms if it manages to break even; typically these facilities do not make a profit. Gonzalez-Feliu (2011) identifies two categories of economic costs for LSCs: the project development costs (e.g. strategic planning, new investments and pilot studies) and the tactical and operational costs (e.g. daily operations and continuation of the LSC).

Initial questions such as where the funds will come from and who will directly organise the LSC and attract customers to use it are public authorities' primary concern (Huschebeck & Allen, 2005). BESTUFS points out that "without some initial funding from central or local government to pay for the research work and pilot studies, any form of LSC that is not related to a major new property / commercial development is unlikely to proceed" (Huschebeck & Allen, 2005). It also recommends keeping the initial cost base low so that the pilot studies can act as a 'dry run' with minimal investments needed. For example, a pilot study could be run using an existing building which has potential for expansion instead of paying to construct an entirely new building for the purpose.

Once the trial stage is completed and the LSC is up and running, "what has to be demonstrated to [retailers] is that the additional costs associated with an LSC operation may not have to be borne by the logistics company or retailer, or if they do have to be that there may be significant offsets elsewhere in the operation that can reduce if not eliminate them" (Huschebeck & Allen, 2005). Stockholm's tapered approach to sponsoring its LSC was highly successful. During the initial three-year project, the City of Stockholm reduced its funding for the centre from 95% to 40% of the operating costs. At the end of 2005, the LSC was reopened, this time with 100% of the operating costs covered by the users of the LSC. This was possible because of the positive experiences during the three-year project period which increased users' willingness to pay for the service.

Furthermore, results from a study on Stockholm's LSC found that it is important to visualise hidden costs so that customers are aware of how they will benefit from paying for these services (Ottosson, 2005). Overall, the challenge for public authorities wishing to implement an LSC is to clearly communicate the balance of costs and benefits to retailers and carriers. Once this is accomplished, an LSC's "success or failure is ultimately based on the ability of logistics companies to market and operate a freight transport service that meets the needs of its customers at a competitive price" (MDS Transmodal Limited, 2012).

Driving force for implementation

Because LSCs depend not only on a willing public authority but also to an even greater extent on willing private investors and customers, the driving forces for implementation of an LSC can be divided into two parts: social and environmental goals which drive the public authority, and economic goals which drive private sector stakeholders.

Public authorities are the main initiators of LSC schemes. This was the case in all three of the frontrunners in this BEMP. They are mainly driven by the need to reduce traffic congestion and CO_2, NOx and PM emissions. Quality of life for residents and visitors was also high on the list of priorities from the outset. The LSC was seen as a solution which would take many heavy delivery vehicles off the roads, thereby reducing conflicts on the road as well as noise pollution. Therefore, the environmental benefits of an LSC are the main driving force for public authorities. Växjö has a particularly ambitious goal of becoming a fossil fuel free city by 2030, and initial results show that the LSC is on track for helping them meet this goal (Nord, 2013).

Support from private sector stakeholders is an essential driving force for implementing a LSC. However, the business case for a LSC is more difficult to make. LSCs can help to save time across the supply chain and increase the quality of delivery services. Further, less trips and higher load factors result in more reliable deliveries. Once providers and customers experience these benefits first hand after an extended trial phase, they are more likely to be willing to pay for the service themselves, thereby ensuring the LSC's continuation. Stockholm's LSC is a good example of a public authority being the driving force for helping the relevant private stakeholders to realise the LSC's benefits. Ultimately, if the public authority can make the business case clear to private stakeholders, then the LSC will be in greater demand and will consequently attract more deliveries, resulting in greater environmental benefits.

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- London Construction Consolidation Centre (UK)
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5 BEST ENVIRONMENTAL MANAGEMENT PRACTICES FOR LAND USE

Chapter structure

This chapter is dedicated to land use planning, one of the core activities of municipalities in most countries. The main best environmental management practice in this domain is thoroughly described in BEMP 5.1. It contains replicable measures to guide public authorities in improving their environmental performance in the field of land use planning by limiting urban sprawl into green spaces.

Chapter introduction

The world is becoming increasingly urbanised. Europe's process of urbanisation is already far advanced (with 75% of its population living in urban areas) and is projected to increase in the future. As urban populations increase, the tendency is for the land area devoted to urbanisation to increase as well. In particular, it has been estimated that about 80% of the European population will be living in urban areas/zones by 2020 (LUMASEC, 2008).

All EU Member States have various levels of planning from overall regional planning to the spatial planning of the regional administrative authorities down to communal building regulations. The responsibilities vary from one Member State to the other and thus the more general overview given in this chapter should be adapted to the national distribution of responsibilities.

The planning process and (to the extent possible) its implementation is a service provided by the public authority. Urban land use planning is made up of the zoning regulations and the development plan. The landscape plan is an ecological specialised plan that regulates the overall form of communal surroundings as a part of the zoning plan. Further programmes and plans, such as the urban development plan, the framework for urban development or specialised plans such as traffic planning or energy planning are related and should be considered.

The limitation (avoidance) of urban sprawl is a topic of major importance for sustainable settlement area development. Regional and local administrations can play a key role in supporting conservative land use in settlement development due to the planning sovereignty they hold. Selecting and designating which land is to be used for settlement and construction is one of the most important tasks in communal urban land use planning. Land use planning on local level is an instrument of settlement development, an instrument of planning and building laws and regulations and of weighing up the interests of different groups. Therefore, land use planning has a clear relation to environmental, social and economic aspects and thus is an important component of sustainable development on local and regional level.

Technique portfolio

This chapter focuses on limiting urban sprawl, an important aspect on which local public administration have a good control on, and the BEMP presented has a good replicability potential. Other techniques relevant to urban planning which should be considered by public administrations especially at local level, can be found in the EMAS Sectoral Reference Document for the Construction sector, specifically in the initial BEMPs on aspects of Urban Planning. These cover site selection, land consumption and urban sprawl avoidance (which complements the BEMP in the present chapter); biodiversity protection; reducing the urban heat island effect; and water drainage in sealed soils.

The present chapter is also linked to the following chapter (6) which presents best practices on the management of natural area. The focus of the present chapter is on the general planning aspect of land use allocation in the territory of the administration; while chapter 6 provides more practical guidance on the management of green spaces.

5.1 Limiting urban sprawl into green spaces or agricultural land

Description

As urban populations increase, the tendency is for the land area devoted to urbanisation to increase as well (rather than for the city to become denser). Although this process has been strongest in the United States, because of the predominance of single-household detached housing and the ubiquity of the automobile, the spread of urban areas into adjacent green spaces has also been a feature in Europe, where cities have become less compact than they used to be (Figure 5-1and Figure 5-2).

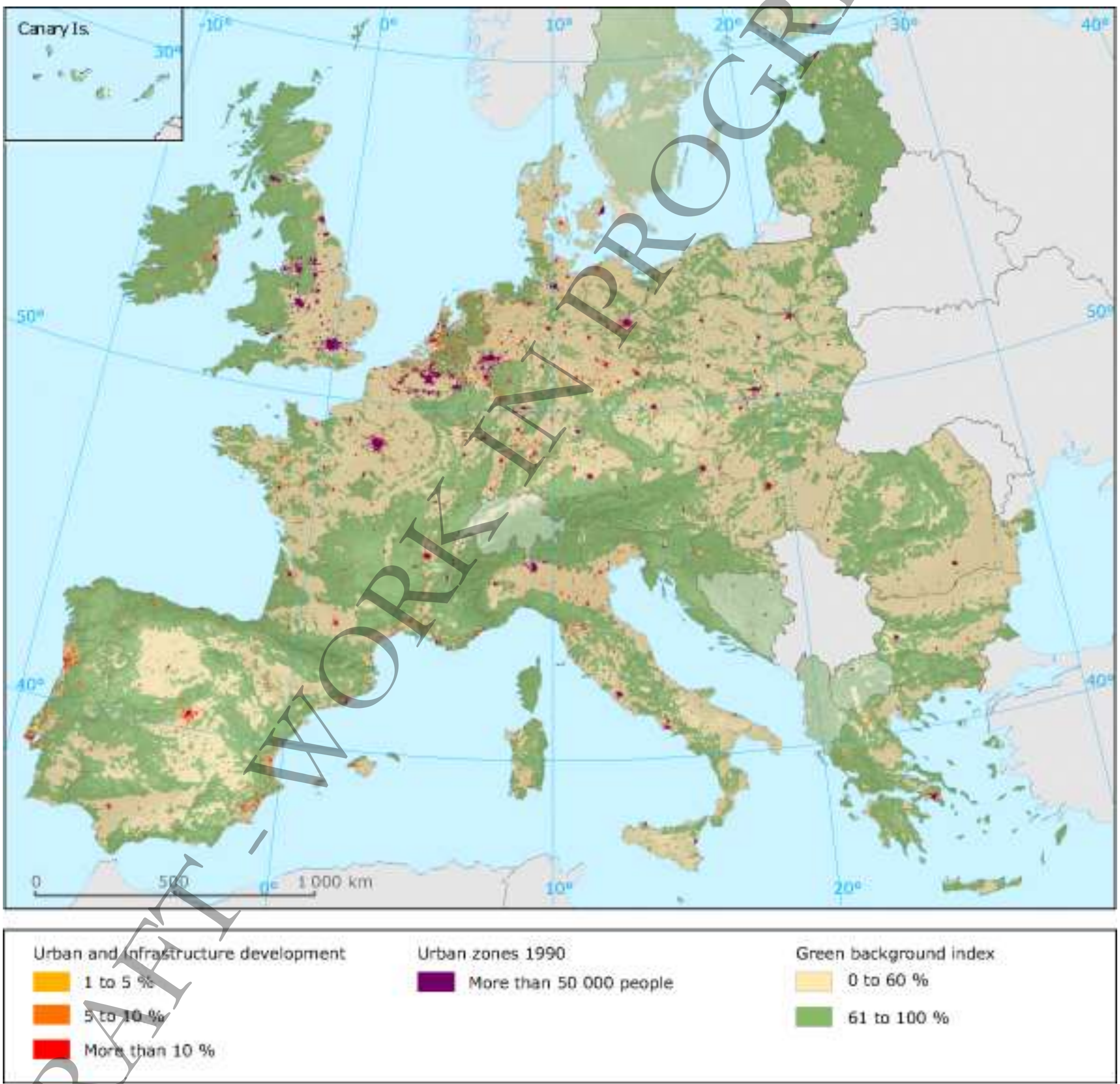

Figure 5-1: Types of urban areas in Europe: urban growth vis-à-vis urban sprawl from 1991 to 2001 (EEA, 2006; Pichler-Milanović, 2007)

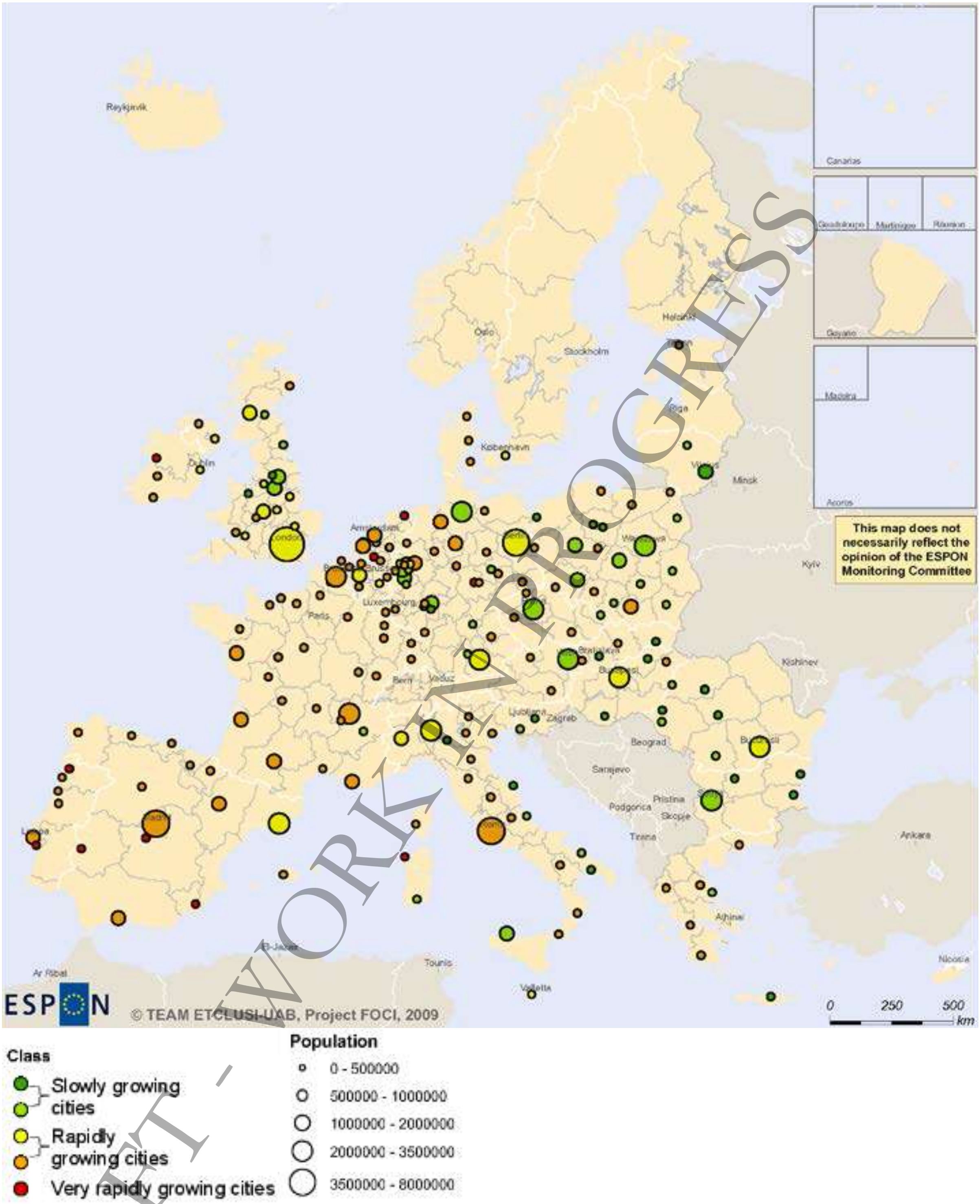

Figure 5-2: Typologies of urban development over the period 1990-2000 (ESPON, 2009)

According to Couch et al., (2007), urban sprawl in Europe is *"to be considered as a process of extending the reach of urbanised areas and not merely a pattern of land use in urbanised areas that exhibits low levels of density, continuity, concentration, clustering, centrality, nuclearity, mixed use and proximity"*. Likewise, EEA (2006) defined urban sprawl as *"unplanned incremental urban development, characterised by a low density mix of land uses on the urban fringe"* and incorporated elements regarding: environmental changes such as sealing of surfaces, emissions by transport as well as ecosystem fragmentation; changes in the social structure of an area, such as segregation, changes in lifestyle and the neglect of town centres; and economic changes, relating to distributed production, changes in land prices and issues of scale. As such, urban sprawl has profound implications for all aspects of sustainable development, not just for the environment (URBS PANDENS project, as cited in Arnstberg, 2003). Figure 5-3 illustrates the difference between the urban growth and urban sprawl (Couch et al., 2007; Pichler-Milanovic, 2008).

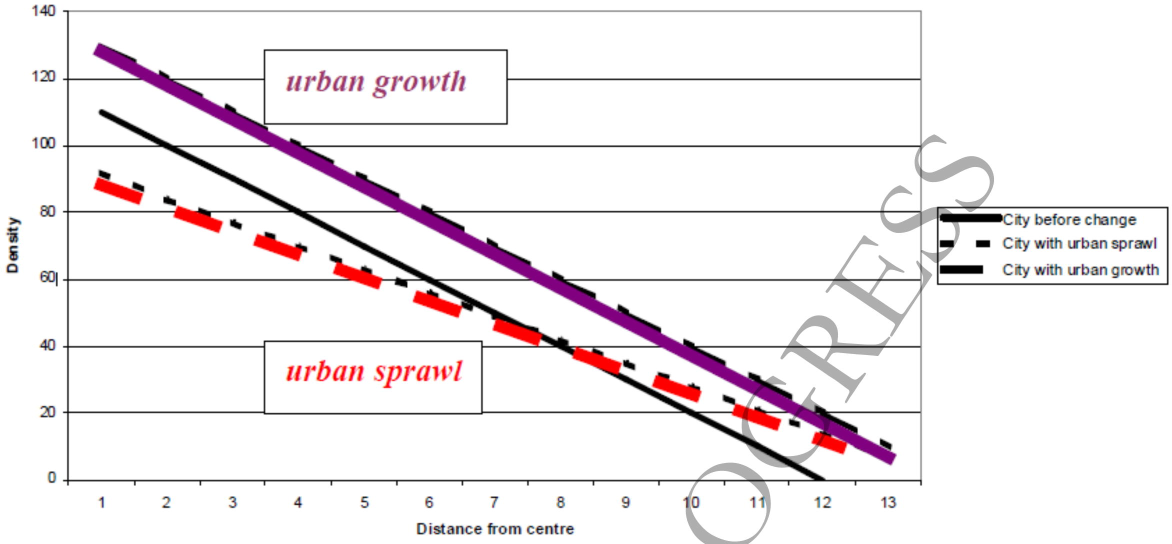

Figure 5-3: Distinguish between urban growth and urban sprawl (Couch et al., 2007; Pichler-Milanovic, 2008)

Urban sprawl is an increasing trend, not driven by population growth but rather made possible by changes in transportation systems and in lifestyle aspirations, with other driving forces including both micro and macro socio-economic trends such as the means of transportation, the price of land, individual housing preferences, demographic trends, cultural traditions and constraints, the attractiveness of existing urban areas, and, not least, the application of land use planning policies at both local and regional scales. Urban sprawl has been in Europe associated with high population density and economic activity, and/or rapid economic growth, and can be seen particularly in areas where EU regional policies have been implemented. According to EEA (2006) new development patterns can also be observed, for instance around smaller towns or in the countryside, along transportation corridors, and along many parts of the coast usually connected to river valleys. Table 5-1 presents the different growth patterns for European urban areas. Overall, Scandinavia is demonstrating a more sustainable pattern of growth, with increasing populations without associated geographical sprawl (Pichler-Milanović, 2007).

Table 5-1: Growth patterns for several European cities; urban growth vis-à-vis urban sprawl from 1991 to 2001 (Pichler-Milanović, 2007)

Growth with containment	Growth with sprawl
Copenhagen, Stockholm	Amsterdam, Athens, Berlin, Brussels, Dublin, Lisbon, Ljubljana, Luxembourg, Vienna, Warsaw
Decline with containment	Decline with sprawl
	Birmingham, Bratislava, Budapest, Leipzig, Liverpool, Prague, Rome

The main reasons that can cause the urban sprawl are listed below:

- Lower land price compared to developed areas of the main core of the city
- Availability of un-built agricultural land
- High rate of urbanization and rapid development activities
- Availability of some municipal services in mixed development without paying for it
- Less control on urban development being located outside the urban limit
- Lower taxes on industries

- Influence of speculators on the agricultural land owners for selling land to developers
- High rate of urbanisation
- Results of failure to match demand of urban infrastructure and services

In order to control/limit the urban sprawl, three following policy categories can be applied; some practical indicative measures (but not a limited list) are listed under each of the three categories (Couch et al., 2007; Pichler-Milanovic, 2008; Christiansen and Loftsgarden, 2011; Halleux et al., 2012):

1) Regulation:
    - spatial land use planning
    - restriction on specific land uses
    - provision of infrastructure e.g. transport, utilities, social facilities
    - density controls and monitor/manage the growth pattern of the cities
2) Economic intervention:
    - tax revenues to attract new residents and/or business
    - trading in development permits
3) Institutional change and management:
    - size and function of municipalities
    - special agencies for urban revitalisation
    - information and targets

A further description of the above listed measures (in the sense of how they can be applied) is presented in the next paragraphs.

An efficient advanced technique that can be used for the land use planning is the use of Geographical Information Systems (GIS) tools. Through the GIS tools, the collection of spatial and timely information on land use and growth pattern (of the cities) is feasible. Therefore it is possible to monitor, manage and plan properly the urban space. Also, a provision of infrastructure about transport etc. can be undertaken. In particular, the monitoring provides the necessary information to the planners and the decision makers about the current situation of the urban area and in parallel provides important feedback and input about the nature of the changes that are planned to take place. Summarising, the GIS tools provide all the necessary detailed land use information, which may assist planners and decision makers to regulate and/or guide the development throughout the urban management process (Nigam, 2008; Rahman et al., 2008).

Another practical technique that can support the control of the urban sprawl is to properly regulate the growing difference between the demand and the supply of the urban services. A key economic element might be to use tax incentives (e.g. tax revenue) to increase demand from households and economic activities (Christiansen and Loftsgarden, 2011). Another key element might be to encourage a higher density of urban areas and to reduce negative impacts as much as possible, e.g. by choosing areas for developing zones with low soil fertility and low ecologic value. This action enables the reduction of land use and does not require investment in building additional infrastructures, e.g. streets, sewerage system etc. for new residential projects. This approach involves making use of fallow land and spaces between buildings, reconstructing or converting unused buildings or structures, in order to obtain denser urban areas. Especially for the buildings some practical measures can be applied like:

- revitalisation of brownfields[55] (this may also lead to the remediation of polluted abandoned areas and reduce land consumption; brownfield areas are often in central locations making them potentially valuable, see also BEMP 6.4),
- closing of spaces between buildings,
- refurbishment of obsolete buildings, e.g. old farm houses, garages etc.
- dividing large building plots to allow the construction of new buildings on the plot,
- adding floors to existing buildings[56] and

[55] Definition made by ISO 21929-1:2011
[56] Wherever it is possible and feasible and does not result in other structural problems of the existing buildings

- improving the quality of land use, e.g. converting unused street areas into building plots.

Summarising, a number of practical measures that can be applied by the public administration and can control/limit the urban sprawl are listed below (Rahman et al., 2008):

1) identification of spaces for densification in urban areas, e.g. using aerial photographs([57])
2) discussion with building owners about their willingness to sell parts of their building plot
3) use of marketing tools to foster a market for spaces between buildings etc.
4) awareness raising of both building owners and parties interested in constructing a building about advantages of densification
5) protection of prime agricultural land
6) control of urban growth and sub-urban sprawl
7) maintenance of life style in the face of growth
8) maintenance of the environmental quality
9) establishment of legal and financial limitations
10) maintenance of the existing greenbelts (or green zones) and plan new ones
11) especially for new building zones:
    - reduction of the size of new building plots as far as reasonable
    - preparation of plans aiming to minimise areas for streets

Achieved environmental benefits

Reducing urban sprawl has obvious environmental benefits (European Environment Agency, 2006):

- Densification reduces the non-renewable land and soil consumption associated with urban sprawl. It also reduces (but does not eliminate) the consumption of raw materials such as gravel and those needed for example for the production of concrete or asphalt. Reducing urban sprawl allows soil to perform its water and carbon absorption functions, and helps reduce degradation of water quality associated with stormwater runoff from sealed surfaces. Reduced urban sprawl also helps preserve the groundwater recharge capacity of soil, hence reducing water scarcity.

- The changes in lifestyle associated with urban sprawl, which see increases in single-person households, also increase the consumption of resources because multiple-person households consume fewer resources such as water, energy and consumables. Increased energy consumption is also associated with low population density areas whose sprawl reduces the energy efficiency of distribution systems.

- Densification typically allows increased public transport usage in contrast with the prevalence of cars in sprawling urban areas. Therefore, densification leads to reduced fossil fuel consumption and the associated greenhouse gas emissions.

- Reducing urban sprawl allows for the preservation of natural areas, intrinsically important but also vital because of the importance of ecosystems. Negative impacts of sprawl are particularly evident in ecologically-sensitive areas such as coastal zones, for example in the Mediterranean which is considered to be a biodiversity hotspot.

- Limiting urban sprawl into agricultural land helps not only preserve the soil and biodiversity values of these, but also avoids the transfer of agricultural activities to less productive areas, requiring the use of more fertilisers.

Appropriate environmental indicators

The appropriate environmental performance indicators for controlling the urban sprawl are listed below (ESPON, 2012):

- *Artificial surfaces*: $km^2_{\text{artificial surface}}/km^2_{\text{total surface}}$; description: any kind of impermeable built-up area: buildings, roads, any part with no vegetation or water, etc.; artificial surfaces can be

[57] For more information please visit the link below: http://www.raum-plus.info/

disaggregated according to their main function: housing, industrial and commercial, infrastructures

- *New artificial areas*: $km^2_{new\ developments}$/ $km^2_{artificial\ surface}$; description: areas occupied by new buildings developments, roads etc.
- *New artificial areas on brownfield*: $km^2_{new\ artificial\ areas\ on\ brownfields}$/ $km^2_{total\ new\ artificial\ areas}$; description: Brownfields interested by new buildings developments, roads etc.
- *Ratio of built-up area*: Percentage (%) of built-up area of total land area
- *Increase of built-up area*: Percentage (%) of new built-up area over total built-up area at the beginning of the period
- *Land take per capita*: Increase of built-up area divided by the total population
- *Degree of redevelopment*: Percentage (%) of redevelopment over all new built-up areas for the period

Cross-media effects

Densification is often understood as developing abandoned land such as brownfields, which, although they might not count as usable green space for humans, can be an excellent habitat for some species. However, some trade-offs have been identified, in particular the densification by definition will consume open space, leading eventually to a possible conflict between densification on the one hand, and maintaining and valuing green spaces in cities on the other (the approach described for instance in BEMP 6.4). There are ways to overcome this apparent contradiction, for example by integrating green and blue design elements into the city and thereby making better use of the space available. Indeed, some areas of what is technically open space might not be useful space if it is at the interface of public and private space, as it is the case in modern suburbs (Ståhle and Marcus, 2009). Finally, the densification that uses non-useful open spaces creates additional useful open spaces or integrates design features such as green roofs or sustainable storm-water management measures, which can actually increase more the green space and eventually improve its environmental value.

Operational data

This section presents actual data from various case studies and discusses further the developed policy measures to control urban sprawl.

<u>Case study: Stockholm, Sweden</u>

Stockholm's landscape has been profoundly shaped by its geography: the location of the city on several islands surrounded by water has affected its growth. Rather than uncontrolled sprawl, as has happened in many cities throughout the world, Stockholm between the 1930s and the 1980s is an example of planned sprawl, with the city's rapid growth being directed in a way that allowed for green 'wedges' and other green areas to preserve inhabitants' access to natural spaces (Arnstberg, 2003).

The green wedge approach was a success, allowing for radial development along main public transportation lines that preserved natural spaces and associated biodiversity but also created a city with a high quality of life. Since the 1980s, however, Stockholm has managed its growth in emphasising the development of areas within the city's boundaries rather than allowing growth at the city's fringe. This new approach has been stimulated by important population growth combined with the realisation that Stockholm's green and blue spaces needed to be actively preserved from sprawl. Many stakeholders and planners proposed to build on semi-central industrial land and save green space due to environmental concerns and Not-In-My-Backyard effects (Ståhle and Marcus, 2009).

Stockholm is anticipated to keep growing; its population is over 800,000 and anticipated to reach almost a million by 2030. Stockholm's Regional Plan builds on the idea of sociotopes, which define uses and values of space, and define the ideal distance between inhabitants and different types of open spaces. Stockholm's land use planning also takes into account climate change and its ambition to be a fossil fuel free city by 2050.

As a result of the city's densification approach, areas prime for redevelopment have been identified and brownfield sites in the city have been subject to development, as is the case in Hammarby Sjöstad. In addition, planners and stakeholders from the city are seeking to develop a polycentric dense settlement structure in order to link Stockholm to regional town centres at the periphery of the city (Stockholm City Council, 2010).

<u>Case study: Bristol city, UK</u>
About 26% of the Bristol's City Council's administrative area has impermeable surfaces and is soil sealed. The Bristol Local Plan has successfully promoted brownfield development and densification of the city centres, avoiding development on greenfields. During the last decade 2001-2011, 98% of business development, 95% of new homes and 58% of new industries were on brownfield land. Population density has increased from 53 to 60 inhabitants per hectare with particular growth in the city centre. Since 2001 an average density of 230 dwellings per hectare (dph) has been achieved in the city centre (Bristol city), whereas in inner and suburban areas lower densities have been achieved such as 134 dph and 55 dph respectively.

<u>Case study: England</u>
Planning policies in England are in place from the 1940s' and particularly a proper urban containment policy and the use of green belts (which have significant public support). The green belts restrict the development on a band of countryside surrounding an urban zone (either town or city). Furthermore the planning policy statements have also prioritised the redevelopment of brownfield sites. Therefore a strict control of the urban expansion is achieved (Baing, 2010).

Applicability
Measures to limit the urban sprawl can be implemented by all cities. The applicability of the described techniques is increased by involving the public in the decision making process and maintaining the existing urban green areas. The public involvement can be achieved by the so called 'Open green policies' where for instance public can participate in discussions about the establishment of stepping stones between green spaces (Mabelis and Maksymiuk, 2010).

It is important to highlight that cities may have a vested interest in promoting urban sprawl, for instance some municipalities may promote the urban sprawl in order to attract new inhabitants and increase thus the taxpaying population. On the other hand, it can also be the case that there is no single authority at the metropolitan area which can coordinate the policy for land use planning for both a town centre and its surrounding suburbs (if they are managed by different town governments); in this case, the application of this BEMP requires an additional layer of concertation between the relevant layers of public administration.

Economics

From an economic perspective, it has been reported that urban sprawl is more costly from the urban development because of the following reasons (EEA, 2006):

- increased household spending on commuting from home to work over longer and longer distances;
- the cost to business of the congestion in sprawled urban areas with inefficient transportation systems;
- the additional costs of the extension of urban infrastructures including utilities and related services, across the urban region.

Driving force for implementation

In addition to the environmental benefits linked to reducing urban sprawl, which have been explored previously, there are also a series of socio-economic benefits which can act as driving forces for its implementation (EEA, 2006):

- Limiting urban sprawl along river valleys and in lowlands can reduce the economic and infrastructural impacts of flooding, which becomes far more costly as floodplains are built over due to the high value of land prices within them. Limiting sprawl in coastal zones will also reduce the impacts of predicted flooding from climate change driven sea-level rise.
- Urban sprawl generates greater segregation of residential development according to income. Consequently, it can exacerbate urban social and economic divisions. Social polarisation associated with urban sprawl is in some cities so apparent that the concept of the 'divided' or 'dual' city has been applied to describe the divisions between the inner city core and the suburban outskirts.
- Denser urban environments can reduce the costs associated with urban sprawl, which is more expensive because of commuting costs, the business costs due to congestion and the additional cost of extending transport, electricity, waste collection and other infrastructure and services to outlying areas.
- High-density cities which maximise high-quality open spaces while integrating water features offer a higher quality of life since the green spaces are actually used and since they are often associated with sustainable transport options that have positive implications for air quality, noise, etc.

Reference organisations

Some indicative reference public administrations are listed below:

- Stockholm City Council (2010), Guide to the Regional development plan for the Stockholm region – RUFS 2010: How we will become Europe's most attractive metropolitan region. Stockholm, Sweden: Stockholm City Council.
- Greater London Authority - GLA (2010), The draft climate change adaptation strategy for London – Public Consultation Draft, London: GLA.
- Malmö city has created several world leading examples of sustainable construction and regeneration which have actively incorporated innovative greening strategies, including green roofs; green fences (green walls), open storm water management and aquatic rich ponds as well as tree planting strategies. Western Harbour (WH) is a new city quarter, built on former industrial land, integrating green spaces are in the development to promote biodiversity and ecosystem services. Before developers can buy land in WH, they have to agree to compensate their development by incorporating green points, by which approximately 50% of the area can be considered 'green'.

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Ståhle A., Marcus L. (2009), Compact sprawl experiments – four strategic densification scenarios for two modernist suburbs in Stockholm. In D. Koch, L. Marcus & J. Steen (Eds.) Proceedings of the 7th International Space Syntax Symposium. Stockholm, Sweden: KTH.

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6 BEST ENVIRONMENTAL MANAGEMENT PRACTICES FOR GREEN URBAN AREAS, NATURE AND BIODIVERSITY

Chapter structure

This chapter is intended to guide public authorities in the management of their green spaces. It starts by introducing the so called Local biodiversity Strategies and Action Plans (BEMP 7.1), it continues mentioning the blue-green networks (BEMP 7.2) and the concept of green roofs (incorporating renewables) (BEMP 7.3) and it ends by describing how derelict green and fringe areas can obtain a new higher environmental value (BEMP 7.4).

Chapter introduction

Europe is one of the most urbanised continents. The vast majority of Europeans live in cities and towns, and the consumption of land continues apace. Cities occupy just 2% of the surface area of the planet, but absorb a staggering 75% of the World's natural resources (EEA, 2009). Cities continue to expand and, for instance, in western Germany, the average annual expansion of built-up areas is of 47,000 ha per year, which, as an illustration, is equivalent over five years to the surface of Greater Copenhagen (EEA, 2006). In terms of green spaces, there are two main consequences of urbanisation: firstly, urbanisation particularly if it is done in a sprawling way reduces green spaces outside of the city (countryside and natural areas); secondly, increasing urban populations have traditionally tended to reduce the availability of green spaces within cities themselves. In general, northern European cities tend to have more green space per inhabitant than cities in the south of Europe. Approximately 45 million people in Europe have limited access to green spaces since they live in cities with between 2 and 13% of green spaces (Fuller and Gaston, 2009).

Urbanisation can be an opportunity or a threat for green spaces and biodiversity. In many cases the high quality urban green areas are mixed with dense and compact built up zones. Proper urban design can reduce the need for additional urban land-take and fragmentation. It can, at the same time, penetrate the city with greenery/lawn and promote biodiversity as well. Creating and improving green areas, revitalising brownfields, greening roofs and walls, at the same time as maintaining urban density and compactness, maximises the amount of ecosystem services delivered within cities and the ecological footprint. With the right form and organisation, urban areas can provide opportunities, not merely threats, to biodiversity (EEA, 2010).

It is estimated in United Nations Environment Programme's (UNEP) Global Biodiversity Assessment (Heywood, 1995) that, on a global level, biodiversity is decreasing at a faster rate now than at any other time in the past. The situation in Europe is also a cause for concern. The rich biodiversity of the European Union has been subject to slow changes over the centuries, due to the impact of human activities. The scale of this impact has accelerated dramatically in the last few decades. The assessment by UNEP confirms that in some European countries up to 24% of species of certain groups such as butterflies, birds and mammals are now nationally extinct. The International Convention on Biological Diversity confirms the following main drivers for loss of biodiversity:

- Transformation or destruction of habitats
- Overexploitation of natural resources
- Climate change
- Emissions /Pollution
- Invasive species

In all EU Member States, land urbanization and the construction of infrastructure is directly connected with local (biodiversity) policies. Local governments are at the front line when it comes to managing natural resources. Their day-to-day-planning decisions have direct impacts on the environment. It is therefore imperative that biodiversity considerations are integrated into urban planning, urban development and management of urban natural resources. Urban biodiversity may refer to plants and animals that occur within the built environment, for example falcons that nest on buildings; or it may refer to remaining biodiversity that occurred in the area long before people built their structures, for example patches of vegetation that have so far survived encroaching development. The protection of natural and anthropogenic green areas within urban areas is not only of vital importance for the conservation of biodiversity, but also for the mitigation of negative impacts of climate change in the cities - microclimatic function of green areas.

Landscape fragmentation caused by transportation infrastructure and built-up areas has a number of ecological effects. It contributes significantly to the decline and loss of wildlife populations and to the increasing endangerment of species in Europe, for example, through the dissection and isolation of populations, and affects the water regime and the recreational quality of landscapes. In spite of the planning concept of preserving large un-fragmented areas, fragmentation has continued to increase during the last 20 years, and many more new transportation infrastructure projects are planned, in particular in Eastern Europe. The amount of variation in the level of fragmentation that was explained by the predictor variables was high, ranging from 46 to 91% in different parts of Europe (EEA, 2011).

Four out of five Europeans live in cities and towns. Man-made and virtual surroundings dominate the senses and lives of urban citizens. So to a large degree they have lost contact with the diverse multitude of life that keeps them alive. This is one of the reasons, why they hardly understand the pressing importance of preserving biodiversity. Local administrations can be leaders in making the population aware of the need to stop the loss of biodiversity.

Studies in the Netherlands demonstrate that children with good access to green open space, fewer high‑rise buildings and more outdoor sports facilities are more physically active. Similarly, studies of eight European cities show that people who live in areas with abundant green open space are three times more likely to be physically active and 40 % less likely to be overweight or obese (Ellaway et al., 2005). School children who have access to, or even sight of, the natural environment show higher levels of attention than those without these benefits (Velardea et al., 2007). In particular, the links between urbanisation (in terms of noise, air pollution etc.) and human health have been proven, as has the connection between the availability of green spaces and human health. Not only do green spaces allow urban residents to escape from some of the negative aspects of urbanisation, by reducing noise and purifying the air, but they also provide benefits in and of themselves: contact with green spaces has positive psychological implications. Green spaces are therefore one of the key factors in determining quality of life in cities.

Green spaces also provide a range of ecosystem services that are essential to the functioning of human societies. For instance, they help improve urban air quality, attenuate storm-water and hence reduce the risk of flooding, reduce the urban heat island effect and help human societies adapt to climate change. When green spaces are eliminated or altered, they lose the ability to provide these services and we must then find (costly and energy-intensive) ways to reproduce the services that were once freely available. Furthermore green spaces provide also ecosystem services, for instance pollination by bees and other insects is one representative example.

Techniques portfolio

Four best practices associated with green spaces and biodiversity are presented in this chapter. The first BEMP is the implementation of Local Biodiversity Strategies and Action Plans (LBSAPs), through which cities can set goals and formulate strategies for biodiversity enhancement and ensure the integration of these into wider urban decision-making processes. Likewise, the establishment of Blue-Green networks is the second BEMP presented in this chapter. Although there is no single methodology for their establishment, they are a valuable concept which can bring about a series of environmental benefits but also benefits linked to human health and city economies. The third BEMP is regarding the construction of green roofs, which help cities to mitigate their urban heat islands among other environmental benefits such as providing habitat for species that live in urban areas deliver other benefits relating to storm-water management and air quality among others (also the incorporation of renewables is mentioned in this BEMP). The scope of the fourth and final BEMP is to give a new environmental value to the derelict green and fringe areas within cities. Therefore the expansion of the cities into adjacent countryside is prevented as well as the useful green spaces within cities may be increased.

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6.1 Establishing and implementing a local biodiversity strategy and action plan

Description

The Local Biodiversity Strategy and Action Plan (LBSAP) is a useful instrument that can be used by the Local Authorities/Public Administration for outlining a broad strategy and implementing specific actions in order to protect and eventually enhance the local biodiversity. However, the linkage between cities or urban areas and biodiversity is a rather complex issue. It has been reported that even though cities occupy only approximately 2% of the total earth's land surface, over 50% of today's world population lives in cities, which is estimated to rise up to 90% by the year 2100 (Puppim de Oliveira et al., 2011; Puppim de Oliveira et al., 2014). Therefore it is important to compile appropriate local biodiversity plans in order to maintain the biodiversity aspects in and around the cities.

The methodology to implement a LBSAP is described in the next paragraphs.

Initially, the goals/objectives of the LBSAP and the overarching strategy should be precisely defined by the public administration staff. The aforementioned elements can be formulated through dialogue with experts and stakeholders, public debates, targeted workshops etc. A wide range of actions should be discussed/proposed during the external dialogue with stakeholders and experts, which range from the collection of primary data like number and population and the kind of the native species in the given examined territory to set quantitative (if feasible) targets for conservation and restoration. Some representative (non-exhausted list) actions of a LBSAP are in-depth listed below (ICLEI, 2013; Puppim de Oliveira et al., 2014):

- Assessment of the biodiversity (e.g. species, crop/plant varieties), habitat and management within the territory, ongoing restoration and rehabilitation of degraded areas and control of invasive areas etc.
- Assessment of the conservation status of species within ecosystems
- The formulation of priorities within the given territory together with specific biodiversity targeted actions[58]
- The formulation of the targets (either short/medium or long-term goals) for conservation and restoration
- The compilation of an entire plan including timelines, budget available, milestones, partnerships for implementation and their responsibilities

Another supplementary but important step is the communication of the LBSAP to the citizens and/or stakeholders of the given territory.

The next step is that public administration should ensure the promotion of the outcomes regarding biodiversity as well as their effective implementation. Raising awareness actions must be undertaken by the public administration in order to increase the community's understanding and awareness of biodiversity issues that affect the city and can thus impact on the lifestyle of the inhabitants. The successful implementation of the LBSAP plan is ensured by the participation of the community and the potential establishment of partnerships and collaboration with relevant organisations, NGO's etc. (ICLEI, 2013).

The LBSAP plans can be implemented easily by the local authorities due to access to many planning, financial and regulatory instruments. Those instruments can also be used for the promotion of the strategy to be followed. A (non-exhaustive) list of such instruments is listed below (ICLEI, 2010):

- Local government plans including plans for land-use, housing development, environmental management, infrastructure and economic development
- Public consultation

[58] Each enclosed action should be well and clearly designed in terms of the successful implementation (i.e. which organisation is going to implement it, in which timeframe, under which context etc.). Moreover the funding requirements and potential funding sources should also be mentioned (ICLEI, 2013).

- Financial incentive measures including tax incentives, property tax rebates, grants
- Non-financial incentive measures including recognition and local award schemes, training and technical support
- Market-based incentives such as procurement policies, biodiversity offsets and sustainable ecotourism
- Disincentive measures to discourage activities that are harmful to biodiversity such as imposing fines and penalties
- Establishment of protected natural spaces

One way of implementing the LBSAP strategy is to create a stepwise guidebook including all the important steps that have to be undertaken by the public administration. In particular, a range of proposed actions can be prescribed such as the expansion of protected areas, implementation of awareness campaign, the restoration of degraded habitat(s) and/or the adoption/establishment of specific regulations or local rules (UNU-IAS, 2007; ICLEI, 2013). Table 6-1 presents an entire structure of the LBSAP showing the important steps, the proposed actions together with few suggestions (UNU-IAS, 2007). Afterwards, a new table (for instance Table 6-2) can be prepared that provides the information on how each action has to be undertaken and by whom and if possible to find funds.

Table 6-1: Stepwise guidebook on structuring the LBSAP on different stages; specific actions and suggestions are also presented (UNU-IAS, 2007)

Action	Description/Suggestions
Planning stage	
Identify the region to be applied	
Set the timeframe for the LBSAP preparation	The preparation stage should not be a long process; a very long duration may result in further delays
Identify potential sources of funding the LBSAP	The availability of different funding sources must be deeply investigated
Set the goal(s) and objectives	The goal(s) should be very clear aiming at the conservation of the biodiversity, sustainable use of biodiversity and sharing the benefits to the inhabitants Regarding objectives, protect the rare endemic species (fauna and flora) Reconsider the old goals and objectives (if exist)
Stakeholder involvement; ensure their participation	Identify the relevant stakeholder and ensure their involvement during the process
Identify key issues for action	They key actions may differ from area to area; should be distinguished into short and long-term actions
Develop strategies to integrate biodiversity conservation and local development	An example can be the reform of the land use of the given territory i.e. rules to reconsider the residential development etc.
Preparation stage	
Review of secondary information	Analysis of earlier management plans (if exist) and other legal instruments (if any)
Drafting the LBSAP	The plan should be written in a comprehensive and sound way
Review and external consultation	Organise workshops or set up dialogue with the stakeholders and experts
Finalise the LBSAP	
Implementation stage	
Raise the awareness on the LBSAP	Some examples: run awareness campaigns of the LBSAP, organise appropriate (biodiversity) trainings etc.
Monitor the implementation	Staff from public administration should be in charge of the implementation of the LBSAP, e.g.: looking for funding possibilities, checking the milestones and timeframe to be met, developing appropriate indicators to monitor the progress

Table 6-2: Establishment of LBSAP strategy; focus on how actions can be implemented and by whom; some actions are presented as examples (actions act as an example, the list is not exhaustive)

Actions	How might be done	Who	Funding
Inventory of local species that are threatened or at risk	Desktop research Monitoring results (if exist) Local knowledge and observations (primary data obtained)	Regional council Stakeholder and/or experts groups Association or other groups/societies in the analysed territory	Investigation
Make biodiversity information available to all council staff	Make information available on the (regional) council Produce dissemination materials	Stakeholder and/or experts groups Regional council	Investigation
Identify high priority or high risk sites for conservation	New sightings and fields assessments	Stakeholder and/or experts groups	Investigation

Achieved environmental benefits

The conservation of biodiversity is an important task within the municipalities. In Figure 6-1 the relation between number of species and area in the European cities is illustrated whereas in Figure 6-2 the percentage of species in relation to the level of the urbanisation is also depicted (Werner, 2013). As a general remark, from both figures it is resulted that the number of species increases in non-compacted cities or in areas with low level of urbanisation (Werner, 2013).

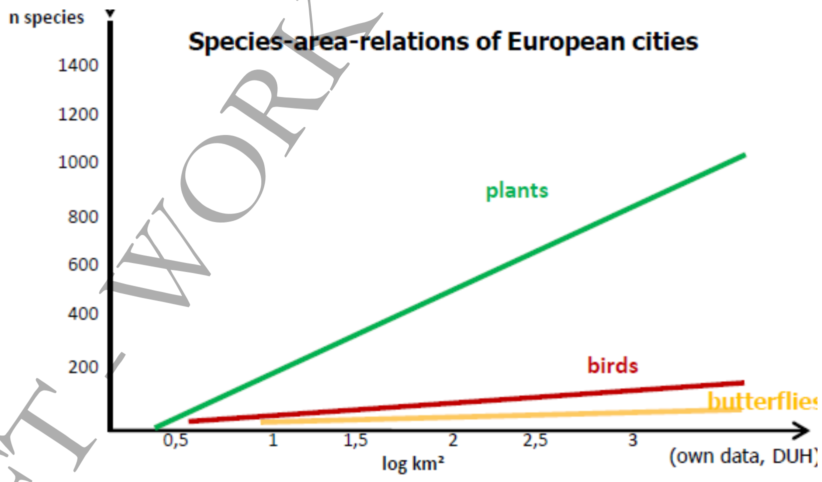

Figure 6-1: Number of species in relation to the area of European cities (Werner, 2013)

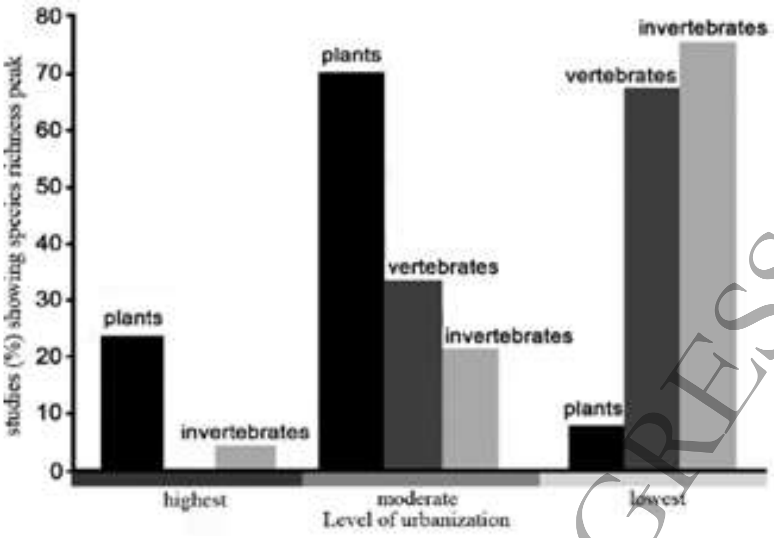

Figure 6-2: Percentage of studies showing species richness peak in relation to level of urbanisation (McKinney, 2008; Werner, 2013)

Another significant benefit of the formulation of LBDAP is the creation of a healthy and attractive living environment for the inhabitants. In particular, the improvement of the health and wellbeing of the inhabitants within cities is well achieved (DEFRA, 2007).

Furthermore LBSAP contributes to the establishment of natural habitat, which perform best in terms of the climate change impact (DEFRA, 2007).

Appropriate environmental indicators

The appropriate environmental performance indicators are listed below:

- Percentage (%) and number of native species (including also the kind of the species e.g. birds, butterflies etc.) in the urban area
- Percentage (%) of natural-semi natural areas compared to the total urban area
- Green space per inhabitant ($m^2_{greenery}$/inhabitant) – distinguished into urban, semi-urban, rural areas.

Cross media effects

There no reported cross media effects from the implementation of LBSAP.

Operational data

In this section examples from the implementation of LBSAP are presented.

Case study: Barcelona city, Spain

The local authorities decided to formulate a LBSAP with the following goals:

- Preserve and enhance the natural heritage of the city and prevent species and habitats from disappearing
- Implement the maximum amount of green infrastructure
- Obtain the maximum number of social and environmental services from green infrastructure and biodiversity
- Make progress in educating society to place greater value on green infrastructure and biodiversity
- Make the city more resilient in the face of future challenges such as climate change

The communication of the LBSAP with its citizens uses measures such as park guides, environmental awareness monitors, information brochures, technical manuals, posters etc. Also other dissemination strategies exist like a bimonthly magazine (since 1992).

Among others, an indicative list of strategic measures is listed below:

- Maintenance of the existing Natura 2000 network areas (total surface of 9,698 ha)
- Maintenance of the public parks, remaining urban green areas, green infrastructure, beaches and sea habitats (total surface of 1,955 ha)
- Maintenance of more than 160,000 trees lining the streets and approximately 75,000 trees in parks and gardens; a total of 200 species in the city.
- Maintenance of flora present in parks and gardens, including native and exotic species (1,172 species of trees, shrubs, climbing plants and persistent perennial plants).
- Vegetation in buildings (green walls, balconies, terraces and landscaped roofs) with its associated fauna, particularly birds (alpine swifts, swifts, swallows and western jackdaws).
- Fauna present in the city: 103 native species of vertebrates; 72 vertebrates protected by law: 2 amphibians, 8 reptiles, 55 birds and 7 mammals

Summarising, with the implementation of the aforementioned plan/strategy, the indicative values of 6.82 $m^2_{greenery}$/inhabitant and 17.33 $m^2_{greenery}$/inhabitant have been achieved in urban fabric and semi-urban area.

Applicability

The compilation and development of biodiversity plans and strategies is a fully applicable BEMP by the public administration. However, the success of those plans and strategies is highly influenced by their practicability as well as the priorities set according to the needs of the public administration. Likewise, the frequency of the dialogue with the external stakeholders and experts (from the given examined territory), the elaboration and eventually the implementation of the selected biodiversity measures as well as the continuous staff involvement from the public administration are important key elements, which are responsible for the LBSAP success (Werner, 2013).

Economics

It is rather difficult to provide economic figures regarding the development and formulation of a LBSAP. However, it should be noted that public administration has access to several financial instruments that might be used either for the formulation or for the implementation of the proposed biodiversity actions (described in LBSAP).

The healthy and sustainable ecosystems create economic benefits increasing land value through improved landscape by providing a valuable tourism. Therefore there is the possibility for absorbing the costs for the preparation of the LBSAP by the significant outcomes and benefits.

Driving force for implementation

The LBSAP is a valuable tool that can contribute to build a sustainable city. In particular they are important tools, which contribute to the conservation of the biodiversity in a given territory as well as contributing to the improvement of the wellbeing within the cities.

Reference organisations

ICLEI (Local Governments for Sustainability) provides a good portal for the required information concerning biodiversity actions within cities. In the following website more relevant information can be found: http://www.iclei-europe.org/topics/biodiversity/.

The entire LBSAP for Barcelona city is online available at: https://w110.bcn.cat/MediAmbient/Continguts/Documents/Documentacio/BCN2020_GreenInfraestructureBiodiversityPlan.pdf

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6.2 Creating blue-green networks

Description

Green infrastructure has been defined as a "*network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services*" (Baró et al., 2015). "*It incorporates green spaces and/or blue if and when aquatic ecosystems are concerned and other physical features in terrestrial (including coastal) and marine areas"* (EC, 2013). For instance, in urban areas, green infrastructure elements may consist of parks, urban forests, allotments, street trees, green roofs, etc. (Landscape Institute, 2009; Baró et al., 2015).

The development of blue-green networks is an important and efficient way to improve the quality of the cities as well as mitigating the effects of the climate change impact and the food and energy shortages (Vandermeulen et al., 2011; Urban green-blue grids, 2015).

Local public authorities can create blue-green networks in their territory with the aim of re-creating a naturally-oriented water cycle while contributing to the amenity of the city by bringing water management and green infrastructure together. This is achieved by combining and protecting the hydrological and ecological values of the urban landscape while providing resilient and adaptive measures to deal with flood events.

In particular, the blue-green networks recognise the vital role played by water and green spaces in the urban environment in terms of quality of life, health, biodiversity conservation and economic development. The blue-green networks generally refer to an urban space development concept defining a network of existing and/or restored rivers and their valleys (blue areas), and green areas (agricultural areas, parks, old orchards, wastelands, degraded areas and others) as a basis for spatial planning of cities, which will provide sustainable development and adaptation to global climate change.

There is a series of measures that result in the construction of efficient blue-green networks within cities. For instance, the creation of buffer zones around the green areas and rivers, allowing for more intensive urban functions, can contribute to the protection and maintenance of the ecological processes within the network (University of Łódź & City of Łódź Office, 2011). In fact, buffer zones are effective means of minimising the conflicts between potentially incompatible land uses and do ensure a minimal separation. They may vary considerably leading to significant differences in the physical, cultural socio-economic aspects and in plant cover and soil use. In order to choose the most suitable buffer zone, the local conditions have to be taken into account. Some examples of buffer zones with at times fundamentally different characteristics include industrial/residential buffers, sensitive habitat buffers, riparian buffer and public facility buffers (Placer County California General Plan, 1994).

But also blue-green networks can take a variety of shapes and sizes, and can either be set up by regenerating and connecting remaining natural spaces in a city or by implementing protections to ensure natural spaces are preserved. The idea of a network is vital, as it recognises the importance of corridors for the enhancement of biodiversity, and can also be linked to other urban networks such as the transport network, by linking these natural spaces with cycling and walking paths.

Furthermore another measure that can be applied under the blue-green network is the creation of areas where storm-water management is undertaken (blue measures are mentioned here). In particular, eco-hydrological measures and/or ecosystem biotechnologies can be applied such as application of bio-filtering systems, constructed wetlands, river rehabilitation, building reservoirs with increased capacity due to phyto-technology applications (the use of plants to address technological challenges), and other relevant measures. In particular, increased retention of purified storm-water in the city landscape will result in lower runoffs during storm-water

events, lowering the costs of investments in storm-water infrastructure, reducing economic losses after flooding, and thus improving functioning of the waste water treatment plant and the rivers quality around cities (University of Łódź & City of Łódź Office, 2011).
Other green measures can be the establishment of alternatives for individual and public transportation by providing space for bike routes, pedestrians and trams, the improvement of the air quality in the city to contribute to a healthier environment and eventually to reduce the number of cases of illnesses (University of Łódź & City of Łódź Office, 2011).

The combination of green and blue measures (i.e. measures like filtration and buffering) is illustrated in Figure 6-3 where the presence of biotopes that are connected to each other is essential for exchange and dynamism (Ministerium für Klimaschutz NRW, 2011).

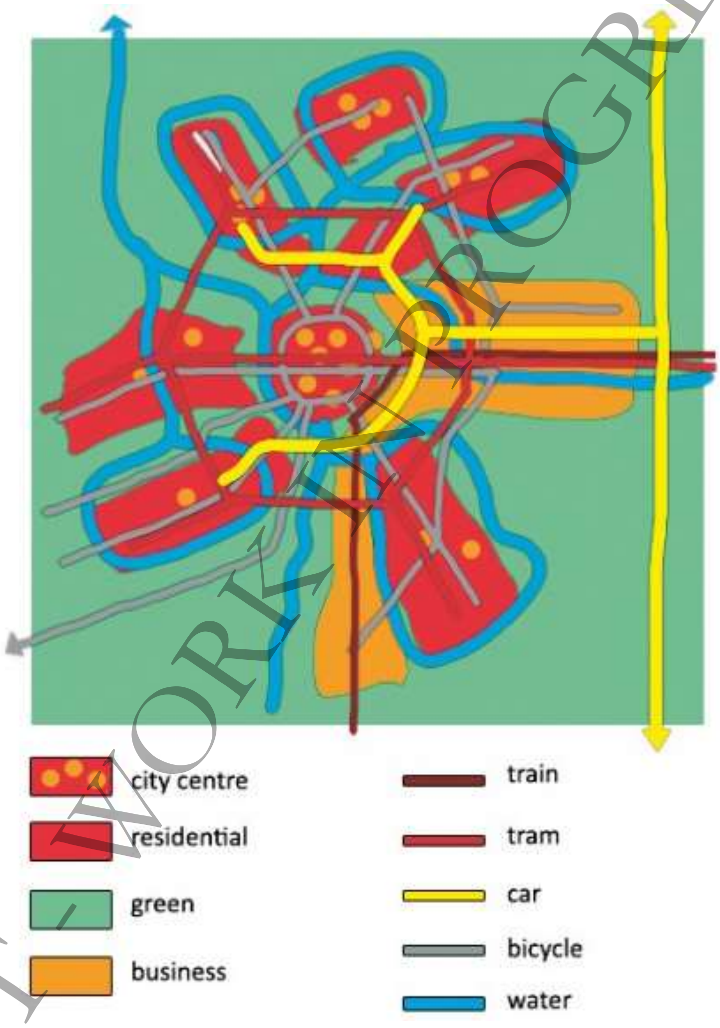

Figure 6-3: Combination of green and blue measures within a city (Ministerium für Klimaschutz NRW, 2011)

Achieved environmental benefits

The creation of Blue-Green networks brings a number of environmental benefits which are closely linked to ecosystem services. For example, the green spaces absorb rainfall and therefore decrease the risk of flooding, absorb CO_2 and therefore mitigate climate change, filter particulates and therefore improve air quality, and provide habitat for flora and fauna, among other advantages.

Appropriate environmental indicators

Appropriate environmental indicators for the creation of blue-green networks are:

- Green urban areas, expressed as $km^2_{green\ and\ blue\ areas}/km^2_{total\ area}$; furthermore, green and blue areas are disaggregated into the following categories: i. anthropogenic greenery and green space: greenery on impermeable surfaces, managed green space (roof gardens, roadside plantings, golf courses, lawns, urban parks, etc.); ii. natural greenery: protected areas and natural ecosystems (all areas with natural ecosystems, national parks, nature reserves, etc.); iii. artificial water bodies (reservoirs, artificial lakes, drains, etc.); iv. natural water bodies (rivers, streams, lakes, etc.).
- Recreational green urban areas (RGUA), expressed as km^2_{RGUA}/inhabitants and/or $km^2_{RGUA}/(km^2$ of the total municipal surface); the RGUA areas can be classified into i. urban parks and gardens, ii. other recreational and accessible urban areas (but not classified as parks and gardens).
- Accessibility of RGUA: citizens living within 300 m, expressed as (number of citizens living within 300 m of a RGUA)/(total population); this particular indicator can be calculated using GIS software, initially different layers must be produced for green areas and then for population; the next step is the comparison of these two layers.
- Roadside trees in the urban area, expressed as (number of trees)/(total population); trees planted along streets and squares (not in parks and gardens).
- Application of blue measures within a city e.g. storm-water management, eco-hydrological measures etc. (Y/N).

Cross media effects

There are no reported cross media effects from the implementation of this BEMP.

Operational data

Different cities and countries have applied the Blue-Green idea in various forms, sometimes focusing on different aspects. In France for example, the government is implementing the Green and Blue infrastructure, a landscape management tool aiming to enhance biodiversity. The network aims to create or preserve key 'reservoirs' for biodiversity and to link these through ecological corridors vital to the free movement of species. Its establishment will first be guided at the national level then followed by regional schemes for ecological coherence which cities and other local bodies will have to take into account when undertaking any planning activities. One example of a simple action to be taken at the urban level to ensure ecological continuity is to create small openings in yard fences that have limited the free movement of fauna such as hedgehogs and toads[59].

<u>City example: Nantes, France</u>
A representative example from France is the city of Nantes. The percentage of public and private green spaces and water areas, excluding farming land, over the total surface (6,523 ha), was 40% in 1999 and 41% in 2009. In other figures, it has been calculated a surface of 54,771 ha of public green areas in Nantes Metropolis, which is equivalent to 57 m2 of public green spaces per inhabitant as well as 100% of the inhabitants live at less than 300 m away from a green space. Furthermore it has been reported that from 1999 to 2009 there was a 4% increase of the public and private water areas, while 100 ha were added in the surface of the green areas (European Green Capital Award Nantes, 2010).

[59] More information about French strategies (in French) can be found at the link: http://www.developpement-durable.gouv.fr/-La-Trame-verte-et-bleue,1034-.html

City example: Vitoria Gasteiz, Spain

The municipality of Vitoria Gasteiz accounts 1,091 Ha of public green areas (33% of the city's urban area). During the period 1974-2010, the urban area used for green spaces has doubled, reaching around 478 ha, 20 m^2 per inhabitant. If the current extension of the Green Belt (613 ha) is included, this value increases to close to 46 m^2 per inhabitant. One of the main peculiarities of the Green Belt in Vitoria-Gastiez is its origin. Some of the urban fringe parks were originally degraded areas. The recovery of these spaces, initiated in the mid-90's and at the present time the Green Belt forms a continuous and unified network, formed by several parks that will add 613 ha altogether. Over the next few years, it is planned that this will be extended to 787 ha. Nearly 100% of the citizens of Vitoria-Gasteiz live now within 300m of open public zones and green spaces.

City example: Oslo, Norway

In Scandinavia, Oslo, Norway, there is another example of a city that has created a Blue-Green network. The network fulfils several aims: to protect the city's drinking water sources – these are of high quality and as a result of the protection they receive enable cost effective treatment of the water supply; to create recreational opportunities for the city's inhabitants, who are never far from water or green spaces; and to preserve Oslo's local biodiversity. Green and blue areas, namely fields, forests, rivers and the sea, make up two thirds of the city's area. In particular, the total area of the Municipality of Oslo is 454 km^2 (including land area, lakes, rivers and streams). This consists of 301 km^2 of forest (66%) and 153 km^2 of built-up area (34%). Within the built-up area, public green areas cover 29.000 Ha (19% of built-up area), about 52 m^2 per inhabitants. As a result, 95% of Oslo's inhabitants live within 300 metres of a green area. The easy access and clean state of Oslo's green and blue areas, and the leisure and recreation opportunities these afford, are the aspect most appreciated by the city's inhabitants. Oslo is rich in biodiversity, housing two thirds of Norway's species, and includes elk and lynx. Oslo has designated a green belt around the city, and manages natural spaces based on ecological principles while taking into account multiple uses and recreational use. The green belt also serves as a protection area for the city's drinking water intakes from surface sources. Although Oslo benefits from its location on a fjord, it has also been impacted by past industrialisation, agricultural activity and urban development. For example, its rivers and coastal waters were not always as clean as they are now, and many of the city's rivers have been paved over. Oslo is working on re-opening these rivers and on creating green corridors connecting the rivers to the surrounding forests. The city has prohibited building within 20 metres of river banks (City of Oslo, 2011).

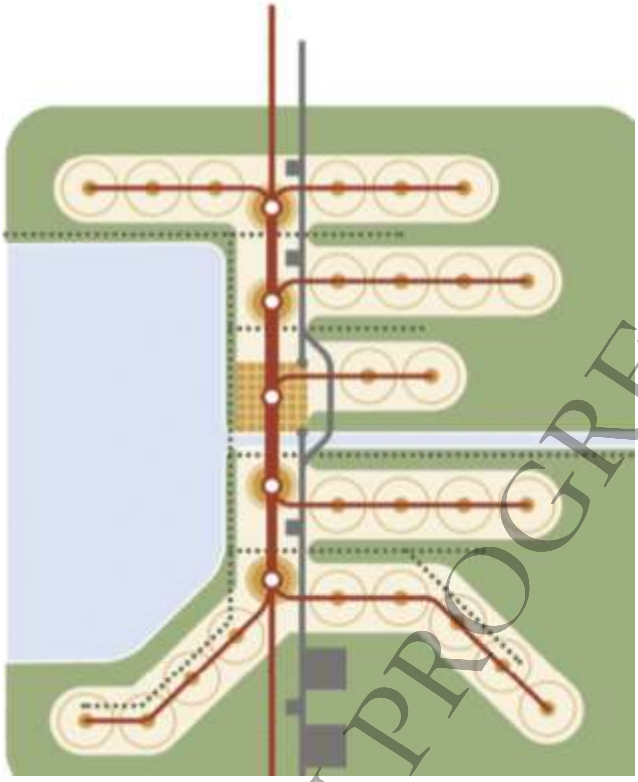

Figure 6-4: Coordinated sustainable management plans in Oslo; green areas and waterways (water to access) are also illustrated (City of Oslo, 2011)

City example: Ashford, UK

Another example of Blue-Green Network is represented by the Ashford (UK) Green Corridor, a green space that runs right through the English town. The Green Corridor is made up of parks, recreation grounds and other green spaces alongside the rivers that flow through Ashford. It has been designated as a Local Nature Reserve, and is being looked after by a partnership of organizations. Ashford has been growing steadily since the early 19th century. As the town has expanded, land close to the rivers has not usually been built on due to the risk of flooding and has thus been protected as green space. The Green Corridor is managed to cater for all its different users, to maintain facilities, look after the environment and ensure safety. As well as helping people to use the Corridor, habitats for wildlife will be conserved and improved: for example, some areas of grass currently cut on a regular basis will be allowed to grow to provide habitats for a variety of plants and animals. Because the Green Corridor areas are right next to Ashford's rivers, many of them hold floodwater, thus protecting homes and businesses. Ashford's rivers are surprisingly natural considering their urban surroundings, and are home for many wild plants and animals. Kingfishers, grass snakes, dragonflies and damselflies can all be seen. Ponds like the one at Bowen's Field attract amphibians. Singleton Lake, an artificial lake in the area, is a habitat for wetland birds and Buxford Meadow, a wet grassland in the Area, presents an enormous range of plants, insects and other species[60].

City example: Lodz, Poland

Lodz was in the past years a significant textile production centre. Restoring the city's rivers is seen as a way to address all of these challenges and regenerate the city in a multi-dimensional way. Lodz is implementing a concept whereby water and green spaces are at the heart of urban development and deliver a series of benefits to the environment, human health and the local economy. The lack of green spaces and open waterways in the city, combined with the health problems created by the low infiltration rates (causing high dust and pollution levels, an urban heat island and low humidity levels), have affected the quality of life of Lodz's inhabitants. The

[60] http://www.ashfordgreencorridor.org.uk

Blue-Green measures (Figure 6-5) consist of creation recreational areas, contributing to health and quality of life, low-carbon transportation options such as cycling and walking, sustainable storm-water management infrastructure, decreasing runoff and improving its quality, improved air quality and a more attractive and revitalised city. The city, by developing natural storm-water treatment systems, is taking a future-oriented and climate change-conscious approach. Protecting the most biodiverse parts of the city for instance the river valleys, and being connected to green areas in the periphery of the city, the Blue-Green network will contribute to the conservation of species and habitats in the region (Loftus, 2011b and University of Lodz & City of Lodz Office, 2011).

Applicability

Since Blue-Green networks can range from small-scale endeavours to all-encompassing city plans, they are replicable in most settings. The example of Lodz shows the case of a city starting from a challenging baseline situation; cities with fewer modifications to natural habitats may find it easier to implement.

As shown in the case of Lodz, cities do not exist independently from their surroundings, for instance both green spaces and water bodies are connected with areas that are often beyond the political boundaries of a city. Blue-Green networks will often need to take this into consideration and coordinate with the political entities managing their contiguous territories or the landscapes which they have an interest in preserving. Many cities for example make an effort to protect the catchments that supply their drinking water so in order to improve water quality and reduce the costs associated with treatment.

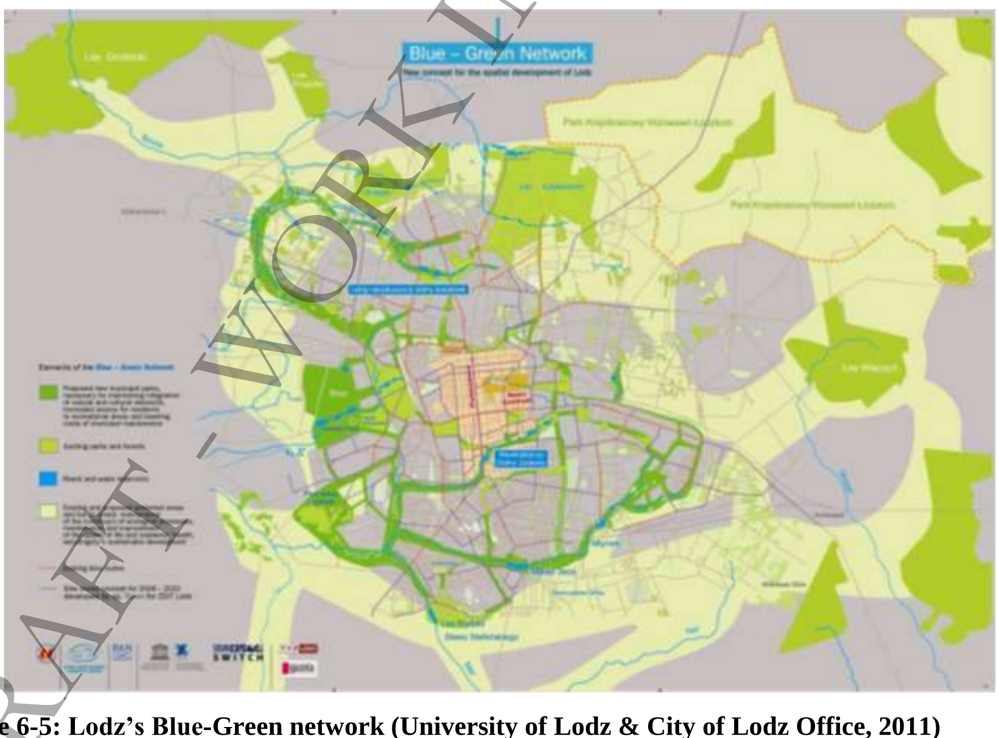

Figure 6-5: Lodz's Blue-Green network (University of Lodz & City of Lodz Office, 2011)

Economics

Costs will vary according to the level of complexity and the chosen elements, type of facilities, intensity of usage etc. Some of the returns associated with the implementation of this BEMP will be perceived by the local authority, for example in terms of reduced storm-water management costs or reduced costs associated with flooding damage to public infrastructure. However, other returns will either accrue to others, for example when citizens benefit from recreational opportunities, or will not be immediately quantifiable, for example in the case of health care expenditure reductions. However, there have been tremendous efforts to place monetary value on green infrastructure, in order to allow for a clear visualisation of costs and benefits. This in turn may help stimulate investment, since it allows decision makers to evaluate economic returns at the regional and community scale. Figure 6-6 offers a highly simplified method of calculating the economic benefit of investments in green or blue infrastructure. The economic benefits to individuals and society, government and business that can be derived from a huge variety of benefits having an economic value are added up. Then in a second step the costs related to the intervention such as development and capital costs as well as management and maintenance costs are subtracted from the economic benefits. By doing so, the net economic benefit or cost can be obtained. Since this calculation remains rather theoretical, a case study from the St. Helens in the UK will visualize how this calculation can be done in practice.

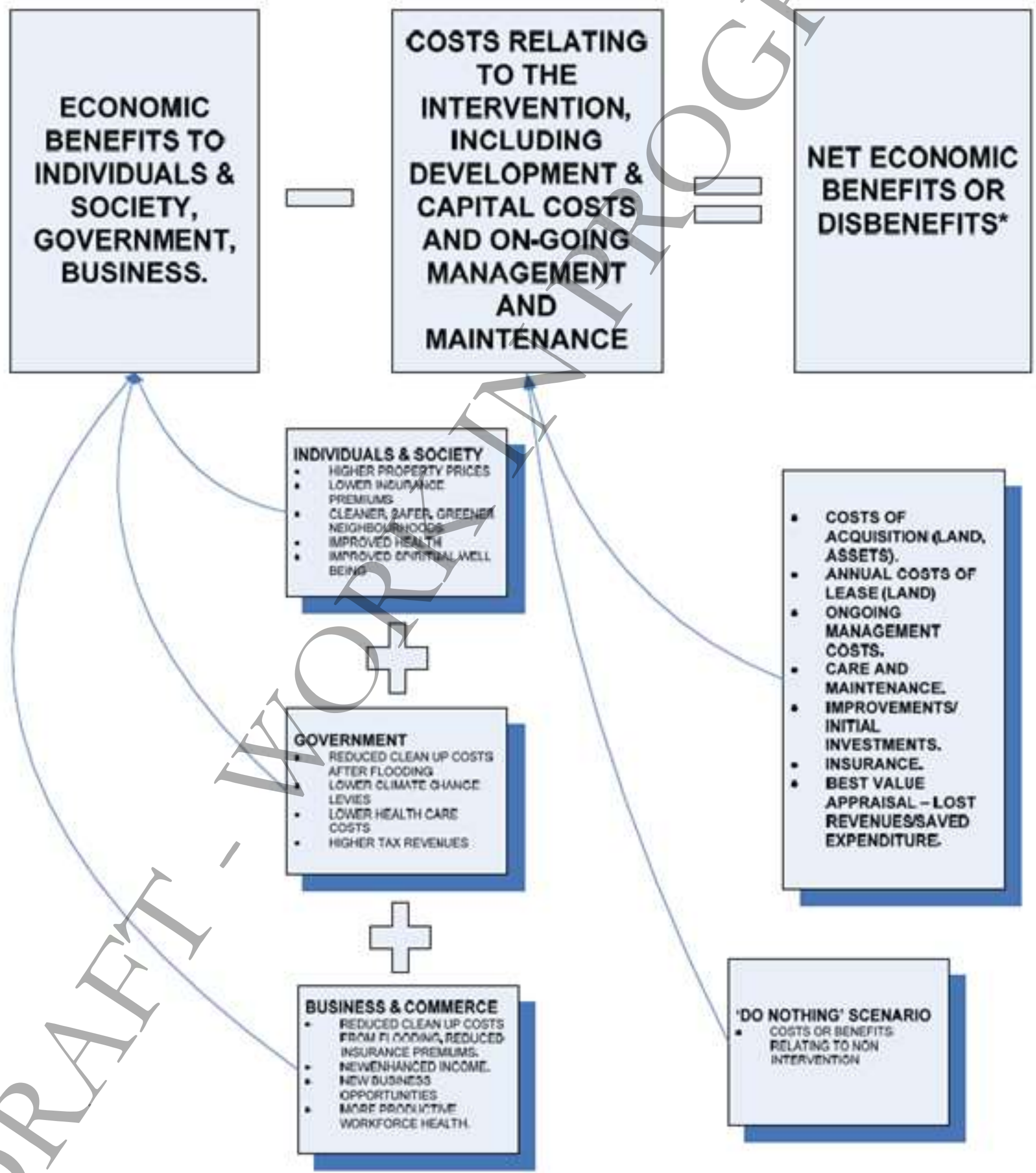

Figure 6-6: Estimating economic value from green infrastructure investment (Urban Open Space Foundation 2003/ECOTEC, 2008)

A representative example of construction and maintenance costs of greens is the city of Berlin. The average construction of greens ranges from 5 €/m^2 for greens located close to the city periphery (estimated an average quality without particular infrastructure) to 201 €/m^2 for greens located near the city centre (with high quality and cost-intensive infrastructure). Regarding maintenance costs of greens, an average ranges from 2 €/m^2 annually for greens with no particular infrastructure to 7 €/m^2 annually for greens with cost-intensive infrastructure. It should be noted that an average life span of green is considered as 15 years (Krekel et al., 2015).

Driving force for implementation

In addition to environmental benefits, Blue-Green networks provide a number of non-environmental advantages which include: improving human health by bettering air and water quality as well as providing opportunities to exercise; providing opportunities for low-carbon transportation if they incorporate cycling and walking paths; and creating more aesthetically pleasing cities which attract tourists, new residents and businesses.

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- The French Green and Blue Infrastructure: http://www.developpement-durable.gouv.fr/-La-Trame-verte-et-bleue,1034-.html
- The urban green blue grids is a network, which provides all the required information for establishing or creating blue-green networks within cities: http://www.urbangreenbluegrids.com/measures/connection-of-biotopes-to-the-outlying-areas-and-green-blue-networks/

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6.3 Fostering the deployment of green roofs and integration with renewable energy generation

Description

Cities are characterised by the extent of impervious surfaces within them. The buildings occupy a large proportion of urban areas, which results in a biodiversity loss as well as a lack of green spaces. Therefore green/brown roofs can be one way in which urban areas can add green spaces within their periphery, creating a series of benefits for the environment and human health as well.

The green roofs can also be combined with solar energy. In particular, the combination of green roofs and the installation of photovoltaic (PV) panels (or even solar panels for the generation of hot water) is a good way to foster the ecosystem approach within an urban area (e.g. cities).

The structure of this BEMP deals initially with the description and the technical characteristics of the green roofs and secondly deals with the installation and positioning of the PV on the rooftop.

<u>Green roofs</u>
A green roof is a common roof (or a deck) of an existing building onto vegetation (or habitat in general), which is intentionally grown for wildlife, is established. According to the water storage capacity, energy saving potential of the building, kind of habitat that is achieved/established etc. different types of green roofs can be constructed (Green roof guide, 2012).

In principle, the selected vegetation is a key element for the construction of the green roof. Basically the green roofs are classified into the following categories according to the vegetation used: extensive, semi-extensive[61] and intensive. The extensive green roofs are ideal for the growth of drought-tolerant plants, e.g. sedum. Those plants need very little maintenance, whereas irrigation is not required. Because of the little maintenance they are often the choice for building owners who are looking to reduce costs and improve the environment as well. For the semi-extensive type of green roofs, plants like shrubs, perennials, herbs or grasses can be used (in general plants which do not have large irrigation need or depends upon the local weather conditions. Also, due to the fact that those roofs are open to the public, hard paved areas can be constructed. The intensive green roofs the growing media is usually fairly deep and can support trees growth. A roof top garden or a patio is a typical example of an intensive roof. Figure 6-7 depicts pictures from the three aforementioned types of green roofs (Getter & Rowe, 2006; Green roof guide, 2012).

Figure 6-7: Types of green roofs; the order from the left is intensive, semi-extensive, extensive

[61] In the literature can be also found as semi-intensive

The extensive green roofs are further classified into the sedum[62] (or substrate-based planted or mats), which is constructed when aesthetic or visual impacts are important, and into biodiverse when a number of local plants and trees with locally sourced growing mediums are chosen. For the first case (sedum) the thickness of the growing medium is approximately 50 mm and is visually consistent throughout the year. In the second case (biodiverse roof) the visual impact may change during winter. Also this kind of extensive roof may result in a better habitat that attracts and sustains local birds, insects and invertebrates. Moreover locally sourced materials to form the base e.g. soil or other similar construction materials are used, which improves the biodiversity potential of the roof. As a general remark, the extensive green roofs provide better habitat than intensive roofs and usually plants that can survive on the shallow low-nutrient substrates that form their growing medium are used. Also, extensive green roofs provide good storm-water attenuation as well as improve runoff quality. Indeed, when green roofs are designed in order to maximise storm-water capture they usually use fertile soils and intensive plant cover, usually Sedum, whose use is not optimal for biodiversity (Bates et al., 2006). This kind of green roof can be also found in the literature as brown roof. Summarising, the main technical characteristics of green roofs are presented in Table 6-3.

Table 6-3: Technical characteristics of a green roof linked to the vegetation (Green roof Centre, 2007; Green roof guide, 2012)

	Extensive	Semi-extensive	Intensive
Overall depth (cm)	8-13	13-18	18-60+
Saturated weight (kg/m^2)	60-170	-	200-500+
Plants	Mosses, sedums, succulents, herbs and few grasses	Selected perennials, sedums, ornamental grasses, herbs and little shrubs	Perennials, lawn, putting green, shrubs and trees, rooftop farming
Irrigation	No (not recommended)	Partially (according to local weather conditions)	Yes
Maintenance	low	medium	High
Costs	low	medium	high

A typical engineering design of a green roof is illustrated in Figure 6-8 where the required layers are also presented. The size of each layer (thickness) depends upon the vegetation on the rooftop (i.e. needs for irrigation etc.) and/or the heating/cooling targets of the building that have to be achieved (i.e. with the green roof the heating and cooling loads of the building decrease). In particular, the different layers from the top of the building roof (or from the bottom of the green roof structure) are listed below (Figure 6-8):

1. Roof resistant barrier
2. Protection layer
3. Drainage layer, which allows water to flow
4. Filter layer, usually filter fabric, which prevents clogging
5. Growing medium, a substrate, which is composed of organic matter and inorganic material
6. Vegetation

[62] Sedum is one of the principal vegetation systems that can be used; is very drought and wind tolerant, form a dense covering, is visually attractive and they can form either into a blanket/mat system or a substrate-based planted or hydro seeded system.

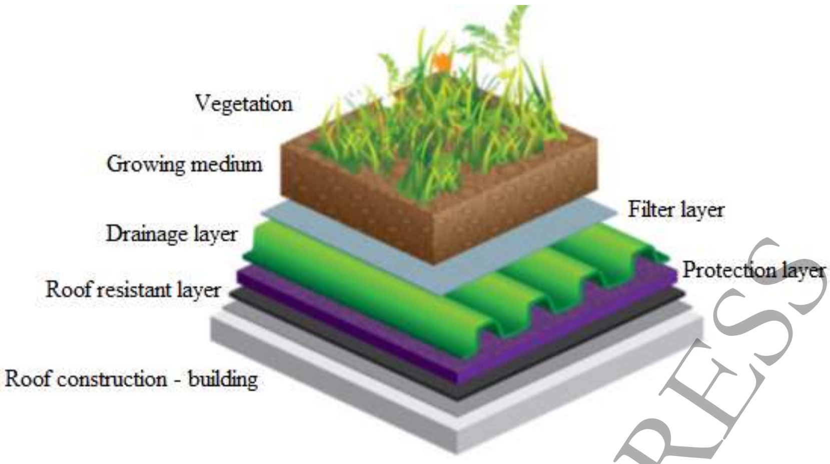

Figure 6-8. Green roof layers; a typical engineering design (Green roof guide, 2012)

Also, the rainfall recovery is an important aspect that has to be addressed by the project developers. In particular, there are technical solutions, which recommend the coupling of green roofs with other systems which collect the rainfall accumulations (Ascione et al., 2014).

An important element that must be taken into account before the construction of a green roof is the estimation of the maximum load that the building can support. Certain parts of a roof are stronger because they are supported either by a load-bearing wall or by pillars. In addition, the roof can be checked for water-tightness. As a general remark, the building must be in perfect condition because any repairs to the roof will be more costly to carry out once the green roof has been installed.

Furthermore, the installation of the growing medium and all the necessary layers is also a rather important construction element. In case the roof is not flat then the pitch must be calculated. As a general rule, the growing medium remains stable on a pitch of up to 25^{o}. But when the slope is greater, one may need to fix metal, wood or plastic support construction base to the roof membrane to hold everything in place and to avoid any erosion by heavy rain. Moreover, it is important to ensure roof access. The roof must be accessible both during construction and for periodic maintenance.

The sun exposure and the direction and the speed of the winds are also a key element for the construction of the green roof. Those two elements determine the type of the plants to be used as well as their position[63].

<u>Combination of green roofs and photovoltaic panels or solar panels</u>

This technological combination contributes significantly to the development of an ecosystem approach as well as generating electricity from renewables[64]. In general, the efficiency of the PV panels is highly influenced (negatively) by the high temperature. On the other hand, the evapotranspiration from the plants on a green roof affects positively the energy efficiency of the PV panels. From a technical perspective, the temperature in the black and grey surface (parts) of the PV panels is increased during the summer, especially when the sun is at its peak (in terms of energy generation). Moreover, the high surface temperature of a convenient building roof can also affect the ambient temperature (increase) of the air (environment) around the PV panels thus reducing their efficiency (Green roof guide, 2012).

A green roof maintains a lower surface temperature as compared with a convenient building roof because the plants on the roof transpire. Therefore, this transpiration contributes to the maintenance of the temperature of the ambient air around a PV panel approximately between 20 to 28^{o}C. Given this concept, the green roof contributes positively to the efficiency of the PV panels. Regarding positioning, the PV panels should be properly installed followed the standard

[63] For instance, tall plants need to be protected from winds if they are not to be uprooted.

[64] The generated electricity can either be distributed in the existing grid network or be used for building purposes.

angles range from 25^{o} to 45^{o}. For the installation of the PV panels, the structure of the green roof provides the necessary load for preventing wind suction with the installed array of panels (Green roof guide, 2012). Therefore complicated technical solutions for efficient panels mounting are not required (Figure 6-9).

Concerning the equipment used, the aforementioned concept can be also built by installing solar thermal panels for the production of hot water instead of PV panels for electricity generation. The positioning and orientation technical aspects (limitations) are the same with the PV, which discussed later.

Figure 6-9 illustrates the combination of green roofs and PV (or solar thermal) panels.

Figure 6-9: Combination of green roofs and PV panels; on the right picture a solar thermal panel is presented

Summarising, it is best for the public administration to develop appropriate policy schemes that support the construction of green roofs in existing and retrofitting buildings. In particular, such schemes can incorporate all the technical aforementioned aspects concerning their implementation in existing buildings for a given urban area/city. The second step is the establishment of local incentives in order to subsidise the technical projects. However, the formulation of such plans should be done very carefully and local parameters should be taken into consideration. Regarding the local parameters, an indicative example of the measures of such a plan is listed below:

1. For warm climates, it is important to identify the districts where the temperature is higher and exceeds 30^{o}C. Afterwards it is important to identify the large areas (large surfaces of the buildings[65]) in order to suggest to construct a green roof.
2. For climates with high rainfall, extra priority should be given in the application of sustainable drainage measures.
3. In order to provide a significant level of evaporative cooling and rainfall attenuation, green roofs should consist of an adequate depth of substrate covering a significant area of a roof. A minimum suggested target is 80mm substrate depth over 80% of the roof area (Maurer, 2009).
4. Generate green electricity from renewables (i.e. electricity through PV panels and/or hot water from solar panels).

Achieved environmental benefits

Green roofs provide a series of environmental benefits which are listed below:

- *Storm-water attenuation*: Green roofs help reverse the effects of impermeable surfaces on storm-water management, by reducing runoff and peak flows (volume). Rainwater is

[65] For instance, in Greater Manchester authorities it is recommended that buildings with a roof larger than 1,000 m^2 should install a green roof.

captured by the roof and either evaporates and transpires or is released at much slower rates once the surface becomes saturated, depending on the type of green roof and the intensity of rainfall. It has been reported that green roofs can reduce runoff by 60 to 100% (Getter and Rowe, 2006).

- *Water savings*: If storm-water is captured from green roofs, it can be reused for a number of non-potable applications such as toilet flushing or garden watering, thereby reducing the quantity of water that needs to be abstracted and treated to drinking water standard.
- *Energy savings:* Green roofs provide shading by reducing solar energy gain and also insulate buildings, reducing fuel and electricity use for both cooling and heating. Given the large percentage of urban energy use from buildings, green roofs can have a significant impact on urban energy consumption, with associated greenhouse gas emission reductions as well as cost savings. At the same time, green roofs can also reduce the need for heating in winter and for cooling in summer, and are therefore suitable for cold and warm climates, as well as for continental climates which are subject to strong seasonal temperature variations. Moreover, green roofs also improve the efficiency of air conditioning systems by reducing the temperature of the intake air.
- *Reduced urban heat island effect:* Urban surfaces have a low sunlight reflected fraction and therefore absorb much solar energy. This, in addition to the lack of evapotranspiration from impermeable urban surfaces, helps create the urban heat island effect, where urban temperatures are higher than those of the surrounding countryside. Green roofs contribute to the reduction of the related impacts due to the higher sunlight reflected fraction and also allow evapotranspiration.
- *Air pollution reduction and CO_2 absorption:* Green roofs help reduce airborne contaminants and particulate matter, improving the health of urban residents, and their plants also absorb carbon dioxide emissions. Air quality is also improved due to the increased humidity and oxygen levels.
- *Habitat provision:* Green roofs provide habitat for insects, birds and microorganisms.

On the other hand, the installation of PV panels can contribute to the creation of extreme shading underneath the panels. On one hand the shade may affect the growth of the vegetation on the green roof but on the other hand it may provide a unique shady habitat. Another element is the water run off form the surface of the panels. This amount of moisture can be concentrated at the bottom of the PV panels (or underneath of them) establishing/creating a greater diversity of vegetation than would be expected on a fully exposed green roof. Table 6-4 reflects the aforementioned findings and they are data coming from a German example in Ufa-Fabrik in Berlin Tempelhof (Köhler et al., 2007).

Table 6-4: Vegetation dynamics under the PV installation (Köhler, et al., 2007)

	Before panel installation **1992-1999**	Northern roof of the roof without PV panels **2001**	Northern roof of the roof without PV panels **2006**	Southern part of the roof, vegetation under the PV panels **2001**	Southern part of the roof, vegetation under the PV panels **2006**
Average number of plant species	41	41	51	43	63
Average cover of all vascular plants plant species (%)	89	85	95	97	90
Average height of all plant species (cm)	65	110	70	118	90

Average cover of the genus Sedum typical for extensive green roofs (%)	22	48	46	27	25
Number of plants benefited by the shade of PV panels				7	17

As a general remark, the environmental performance of each of the discussed roof types in this BEMP is presented in Table 6-5.

Table 6-5: Environmental performance of the different green roof types (Green roof guide, 2012)

	Water attenuation	Water runoff	Energy reduction	Biodiversity	Maintenance
Sedum mat	x	x	x	x	Medium
Sedum	xx	xx	x-xx	x-xx	Medium
Extensive	xxx	xxx	xxx	xxx	Very low
Biodiverse	xxx	xxx	xxx	xxxx	Very low
Intensive	xxxx	xxx	xxx	xxx	Very high

x: poor, xxxx: very good

Appropriate environmental indicators

The main appropriate environmental performance indicators for this BEMP are:

- Number and kind of species living on the rooftop (local biodiversity)
- Percentage or number of buildings with green roofs in the given urban area
- Percentage of the green roofs surface out of the total surface of an urban area ($m^2_{green\ roof}/m^2_{urban\ area}$)
- Number (no.) or percentage (%) of the green roofs in the given city/urban area
- Use of local materials, expressed either:
  - as a number (no.) or
  - as an amount (kg)

  The collected data have to be disaggregated according to different materials used e.g. seeds, branches, sand, stones etc.
- In case of installed PV panels on the green roof:
  - Capacity of electric energy installed (kW_p) on the rooftop
  - Amount of generated electricity (kWh/year)

Cross-media effects

Green roof benefits are sometimes mutually exclusive, and the following trade-offs should be taken into consideration (Philip, 2011):

- Green roofs designed with the main objective of reducing storm-water runoff require high vegetation cover supported by a fertile soil. This can lead to nitrate leaching which compromises water quality in the runoff that flows from the roof. In addition the plant species that are good for attenuation (such as Sedum) reduce the potential for biodiversity development.
- Depending on climatic conditions, green roofs may restrict the collection and reuse of rainwater from the roof surface, particularly where the objective is to attenuate storm-water in soils and plants. Designs can however be chosen that optimise reuse opportunities by

providing natural treatment of rainwater through soil filtration, although such designs are unlikely to offer the same biodiversity and aesthetic benefits.

Operational data

In this section, already implemented examples are presented.

Germany, Austria and Switzerland have established related policy frameworks and political support for green roofs. For instance, Germany has a legal framework and guidelines for the construction of green roofs on new flat-roofed or shallow pitch roofed (up to 20^{o}) buildings. There are local regulations in place, which subsidise the installation costs up to 50%.

Case study: Linz, Austria

The city of Linz in Austria consists of a building area of 3,600 ha. The local authorities introduced suitable building plans in 1985, which basically were legal means towards the implementation of green roofs. The most important elements of these plans were that the green roof construction has to consist of a vegetation layer (above the drainage layer) with at least 8 cm for extensive green roofs and from 15 to 50 cm for intensive green roofs. Additionally, the coverage vegetation should extend of at least minimum of 80% of the total roof area. However, this plan also identified areas where it was mandatory to build green roofs such as roofs of subterranean parking or underground buildings or areas of mixed use and where expansion is limited. In particular, green roofs were mandatory for new buildings with a surface more than 500 m^2 and where extensions to existing buildings larger than 100 m^2. Also, it was mandatory for new residential buildings and new industrial/commercial buildings with a surface larger than 100 m^2 and 500 m^2 accordingly[66]. The results of this scheme for the time period 1989-2005 are illustrated in Figure 6-10. In fact, the development of the surface of sponsored green roofs is presented in combination with the total surface of green roofs. For the same time period, Figure 6-11 illustrates the distribution of the installed green roofs (Maurer, 2006).

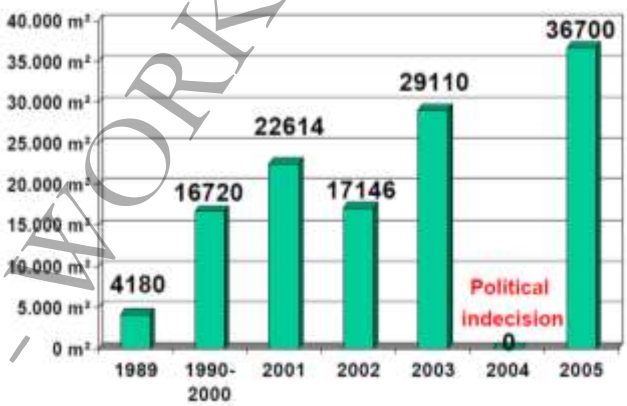

Figure 6-10: Development of the surface (in m2) of the green roofs in city of Linz over the period 1989-2005 (Maurer, 2006).

66 Exceptions: i. where the building has at least 60% green space within its plan, ii. roofs with a pitch > 20 degrees

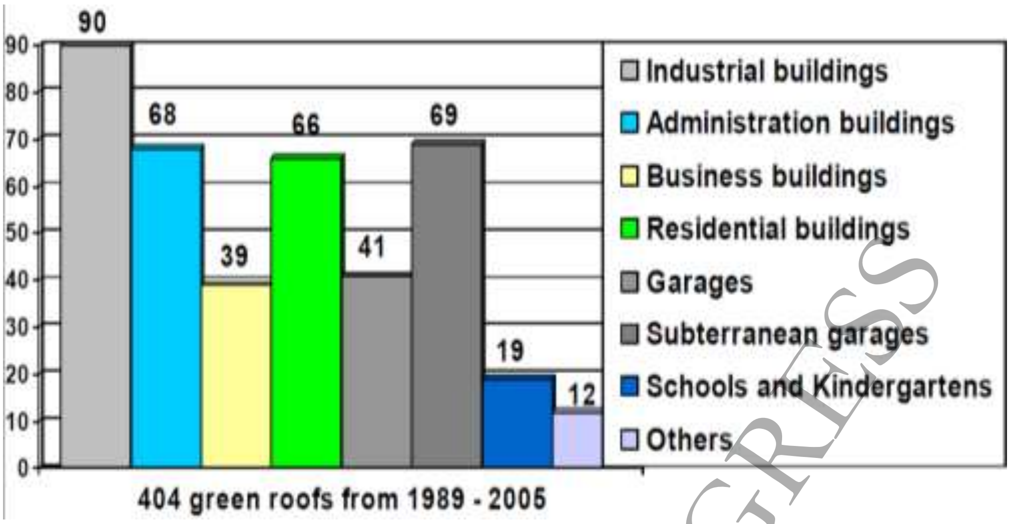

Figure 6-11: Distribution of the installed green roofs in city of Linz over the period 1989-2005 (Maurer, 2006)

<u>Case study: Basel, Switzerland</u>

The city of Basel, Switzerland has promoted the installation of green roofs through a number of various policies and schemes. Therefore the local authorities formulated two incentive programmes in order to provide subsidies for the installation of green roofs. Specific guidelines were introduced either for new or renovated flat roofs greater than 1,000 m^2 which has to be green and a mandatory consultation with a city expert has to be undertaken. For instance, measures like use of specific local materials (like native flora and fauna etc.), precise definition the depth of the growing medium, use of native soil etc. are important elements to create a valuable habitat. It has been reported that more than 85,000 m^2 of roof areas has converted to green since the late 1990s resulting in savings of 4 GW/year of energy (Drivers Jonas LLP and EDAW AECOM, 2009).

Applicability

The establishment of a policy scheme by the public administration bodies is feasible and can be easily fully applicable. Moreover, the green roofs are in general applicable to all the existing and retrofitted buildings. Below some special aspects/technical considerations/limitations are listed. However, as it was mentioned in the Description section, and especially for the retrofitted buildings, the ability of the building to hold the load from the installed green roof (and the PV/solar panels if exist) should be carefully assessed in prior to the construction phase.

- The intensive green roof requires a deeper layer of growing medium and thus generates significant costs as well as weight, which needs to be supported by the construction of the building. They also require more maintenance.
- The intensive green roofs can be (usually) constructed in flat roofs and made accessible to the public. They are designed to house plants and shrubs that require regular maintenance and generally need a thicker layer of substrate on which to grow (thicker growing medium).
- The extensive green roofs are lighter and they can be installed on large surfaces such as those of industrial buildings or sporting facilities (Getter and Rowe, 2006).
- The extensive green roofs is not made accessible to the public, whereas can be constructed either on flat or sloped roofs, and are designed to require little or no maintenance. The substrate layer on extensive green roofs is thinner and they therefore house moss, herbs, grass or succulents (Getter and Rowe, 2006).
- Often blanket systems are the only type that can be used on existing buildings due to load restrictions. On new buildings, however, where additional structural loading can be taken into account during the design and construction process, substrate systems (which can comprise recycled materials) are preferred because of the greater environmental benefits they bring.

Economics

It is rather difficult to quantify the capital costs of a green roof. Several parameters may influence those costs from the type of the roof to be constructed, the vegetation to be used or in general from the objectives of each project. However, the capital costs for an intensive green roof is relatively high as compared with the extensive type (Berardi et al., 2014).

For instance, parameters like the height of the building, thicknesses of the layers used, vegetation used and other supplementary systems (e.g. irrigation if needed) in parallel with many other factors influence strongly the installation cost. An indicative cost of 140 £/m^2 (about 190€/m^2) has been estimated by the Green Roof Guide included waterproofing and insulation. The same organisation also calculated an indicative installation cost for semi-extensive green roof, which ranges from 80 to 120 £/m^2 (110-165€/m^2).

For the construction of green roofs, there are also some economic benefits and barriers, which are summarised in Table 6-6 (Berardi et al., 2014). It should be noted that it is also difficult to quantify them because of the certain specificities and local parameters e.g. value of the buildings, labour costs etc.

Table 6-6: Economic benefits and barriers of green roofs (Berardi et al., 2014)

Economic benefits	Economic barriers
Reduce energy consumption	High construction cost
Increase thermal insulation in retrofitting	High maintenance cost especially with intensive green roofs or hen irrigation is needed
Reduce maintenance costs of roof due to lengthening life	Complexity of construction
Reduce costs of water rain off and urban infrastructure	Risks of failure
Improve market and price of the buildings	Expensive integration in existing buildings if adjustments to the structure are needed
Increase usable surface of the building	

Additionally, in some European countries local policy instruments that promote the construction of the green roofs are already in place. For instance, in Copenhagen, Denmark all new roofs with a roof pitch under 30° have to be landscaped, providing there is no structural engineering reason preventing it. Likewise, in Munich, Germany, there is an obligation to landscape all suitable flat roofs with a surface area more than 100 m^2; in Esslingen, Germany, 50% of the cost of green roofs is paid back, whereas in Darmstadt, Germany, owners receive up to 5,000 € for planting a green roof (Berardi et al., 2014).

As it was previously mentioned in the environmental benefits, the green roofs contribute to the reduction of the energy loads of a building. In particular, in cold climates, green roofs were slightly more cost-effective than the traditional roofs. For instance, EC (2013) and Ascione et al., (2013) reported that the annual energy costs for a building with a traditional roof in Oslo were estimated at 11,529 €, which were 551 € more than a green roof. However, for the green roofs where plants require irrigation (see Description section), it has been reported that the cost of watering in warm climates outweighed the benefits gained from reduced energy demands. For example, annual energy and watering cost for a traditional roof in Seville were estimated at 14,314 €, which are 32 € more than for the most suitable vegetation of a green roof. The payback period time was estimated rather long and in Southern Europe the installation cost was never repaid (Ascione et al., 2013; EC, 2013).

Although the installation of a green roof is more expensive than that of a normal roof, green roofs do generate important direct cost savings in terms of energy consumption and storm-water management and less direct savings for society as a whole (health, amenity, aesthetics etc.)

Green roofs, by attenuating storm-water, can help defer or replace expenditure linked to traditional storm-water infrastructure. For instance, according to Peck (2005) and Getter and Rowe, (2006) converting 6% of Toronto's roof surfaces to green roofs would be equivalent in terms of storm-water retention to building a storage tunnel worth over 40 million €. The life cycle costs of green roofs can be lower than those of normal roofs, particularly so in countries such as Germany where the widespread uptake of this technology has allowed for economies of scale (Bates et al., 2006). Table 6-7 compares the costs and benefits associated with a conventional gravel roof and an extensive green roof over a 40-year period.

Table 6-7: Cost-benefit analysis for green roof versus gravel roof (Adapted from Giesel, 2003)

Gravel-covered roof		**Extensive green roof**	
Costs		Costs	
Gravel cover 5 cm (5 €/m^2)	5,000	Precautionary measures (10 €/m^2)	10,000
		Green roof (20 €/m^2)	20,000
Repair	4,000	Repair	0
Partial renewal after 20 years	27,500	Partial renewal after 20 years	0
		Regular maintenance (0.50 €/m^2 for 40 years)	20,000
Benefits		Benefits	
Reduction of sewage disposal costs	0	Reduction of sewage disposal costs (0.60 €/m^2/year)	-24,000
Improved thermal insulation	0	Improved thermal insulation (0.06 €/m^2/year)	-2,400
Costs minus benefits	**36,500**	**Costs minus benefits**	**23,600**
Overall savings versus the green roof after 40 years	**0**	**Overall savings versus the green roof after 40 years**	**12,900**

Driving force for implementation

All the already listed environmental benefits (under the Achieved Environmental benefits) act as the main driving forces for implementation. Apart from them, there are also other positive impacts such as:

- *Cost savings:* By protecting the roofing membranes from damage linked to solar radiation and temperature fluctuations, green roofs help extend the life span of roofs – sometimes doubling it. Moreover, green roofs can increase property values because of their aesthetic value. Finally, the energy savings mentioned previously also help reduce costs.
- *Aesthetic value:* Green roofs are attractive to look at and provide health benefits linked to contact with green spaces.
- *Employment creation:* By requiring substrate, plants, installation and maintenance, green roofs can help boost local landscaping businesses.
- *Use of waste material:* Green roofs, and brown roofs in particular, can reuse waste material as a substrate, for example from construction sites. This reduces the pressure on landfills, the costs of transporting this material, and can lead to financial savings. Best practice within London requires the sourcing of construction material from local and sustainable sources, so that green roofs with the deepest substrate are considered more optimal.

Reference organisations

There are several organisations, associations, clusters of public administration etc., which have already in place suitable local policy schemes for the construction of green roofs. An indicative list (not exhaustive) is presented below:

- Greater London Authority. (2008a). Living roofs and walls – technical report: supporting London plan policy. London, United Kingdom: Greater London Authority.
- Greater London Authority. (2011). The London plan – Spatial development strategy for Greater London. London, United Kingdom: Greater London Authority.
- Greater London Authority (GLA). (2010). The draft climate change adaptation strategy for London – Public Consultation Draft. London: GLA
- The Green Roof Centre, Sheffield University. www.thegreenroofcentre.co.uk
- Living Roofs, the independent UK website to promote Green Roofs. www.livingroofs.org

- The number of green roofs varies a lot across Europe, mainly as a consequence of the presence or lack of incentives and policies to encourage them. Germany is the world leader in green roof construction, with many cities having incentives in place to encourage their installation. These incentives enable the cities to achieve cost savings in comparison with traditional large-scale stormwater management options. "For example, the city of Esslingen in Germany will pay up to 50% of the cost of installing a new green roof, and the city of Darmstadt will pay up to 5000 Euros toward a new green roof" (Getter and Rowe, 2006). Switzerland is another green roof leader, with similar city-level incentives: in Basel for example "homeowners can claim 20% of green roof investment costs for converting unused rooftops to vegetative rooftops. This policy was so successful that in 18 months an area the size of seven football fields was greened. Now, there is a new law in that city that all new flat roofs must be greened" (Brenneisen, 2004 as cited in Getter & Rowe, 2006).
- Scandinavia is yet another leading region in the installation of green roofs. For example, the environmentally-friendly Augustenborg neighborhood of Malmö, Sweden, is home to several green roofs, including one of over 10000 m^2 called the "Augustenborg Botanical Roof Garden". The green roof attenuates storm-water, insulates the buildings but also encourages local biodiversity. The green roofs of the neighborhood are part of a wider sustainable storm-water management strategy which aims to attenuate and collect storm-water in order to reduce local flooding. The roof garden is open to the public and is accessible, increasing the learning opportunities that can be derived from it. Augustenborg has made the most of this green roof, promoting it through brochures, and the botanical roof garden building is also home to the Scandinavian Green Roof Association. The Institute disseminates lessons learned and provides training but also undertakes research into simple and cost-effective green roof solutions.
- Green roofs have been used in many countries with widely varying climates and therefore have an important replication potential (Bates et al., 2006), but these differing conditions should be taken into account in project design. Plant selection is important: indeed, climatic conditions such as temperature and precipitation can affect the survival of different plant species, as can very localised microclimatic factors such as air vents. Drought tolerance is the most important variable to factor in when choosing plant species; succulents are often chosen.
- Green roofs are not suitable for all roofs, as they entail substantial additional weight, particularly for the heavier intensive green roofs. New buildings can be designed to accommodate this weight, but existing buildings need to be checked for compatibility prior to installation. Green roofs can help buildings meet guidelines for green buildings such as BREEAM in the UK or LEED in the USA. Brown roofs in particular can play a role in city Local Biodiversity Action Plans (explored in more detail in BEMP 7.1), by helping to create habitat for target species. For example, the black redstart is one of the target species within Birmingham's LBAP.
- In France it is mandatory for all the new commercial buildings to feature roofs that are at least partially covered in either PV and/or solar panels or plants.

Reference literature

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6.4 Giving new environmental value to derelict green areas and fringe areas

Description

As urbanisation increasingly puts heavy pressure on open space, efforts to preserve urban green areas have been growing in recent years. Acknowledging that they contribute to their climate and environmental policy objectives, the European Commission promotes their preservation by incorporating them into national and regional policies across the European Union (EC, 2013). At country level for instance, in Germany, the Federal Government promotes their preservation by incorporating them into its national strategy on biodiversity protection (Federal Ministry for the Environment, Nature Conservation, Building, and Nuclear Safety, 2007). A major challenge in efforts to preserve urban green areas is to highlight their benefits for human development and the environment. In particular, several researchers and organisations have reported the positive effects on well-being, human health and particularly on biodiversity by providing important habitat to hundreds of species (Mitchell and Popham, 2008; Cornelis and Hermy, 2004; Krekel et al., 2015).

This BEMP covers two related types of green / brown areas of relevance in the environmental management of towns and cities: derelict green areas, which have been designated as parks or natural areas but no longer provide optimal environmental value and should be restored; and fringe areas i.e. buffer zones which are usually located at the outer edge of urban settlements and are most at risk of urban sprawl (see chapter 5). In both cases the following technique focusses on the improvement of the environmental value of the sites.

Fringe and derelict green areas are subject to strong tensions from decision makers and urban developers. In particular, abandoned and fringe areas around the core of the cities are threatened because usually they suffer from the symptoms of environmental degradation e.g. illegal dumping, abandoned gravel pits, quarries, illegal bonfires (Beatley, 2012). Fringe and derelict areas associated with urban centres have become numerous, larger and more complex with rapid urbanization. The environmental degradation of these areas is inevitably associated with loss of agricultural land, sometimes unauthorized rapid urban development (urban sprawl), industrial operations, and other environmental issues, which significantly alter the ecosystems.

The urban fringe areas are zones between urban and rural areas where urban and rural activities exist and interact. This interaction may result in positive and negative results. One important positive aspect is the creation of synergies; for instance, the presence of an attractive agricultural landscape, which combines operations like recreation, biodiversity conservation water management and employment creation/growth. On the other hand, the negative aspects can be the presence of a polluting industrial site (or in general the existence of industrial activities) in the urban fringe zone, which leads to depreciation of neighbouring housing (and farmland). Therefore, the public administration (local and/or regional scale) should balance carefully both aforementioned aspects and eventually favour the best usage (SURF, 2012).

The main reasons that fringe areas are not incorporated adequately into an overall sustainable urban management planning are linked to the rapid urbanisation process and the governance of the urban areas (Clark, 2009) and in particular:

- The existing planning capacity is overwhelmed by an ever increasing task
- Urban governance and planning: the fact that in the fringe areas, limited urban planning rules, regulations or planning capacities are in place.
- Land use and speculation: the exploitation of relatively low-cost land by developers for speculation on future expansion rather than immediate development

Valueing green areas

The benefits of maintaining or establishing green urban areas are often perceived as intangible; however, in the face of mounting pressures for other uses and in particular development, a more structured approach can help identify and prioritise the actual benefits that can be expected from a green restoration project.

One of the unique advantages of green areas is the provision of ecosystem services. As described in EA (2011), modern conceptions of ecosystem services represent the convergence of diverse strands of resource protection science and practice that have emerged since the 1980s. The UN Millennium Ecosystem Assessment (MA, 2005) introduced a consistent typology of "ecosystem services" as a basis for assessing the status of global ecosystems and their capacity to support human wellbeing. The MA grouped ecosystem services into four main categories: provisioning, regulatory, cultural and supporting services, which are detailed below:

Table 6-8: Ecosystem services according to the UN Millennium Ecosystem Assessment

Provisioning services	Regulatory service
Fresh water Food (crops, fruit, fish etc.) Fibre and fuel (timber, wool etc.) Genetic resources (used for crop/stock breeding and biotechnology) Biochemicals, natural medicines, pharmaceuticals Ornamental resources (shells, flowers etc.)	Air quality regulation Climate regulation (local temperature/rainfall, greenhouse gas sequestration etc.) Water regulation (timing and scale of run-off, flooding etc.) Natural hazard regulation (storm protection) Pest regulation Disease regulation Erosion regulation Water purification and waste treatment Pollination
Cultural services	Supporting services
Cultural heritage Recreation and tourism Aesthetic value Spiritual and religious value Inspiration of art, folklore, architecture and so on Social relations (such as fishing, grazing or cropping communities)	Soil formation Primary production Nutrient cycling Water recycling Photosynthesis (production of atmospheric oxygen) Provision of habitat

Looking specifically at urban fringes the SURF project has identified that they provide significant value on the following dimensions (Thomas and Wishardt, 2013 and SURF, 2012):

- Providing urban residents with access to nature and recreation
- Protecting nature, providing ecosystems services for towns and cities and conserving biodiversity
- Providing space for urban expansion such as housing and industry
- A location for urban support services like waste transfer, energy generation, water supply, sewage treatment, recycling facilities and landfill sites
- Transport infrastructure
- A location for urban support services such as waste transfer, energy, production, water supply
- Providing food for the towns and cities
- Location for more sustainable living
- Sites for major transport infrastructure, airports motorways etc.
- A source of health and wellbeing
- A source of cultural identity and regional heritage
- A source of enterprise and productivity

Restoring and valueing green areas: principles and approach

The approach to best practice management of derelict and fringe areas can be governed by the concept of green infrastructure. Green infrastructure addresses the connectivity of ecosystems, their protection and the provision of ecosystem services, while also addressing mitigation and adaptation to climate change. It contributes to minimising natural disaster risks, by using ecosystem‑based approaches for coastal protection through marshes/flood plain restoration rather than constructing dikes. Green infrastructure helps ensure the sustainable provision of ecosystem goods and services while increasing the resilience of ecosystems. The concept is central to the overall objective of ecosystem restoration. It also promotes integrated spatial planning by identifying multifunctional zones and by incorporating habitat restoration measures and other connectivity elements into various land‑use plans and policies, such as linking peri-urban and urban areas or in marine spatial planning policy. Its ultimate aim is contributing to the development of a greener and more sustainable economy by investing in ecosystem‑based approaches delivering multiple benefits in addition to technical solutions, and mitigating adverse effects of transport and energy infrastructure.

In addition, the social value of restored green spaces has to be highlighted, in particular when engaging with local residents and broader mebers of the community. White (2013) identifies a small but significant impact of the availability of urban green spaces on the mental health of the population which can enjoy it. Green spaces also offer an excellent medium for educational and awareness-raising efforts on the value of the environment at local level.

Finally the environmental benefits in terms of reduced air pollution, soil remediation or water quality improvement can also help governments meet regulations and reach targets at local, national and European level.

Restoring and valueing green areas: practical steps

In practice, fringe and derelict areas can be restored and improved by applying various measures. Nowadays, urban agriculture has inspired designers to create mobile modular storage/office/educational space specifically geared towards urban farms. One important challenge is to give quality to the planning areas and buildings within fringe areas taking also into account the potential local and regional interactions while respecting the environmental rules in place. For instance, a well-designed housing area can contribute to the conservation of the local biodiversity. In particular, it can improve water quality by installing green roofs and purifying the collected water or generate energy from photovoltaic panels or from geothermal sources (SURF, 2012). On the other hand, some municipalities manage their fringe areas by appending land adjacent to the city limits as an instrument to control growth (Heimlich and Anderson, 2001).

Specific measures/actions that can be implemented by the public administration are outlined in the following bullet points (SURF, 2012; Heimlich and Anderson, 2001):

- Fringe/formerly derelict areas must be clean, clearly signposted, well-connected and easily reached by all members of the community
- On-site renewable energy generation should be included in fringe/derelict areas, if feasible, based on local renewables available (e.g. solar/PV panels etc.)
- Where a new development is proposed in fringe and derelict areas, both pedestrian and cycle paths should be included (ensuring the good connectivity with the metropolitan area of the city)
- Green roofs, sustainable urban drainage systems, and other mitigation measures to reduce surface water run-off as close to the source as possible, can be encouraged
- Construction of features that ensure flood minimisation should be designed and implemented at the earliest possible stage
- Public open space should be maximised and incorporated into a network of existing and new open spaces
- Establish strategic approaches to urban fringes with special attention to green infrastructure and spatial planning

- At regional / national government level, provide guides for government policies and actions on the pattern and intensity of land use, the provision of public facilities, including transportation and development of human and natural resources
- Identification and evaluation of area housing, employment, education and health needs and plans to meet those needs
- Preparation of regulatory and administrative measures to support the entire plan.

Public administrations have the opportunity to support the implementation of the aforementioned measures/actions using the tools below: (SURF, 2012):

- Communication and stakeholders' participation through awareness raising, education etc.; the buy-in from a majority of the citizenship is essential to maintain the value of newly improved areas in the long term. The communication effort can be carried out by the use of online tools like special platforms where experts or local people can express their opinion and leave valuable feedback, town hall meetings, open days etc.
- Regulation and local conditions: specific formal and legal procedures are developed or applied like zoning plans, building permits etc.
- Planning and design: the distribution of activities, the design of areas, structures and buildings in the area are crucial aspects
- Financial tools: important tools that may give funding opportunities in support of the prescribed activities

Achieved environmental benefits

The achieved environmental benefits of this BEMP are listed below (EC, 2013):

- Provision of clean water
- Removal of pollutants from air and water
- Protection against soil erosion, rainwater retention
- Improvement of land quality, soil remediation
- Mitigation of urban heat island effects
- Disaster prevention (e.g. storms, forest fires, landslides)
- Climate change mitigation
- Improved habitats for wildlife, ecological corridors
- Educational value of flaura and fauna
- Well-being for members of the community
- Increase in adjacent land values

One of the most important environmental benefits is the mitigation of the heat island effect. This effect is of particular interest and is clearly demonstrated that both climate change and the urban environment dramatically increase urban risk individually and collectively and these interactions must be integrated into urban planning (Clark, 2009).
The impact of climate change and the associated risks to populations in urban areas is complex, dynamic and dependent on a wide and diverse set of global, national and local urban factors. These interactions are perhaps best exemplified by issues associated with urban heat.

Appropriate environmental indicators

The indicators that can be used by the public administration to monitor the implementation of this BEMP are qualitative and are summarised below:

- Compilation of a plan regarding the environmental management of green areas within an urban area - Y/N
- Communication of the plan (related to the previous indicator) - Y/N
- Implementation of specific measures/actions e.g. biking lanes or pathways to access the green areas according to the plan (link to the previous indicators) – Y/N
- Percentage (%) of green spaces in the fringe/derelict areas

- Number of Ecosystem Services categories (according to the UN millennium assessment) where progress has been recorded

Cross-media effects

As outlined in BEMP 5.1 on urban sprawl, the management and refurbishment of green areas within towns is a complex and sensitive issue which goes beyond the practice of environmental management, but also encompasses fundamental policy choices for stakeholders in an urban area, underlined by the conflict between development and the preservation of natural capital. In the case of fringe areas or green areas closer to the city centre, there is a conflict between the push to favour denser habitat towards urban centres in order to limit expansion in surrounding (formerly agricultural or natural) land. While this BEMP is focussed on maintaining green areas as such and making the most of scarce land resources to maximise their environmental value, broader trade-offs might be reached in local circumstances to achieve a balance between greener and denser urban habitats.

Operational data

In this section examples from providing environmental value to fringe and abandoned areas are presented.

<u>Case study (green area refurbishment): Mayesbrook Park, Barking and Dagenham, United Kingdom (see MB 2012)</u>

Mayesbrook Park is a green area in the London borough of Barking and Dagenham which had fallen into dereliction following years of neglect and unremediated pollution since it first opened in the 1930s. With a changing climate and a new millennium, the decision was made to bring the park up to date. The Mayesbrook Climate Change Park was born when a group of partner organisations collectively agreed to undertake a demonstration project of urban river restoration within Mayesbrook Park. The project received funding from a range of public and privately funded organisations. Local people were consulted on their views and a Masterplan was produced to bring the whole park back to life.

In 2011 the first phase of works started to improve the park. The Mayes Brook has been brought back into the park within a widened meandering river channel creating an attractive river landscape. This new river system, with a gravel river bed and banks, provides an ideal wetland habitat for wildlife and at times of high rainfall water levels are able to rise in a controlled and natural way within a newly created fl oodplain. At the same time the water quality of the brook has been improved by tackling pollution at source. All this work has helped the Mayes Brook to get closer to the new higher standard for rivers set by the EU Water Framework Directive. Surface water drainage from the adjacent Olympic training facility has been 'plumbed in' to the restored river to help the area cope with high rainfall. More trees have been planted to provide shade in hotter drier summers, and to fi lter airborne pollution. In many places the grass has been left longer to give it more chance of surviving hot, dry summers. All of these changes will help the park to be more resilient to a changing climate with more winter floods and summer droughts predicted for the future.

New features include:

- New signage and footpaths make the entrances more welcoming.
- A rolling parkscape area of meadow and trees forms a relaxing heart of the park.
- A new natural play area complete with zip wires, mounds and climbing nets give plenty for children to enjoy.
- Dozens of new seats and picnic benches make a more restful place to enjoy the outdoors.
- A new, free to use 'outdoor gym' was created to promote more active lifestyles.
- The sports pitches and facilities are grouped together to create a vibrant sports zone.
- Mayesbrook Park is also now home to the SportHouse which, along with Mayesbrook Athletics Arena, was used as a training venue for the 2012 Olympic Games.

With the Mayes Brook released from its metal fence and concrete channel it has now become a haven for wildlife. This has extended the Site of Interest for Nature Conservation from the southern section to the whole one mile length of the park. Aquatic plants such as reeds and rushes have been planted in ponds and backwaters, creating a rich habitat for wetland species.
5,000 new trees have been planted, providing shade from the sun and a habitat for birds and insects. A dedicated nature reserve with limited public access creates a quiet space for nesting birds and small vertebrates. A second phase of improvements, dependant on further funding, will see a new visitor centre, a café and a garden with plants suited to a changing climate. The park's two lakes will also be restored to ensure cleaner water so that angling and boating facilities can once again be provided.

<u>Case study: city of Bradford, Haworth area, United Kingdom</u>
A simplified summary of the key changes since 2010 that have affected the context of urban fringe community engagement with higher level decision making is illustrated in Table 6-9 (Thomas and Wishardt, 2013). In fact, suitable policies at levels from parish to regional were designed in order to encourage the community engagement in urban fringe issues to try to integrate with more strategic level plan-making in the wider city of Bradford, Haworth area.

In this example special attention was given both to the promotion of the local economy and urban development and to the engagement with fringe and abandoned areas/zones within the greater area of the city. Therefore after the implementation of the measures, a significant increase in the entrepreneurship was reported in the whole region. In particular, around 500 small and medium enterprises were established between 2010 and 2013. These entrepreneurs decided to start and run their business in that region because they preferred to work and live close to big city facilities but enjoying the benefits of an attractive rural/fringe surroundings.

Table 6-9: Summary of key changes for the Bradford urban fringe areas before and after 2010; changes at different scales are listed (Thomas and Wishardt, 2013)

Level/ type	Before 2010	early 2013
Regional scale • Spatial planning • Economic development • Rural development	Yorkshire Forward & Yorkshire Regional Assembly produce regional spatial and economic plans, coordinate rural development funds from EU and UK Govt (LEADER, Market Towns etc.)	Regional agencies abolished and plans redacted Central Ministerial oversight of EU & UK Govt funds
City Region scale • Economic development • Green Infrastructure & Environmental • Spatial planning	Leeds City Region Board leads on economic growth plans, green infrastructure etc. Spatial planning left to other levels; West Yorkshire rural officers group focus on UF issues in sub-region	LCR Board and new LEP take over growth planning; possible role in spatial planning; limited engagement with environmental & social issues; West Yorkshire Rural Partnership uncertainty
Trans-boundary • South Pennines landscape • Local nature partnerships	South Pennines rural/ fringe development agencies: Pennine Prospects LEADER & related projects	South Pennines rural/ fringe development agencies: Pennine Prospects LEADER & Lottery funded landscape projects (potential) Local Nature Partnerships
City/ District scale • Community planning • Spatial planning	Bradford Council coordinates community strategy via LSP; neighbourhood forum & community officers liaise with parishes	LSP ended; community officers reassigned – reduced local-city liaison
Parish/ locality scale	Parish Councils active in urban fringes	Parish Councils active in urban fringes New Localism measures may boost community engagement

<u>Case study: London Borough of Tower Hamlets, UK</u>

The Tower Hamlets council in United Kingdom developed a fringe area action plan addressing social, economic and environmental aspects. Regarding environmental aspects, certain measures were decided to be implemented, which are summarised below (Tower Hamlets, 2007):

- Sustainable communities through high quality design and environmentally sustainable measures e.g. energy use, water consumption, specific construction rules etc.
- Protection and improvement of public open spaces and improving access and links amongst existing open spaces and green chains
- Planning a network of open spaces (existing and new) including play areas
- Green roofs, sustainable urban drainage systems and other mitigation measures to reduce water run off as close to the source as possible
- Clean the green spaces in fringe areas and create additional composting plants and ensure that the new plants include the provision of suitable accessible waste and recycling storage facilities
- Extensions and improvement of riverside walkways, maintenance and clean the bicycle and walking paths, put clear signs etc.

A representative example is that the spatial strategy of the fringe action plan foresees the creation of at least 6 ha of new and improved public open space within the City Fringe. The Council will also seek additional publicly accessible open space in order to expand the existing ones. It has been reported that the new public open spaces in the City Fringe will help the borough to maintain its overall target of 1.2 ha per 1,000 population.

As a result, a number of new public open spaces have recently been created as part of major developments, including a new public square in the redeveloped Royal London Hospital and Bishops Square near Bishopsgate, proving new public open spaces can be created in the City Fringe with good planning and good design. Likewise, other measures have been identified through the Area Action Plan as part of large-scale development proposals.

<u>Case study: river Don project, Aberdeen</u>

In Aberdeen, there are two rivers that cross the urban fringe area; the river Dee and Don in the south and north respectively. Around the rivers, there are areas of culture and historic importance, while the access to the river for city residents was poor. Therefore local authorities thought to set up a network building (for the areas around the two rivers) in order to involve the inhabitants in all stages of area development. In particular, in the inventory stage inhabitants were invited to participate to the inventory of green space quality (issues like quantity, quality, distribution of different types of open spaces etc.). Also other issues were discussed like, planning, decision making, communication and maintenance. The followed approach allows experts to understand the quality of the open space and to create awareness among inhabitants whereas allow them participate in the process of green space improvement. The next step was to communicate the findings of the set up network with other adjacent municipalities, which eventually was adopted by them (de Vries et al., 2012).

<u>Case study: creating synergy, City of Almelo, the Netherlands</u>

All the business sites of Almelo are located in the fringe areas. Environmental activities improve the quality of the green space on these sites contribute to improved ecological connections between urban and rural areas but also to make those sites more attractive to the workers/employees. Therefore, Almelo municipality brought together all the stakeholders and the decisions makers in order to work on the nature protection and biodiversity issues providing a new environmental value to fringe areas. This group decided to propose measures that can improve the biodiversity of that area and proposed certain measures to companies such as construction of green roofs, nesting facilities etc. and to open spaces (e.g. ecological meadows etc.) (de Vries et al., 2012).

<u>Case study: city of Enschede, Enschede, the Netherlands</u>

In this case study, a 'green' housing development in the urban fringe was promoted in order to make the city more attractive and eventually to attract more tourists. Based on those directions, the Enschede Round was created, which was a cycling/walking track (also published on the website and on a map). Therefore the sustainable management of the fringe area was succeeded to provide an environmental value to the fringe area of the city and to bring together entrepreneurs who developed a combined website to present their activities and services in the area (de Vries et al., 2012).

Applicability

This BEMP is fully applicable by the public administration and there are no technical limitations for its implementation.

Economics

<u>Mayesbrook Park</u>: According to EA (2011), the overall economic benefits of the Mayesbrook Park regeneration are likely to be substantial compared to the planned investment. Assessed over 40 years (and with increase in property values assessed over 100 years), the lifetime benefits of the parkland and river restoration should amount to about £27 million. When compared to the estimated costs of the whole Mayesbrook Park regeneration scheme of just under £4 million (including the river restoration works), this produces a benefit-to-cost ratio of £7 for every £1 invested.

St Helens: The industrial city of St. Helens is located between the cities of Liverpool and Manchester and its population is approximately 100,000 inhabitants. Due to the fact that St. Helens is an industrial city, local authorities wanted to attract more tourism, economy and investments, increasing the quality of life. Therefore an Urban Fringe Action Plan was compiled in 2006, having a special focus on green infrastructure. The two described main points are: i. the Mersey Forest, which for the last ten years has been planting new community woodlands and reclaiming derelict land and ii. the "Countryside In and Around Towns" point, which main aim was to demonstrate how planners can make the most of the open spaces in and around urban areas. The total funding of about £80,000 was secured for the implementation of that urban fringe action plan. Many economic benefits arose from those investments, i.e. the land and property values were increased. The area on the edge of the town, called Bold Moss, transformed into a community woodland. It was reported that the property values in the surrounding area raised by £15 m as a direct result, while the value of new developments estimated approximately £75 m. In the case of the Forest Park was expected to attract over 100,000 new visitors per year and it was predicted that will bring an extra £4 m of investment into the area (Nolan, 2008).

As a general remark, when these economic benefits are put in a relation to the investment cost (assuming they are complete), it becomes clear, that investments in green infrastructure can indeed provide a local government with immediate economic benefits.

Driving forces for implementation

The forces that drive the urban growth are well known and understood. The population growth and household formation result in land use changes by the redistribution of the population. Therefore the careful management of the land use, especially the fringe and abandoned areas, which are located around the metropolitan centre of the cities, must be implemented carefully taking into account the various local environmental parameters e.g. biodiversity etc. Especially at local level, urban ecosystems and urban climate change impacts need to be given more consideration in urban planning.

Reference organisations

- Mayesbrook Park (London borough of Barking and Dagenham)
- Partner cities and organisations in the SURF project (see SURF2012)
- Brixham city has prepared a comprehensive study regarding the incorporation of the nearby fringe areas, which is available online: https://www.torbay.gov.uk/bufmainreport.pdf.

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7 BEST ENVIRONMENTAL MANAGEMENT PRACTICES FOR LOCAL AMBIENT AIR QUALITY

Chapter structure

This chapter covers Strategies to improve Air Quality. It contains a general overview of the specific area, followed by applicable guidelines and a best environmental management practice. Reference literature is provided to supplement the overview given.

Chapter introduction

Human prosperity, health quality and recreational opportunities are contingent on the amenities and resources provided by our environment. The environment supplies common goods and assets that contribute immensely to our daily lives. Environmental Services act to preserve these benefits, and contributes to the sustainable use of scarce resources.

Environmental goods and services are defined by UNCTAD as "those goods and services which measure, prevent, limit or correct environmental damage to water, air and soil as well as problems related to waste, noise and ecosystems and (may) include clean technologies, processes, products and services which reduce environmental risk and minimise pollution and material use depending on a country's level of economic development" (UNCTAD, n.d.).

Economic growth has put a greater strain on environmental resources than ever before. The increase in manufacturing activities coupled with higher consumption rates has resulted in the rapid exploitation of raw materials. Environmental goods and services can play a role in curbing this through promoting more sustainable development.

Today there is an increasing awareness of the importance of preserving these common environmental goods. This increase in environmental awareness, both at public and political level, has led to a huge growth in the number of services designed to protect the environment. Whereas originally environmental services were dictated by basic market needs, such as waste management, increasingly environmental services are a result of the requirements created by environmental legislation, be they at national or European levels. Waste, water and air pollution have received the greatest attention in terms of policy and regulations, as these are the areas in which pollution is most obviously harmful and causes the most salient environmental degradation.

On one hand, clean air is an important prerequisite for good health and quality of life for citizens, making it a high priority for public administrations – especially local authorities. On the other hand, many activities (also contributing to quality of life) connected to modern-life have an impact on air-quality on the local level: all economic sectors as well as citizens mobility choices, to name two examples, are tied to various levels of emission of airborne pollutants.

In order to limit exposure of citizens as well as ecosystems to harmful airborne pollutants, EU-legislation introduced hard immission-limits. Exceedance of the limits carries the obligation of developing and implementing short-term action plans and long-term air-quality-plans. Additionally, the member-states had to introduce systems to monitor the current air-quality and compliance with emmission-limits. The monitoring systems are usually maintained on regional or national level and even the short and long term planning may be done on a regional level. Although – at least in theory – the influence of a local authority on air-quality planning maybe limited, in reality, the planning process will happen in close cooperation with the local authority since the majority of measures has to be implemented on the local level by the local administration.

At the same time, local authorities should work together closely with neighboring authorities: firstly because many air pollutants travel far – so a good air quality planning in the surrounding area is of high interest – and secondly pollution can be the result of the relation of a city to the region, e.g. because people live and work at different places.

Technique portfolio

This chapter focuses on one of the most salient and pressing areas in which environmental services have been put into place: air quality.

In order to improve air quality and reduce pollutants a number of areas can be targetted by PA such as land use planning, transport, energy production and energy efficiency, education of citizens and industrial activities All these aspects are presented in the comprehensive BEMP descrived in this chapter.

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EUROSTAT. (2009). *The environmental goods and services sector*. Available from: http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-RA-09-012/EN/KS-RA-09-012-EN.PDF

7.1 Improving local ambient air quality

Description

Air quality declined markedly in the developed world in the 19th century, as the industrial revolution saw the spread of emission heavy manufacturing factories and power generation plants. As the correlation between air pollution and adverse health consequences has been better understood, national governments and more recently the EU have enacted legislation and policies to ensure minimum levels of air cleanliness are maintained. Policies setting legal limits on the level of emissions permitted by road transport and industrial combustion have resulted in an improvement in air quality and a reduction in pollution-induced health effects. Air quality in Europe still requires improvement however. The major contributors to air pollution are sulphur dioxide (SO_2), nitrogen dioxide (NO_2), particulate matter (PM), carbon monoxide (CO), and ozone (O_3). The burning of fossil fuels (particularly coal and oil) for heating, power and motor vehicles contributes directly to the release of SO_2, NO_2 and CO_2 into the atmosphere.

Pollution levels are determined by the rate of emissions versus the rate of dispersion and removal processes. These processes are governed by meteorological conditions and the geographical location of the city. Pollution levels are governed by local emissions as well as pollution brought in from nearby areas.

To improve air quality, local public administrations should consider all aspects of urban planning including land use planning, transport, industries present, energy production and energy efficiency. Citizens must also be educated as to the effects and importance of air quality and be incentivised to use sustainable transportation practices. In fact, transport is the main sector responsible for air pollution in many cities, therefore, a correct transport policy encouraging public transport and green transport solutions is one fundamental step in solving air pollution issues (see chapter on mobility). Having a structured approach to air quality management, with strong managerial oversight and a detailed, applicable plan is necessary to improve air quality. Air quality goals, both short term and long term, must be set in advance with local authority participation. These goals should be evaluated regularly.

Street cleaning also plays an important role in air pollution abatement. Suspended road dust, caused by studded tyres, road salt and sand used in winter, also have an important impact in lowering air quality in cities. Therefore, improving street cleaning can contribute to better air quality. Moreover, for example, in Stockholm measures to reduce non tail-pipe emissions have included banning the use of private cars with studded tires in some streets to reduce road wear. The road material is also important - as the harder it is, the lower the emissions (but this results in more noise than soft asphalt).

Achieved environmental benefits

Lowering levels of air pollution reduces the levels of sulphur dioxide (SO_2), nitrogen dioxide (NO_2), particulate matter (PM), carbon monoxide (CO), and ozone (O_3) in atmosphere. This has also a great benefit on biodiversity since this is also affected by air pollution. In fact, air pollution leads to higher nitrogen deposits within soil, which has the capacity to disrupt the biological processes of plants. Nitrogen is absorbed by the roots and transported to the leaves, which results in reduced growth, yellowing of the leaves and in the case of some plant species, death. If substances build up in the tissue of vegetation they can also affect the health of wildlife that consume the vegetation.[67] There is evidence to suggest that nitrogen deposits resulting from air pollution have reduced the diversity of plant species in Europe.[68]

[67] http://environment.alberta.ca/02235.html

[68] http://jncc.defra.gov.uk/page-1426

Appropriate environmental indicators

Appropirate environmental indicators for air quality are reported in the table below.

Table 7-1: Appropriate environmental indicator for air quality

Name	Unit	Notes
PM10 daily and annual average concentrations	$\mu g/m^3$	In case these concentrations have been registered in more monitoring stations, the value reported could be referred to: - average value of all monitoring stations; - worst value of all monitoring stations.
PM2.5 daily and annual average concentrations	$\mu g/m^3$	In case these concentrations have been registered in more monitoring stations, the value reported could be referred to: - average value of all monitoring stations; - worst value of all monitoring stations.
NO_2 daily and annual average concentrations	$\mu g/m^3$	In case these concentrations have been registered in more monitoring stations, the value reported could be referred to: - average value of all monitoring stations; - worst value of all monitoring stations.
O_3 daily and annual concentrations	$\mu g/m^3$	In case these concentrations have been registered in more monitoring stations, the value reported could be referred to: - average value of all monitoring stations; - worst value of all monitoring stations.
SO_2 daily and annual concentrations	$\mu g/m^3$	In case these concentrations have been registered in more monitoring stations, the value reported could be referred to: - average value of all monitoring stations; - worst value of all monitoring stations.

Operational data

City Example: Air quality improvement in Helsinki, Finland

The city of Helsinki is enacting measures to improve its already impressive air quality standards. The city has drawn up an air protection action plan for 2008–2016, outlining long term measures, goals, and evaluation methods to further lower emissions and pollutants. The plan was approved by the city council in May 2008.

The vision for 2016 is to permanently improve air quality and lessen the negative impacts of pollutants on residents' health, thereby improving living conditions.

Helsinki's plan contains 43 measures, which focus on land use planning and transport, street dust, fine particles, research and communication. It includes measures designed to reduce levels of nitrogen dioxide (NO_2) and focuses on significantly reducing fine particles (PM_{10}), due to the associated health risks. It also includes a separate communication plan aimed at providing the public with air quality information and recommendations on how to reduce emissions and avoid exposure.

Under national legislation the creation of the action plan was mandatory. The Government Decree on Air Quality states that if the limit value for any emission or pollutant is exceeded (as set by the decree), the local authority must create an air quality action plan to rectify the situation. In Helsinki the limit value for NO_2 is exceeded in the city centre, as a result of traffic exhaust emissions (it is generally exceeded along busy roads and in downtown Helsinki).

The Helsinki Metropolitan Area Council (now HSY Helsinki Region Environmental Services Authority) has simultaneously prepared an air protection action plan for the entire metropolitan area, which contains background data along with measures for which the HSY is responsible. The cities of Espoo, Vantaa and Kauniainen have also prepared their own action plans.

In recent years the city's air quality has improved greatly and today it is high by international standards. This is thanks partly to the sustainable district heating system, which has resulted in the reduction of smoke stacks, and thanks to falling emissions from buildings, industry and electricity production. Small scale wood burning does however remain the cause of local air quality issues.

Figure 7-1 reports the "Air Quality Index". The colour coded index is based on health impacts, limit values and guidelines for air quality. When air quality is poor, health impacts are possible on sensitive individuals.[69]

Table: Air quality classes and the connection between health impacts

Class	Health impacts	Other long-term impacts
Very poor	Adverse effects possible on sensitive subpopulation	Clear impacts on vegetation, material impacts
Poor	Adverse effects possible on sensitive individuals	Clear impacts on vegetation, material impacts
Fair	Unlikely effects	Clear impacts on vegetation, material impacts
Satisfactory	Very unlikely effects	Mild environmental impacts
Good	No health effects	Mild environmental impacts

Figure 7-1: Air quality classes and the connection between health impacts. Source: HSY

In Figure 7-2 the quality readings are based on the index value that most harms air quality. Therefore if one of the indices is in the range of poor whilst the rest are in the range of satisfactory, the index will be shown as poor regardless of other values:

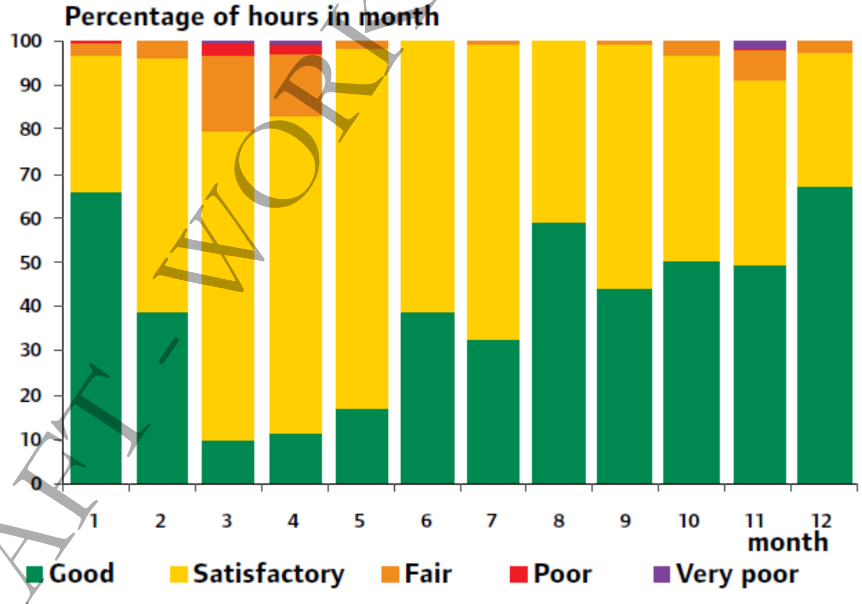
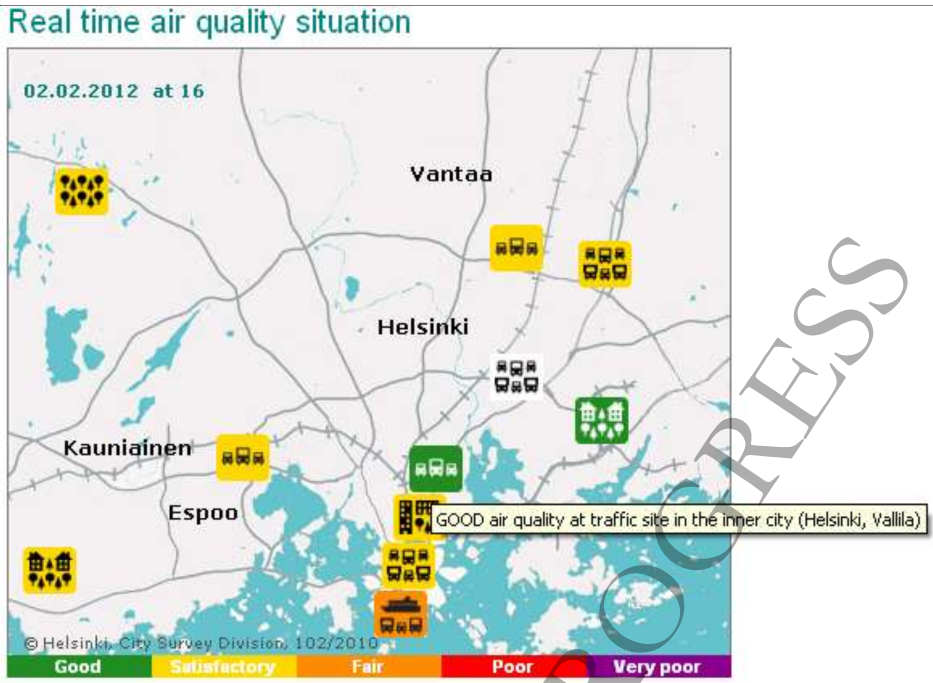


Figure 7-2 Helsinki air quality by month. Source: YTV

Figure 7-3: Real time air quality situation map for Helsinki, Finland. Source: HSY

Local authorities monitor the quality of ambient air at eleven sites, plus two sites for the Region

[69] http://www.hsy.fi/seututieto/ilmanlaatu/suunnittelijat/Sivut/asematkartalla.aspx



of Uusimaa, which are considered representative of other similar environments. The results of these stations are updated every hour to the HSY website, available for the public to view (figure 3.33). Seven are in permanent locations, whilst four move yearly. The measurements are used in studying the impacts of traffic and energy production on air quality, and in assessing air quality in residential areas and background areas (YTV, 2007).

The results of these measurements are available through an interactive online map that shows the results in real time. Users can click into the icons for more detailed information, including a graphical representation of the level of each pollutant, and the number of times a pollutant has exceeded the limit value at the monitoring site.

Users can also view a Google maps overview of each monitoring device throughout the city. The map, presented in **Figure 7-4**, provides information at each site in which air quality has been measured in the city historically. It shows past annual measurements, how busy the environment is on average and traffic volume.

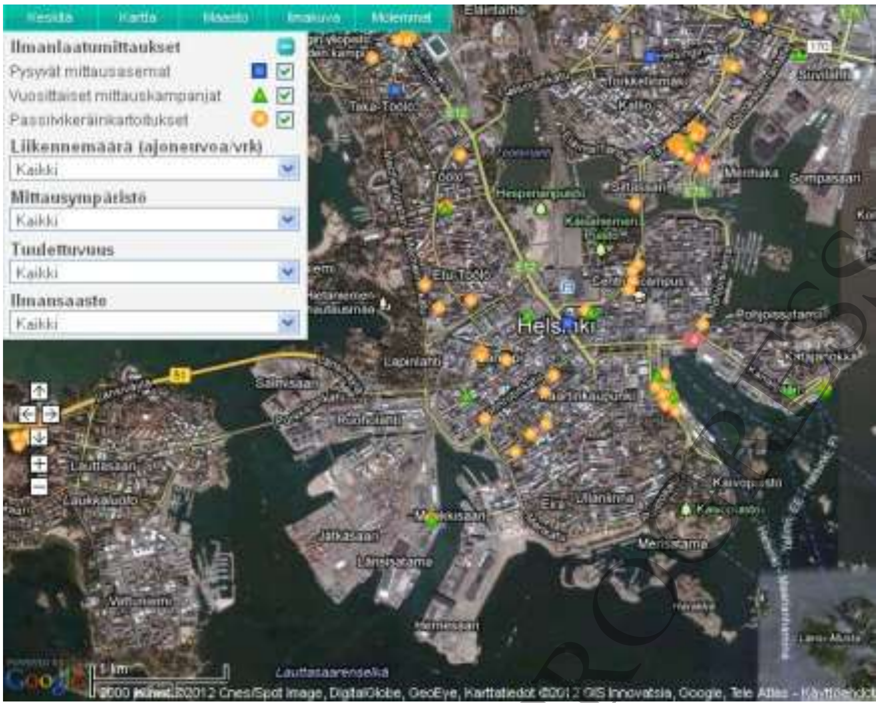


Figure 7-4: Google map of air quality in Helsinki, Finland. Source: Google

To deal with a sudden decrease in air quality the city has created an air quality readiness plan. The plan covers three different types of episodes which would cause quality to suddenly change - an increase of nitrogen dioxide concentrations as a consequence of traffic emissions, a rise in street dust concentrations, or a high amount of smoke coming from a large terrain or building fire.[70]

Long range emissions are a major source of particles for Helsinki. Wildfires in Russia and other parts of Europe can contribute to the level of PM_{10} increasing greatly. As much as over half of the average particle concentrations in the metropolitan area are caused by the long range transport of particles from other countries. During a long range transportation episode visibility may be reduced and smoke may be detected in the air (City of Helsinki , 2010).

If it seems likely that air quality will deteriorate to the level that the air quality readiness plan is activated, information is sent automatically to the public from the city's health departments, HYT and the Helsinki Environment Centre. Citizens are warned prior to the air quality deteriorating. This health and safety information is broadcast online and through traditional media.

The air protection action plan is separated into seven sections. For each measure an objective, a respondent and impacts have been specified. In evaluating effectiveness, consideration has been given to air quality and other environmental impacts, costs, timeframes and feasibility. The National Public Health Institute has also evaluated the health impacts of the action plan:

1. General measures - includes international and national measures that Helsinki is helping to promote and implement. Helsinki will serve as a pioneer and exemplar in introducing measures. It is hoped their good example will motivate other countries to follow. The measure will influence taxation and legislation, influence international decision making through lobbying organisations and networks, encourage other countries to reduce particulates that can be dispersed over long distances, serve as an example for other countries and promote the

[70] http://www.hel.fi/wps/portal/Ymparistokeskus_en/Artikkeli?WCM_GLOBAL_CONTEXT=/Ymk/en/Customer+Service/Publications/Publications/Publication_11_07_summary

implementation and development of public transport projects.

Measures

1. Influence taxation and legislation
2. Influence international decision-making through lobbying organisations and networks
3. Encourage other countries to reduce particulates that can be dispersed over long distances
4. Serve as an example
5. Promote the implementation and development of public transport projects

2. Land use planning and transport – In Helsinki motor vehicles are the primary threat to air quality, with the number of cars quadrupling in the Helsinki metropolitan area since the middle of the 1960s. Diesel cars were previously promoted in the city, as their CO_2 emissions are significantly lower than petrol vehicles. This resulted in the number of diesel cars on the streets increasing. However, whilst diesel cars are lower in its emissions of CO_2, they are far higher in emissions of pollutants. The introduction of more and more diesel cars had the negative consequence of increasing levels of NO_2 in the atmosphere rapidly.

City planners intend to tackle the air pollution caused by private vehicles through emphasising air quality requirements in city land use planning, particularly people's exposure to pollutants. Public transport use will be increased and cross-city lines developed, as this is where traffic is currently heaviest and thus air pollution most severe. Incentives to purchase low-emission vehicles and congestion charges are also being used.

An online journey planner was created by the Helsinki municipality, providing users with information on the best public transport options to reach their stated destination. The planner shows the times and cost of different public transport methods available, combining methods within the same journey where necessary. It also provides a map, displaying stops and journey routes, and the overall CO_2 emissions of the journey. Park and ride information is also provided, as well as a price calculator, allowing potential travellers to predict the cost of their public transport use over a period of time. Helsinki was one of the first municipalities in Europe to enact such a planner. The main aims of the planner are to reduce congestion, enhance public health and protect the environment.

To make inter-modal public transport easier and more accessible, Helsinki has introduced an integrated ticket system. HSL's tickets are valid on buses, trams, the Metro, commuter trains and Suomenlinna ferry. It is possible to transfer from one vehicle to another with the same ticket.

The city has also set up so-called "environmental zones", which only low-emission buses and waste trucks may enter. Incentives for the purchase of low-emission vehicles are being introduced, such as reduced parking fees in the city centre.

Pedestrian zones are being developed and cycling and walking encouraged. The city is also looking into offering large companies direct mobility services.

The action plan also contains measures aimed at reducing ship emissions.

Measures

1. Take air quality requirements into consideration in land use planning
2. Make public transport more attractive
3. Develop cross-city lines
4. Promote low emissions
5. Study possibilities to establish a low-emission zone
6. Study and introduce traffic management and pricing mechanisms suitable for Helsinki
7. Develop possibilities to use public transport for leisure travel
8. Offer businesses advice on sustainable transport
9. Prepare transport plans

10. Collect information on emissions from small-scale water traffic and work machines
11. Reduce ship emissions
12. Introduce environmentally-based harbour and fairway charges
13. Develop the evaluation of emissions from harbour activities and their impacts on air quality

3. Street Dust – The city is addressing this by shifting the clearing of snow and the responsibility of street cleaning to a single actor, and improving the efficacy of street dust reducing machinery. The planning and construction of streets will also take into account concerns over street dust.

In Helsinki, the high level of dust that occurs in springtime due to melting snow is problematic for the city – at these times the levels of particulate matter may be elevated for weeks. The dust comes from grit accumulated in snow banks and on road sides during the winter, from the wearing down of tires and asphalt, and from exhaust gas particles (YTY, 2010). The action plan addresses this problem, outlining measures such as sprinkling the streets with saline solution.

Street cleaning is used to remove material from street surfaces that could potentially lower air quality. Larger sized loose material can be efficiently removed by street cleaning, but efficacy drops when attempting to clean smaller pieces of debris (conventional street cleaning equipment is not suited to removing PM_{10} sized dust particles). Attention has shifted to suction sweeping and pressurised washing from brushing, as the former is more effective. Pressurised washing was proven to reduce PM_{10} levels by 15 – 60%, compared to washing. It was also observed that when gritting streets, using salt rather than sand contributes to lowering atmospheric particulates.

If dust levels are forecast to be high for a number of days, the city will advise the Public Works Department and the Uusimaa Road Administration to engage in street cleaning and binding (see below). The presence of construction sites within a city can play a sizeable role in influencing dust levels, particularly during summer when dust levels from other sources are low.

In order to combat street dust, Helsinki has come up with a method to bind it, keeping it at road surface level rather than being circulated into the air by vehicles. The process involves adding dust binding agents to water, such as calcium chloride ($CaCl_2$), magnesium chloride ($MgCl_2$) and calcium magnesium acetate (CMA). These dust binding agents also lower the freezing point of the liquid. Water can be used as a dust binding agent but is ineffective as it soon evaporates.

For dust binding to be effective, treatment must be repeated frequently and cover large areas (after treatment dust levels tend to return after four to five days). Dust binding is not a total solution however as the dust itself is not removed.

Measures

1. Manage street cleaning as a whole
2. Participate in research aimed at reducing street dust
3. Study and introduce means to reduce the use of studs on winter tyres
4. Consider street maintenance requirements in planning
5. Consider dust properties in street construction
6. Reduce dust from building sites and street construction
7. Improve the quality of the machinery used in reducing street dust
8. Improve the quality of sand used to prevent icing
9. Develop the use of salt to prevent icing
10. Develop dust binding in episodes
11. Increase snow removal particularly near roads
12. Speed up street cleaning in the spring and start sooner
13. Develop work quality and quality assurance

4. Energy production – Energy production emissions are strictly regulated, so the action plan does not add anything to this field. Furthermore emissions from energy production have practically no impact on the city's air quality thanks to high smokestacks.

5. Particulates - Small-scale wood burning significantly affects local air quality. However, using good, dry wood and the right burning technique considerably reduces emissions. The action plan supports and encourages the adoption of low-emission heating systems. Provisions concerning small-scale wood burning will be added to the city's environmental protection and waste management ordinances.

Measures
1. Encourage the use of low-emission heating systems
2. Add provisions concerning small-scale wood burning to the city's environmental protection and waste management ordinances
3. Participate in research concerning particulates

6. Research – Research will be conducted into efficient measures to reduce air pollutants. Research action plans include:

Land use planning and traffic:
- Study of possibilities to establish a low-emission zone
- Study of traffic management and pricing mechanisms suitable for Helsinki
- Study of possibilities to offer businesses advice on sustainable transport
- Collection of information on emissions from small-scale water traffic and work machines

Street dust:
- Commissioning of research on reducing street dust

Communications and education:
- Planning of a mobility management centre in connection with the proposed ecoefficiency service centre (if established)

7. Communications and education – The plan aims to increase residents' environmental and air quality awareness through theme days, brochures and education. It is hoped that residents themselves will adapt their behaviour to improve air quality in ways such as adopting an economical driving style, using public transport and so on. Schools will also encourage pupils to walk, bike and use public transport.

Measures
1. Increase information on street cleaning for different target groups: residents, properties, real estate companies
2. Plan a mobility management centre in connection with the proposed eco-efficiency service centre (if established)
3. Increase campaigns to promote public transport and include information on air quality in them
4. Provide information on recommendations concerning small-scale wood burning
5. Reduce idling
6. Arrange education on driving economically
7. Develop inter-city cooperation in environmental education
8. Increase residents' air quality awareness and promote sustainable transport options

It is imperative that citizens are informed regarding air quality and are advised on a course of action in the case of a sudden deterioration in quality. In it’s air quality readiness plan, Helsinki states: “Communication is a fundamental element of the actions in all episodic situations. During situations of air pollution, the behaviour of the city residents is guided by means of the information and recommendations, which they are made aware of through the actions of the authorities.”

Applicability

In many cities, the main challenge to clean air is the amount of traffic on the city streets. In this sense mobility management and air quality improvement are extremely linked (See chapter on mobility). Measures for improving air quality can be implemented by all public administrations at different levels and targeting specific local issues.

Driving force for implementation

Cities are by definition interested in enhancing the quality of life of their citizens, and offering them a pleasant environment to live in. Cities also have the highest concentration of air pollution; therefore it is important that local and governmental authorities play an active role in improving air quality standards, as individual citizens are incapable of changing the air quality situation unaided. Better air quality also has benefits in terms of reduced strain on health care infrastructure. The urban area is also made a more attractive place in which to live and work.

Economics

"Air pollution is one of the most serious environmental problems in urban areas around the world. The rapid process of urbanization and extensive energy utilization (mostly due to rapid economic expansion and population growth over the past few decades) has made urban air pollution a growing problem. The air contains varying levels of pollutants originating from motor vehicles, industry, housing, and commercial sources. The effects of air pollution have multifaceted consequences for human welfare. […] Notably, numerous studies have shown that air pollution adversely affects human health. Epidemiological evidence supports an association between exposure to ambient air pollutants and various health effects, such as respiratory symptoms or illness (e.g. asthma), impaired cardiopulmonary function, reduction of lung function, and premature mortality. In particular, the most serious health impacts include a significant reduction in life expectancy, and premature death, both of which are strongly linked to exposure to PM. Although exposure to air pollution damages the health of everyone, numerous studies have shown that certain groups of vulnerable people (e.g. elderly people, children, and those with underlying disease) are at greater risk of being affected by air pollutants" (Retrieved from: Pervin, 2008). This represents a heavy cost for national health systems providing care. It is therefore in the best interest of public administration to reduce diseases created by air pollution. As cities are the centre of economic output, the societal costs of developed countries is estimated to be 2% of the Gross Domestic Product. The ailments caused by poor air quality may also lead to a correlative loss in productivity (Hester, 2009).

Reference Public Administrations

There are numerous publications on air quality in Helsinki published online, providing an in-depth look at the city's commitment to clean air. Documents include:

- Air quality in the Helsinki metropolitan area: http://www.hsy.fi/seututieto/Documents/Ilmanlaatu_esitteet/air_we_breathe.pdf

- Environmental Sustainability Issues and Challenges in Helsinki 2010: http://www.hel.fi/wps/wcm/connect/7d593d004298169a9779bf4b956b8a55/Environmental+Sustainability+-esite_nettiin.pdf?MOD=AJPERES&lmod=-918449852&CACHEID=7d593d004298169a9779bf4b956b8a55

- City of Helsinki Air Quality Action plan for the Period 2008-2016 Abridgement: http://www.hel2.fi/ymk/Ilmansuojeluohjelma/summary.pdf

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8 BEST ENVIRONNEMENTAL MANAGEMENT PRACTICES FOR NOISE POLLUTION

Chapter structure

This chapter is dedicated to strategies to reduce noise pollution. It contains a general overview of the specific area, followed by a BEMP on monitoring and reducing noise pollution.

Chapter introduction

Excessive noise harms the environment, lowers the quality of life and it is negative to our health. Noise interferes with business activities as well as human leisure time and disrupts sleeping patterns. Prolonged exposure to noise can alter social behaviour, causing irritability.
According to the European Environment Agency, noise (defined as all unwanted sound that is loud, unpleasant or unexpected) above 60 Ldn dB(A)[71] constitutes noise pollution. Around 67 million people in Europe suffers from traffic noise levels (EEA, 2007).
In the past, noise was considered merely an unfortunate by-product of technological progress and therefore it was accorded a lower priority than other environmental concerns such as air or water protection. However, as the adverse health effects of excessive noise exposure were better quantified, the issue has gained attention.

Technique portfolio

This chapter focuses on a very important area in environmental management: noise pollution.

In this chapter, a best practice for firstly monitoring and then reducing noise pollution, in order to reduce its negative environmental and health effects is presented. This BEMP can be implemented as stand alone measures, or together with BEMPs addressing other environmental areas or services, depending on the capacity of the public authority.

References

European Environment Agency (2014). Exposure to and annoyance by traffic noise (TERM 005) - Assessment published Dec 2014. Available at: http://www.eea.europa.eu/data-and-maps/indicators/exposure-to-and-annoyance-by-1/assessment

[71] Ldn is an indicator based on an average annual 24 hour period, calculated from the average A-weighted sound pressure levels throughout the day (A –weighting is an adjustment that takes account of the way human ears hear different frequencies). The measurement encompasses three separate periods, day, evening and night, and reflects the differing sensitivity to noise during these periods. 5db is added to evening measurements and 10db is added to night measurements.

8.1 Monitoring, mapping and reducing noise pollution

Description

The first step public administrations have to take is to draw up "strategic noise maps" for major roads, railways, airports and agglomerations, using harmonised noise indicators to monitor noise pollution. These maps present in detail noise levels in the different sectors throughout the urban area, and are used to pinpoint areas in which noise reduction activities are necessary. Noise maps show the noise on an average day in an average year. Environmental Protection UK summarises the purpose of strategic noise maps as (Environmental Protection UK, 2012):

- To enable the assessment of the exposure of population to noise – by linking population data to the noise levels on the maps;
- To assist in the identification of areas that have good environmental noise quality ('quiet areas');
- To inform the development of action plans to manage the exposure of populations to noise; including reduction if necessary, and, in urban areas, prevent locations of existing quiet from becoming noisy;
- To raise public awareness and engage everyone affected in the development of noise action plans.

The main indicator used to describe the noise levels on the maps is Lden, expressed in A-weighted decibels - dB(A).

The second step is that public administrations inform the public about the effects of noise pollution through an effective communications campaign.

The final step is that public administrations create noise action plans to reduce local noise levels and maintain environmental noise quality where it is good, based on the results of the noise map. Noise action plans create a blueprint for the management of environmental noise and its effects. Figure 3.20 from the SILENCE project outlines the steps involved in creating an effective noise plan:

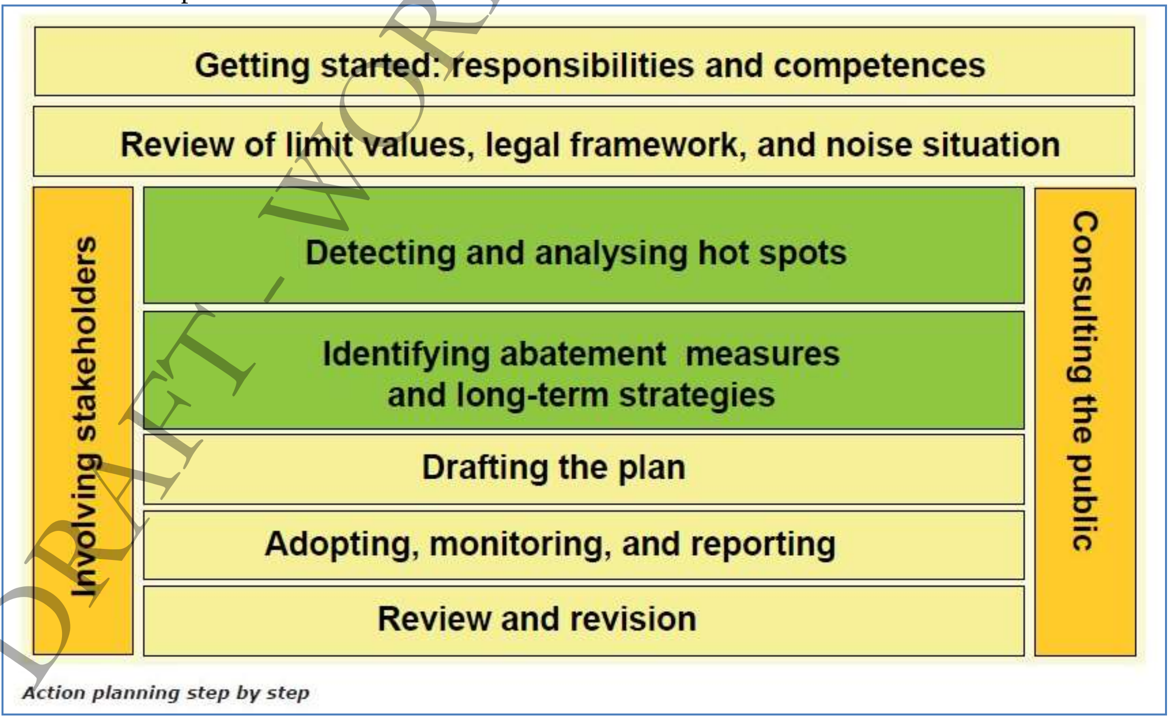

Figure 8-1: Noise planning, step by step. Source: Kloth et. al, n.d..

Effective measures to reduce noise in cities are the following (Kloth et al., n.d.):

- Noise screens and tunnels

- Low noise road surfaces
- Building insulation
- Low-noise trams
- Renewal of public transport fleet
- Low-noise waste collection vehicles
- Redesign of street space
- Reducing traffic volume
- Bans on trucks

Achieved environmental benefits

Reducing noise in cities has mainly benefits on human well-being. However, biodiversity is also affected by noise pollution and it alters the their natural behaviours. Animals that evolved with hearing sensitive enough for the quietest conditions are now having their usual habitats disrupted by man made noise. Animals such as bats are refusing to hunt in noisy areas, whilst frogs and bird species are unable to communicate for reproductive means due to noise (WHO, 2012).

Appropriate environmental indicators

Appropriate environmental indicators for monitoring noise pollution are presented in the table below.

Table 8-1: Appropriate environmental indicator – Noise

Name	Unit of measure	Description
Complaints about noise pollution	Number	Complaints about noise pollution received by the local administration in a year.
Noise levels exceeding local limit values	%- n. measurement of noise exceedings/ n. total measurements	Measurement of noise levels exceeding the limit values set by the local acoustic mapping.
People exposed to noise levels exceeding local limit values	%- people exposed to noise exceeding /total population	People exposed to noise levels exceeding local limit values set by the local acoustic mapping.
People exposed to daily noise levels	% - people exposed to noise during day, evening and night/ total population	Number and percentage of people exposed to noise levels measured outdoors during day, evening and night (Lden). From the broad overview of the limit values in a large number of Countries, and from the scientific evidence, there seems to be a consensus that Lden around 50-55 dB (or the equivalent level in other units) would represent a good noise quality in an urban area. Data can be disaggregated by traffic source: road, rail, industry, air.
People exposed to night noise levels affecting health	% - people exposed to noise during the night/ total population	Number and percentage of people exposed to noise levels measured outdoors during the night (Lnight): > 40 dB(A) - health-based limit value (set by WHO) which is necessary to protect the most vulnerable groups such as children, the chronically ill and the elderly. > 55 dB (A) - interim target

		recommended in for exceptional local situations where the achievement of 40 dB (A) is not feasible in the short run. Data can be disaggregated by traffic source: road, rail, industry, air.

Operational data

The city of Stockholm utilises the a noise map to identify buildings most affected by noise pollution, and calculate the number of residents affected and the cost of protective actions. This also takes into account the number of windows and maximum noise level for each building. Over 10,000 buildings have been identified as sites for noise reduction measures.

In addition, Stockholm is erecting noise barriers (around 50km have been built), improving building window insulation along road ways, putting restrictions in place on heavy goods traffic on city streets at night, reducing the speed limit from 50km/h to 30km/h, creating environmental zones and placing a ban on vehicles older than eight years from travelling in the city centre. Noise issues are taken into account when designing and locating houses and in traffic planning. As part of the "Traffic noise and planning" project, the City of Stockholm cooperated with other actors to develop guidelines regarding the design of buildings that achieve a good acoustic environment. The city is also testing and developing quiet road surfaces. The city has set up two permanent noise monitoring stations that measure noise levels 24 hours a day (Axelsson, 2011).

In Leeds, United Kingdom, the city has implemented traffic calming measures to combat both noise and air pollution. According to the city: "[The scheme keeps] the balance in favour of the residential function of the street and [reduces] the domination of motor vehicles". Speed humps, chicanes, road narrowing, planting and other measures were introduced to both physically and visually reinforce the message that the motorist is only a guest in the area and that the residential function takes priority. One problem the scheme has faced is that slowing cars require a great deal of deceleration followed by acceleration, which can add to noise levels. The scheme is therefore hoping to incorporate measures that allow for the constant use of 3rd gear. According to the report, where speeds have been reduced from 50km/h to 30km/h, typical reductions in noise levels have been between 4-5 dBA. (Harvey, n.d.) It was also shown that granite roadways result in noise levels between 3-5 dBA higher than smooth asphalt, even if restricted to a small area of carriageway.

City example: Noise reduction in Oslo, Norway

Over the last number of years the city of Oslo has introduced substantive measures to reduce noise pollution, particularly in the field of transportation. The city is committed to noise reduction and has set the goal to reduce the noise impact by 10% by 2020 compared to 1999.

One of the major sources of noise in Oslo is road traffic. Road traffic is an increasing problem for the city, which intensifies during the winter months. About 1.3 million people are exposed to road traffic noise levels exceeding 55 dBA outside their homes in Norway ("Road traffic noise", 2008).

In order to address this, the city has introduced a number of measures aimed at private vehicles. The city has lower speed limits and introduced a charge for studded tyres (studded tyres can cause greater wear and tear on roads, which increases noise emissions). Road surfaces are renewed regularly by the city, as newer road surfaces produce less noise. The "**Project Environmental friendly pavements",** which ran from 2004-2008, conducted research on optimising the environmental properties of road surfaces in order to reduce the environmental impact on surroundings, including noise pollution ("Road traffic noise", 2008). Trial areas for quiet road strips have also been established. In a further effort to reduce transport noise, the city is building tunnels for road traffic, mitigating noise pollution in the surrounding areas. Figure

8-2 depicts a noise map of the city for road and rail traffic.

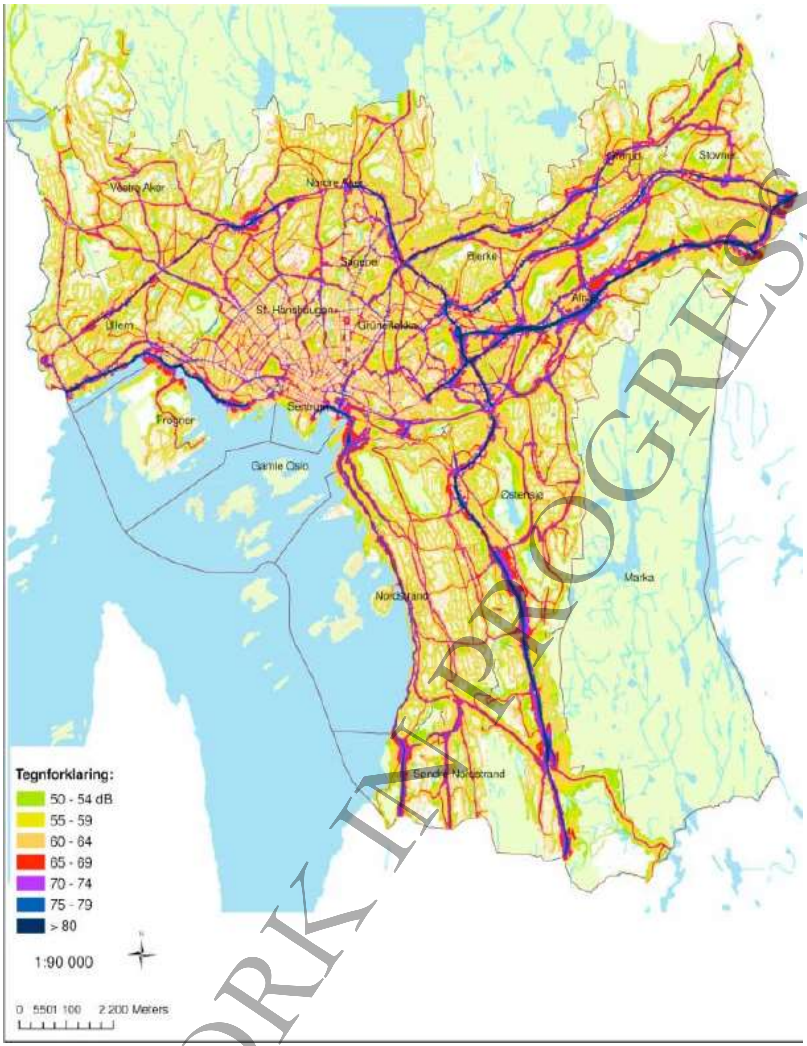

Figure 8-2: Noise map for road and rail traffic in Oslo, 2006. Source: Oslo Kommune, 2008

As well as improving public transport and encouraging behavioural change, the city is also implementing direct noise reduction measures, such as noise screens along roadways. Subsidies are granted from the city to citizens for the purposes of insulating and soundproofing their property.

Rail and transportation also represents a major source of noise for the city. The city employs a holistic approach to reducing rail traffic noise, focusing on direct measures such as erecting noise screens to limit noise exposure along the tracks, and measures to address the noise at source, such as increased maintenance of tracks and stations to reduce squealing and rolling noises. Authorities identify problem areas and carry out track grinding and lubrication. The city is also replacing older trains with newer, quieter trains. The tracks themselves are being upgraded, as are foundations in order to reduce vibrations.

By the nature of activities conducted within them, ports generate high noise levels. To address this, the Port of Oslo participates in the Noise Management in European Ports (NoMEPorts) project. The main objective of NoMEPorts is the reduction of noise, noise-related annoyance and health problems of people living around port industrial areas through a noise mapping and management system (Port of Oslo, n.d.). The handling of goods containers (and the equipment used in handling) can lead to noise emissions far exceeding EU regulation levels. To address this the city has provided engine insulation, and has started a process to procure vehicles with more silent engines. Silent-working cranes have replaced traditional forklifts.

Increased care has been placed on the handling of empty containers, which can generate large amounts of noise when moved. Empty containers have also been stacked in walls close to built up areas and used as sound barriers. To reduce excess vibrations, the port terminal area has been completely asphalted. Vegetation zones and noise screens have also been established in the terminal area.

Additional measures carried out by the port authorities are summarised as (Port of Oslo, n.d.):

- Development of a programme simulating noise effects
- Replacement of forklifts and reach-stackers with gantry cranes with rubber tyres
- Substitution of diesel engines with electric power
- Reduction of noise from warning bells
- Insulation of our machinery room
- Installation of rubber bricks on trailer trucks preventing sharp noise
- The terminal ground has been asphalted in order to level the surface.
- Establishment of a noise deflection wall

Although these measures have contributed to noise reduction, port neighbours are still subjected to noise levels above EU limits. The port authorities are committed to improving this situation and are constantly revising and improving their noise reduction measures. One such measure is the increased centralization of port activities, making it easier to contain and reduce noise. Electricity is to be provided for docked ships at Oslo port, in order to prevent emissions and prevent noise pollution from ship engines.

After reviewing the noise-map, the city has identified areas suitable for designation as so-called quiet areas. A quiet area is defined by the city as: "Areas which offer recreation, outdoor experiences and/or cultural activities in surroundings sheltered from or distant from dominant noise sources". These areas preferably have noise levels below 50dB and are protected through traffic management, noise screening and regulation of industrial activities.

Source: Oslo Kommune (2008, December 5)

City example: Westminster, United Kingdom

Westminster's sound environment is complex and noise is a serious issue. In 2008-2009 the council received 19,026 noise service requests. Compared to outer London and the rest of the UK it is relatively noisy in Westminster and the quieter night time period is short. Noise levels at the rear of properties tend to be significantly lower than at the front of properties.

Average noise levels in Westminster are 62 decibels (dB) LAeq in the day (07:00 – 19:00 hrs) and 55.7dB LAeq in the night (23:00 – 07:00 hrs). This is significantly higher than in outer London and in common with most urban areas.

Road traffic is the main source of noise in Westminster, and it is the biggest cause for concern amongst residents. Thirty-seven percent (37%) of residents questioned said that road traffic noise had bothered them in the last 12 months. Other major sources of noise include construction work, roadworks, neighbours, commercial premises, air conditioning units and aircraft. Figure 3.25 presents a noise map of Westminster.

Figure 8-3: Westminster, London noise map.

In response to concerns about noise, Westminster City Partnership (WCP) made a commitment to tackle noise pollution. WCP produced the Westminster City Plan 2006-2016 (Sustainable Community Strategy) which sets out a vision for Westminster's future and highlights this commitment to take action to reduce noise and protect noise sensitive and quieter areas. To enable this, the council decided to produce Westminster's first Noise Strategy, and has:
• Carried out research on the city's sound environment
• Established a panel of noise experts to provide advice on the strategy
• Consulted with the public on the scope and detail of the noise strategy, this included formal consultation on a Noise Issues and Options Report, 2008 and formal consultation on draft of this noise strategy in summer 2009.
The aim of the Westminster Noise Strategy is to contribute to improving the health and wellbeing of Westminster's residents, workers and visitors by reducing noise pollution and enhancing the city's sound environment.
Minimising noise impacts is complicated by the large number of different noise sources, where they are and when they cause a problem. Noise sensitive developments are often in close proximity to noise generating developments. These challenges to developing comprehensive noise strategies are further complicated by the number of different organisations with noise management responsibilities and powers.
Councils have limited powers in relation to many noise sources, but Westminster City Council has taken action to reduce noise pollution and its impacts in many ways. This has included:

• A 24 hour, year round reactive Noise Team service which deals with noisy neighbours, building sites, plant noise, burglar alarms, noisy licensed premises and a host of other environmental problems
• The introduction in 2008 of a proactive noise service which tackles the most longstanding and difficult to resolve problems
• Developing strong noise policies, in consultation with the community, as part of the council's Unitary Development Plan and Statement of Licensing Policy
• Applying a Code of Construction Practice to minimise environmental impact during construction of major projects
• Investing in infrastructure to support quieter transport modes – such as electric car re-charging points
• Working with entertainment venues to assess their noise impact and ensure preventative solutions are implemented
• Acoustic monitoring, data collection and analysis to gain evidence for use in enforcement

related to planning and licensing matters
• Setting noise limits on outdoor concerts and events and monitoring these for compliance
• Taking action to minimise noise from the council's own waste collection services and street cleansing services including:

- glass recycling bank collections are restricted to 07:00 – 22:00 hrs and in parts of Soho with higher numbers of residents 08:00 – 22:00 hrs
- using quieter plastic tipped shovels
- restricting the hours of mechanical sweepers
- implementing an eco driver training system which also has noise reduction benefits.

The strategy has been informed by several research studies on the city's noise environment, a review of relevant policies and legislation and results of consultation on the Noise Issues and Options Report, 2007 and the draft Noise Strategy, 2009. The strategy is shaped by four key objectives:

• Reducing noise levels
• Reducing noise incidents
• Minimising the impact of noise on noise sensitive developments
• Protecting and creating tranquil areas and sounds with positive associations.

There are four noise policies designed to help achieve these:

1. Noise conscious city management, planning and licensing
2. Reducing transport and servicing noise and impacts
3. Integrated noise management and enforcement
4. Tranquil areas and positive sounds.

The strategy also includes a series of short, medium and long-term actions that have been developed to bring about improvements in the council's operations and to facilitate lobbying and engagement with external organisations.

Source: City of Westminster, Westminster Noise Strategy 2010 – 2015, available from http://www.westminster.gov.uk/workspace/assets/publications/Final-Westminster-Noise-Strategy-1269269299.pdf

One of the newest and most innovative measures to address noise pollution is the practice of "soundscaping". Soundscaping is a concept in which architecture is constructed not just on aesthetic and functional principles, but also taking into account acoustic qualities. Soundscaping, in short, is the acoustic design of outdoor space.
Soundscaping is not necessarily about achieving silence, it is about achieving sounds that are congruent with the landscape, giving greater preference to the sounds people prefer. Soundscaping allows authorities to reimagine the sounds of a modern city, making sound a considered resource.
The difference between the approach of traditional noise abatement and soundscaping is summarized in

Table **8-2**:

Table 8-2: Comparison of noise control and soundscape approaches.

Noise Control Approach	Soundscape Approach
– Sound as waste	– Sound as resource
– Concerns sound of discomfort	– Concerns sounds of preference
– Human response related to level of sound	– Preference often unrelated to level—quiet not the objective
– Measures by integrating across all sound sources	– Requires differentiation between sound sources: wanted sound from unwanted sound
– Manages by reducing level	– Manages by 'wanted sounds' masking 'un-wanted sounds'

A soundscape design requires input from a wide range of stakeholders including local authorities, architects, developers, consultants, local inhabitants, and so forth. Figure 3.24 illustrates the design process of soundscaping:

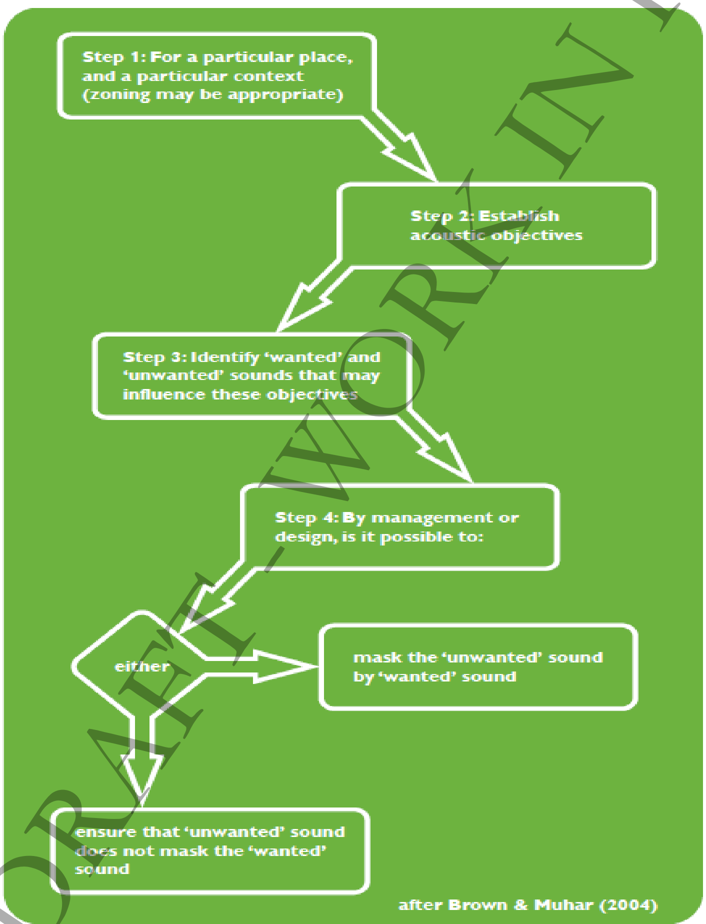

Figure 8-4: Design process of soundscaping. Source: Brown & Muhar, 2004

Applicability

A holistic approach to noise reduction that includes noise mitigation activities as part of achieving wider environmental goals is an excellent way to achieve reduction in noise pollution.

Depending on the local situation, Pubic Administrations can choose the most appropriate and effective range of measures in order to decresase noise. However, firstly there is always a need of monitoring noise in order to take better decisions. Construction, industrial activities and transportation systems play a large role in noise pollution in Europe. Therefore, mainly municipalities affected by these factors are the target group for this BEMP.

Driving force for implementation
As well as health, curbing noise pollution has financial benefits. Economically noise pollution reduces property prices in affected areas and can structurally damage buildings through increased vibrations (OECD, 1997). Health conditions associated with noise pollution also add to infrastructural strain on health services, and increase expenditure on pharmaceutical goods, such as sleeping tablets. European Commission estimates of noise pollution's cost to Europe's GDP range between 0.2% and 2%.

Economics
It has been demonstrated that noise abatement measures perform well in cost-benefit measures. A study carried out by FEHRL using the rate €25 EUR per decibel per household per year found that quieter tyres could produce benefits to the public of between €48 and €123 billion in the period 2010– 2022 (EEA, 2010). The European Commission Working Group Health and Socio-Economic Aspects (WG-HSEA) in the position paper 'Valuation of noise' recommends the use of a benefit of €25 per household per decibel per year above noise levels of Lden = 50–55 dB (EEA, 2010).

Excess noise can lower property prices. According to the EEA "it has been found that properties exposed to higher noise levels will have a lower value on the market than a similar building exposed to a lower noise level. This is valid for residential houses (for which there is extensive literature) but probably also for office buildings. The best estimate is that house prices loose 0.5 % of their value per decibel over 50–55 Lden. (EEA, 2010)

Reference public administrations
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- City of Oslo
- City of Stockholm
- Leeds

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9 BEST ENVIRONMENTAL MANAGEMENT PRACTICES FOR WASTE MANAGEMENT

Waste management is very often part of the responsibilities of municipalities and a very relevant environmental aspect.

On average, each EU citizen consumes 16 tonnes of materials annually, and generates about 480 kg of waste (EC, 2011; Eurostat, 2015). The total waste generation in the EU 28 in 2013 was about 2.5 billion tonnes (Eurostat, 2015) and, although the generation of waste during the last years has been stagnant in Europe, this is mainly due to the decrease of consumption caused by the economic crisis.

Waste management systems differ significantly across municipalities and EU Member States, varying from 1% to over 90 % disposal of untreated waste to landfills. The percentages of waste undergoing different treatment or disposal options across the EU 28 in 2013 are presented in Table 9-1.

Table 9-1: Percentages of total wastes undergoing different treatment or disposal options across the EU 28 in 2013

	Generated, (kg per person)	Treated, (kg per person)	Municipal waste treated, %			
			Recycled	Composted	Incinerated	Landfilled
EU	**481**	**470**	28%	15%	26%	31%
Belgium	439	440	34%	21%	44%	1%
Bulgaria	432	428	25%	3%	2%	70%
Czech Republic	307	307	21%	3%	20%	56%
Denmark	747	747	28%	17%	54%	2%
Germany*	617	617	47%	17%	35%	0%
Estonia	293	253	14%	6%	64%	16%
Ireland	586	531	34%	6%	18%	42%
Greece	506	506	16%	4%	0%	81%
Spain	449	449	20%	10%	10%	60%
France	530	530	21%	17%	34%	28%
Croatia	404	396	14%	2%	0%	85%
Italy	491	474	26%	15%	21%	38%
Cyprus	624	624	12%	9%	0%	79%
Latvia	312	312	11%	6%	0%	83%
Lithuania	433	421	21%	8%	7%	64%
Luxembourg	653	653	28%	20%	35%	17%
Hungary	378	378	21%	5%	9%	65%
Malta	570	526	6%	5%	0%	88%
Netherlands	526	526	24%	26%	49%	1%
Austria	578	550	24%	35%	37%	4%
Poland	297	249	16%	13%	8%	63%
Portugal	440	440	13%	13%	24%	50%
Romania	272	220	3%	0%	0%	97%
Slovenia	414	287	55%	7%	1%	38%
Slovakia	304	278	4%	8%	12%	77%
Finland	493	493	19%	13%	42%	25%
Sweden	458	458	33%	16%	50%	1%
United Kingdom	482	476	28%	16%	21%	35%

Source: Eurostat (2015)

Given the environmental relevance of waste management, this is a priority area of action for local public administrations keen in reducing their environmental impact. The actions they can implement are twofold: on one side, reducing municipal waste generation, and on the other side improving the management of the waste collected, recycled and disposed. Municipal waste consists of waste generated by households and small businesses located on the territory of the municipality and the measures for its prevention, re-use, recovery, recycling or disposal are prioritised following the waste hierarchy presented in Figure 9-1.

Figure 9-1: The waste hierarchy (EC, 2010)

Despite limiting the environmental impacts of waste itself, it should also be mentioned that proper waste prevention, collection and treatment are important activities to improve the recovery of useful materials and to reduce further exploitation of natural resources, moving from a linear to a circular economy (Figure 9-2).

Figure 9-2: the concept of circular economy (WRAP, 2015)

The first and most important step for a local public administration wishing to improve its waste management operations is to establish and implement a policy and an action plan for waste prevention, re-use and recycling. Identification of (i) the waste fractions with reduction and re-use potential, (ii) the best waste collection system to be implemented and the measures for its optimisation, (iii) long and short term targets for reduction, re-use and recycling of waste are the basic elements to be firstly investigated.

Local public administrations can focus also on improving the environmental performance of the waste treatment operations i.e. sorting facilities. Depending on the collection strategy adopted, waste sorting can be performed differently (e.g. in bio-drying mechanical biological plants, by processing of a separately collected plastic and metal fraction into different plastic and metal streams ready for recycling). Maximising the recovery rate of useful materials is the ultimate goal of the operations carried out in waste sorting facilities.

Incineration and energy recovery of residual waste is another area where best practices can be implemented. Incineration of municipal residual waste and refuse-derived fuel can be optimised

in order to achieve the highest energy recovery from the combustion process and to reduce the volume of waste to be disposed, while minimising air emissions. Incineration residues (ashes and slags) can be treated in order to recover further materials (e.g. metals) and then, after appropriate treatment, ashes can be employed for (low) end applications (e.g. in the construction sector).
Finally, landfill management (when these are in use or were used in the past by the municipality) is also directly influenced by local public administrations. Thereby, rehabilitation plans which include the recovery and management of leachate, the capping and restoration of the surface and the recovery and use for energy generation of the landfill gas produced are the main elements for the best management of landfills.

This report does not go further in depth than this introductory view for local public administrations on how waste management can be best managed. This is because a specific document on this topic, with a comprehensive set of best environmental management practices addressed to local authorities, has been developed by the JRC[72] in the framework of the development of an EMAS Sectoral Reference Document specific to the waste management sector. It is therefore recommended that local public administrations refer to that document when looking for BEMPs in waste management.

Another important source of guidance, especially at the waste treatment installation level, are the different Best Available Techniques Reference Documents (BREFs)[73] developed under the Industrial Emission Directive (2010/75/EU). These documents present Best Available Techniques (BATs) that local public administrations can use as source of information to improve their waste management operations. The relevant BREFs in this case are:

- the Reference Document on the Best Available Techniques for Waste Incineration;
- the Reference Document on Best Available Techniques for the Waste Treatments Industries;

Finally, the Landfill directive (1999/31/EC) provides information on the management of landfills, including leachate and landfill gas monitoring and management and closing and after-care procedures.

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[72] Best environmental management practice report on waste management: http://susproc.jrc.ec.europa.eu/activities/emas/waste_mgmt.html

[73] For more information on the content of the Best Available Techniques Reference Documents (BREFs) and full explanation of terms and acronyms, refer to the European Integrated Pollution Prevention and Control Bureau website: http://eippcb.jrc.ec.europa.eu/

10 BEST ENVIRONMENTAL MANAGEMENT PRACTICES FOR WATER CONSUMPTION

Chapter structure

This chapter provides guidance on the sustainable management of urban water. It starts by introducing the main elements of water management in European cities then explains the reasons that should push public authorities towards making efforts to improve their water management. Afterwards, Best Environmental Management Practices that can help public authorities do so are detailed.

Chapter introduction

Traditionally, European cities started on the path of water management by supplying water to their citizens, gradually taking on responsibilities such as sewerage and drainage as cities expanded and urban population grew. More recently, cities have also taken on pollution reduction and the protection of waterways.

Consumption patterns – both per capita and among the different economic sectors – vary widely among European countries, as water availability, though not always in a way that correlates with precipitation levels: perhaps counter-intuitively, countries such as Belgium and the United Kingdom are actually classified as water-stressed[74]. Roughly speaking, around 45% of water is abstracted for agriculture, 40% for industry and energy production and 15% for public water supply, although water abstraction for agricultural use is higher in southern Europe and that for industrial and energy production purposes is higher in northern Europe (EEA, 2003).

In most of the EU Member States, responsibility for water supply and sanitation provision lies with municipalities, which are regulated by the states. The EU sets the framework legislation for water quality and water resources management. The organization of public water supply and sanitation, however, remains a prerogative of EU member states.

A. Main actors

In the EU-28, drinking water operators are 70% publicly-owned, 15% privately-owned and 10% with mixed ownership, with some variation between Member States. Wastewater treatment plant operators break down in a similar way, with the proportions being 79%, 9% and 12% respectively (EUREAU, 2009). Some countries such as The Netherlands mandate the public ownership of drinking water supply companies. For both drinking water and wastewater operation, France, England and Wales are notable for the very high percentage of private operators, as can be seen in Figure 10-1, which shows the clustering of European countries according to a typology of water service operators. The private sector dominates large-scale water service delivery, with a small group of companies from France (Veolia and Suez) and the UK (such as Britain-based Thames Water) leading the pack while also investing in other countries both within and outside of Europe.

[74] http://www.eea.europa.eu/themes/water/featured-articles/water-scarcity

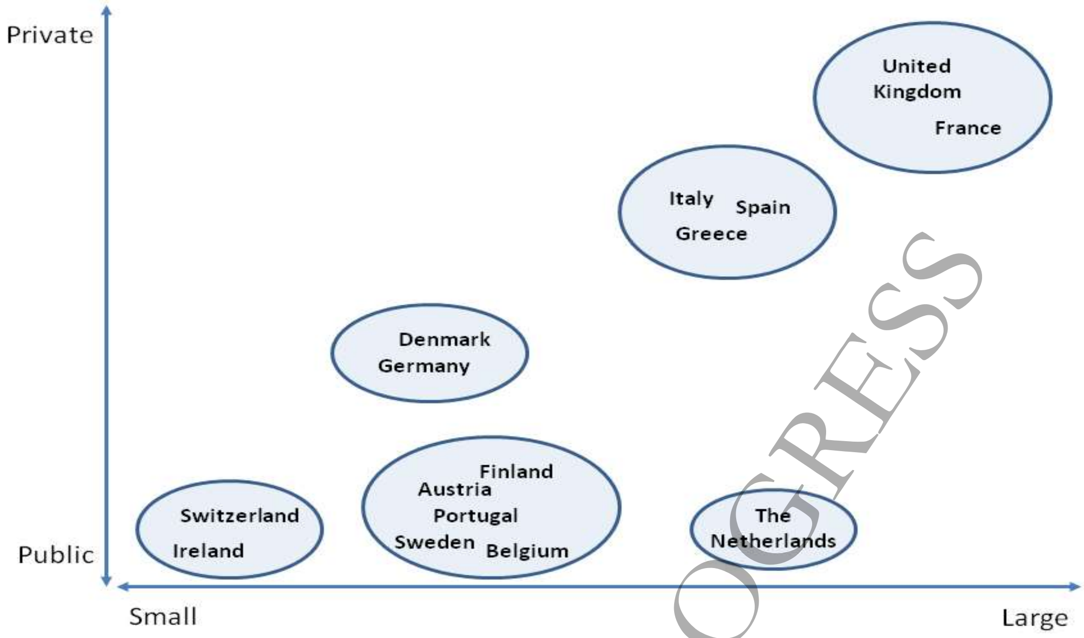

Figure 10-1: Clustering of European countries according to typology[75] of operators (Adapted from: EUROMARKET, 2004)

There are two ways to approach the tasks of urban water managers – the following points will take a sub-sectoral view, examining water supply management, wastewater management and stormwater management in turn. The other way to view these tasks is to look at the end goals, which are to supply water of an adequate quality and quantity and to limit or eliminate pollution to water bodies. These goals are strongly interlinked, particularly when a more sustainable approach to water management is taken; for example, stormwater is then viewed not as an inconvenience or a source of pollution, but rather as a resource (for water supply).

B. Conventional water supply

The conventional approach to urban water supply is very much demand-driven: investments in resource development, abstraction regimes, treatment techniques and distribution networks are made in response to increases in demand. This approach has been in place for many hundreds of years, and has been a success in the sense that it has allowed for the development of complex urban networks; however, its limitations are increasingly being felt. The unsustainable use of resources has led to their depletion in many parts of Europe, depletion which will only become more severe with population growth and climate change. Conventional systems also tend to be highly energy-reliant, costly and inflexible in the face of changing demand patterns. Unless actual water use is charged, a lot of wastage tends to occur; given that distributed water is treated to potable standard regardless of its end use, the implications are even stronger (Philip, 2011a). Another feature of conventional water distribution networks is that they tend to be highly prone to leakage; therefore, active leakage management will be examined as a best practice. The components of water supply management are as follows (Philip, 2011a):

- Resource: Additional water resources are conventionally obtained by damming rivers, abstracting water from lakes, rivers, or aquifers, constructing reservoirs and other means.
- Abstraction: Water withdrawals usually make use of boreholes, pumping equipment and gravity flow channels.
- Treatment: Drinking water is commonly produced through processes such as filtration, sedimentation, aeration, coagulation, disinfection or desalination.

[75] Small operators serve less than 100,000 inhabitants, medium between 100,000 and 10,000,000 inhabitants and large operators over 10,000,000 inhabitants

- Distribution: Water is normally conveyed from its source to its point of use through a distribution network composed of water towers, pumping equipment and pipes, and any leaks in the distribution system are detected and repaired based on economic calculations.

- Demand: Water use is customarily controlled through the metered charge of customers' water consumption.

C. Conventional wastewater treatment

In most cities, blackwater (from toilet flushing), greywater (from kitchen sinks, showers, washing machines etc), stormwater and often wastewater from industrial processes are conveyed via a sewer system to wastewater treatment plants which use several methods for treating the water. Typically, the wastewater is first mechanically pre-treated, then goes through a primary (settlement, mainly mechanical) and then a secondary (biological) treatment stage. Some wastewater treatment plants then perform tertiary treatment on the effluent, which typically involves filtration and nutrient removal.

The outputs of this series of processes are on the one hand liquid, with treated effluent that is discharged to water bodies, and on the other hand solid, with sludge that is typically either sent to landfill or incinerated (having first gone through processes seeking to reduce its moisture content) and is also used to fertilise agricultural crops.

D. Conventional stormwater management

The basic principle of urban stormwater management is the rapid conveying of stormwater away from urban areas as fast as possible to avoid localised flooding. Usually, cities use either combined sewers (where stormwater is mixed with domestic and industrial wastewater and sent to wastewater treatment plants) or separated sewers (where stormwater is collected separately, subjected or not to treatment, and then discharged to the environment), or a combination of both. The paths taken by rainwater are shown in Figure 10-2. In this conventional system, stormwater is regarded as a nuisance rather than as a potential resource.

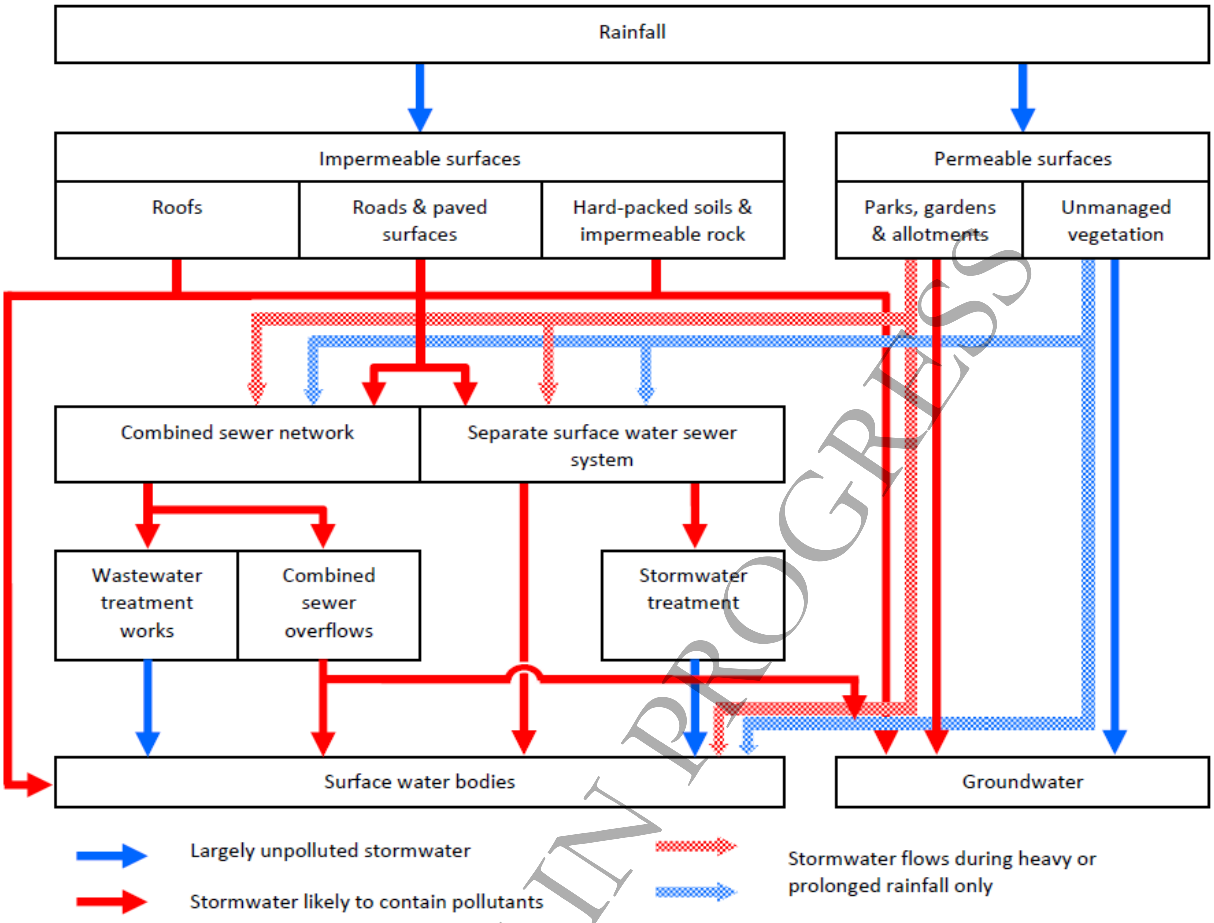

Figure 10-2: Stormwater flows (minus evapotranspiration). Source: Philip, 2011b

Techniques portfolio

In this chapter, two BEMPs are presented, addressing the most critical aspects for water consumption: full metering of final users and water leaks minimisation. In fact, reduction of water use starts on the hand by assessing all consumptions in the area investigated and keeping final consumers informed about it and billed on the quantity of water used and, on the other hand, by minimising as much as possible water leaks along the water distribution network.

10.1 Deploying full water metering at the household/final user level

Description

The technique is that in municipalities/cities/villages, the water consumption is determined by means of displacement, also called mechanical or conventional, water meters that count the volume of water used (Arrequi et al., 2006). The accumulated consumption is characteristically recorded for certain periods (quarterly, half-yearly or annually) (Willis et al., 2013). Residential, public and commercial building is equipped with a main water meter (see Figure 10-3). In multi-unit dwellings (apartments) and multi-residential blocks, each flat/apartment/housing unit is equipped with a water meter. The water bill includes a basic fee but mainly depends on the actual consumption measured by the meter ("polluter pays" principle). Commercial buildings, such as shopping centres or office buildings, public buildings and any other non-residential building or places of water supply are also equipped with a main meter and sub-meters for the relevant consumption areas.

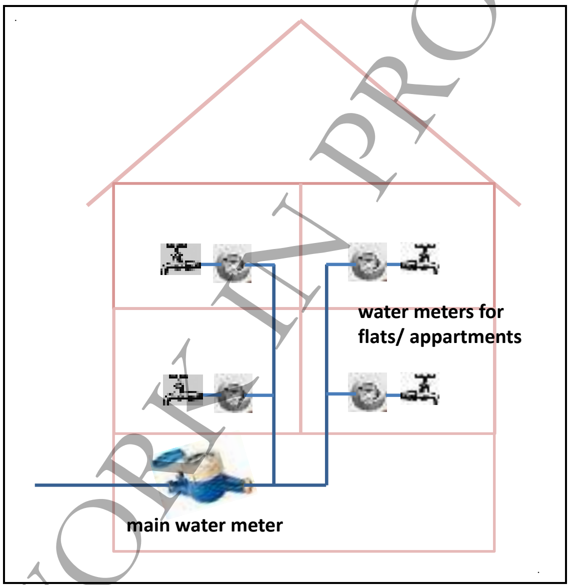

Figure 10-3: Scheme illustrating that every building is equipped with a main water meter and sub-meters for every apartment/flat/housing unit or relevant area of water consumption

The next step is to move from conventional to smart, also called intelligent, meters[76]. They may replace conventional meters or are directly used where water meters are installed for the first time. Smart meters allow the provision of real-time information on how, when and where water is being consumed (Stewart et al., 2010). Smart metering is, in effect, an assortment of components and procedures. It consists of the following key processes of water use data:

- Measurement and data storage in data loggers
- Transfer (also called automatic meter reading) (e.g. Mohassel et al., 2014)
- Processing and analysis
- Feedback to consumers

The mentioned processes of a smart metering system are described in the table below.

[76] Definition of smart water metering: The developments in smart (intelligent) water meters have evolved to a large extent from the energy sector, where smart electricity and gas meters and communication infrastructure have already been more widely introduced (Boyle et al., 2013). Smart meters can automatically and electronically capture, collect and communicate water usage readings in real time or close to real time. This electronic data can be transferred by automated means (e.g. GSM (Global System for Mobile Communication), GPRS (General Packet Radio Service), CDMA (Code Division Multiple Access), drive-by) to servers for storage and the subsequent processing and analysis of data which can also made available to the final user in (close) real time (AWA, 2011; Boyle et al., 2013; Britton et al., 2013; Gurung et al., 2014; Beal et al., 2014).

Table 10-1: Processes of an intelligent metering system (according to Boyle et al., 2013)

Parameter	Measurement and data storage	Transfer	Processing/Analysis	Feedback
Mode	Water meter and data logger technology combinations used to capture information about water consumption. Residential intelligent metering typically uses mechanical meters which generate a pulse signal after a set volume passes through the meter. New meters are velocity meters, such as multi-jet, magnetic flow and, particularly, ultrasonic.	Means by which data is transferred from meters to utilities, customers and back. Data is transferred from the data logger via broadband, cable or wireless (e.g., radio, GSM, CDMA, wireless M-Bus C1 mode*). May be fully remote or require near range collection (e.g., "drive-by" download).	Means by which a utility/third party stores (e.g., data servers) and manipulates (e.g., end-use analysis software package) water use data. Implications for third party access.	Method by which data is provided to customers for interpretation, e.g., postal bill, email, web interface, smart phone application. Behaviour change may/may not ensue.
Frequency	The specified time intervals at which (i) water use is recorded by the meter/between number of pulses; and (ii) data from the meter is collected by the data logger, e.g., 15 min intervals.	How often data is sent or collected by the utility/third party, e.g., yearly, quarterly, monthly, daily, half hourly, "real-time" will vary depending on the type of meter, e.g., pulse versus interval.	The frequency at which water use information is used to update utility operations (e.g., for pressure management).	The frequency at which water use information is communicated to the customer (e.g., yearly, quarterly, monthly, daily, real-time, *etc*.).
Resolution	The granularity of water flow detected by a water meter (e.g., L/pulse). Determined by the purpose, capabilities and settings of the water meter. Resolution of the recorded data by the data logger, e.g., L/15 min (*i.e.*, *frequency of measurement*, above).	Resolution of data remains unchanged, though quality of data (*i.e.*, complete/partial) may suffer from disruptions to transmission process.	Data may be aggregated or manipulated to analyse trends (e.g., leak assessment; end-use analysis).	The level of detail of information provided to the customer, such as usage per unit of time and/or end use breakdown. Comparative framing and benchmarking may aid legibility and comprehension. Content and framing should be informed by behaviour change theory, information about target audience and tailored to the mode in question.

The latest generation of smart meters are velocity meters, namely ultrasonic flow meters (Boyle et al., 2013).

Figure 10-4 provides an example of a modern smart metering system. In this case, the consumption data are read via "drive-by" download using the converter and receiver. Subsequently, the data is processed by means of specific software and cloud computing by the service provider (water supplier); this can be supported by the provider of the smart metering system. In the given case, the smart meters are recyclable and the operation time is 15 years. This lifetime is confirmed by the experience with smart meters for hot water of district heating systems. The design of certain meters (non-foamed and recyclability of the different components) allows their full recycling after their lifetime.

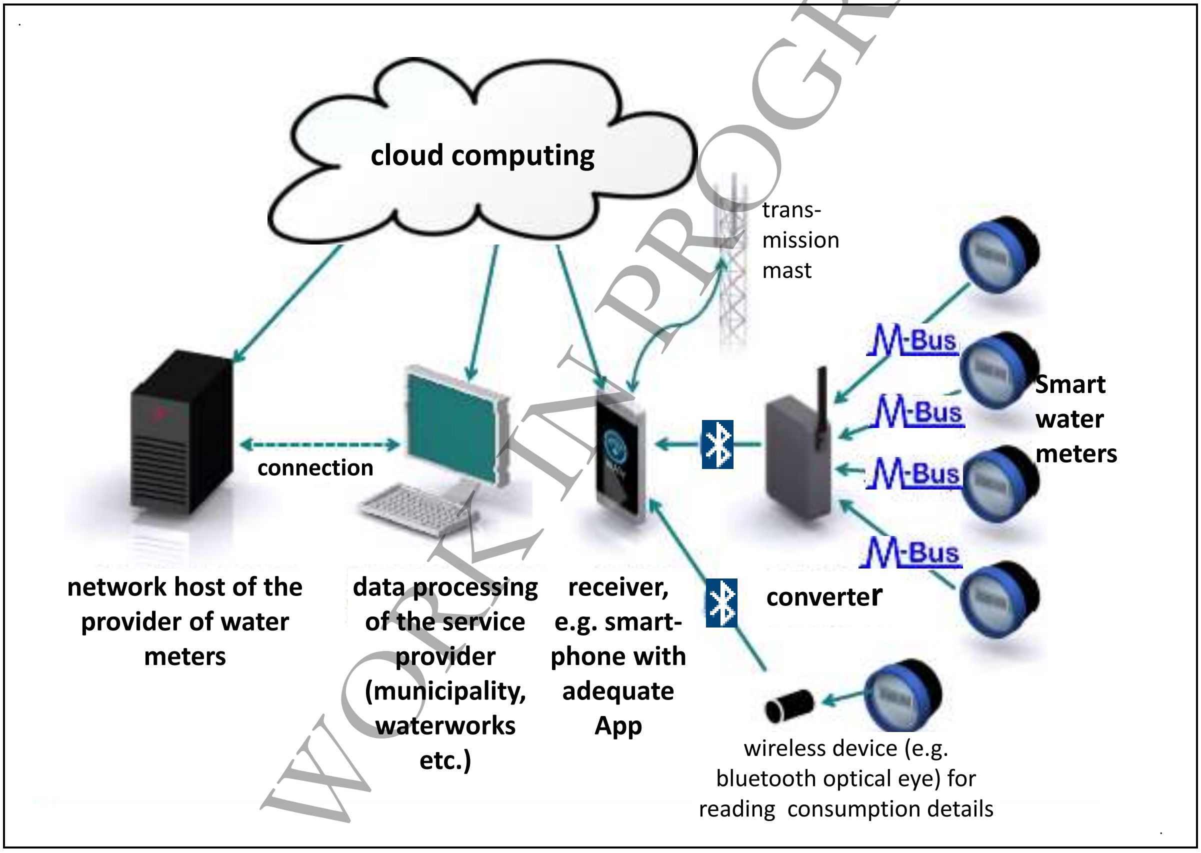

Figure 10-4: Example of a modern smart water metering system indicating the measurement, the storage, processing and analysis of water consumption data

Achieved environmental benefits

Conventional and smart meters lead to a more conscious consumption of water which is thus decreasing and it is associated with the conservation of water resources, with a reduced energy consumption (for pumping and, where required, for treatment), and a reduced chemical consumption where the raw water has to be treated before delivery.

Moreover, smart water meters enable

- a better understanding of time of day residential and commercial consumption and provides a sound basis for seeking behaviour change (more efficient consumption practice) of consumers and, at least, for raising awareness about own water use (Beal et al., 2014),
- the identification of leakages within households (so-called post-meter leakages (Willis et al., 2011; Britton et al., 2013; Beal et al., 2013)) as well as in the water distribution system and network (Beal et al., 2014),

- increasing water end-use (micro-component) insights in residential homes and commercial as well as public buildings (Stewart et al., 2010; Beal et al., 2014),
- helping city and urban planners to better understand consumption trends and exploiting opportunities to extract greater efficiencies from the present supply system (Beal et al., 2014).

Further, the lifetime of smart meters is significantly longer. Usually, conventional meters are exchanged after about six years whereas smart meters are in use for about 15 years. This saves resources and energy for meter production.

In addition, smart metering saves costs for reading the consumption and increases the accuracy of the water quantity consumed.

Appropriate environmental indicators

Following environmental indicators are appropriate:

- Penetration rate of water metering (% households/consumers or % water consumption covered by metering).
- Percentage of smart meters out of total water meters in use.
- Reduction in water use by final users after installation of water meters and/or smart meters

Cross-media effects

There are no relevant cross-media effects known.
When replacing conventional by smart meters, the environmental burden for producing and installing the meters could be considered; however, the replacement often takes place after the lifetime of the conventional meters.

Operational data

For determining the hot water consumption in district heating systems, smart meters have been used for about 20 years. The experience is that they are precise and very reliable. The low-flow cut-off is very low (about 3 l/h). The reading efficiency is practically 100 % (i.e. the drive-by download is 100 %), even in case of systems with several thousand meters (Münster et al., 2012).
The lifetime of the batteries of the meters is about 15 years. The same is true for the lifetime of the meters, known from hot water metering. In some countries, such as Germany, the conventional water meters have to be exchanged every six years. In case of smart meters, a certain percentage is checked for accuracy (sample check). If the result is positive (expected according to the experience with the aforementioned hot water smart meters), the smart meters remain in function for another three years and the procedure is repeated. Finally, after 15 years of operation, the smart meters will be changed.
In case of elevated consumption or to verify a bill, detailed consumption data can be read via a bluetooth optical eye. E.g., the consumption of 460 days (each individual day) is saved in the data logger.
In many water supply systems, there are water meters measuring at the feeding points (e.g. at the water tank outlet) and at certain points in the distribution network. When assuming a water leakage, the flows at these water metering points can be compared with the total flow of all smart meters at end users of the area concerned to determine whether the leakage is before or behind a certain meter within the distribution network.
The evaluation of the consumption determined by means of the end user smart meters can be used to detect, or at least to assume post meter leakages and to inform the consumer (Ferreira et al., 2007; Britton et al., 2013).

Applicability

The technique is applicable to any existing water supply network.

Economics

The costs for conventional water meters are between 10 and 25 EUR.
When first smart meters were applied in Australia, the price for a smart meter with data logger was about AUD$ 1000 (about EUR 700) (AWA, 2011); however, the system applied included smart meters with data loggers from which the data were permanently transferred by means of radio signals. This was very costly. But today, the price is about EUR 75 in Australia (Beal et al., 2014). In Europe, depending on the situation of the individual Member State, the price is in the range of EUR 90-100 up to 150 – 170. This opens up opportunities for much wider deployment (Beal et al., 2014).
The amortisation time for replacing conventional by smart meters is about 6 years. The assumptions for this calculation are (prices from the calculation of the replacement of conventional by smart meters in the German cities Künzell and Pegnitz):

- 5000 meters in households to be replaced
- Average water consumption per household: 110 m^3/yr
- Fee for potable water: 1.3 EUR/m^3
- Fee for waste water: 2.5 EUR/m^3
- Price for one mechanical meter to be replaced every 6 years: 10 EUR
- Price for the casing of the conventional meter (one time): 13 EUR
- Costs for manual reading of the conventional meter: 9 EUR
- Price of the smart meter: 90 EUR
- Price for the software used: 2 EUR
- Costs for automatically reading the smart meter: 0.5 EUR
- Expected annual reduction of water losses: 2 %

In many cases, the initial investment is a considerable obstacle for municipalities.

Driving force for implementation

The driving forces are:

- to reduce the costs for the manual reading and to increase its accuracy,
- to detect leakages and to reduce them (post meter leakages and leakages in the distribution network),
- to improve the quality of the consumption data to cross-check the water balance practically real-time,
- to use the data in order to raise awareness and behaviour of consumers.

Reference organisations

Conventional meters are in use across Europe. In hundreds of municipalities, cities or villages in Germany, the Netherlands, Denmark and Sweden (most probably in other countries as well), all households and other final water users are equipped with conventional meters; the consumption is recorded and billed at least once a year.
Smart meters are in use in following cities and countries:

- New York/US: about 875,000 (Beal et al., 2014)
- Whole United States: about 10 million (Beal et al, 2010)
- Australia: about 20,000 (Beal et al. 2014)
- Delhi/India: about 250,000 (Boyle et al., 2013)
- Mumbai/India: about 150,000 (Boyle et al., 2013)
- Ottawa/Canada: about 210,000 (Boyle et al., 2013)

- Abbotsford/Canada: about 25,000 (Boyle et al., 2013)
- Malta: about 120,000 (Boyle et al., 2013)
- Künzell/Germany: about 5000 (Künzell, 2014)
- Pegnitz/Germany: about 2300 (more 5200 within the next 4 years) (Pegnitz, 2014)
- Skanderborg Forsyning/Denmark: about 6500 (http://www.skanderborgforsyning.dk/)
- Hammel Water/Denmark: about 3200 (http://www.hammelvandvaerk.dk/)
- Sønderborg Forsyning/Denmark: about 3000 (http://sonfor.dk/), additional 15000 smart meters will be installed
- Vestforsyningen/Denmark: 8000 (http://www.vestforsyning.dk/)
- Hjerting Water/Denmark: 3200 (http://www.hjerting.net/).

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10.2 Minimising water leakages from the water distribution system

Description

The management of water losses of municipal water distribution networks is an important element of sustainable water supply. The loss of water - expressed as percentage of system water input - can be significantly varying in developed countries between 2 and 62 % (EC, 2007; EUREAU, 2011; SWAN, 2011, City of Berlin, 2014).

Basically, water loss management consists of four pillars: I -active leakage control, II - pressure management, III - speed and quality of repairs, and IV - pipe and assets management (Figure 10-5).

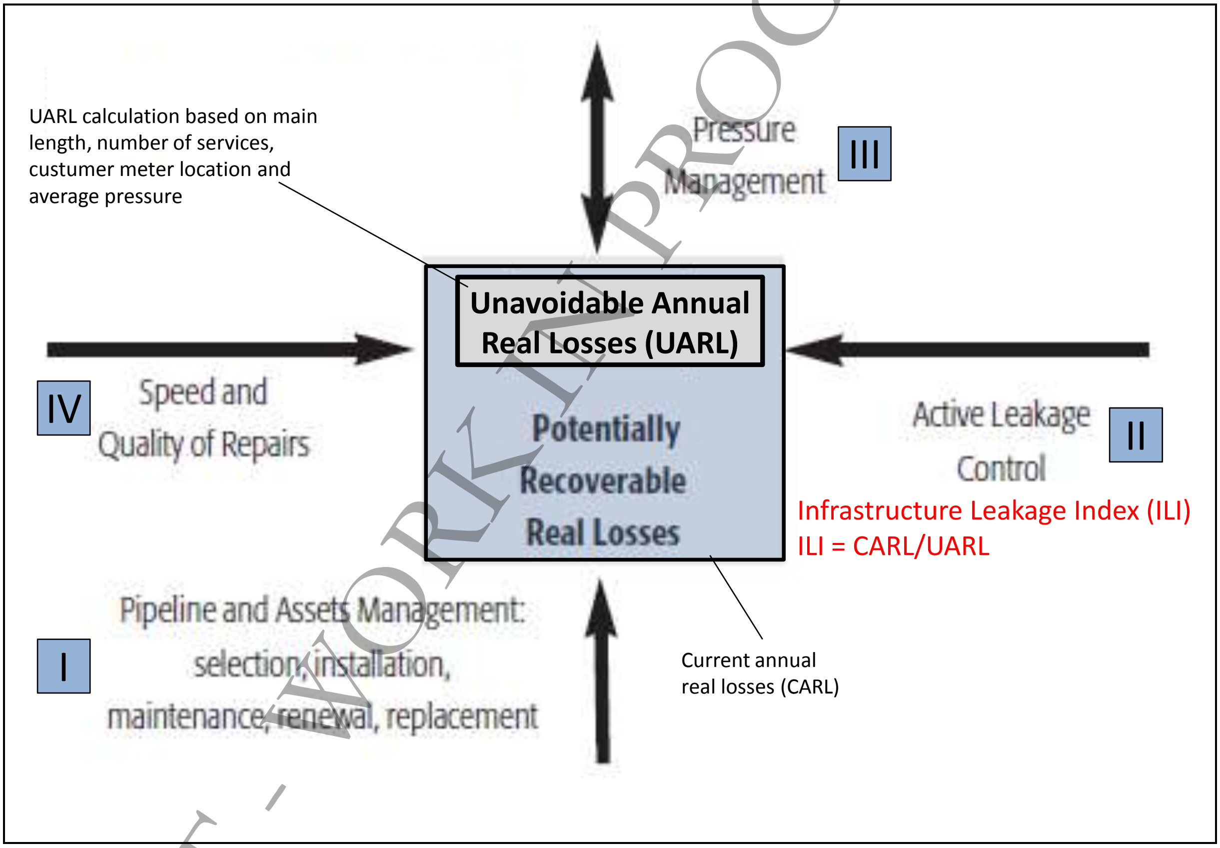

Figure 10-5: The four basic pillars of managing real water losses (Lambert, 2003; Lambert, 2012); the ILI is calculated as the ratio of the current annual real loss (CARL) and the unavoidable real loss (UARL), (Lambert/Hirner, 2000; Lambert, 2003; Lambert, 2012; DVGW W392, 2013)

The pipeline and assets management as the **first pillar** requires a detailed and accurate water balance according to international standard (Table 10-2)

Table 10-2: Water balance of a public water supply system according to best practice (Lambert/Hirner, 2000; Lambert, 2003; DVGW W392, 2013)

<table>
<tr><td rowspan="9">System Input Volume
M^3/year</td><td rowspan="4">Authorised Consumption
M^3/year</td><td rowspan="2">Billed Authorised Consumption
M^3/year</td><td>Billed Metered Consumption (including water exported)</td><td rowspan="2">Revenue Water
M^3/year</td></tr>
<tr><td>Billed Unmetered Consumption *</td></tr>
<tr><td rowspan="2">Unbilled Authorised Consumption
M^3/year</td><td>Unbilled Metered Consumption</td><td rowspan="7">Non-Revenue Water
M^3/year</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="5">Water Losses
M^3/year</td><td rowspan="2">Apparent Losses
M^3/year</td><td>Unauthorised Consumption</td></tr>
<tr><td>Metering Inaccuracies</td></tr>
<tr><td rowspan="3">Real Losses
M^3/year</td><td>Leakage on Transmission and/or Distribution Mains</td></tr>
<tr><td>Leakage and Overflows at Utility's Storage Tanks</td></tr>
<tr><td>Leakage on Service Connections up to point of Customer metering</td></tr>
</table>

*Difficulty may be experienced in completing the water balance with reasonable accuracy where a significant number of customers are not metered. In such cases, authorised unmetered consumption should be derived from sample metering of sufficient numbers of statistically representative individual connections of various categories, and/or by measurement of inflows into discrete areas of uniform customer profile (with data adjusted for leakage and diurnal pressure variations as appropriate).

Such a water balance provides the required overview of the water distribution network which can be illustrated in form of a Sankey diagram (Figure 10-6).

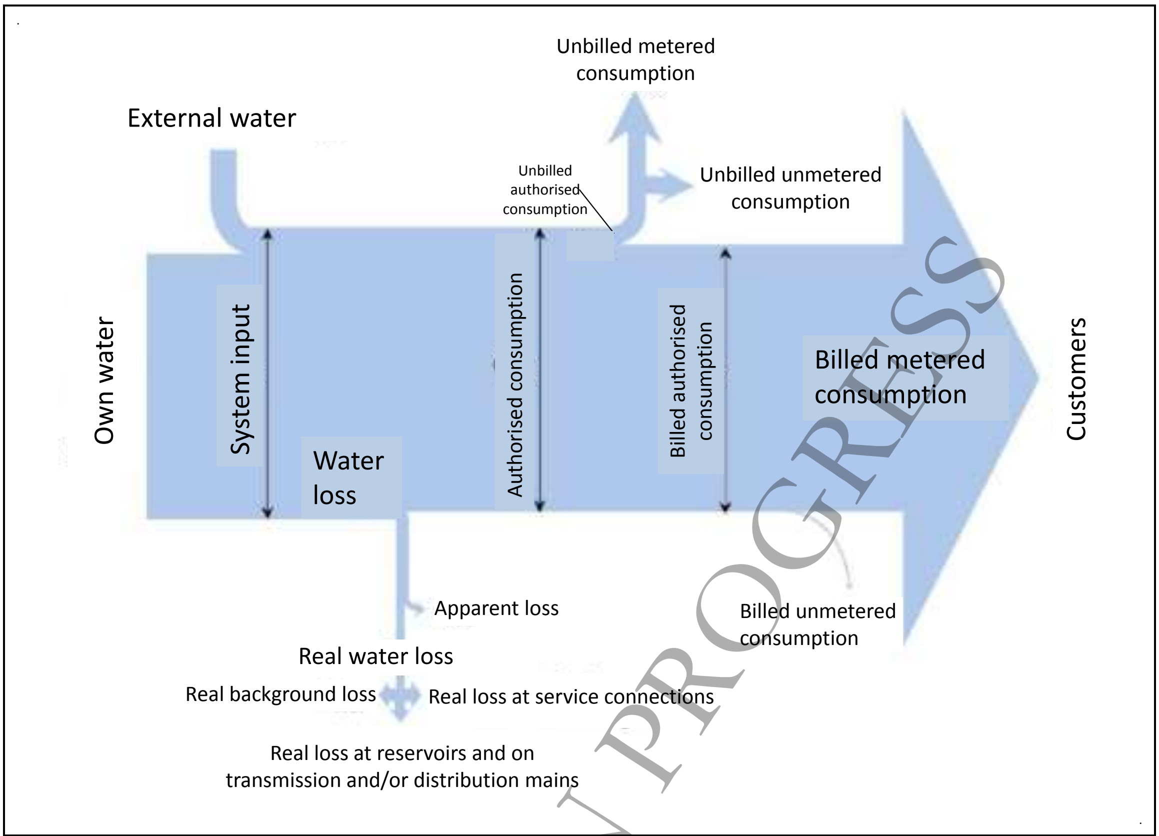

Figure 10-6: Example of a Sankey diagram illustrating the water balance of a water distribution network (DVGW W392, 2013),

NB: On an annual basis, the 'real water loss' is called current annual real loss (CARL), and the unavoidable annual real loss (UARL) is distributedamong the different real losses

However, this is not sufficient to have the required more detailed understanding of the network. For this purpose, the network must be analysed and divided into adequate district metering areas which can also be called leakage monitoring zones. Figure 4 shows an example of the network of the city of Freiburg with about 220,000 inhabitants in the very South-West of Germany. Each of the 18 zones as well as the flow of the water distributed from the water tanks is equipped with continuous flow measurement (magnetic-inductive flow meters which are regularly calibrated). With the data, a water balance of the different zones is established. This enables the detection of sharp consumption increases within a zone, specifically by means of the minimum night flow measurement between 2 and 4 am (according to experience, the flow in this time period is lowest (Lambert/Hirner, 2000; Xu et al., 2014; Debiasi et al., 2014)) and is considered as the baseline consumption. Thus, the area of leakages can be identified. Then, the precise location of the leakage has to take place (see the pillar concerning active leakage control).

In addition, a database is required where all technical installations are listed and georeferenced by means of a geographic information system (GIS) (Diersche et al., 2014), and where the damage statistics, the age of the pipes, the hydraulic data (such as diameter, depth position and flow capacity), type of material, pipe conditions etc. are contained (Heinzmann, 2004).

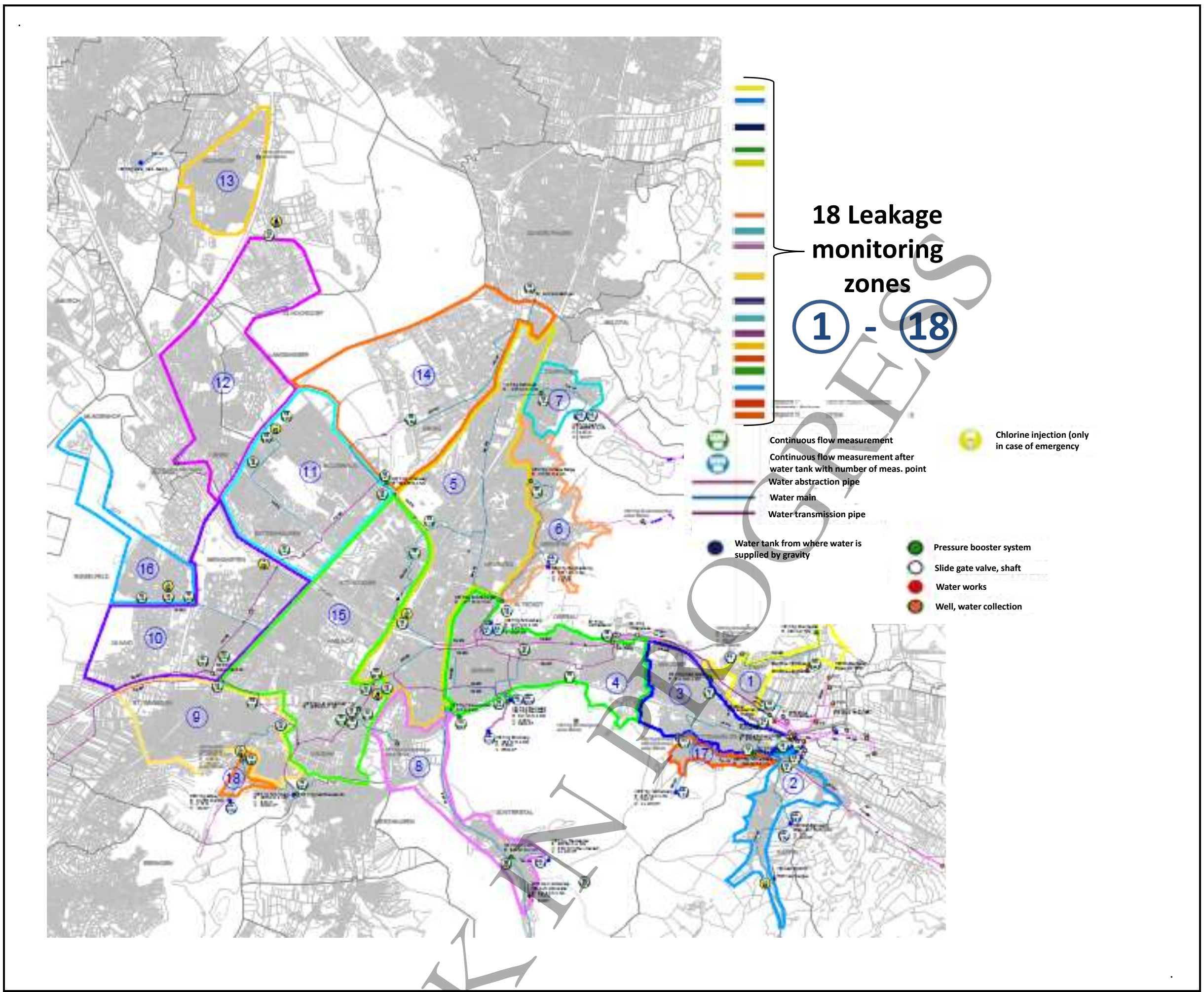

Figure 10-7: Overview of the 18 leakage monitoring zones (metered district areas) of the city of Freiburg/Germany (Diersche et al., 2014)

There are cities where the division of the whole network into zones is difficult, such as Berlin/Germany. There, the alternative is to have a dedicated rehabilitation strategy. On the basis of the careful analysis of network and leakage data, statistical evaluations and forecasts are established. Since 35 years, all damages/leakages of the piping network are documented and processed, and, in combination with economic considerations, such as repair and renewal costs, the annual extent to replace existing pipes by new ones is determined. For this purpose, specific software, such as PiReM is used. As a consequence of this strategy, the leakage rate is on a very low level.

The **second pillar** (indicated in Figure 10-5) is active leakage control to apply timely if elevated or high minimum night flows are detected. This includes the use of techniques to precisely locate a leakage by means of automatic and manual acoustic leakage detection systems (see Figure 10-8 and more details under operational data) or step testing (hydraulic analysis in a metered district area at minimum night flow). The use of hydraulic models can support the identification and localisation of leakages (Debiasi et al., 2014; Nicolini et al., 2014; Xu et al., 2014) but cannot be used as the only measure to detect leakages.

It is important to have an annual budget available enabling systematic active leakage control (Lambert/Taylor, 2010).

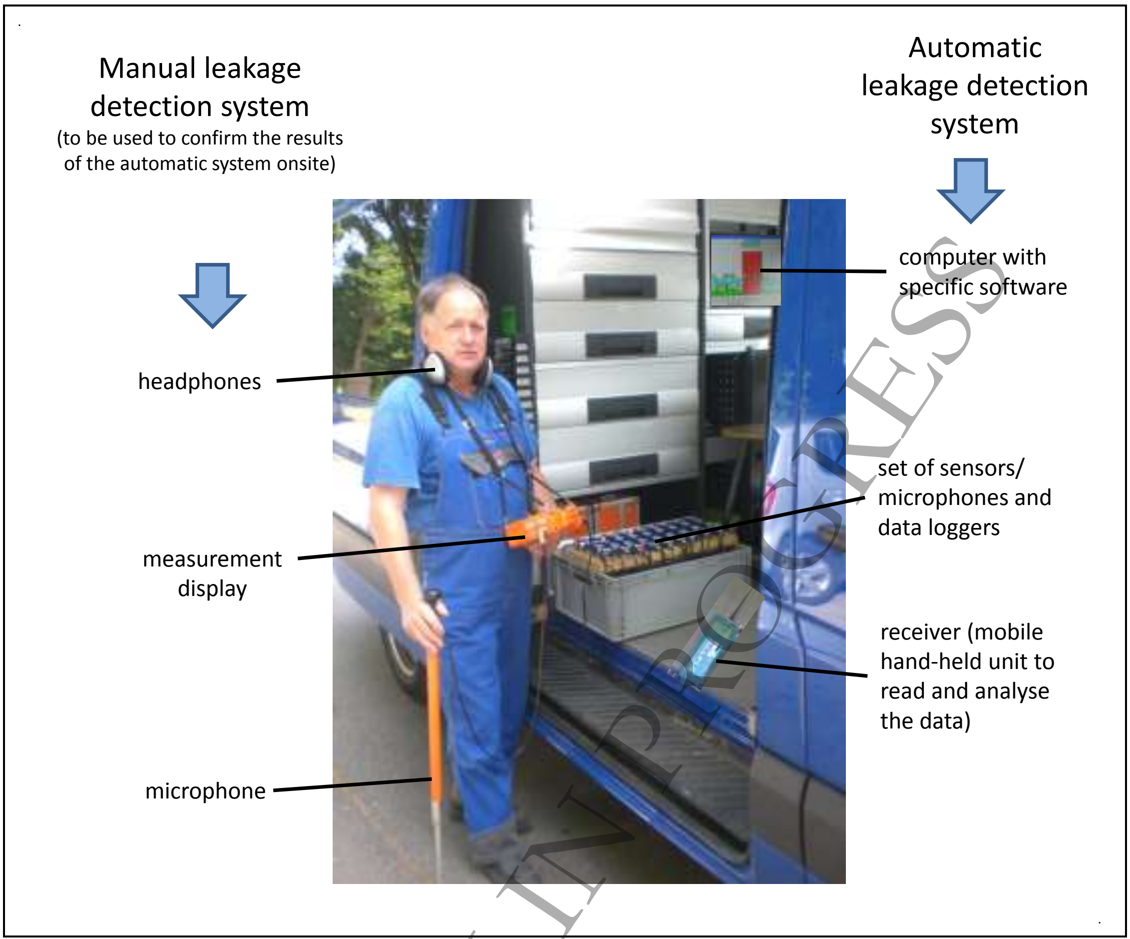

Figure 10-8: Automatic and manual leakage detection by means of acoustic listening sensors, noise loggers including correlators (see more details under operational data)

The **third pillar** of managing water losses is pressure management (Figure 10-5) which is still often underestimated, also in developed countries (Kingdom et al., 2006) although its benefits have been recognised for over 40 years (Thornton, 2003; Xu et al., 2014). For large systems, the assumption of a linear relationship between pressure and leakage rate is an acceptable simplification (Lambert/Hirner, 2000; Thornton, 2003). Consequently, each metered district area should be operated at ‘adequate’ but not excessive pressure by means of transient control, network sectorisation and pressure reducing valves (PRVs) to reduce and modulate pressure in the network (Thornton, 2003; Thornton et al., 2008; Lambert/Taylor, 2010; Mutikanga et al., 2013).

The **fourth pillar** concerns the timely response to all identified faults and leakages on utility infrastructure (instant high quality repair) with own personnel of the municipality or third party contracts or a combination of both. This also includes the availability of optimised resources for maintenance work as well as the adequate budget.

Post meter leakages are not mentioned here but are described in the BEMP on water metering (see Section 10.1).

Achieved environmental benefits

Water losses of only 2-5 %, expressed as a percentage of system input, can be achieved. After reunification in 1990, in the Eastern part of Berlin, implementing the measures described, water losses were reduced from 25% to 4-5 % (Heinzmann, 2004). However, from the technical point of view, this environmental performance indicator alone is not appropriate (see the text below for 'appropriate environmental indicators') but provides a reasonable indication from the ecological point of view.

For the Infrastructure Leakage Index (ILI), introduced in Figure 10-5, best achieved values are below 1.5 (Lambert/Hirner, 2000; Lambert/Taylor, 2010).

The benefits of water leakage control go beyond the water saved itself. Associated benefits include the reduction of energy consumption and greenhouse gas emissions. The energy consumption for pumping and treating 1 m3 of water is 2–42 MJ and varies depending on the source of water. Surface water and groundwater need 2–3 MJ of energy to treat 1 m3 of water (Friedrich, 2002; Racoviceanu et al., 2007; Mo et al., 2011). Recycled water or imported water needs 3–18 MJ/m3 of energy (Lyons et al., 2009; Stokes and Horvath, 2009), while the number for desalinated water is 42 MJ/m3 (Stokes/Horvath, 2009). The reduction of energy consumption is accompanied by a decrease of greenhouse gas emissions. According to (Stokes/Horvath, 2009), under U.S. (California) conditions, around 60 g of CO_2 are emitted for each 1 MJ of electricity consumed in the process of producing and distributing imported (piped-in) water (N.B. this number is based on a mostly natural gas-fuelled electricity grid and may vary depending on the energy mix of a country).

Appropriate environmental indicators

The water loss as percentage of system input volume has been used for a long time as a performance indicator. It is an appropriate measure to define the financial and ecological views of water losses (Lambert/Hirner, 2000). But when regarding the technical view of water losses in distribution systems, real losses (see Figure 10-6) expressed as a percentage of system input volume is unsuitable for assessing the efficiency of management of distribution systems as it does not take into account any of the key influences on real lossees and because differences in consumption influence the value of real losses expressed in percent terms (Lambert/Hirner, 2000; Lambert, 2003; Lambert, 2012).
Other traditional performance indicators for real losses such as losses per length of mains, losses per service connection or per billed property or losses per length of system (length of mains and services) are also inadequate (Lambert, 2012).
Regarding the technical view of water losses in distribution systems, the most appropriate performance indicator is the Infrastructure Leakage Index (ILI) as described above (see Figure 10-5).
There is no direct correlation between water loss as percentage of system input and the ILI; however, for both indicators it can be said that the higher the losses, the higher the values are. Figure 10-9 shows an example for the values of these two indicators.

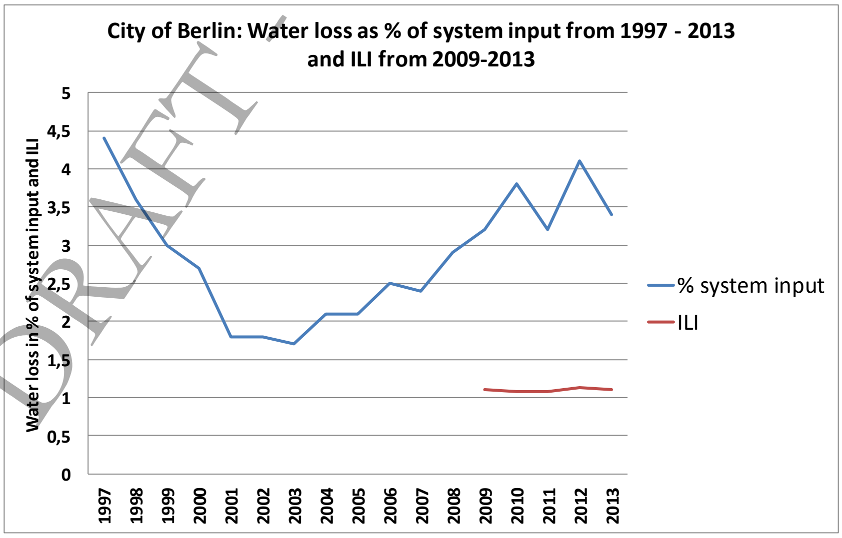

Figure 10-9: Values for the two water loss indicators "water loss as percentage of system input and the Infrastructure Leakage Index (ILI) for the city of Berlin (City of Berlin, 2014); the city started to determine and to document the ILI in 2009.

Cross-media effects

There are no environmental cross-media effects when implementing this BEMP

Operational data

As mentioned above, active leakage control includes the establishment of leakage monitoring zones which can also be considered as metered district areas and the continuous flow measurement and zone-specific water balance. Figure 10-10 provides a typical normal annual consumption curve of a zone which is a pure residential area; therefore the holidays period can be seen so clearly. There are not indications with respect to a significant leakage. However, the minimum night flow is also determined as this provides better indications.

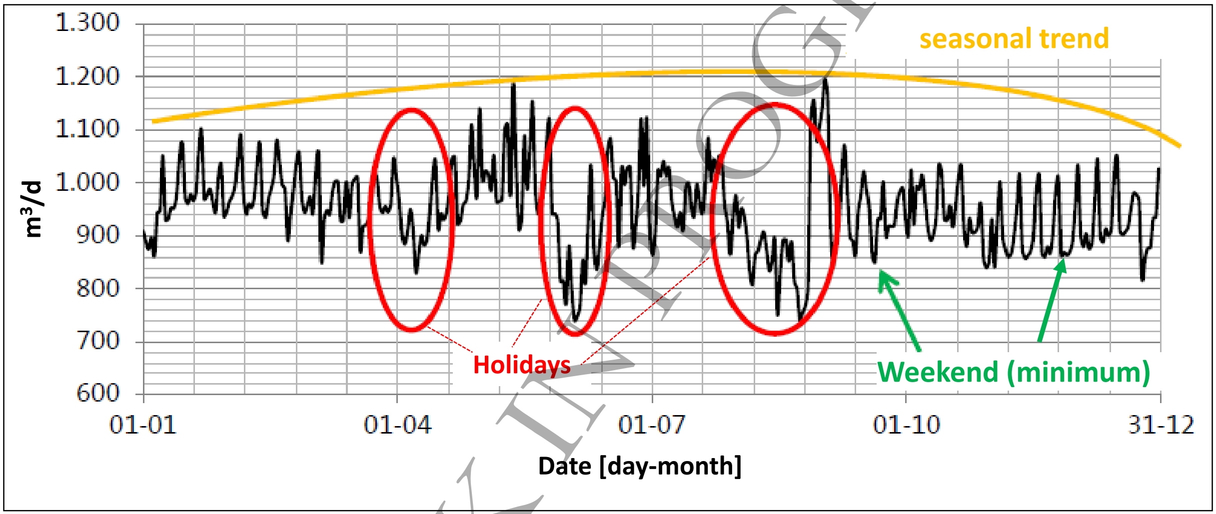

Figure 10-10: Typical normal annual consumption curve of a leakage monitoring zone (Diersche et al., 2014)

In contrary, Figure 10-11 shows an example which, at first sight, could indicate leakages. For the year concerned, there are two periods with gradual increases and two sharp decreases. However, both increases were due to a malfunctioning water meter which had to be repaired twice. In addition, the absolute increase was too big to be a reasonable leakage.

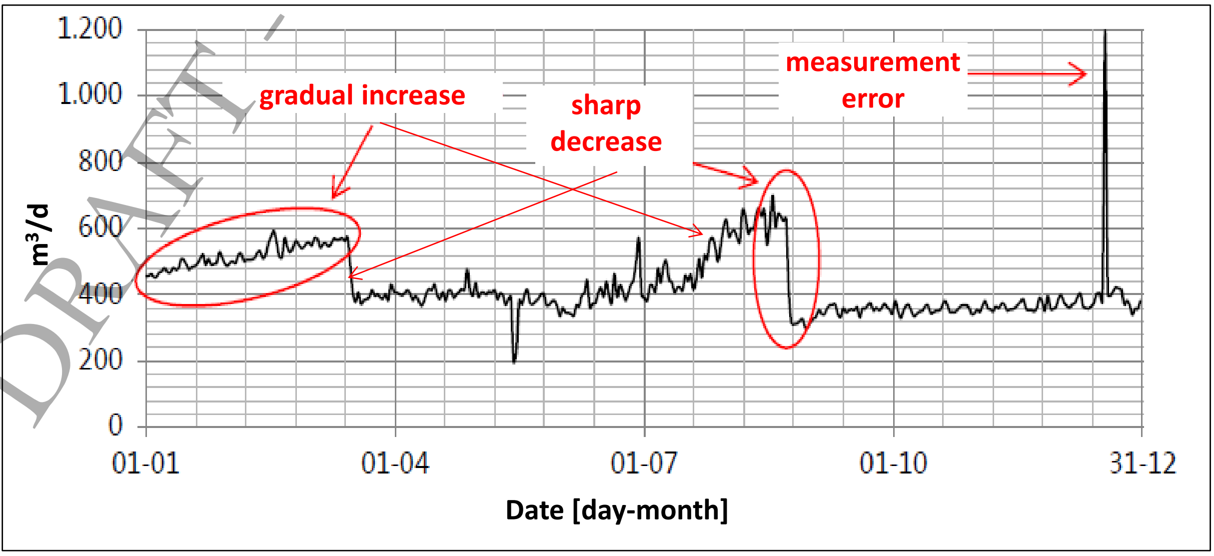

Figure 10-11: Annual consumption curve of a leakage monitoring zone showing two periods with gradual increase and two sharp decreases (Diersche et al., 2014)

When flow measurements show a significant increase of consumption, usually of the minimum night flow (flow between 2 and 4 am), e.g. double the usual flow, the leakage within a monitoring zone is located by means of different techniques, such as automatic and manual acoustic leakage detection systems (see Figure 10-12) or step testing (hydraulic analysis in a metered district area at minimum night flow). In case of the automatic acoustic system, sensors/microphones and a data logger with radio antenna are positioned in the area concerned about every 150 m (the distance depends on the system applied). The noise between 2 and 4 am to cover the minimum night flow is recorded and stored and is automatically processed and analysed. One unit positioned at an underfloor hydrant is shown in Figure 10-12.

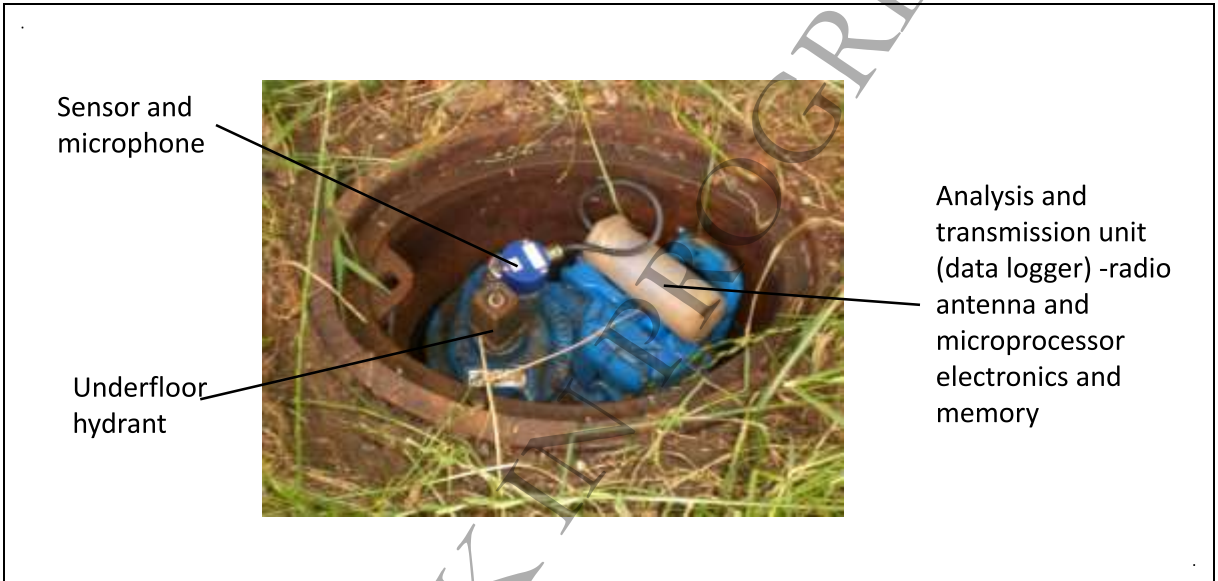

Figure 10-12: Sensor/microphone and data logger/antenna positioned at an underfloor hydrant

Figure 10-13 gives an example for the positions of sensors/microphones with a data logger at different locations of an area where a leakage is suspected. The software automatically evaluates the data and indicates measurement points with an elevated noise level exceeding a given threshold value.

Figure 10-13: Example of a part of a leakage monitoring zone where sensors/microphones with data logger (red numbers) have been positioned (left hand) and the automatic protocol indicating sensors/microphones with an elevated noise level exceeding a threshold value, marked in red (right hand)

The manual acoustic system enables the confirmation of a leakage at a single individual point (hydrant, valve etc.) on site.

Applicability

The technique described is applicable in existing and new water distribution networks and can be retrofitted or applied to any existing water distribution network.
It requires personnel with adequate education and a budget sufficient to implement and to operate the system in order to minimise water losses of municipal water distribution networks.

Economics

Firstly, the management of water losses is associated with economic benefits because less water has to be abstracted, treated and distributed. This does not only include the costs for the water as such but also for chemicals, energy and staff.
Secondly, the early detection and well-done repair of a leakage can prevent considerable damages. In worst cases, the costs for such damages may exceed the costs for a pro-active leakage detection system, e.g. the described automatic acoustic leakage detection system.
There is always a certain background level of leakage that is unavoidable, and the cost of detecting and repairing all leaks may make it prohibitive. Unavoidable annual real losses (UARL) are therefore commonly calculated, and these are a function of the number of service connections, the length of mains pipes, the length of private pipes and the average operating pressure (Lambert, 2003). In the UK, the approach was developed to determine the point at which leakage reduction benefits outweigh the cost of leakage repair. When externalities are included into these costs, this point is known as the Sustainable Economic Level of Leakage (SELL) (OFWAT, 2007). However, the analysis of the SELL approach revealed that there are many uncertainties in estimating the economic level of leakages and the SELL mechanism does not promote efficiency and innovation (OFWAT, 2012).

Driving force for implementation

The advantages of leakage detection and repair are manifold. Leaks cause health risks by contaminating piped water, decrease the quality of service through pressure losses, damage roads, buildings and other infrastructure and increase the chance of further damage to pipes through erosion. Repairing leaks leads to water, energy/GHG and financial savings. Reduced energy use also entails lower operating costs, which also benefit from reduced chemical input, reduced maintenance requirements and staff costs.

Reference organisations

Berlin/Germany; Freiburg/Germany, Hamburg/Germany; Münster/Germany; Copenhagen/Denmark, Amsterdam/Netherlands, Rotterdam/Netherlands; Melbourne/Australia; San Jose/USA, Singapore/Singapore – these cities practice an efficient management of water losses and do achieve very low level of water loss, expressed as percentage of system input volume or as Infrastructure Leakage Index (ILI). They represent best practice examples.

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11 BEST ENVIRONMENTAL MANAGEMENT PRACTICES FOR WASTEWATER MANAGEMENT

Chapter structure

This chapter provides guidance on the sustainable wastewater treatment. It starts by introducing the main elements of wastewater management in European cities and then it explains the reasons that should push public authorities towards the improvement of their wastewater management. Afterwards, some Best Environmental Management Practices that can help public authorities do so are detailed.

Chapter introduction

Wastewater from households and industry represents a significant pressure on the water environment because of the loads of organic matter and nutrients as well as hazardous substances. Industrial production and household consumption increased at a rapid rate during the last century, producing larger amounts of wastewater. With high levels of the population in European countries living in urban agglomerations, a significant fraction of waste water is collected by sewers connected to public wastewater treatment plants. Average connection rates between 80%-90% are reported for Northern, Southern and Central Europe. Eastern Europe still copes with much lower rates of about 40% of the population connected to primary waste water treatment at least (EEA, 2013). The level of treatment before discharge and the sensitivity of the receiving waters determine the scale of impacts on aquatic ecosystems. The types of treatments and conformity with the directive are seen as proxy indicators for the level of purification and the potential improvement of the water environment.

Technique portfolio

In order to address the relevant impacts of wastewater generated from households and industries in the territory of the municipality, this chapter presents six BEMPs which can inspire local public administrations on how wastewater management can be carried-out best.

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11.1 Energy efficient waste water treatment achieving full nitrifying conditions

Description

Best practice for energy-efficient waste water treatment is:

- to have the installed capacity to treat at least twice the dry weather waste water flow (in case of rain or thawing)
- to treat the wastewater at nitrifying conditions (food-to microorganisms ratio of < 0.15 kg BOD_5[77]/kg MLSS[1] x d), and to perform denitrification and phosphorus removal
- to remove suspended solids by means of sandfiltration in case of sensitive receiving water bodies or other tertiary treatment such as activated carbon filtration or oxidation with chlorine-free oxidising agents in order to reduce micropollutants such as man-made hormone-disrupting chemicals (see the technique on tertiary treatment for the removal of micropollutants)
- to monitor on-line organic compounds (total organic carbon), ammonia, nitrate and phosphorus in case of plant capacities of more than 100 000 population equivalents (p.e.) or of a daily inflow of BOD_5-load of more than 6000 kg respectively
- preferably to stabilise primary and excess sludge in anaerobic digesters and to use the produced biogas for on-site electricity production and sludge drying, at least for plants with a capacity of more than 100 000 population equivalents or of a daily inflow BOD_5-load of more than 6000 kg respectively (see the technique on anaerobic digestion of primary and excess sludge and optimal energy recovery)
- to dry the anaerobically stabilised sludge and to send it to incineration or co-incineration plants (e.g. in coal-fired power plants or cement plants) meeting the standards according to the IED[1]; in case of small plants, the mechanically de-watered sludge can be sent to central sludge drying plants (see the technique on drying of sludge and its incineration according to BAT standards)
- To use energy-efficient fine bubble aeration systems in the biological stage, to use energy-efficient pumps and screw lifters, to recover biogas from anaerobic digestion of primary and excess sludge and to use it in energy-efficient turbines producing electricity and heat to be fully used for plant operation (see the technique on anaerobic digestion of primary and excess sludge and optimal energy recovery).

Achieved environmental benefits

The most important environmental benefit is to have clean rivers and natural waters as they are protected from untreated or insufficiently treated waste water in terms of organic impurities (removal efficiency of BOD_5 of more than 98 % and of COD of more than 90 %), inorganic pollutants (heavy metals), nutrients (phosphorus removal efficiency of more than 90 % and nitrogen (removal efficiency of ammonia of more than 90 % and of the sum of inorganic nitrogen compounds of more than 80 %)) and from microorganisms. For a large number of micropollutants, an additional treatment step is required in order to eliminate them at high efficiency (see the technique on the removal of micropollutants).

Appropirate environmental indicators

Appropriate indicators for the removal and energy efficiency of waste water treatment are:

- Concentrations in the discharged final effluent or removal efficiencies of COD, BOD_5[78] ammonia, total nitrogen and total phosphorus
- Electricity consumption (kWh/kg BOD_5 removed)
- Electricity consumption per volume treated (kWh/m^3 of wastewater treated)

[78] BOD_5: biochemical oxygen demand in 5 days; MLSS: mixed liquor suspended solids (biomass in the activated sludge system); IED: Industrial Emissions Directive, COD: chemical oxygen demand

- Annual electricity consumption per person equivalent (KWh/p.e. yr)
- Percentage of electricity and primary energy covered by internal supply (with biogas etc.)

Cross-media effects

For treating waste water at nitrifying conditions, more energy is required compared to plants which mainly reduce the organic load, specifically electricity consumed for the extended fine bubble aeration in the activated sludge system.

Operational data

As an example, a plant achieving best performance is shown in Figure 11-1. This plant treats wastewater from an entire region, incorporating the city of Freiburg i.Br./Germany and 28 municipalities with a total 375 000 inhabitants (2012). Plant capacity is for 600 000 population equivalents, allowing for the treatment of wastewater from industrial and other commercial activities in addition to domestic wastewater.

Figure 11-1: Aerial view of a best practice municipal waste water treatment plant ("Breisgauer Bucht" near Freiburg in southern Germany)

This plant demonstrates best performance as indicated in Table 11-1with low variations (stable performance) as presented for the parameter COD (Figure 11-2), inorganic nitrogen (sum of ammonia, nitrate and nitrite) and ammonia (Figure 11-3) and total phosphorus (Figure 11-4). The emission curves for COD, nitrogen and phosphorus (Figure 11-2, Figure 11-3, Figure 11-4) show the values of flow-proportionally taken 24-hour-composite samples over four years.

Table 11-1: Performance of a best practice municipal effluent treatment plant (example: treatment plant "Breisgauer Bucht" set-up and operated by a grouping of 29 municipalities) – values for 2012

Parameter	**Removal efficiency in % (load in/load out)**	**Annual average concentration in mg/L**	**Min-max-values for 24-h composite samples**
BOD_5	> 98	< 5	no data available
COD	> 90	22	9.5 - 30
Ammonia	> 90	0.1	0.02 – 2.0
Sum of inorganic nitrogen compounds	> 80	8	2.3 - 13
Total phosphorus	> 90	0.6	0.1-0.7

The COD of the final effluent varies between 8 and 36 mg O_2/L. This is due to varying influent concentrations over the year, specifically in the case of rain.

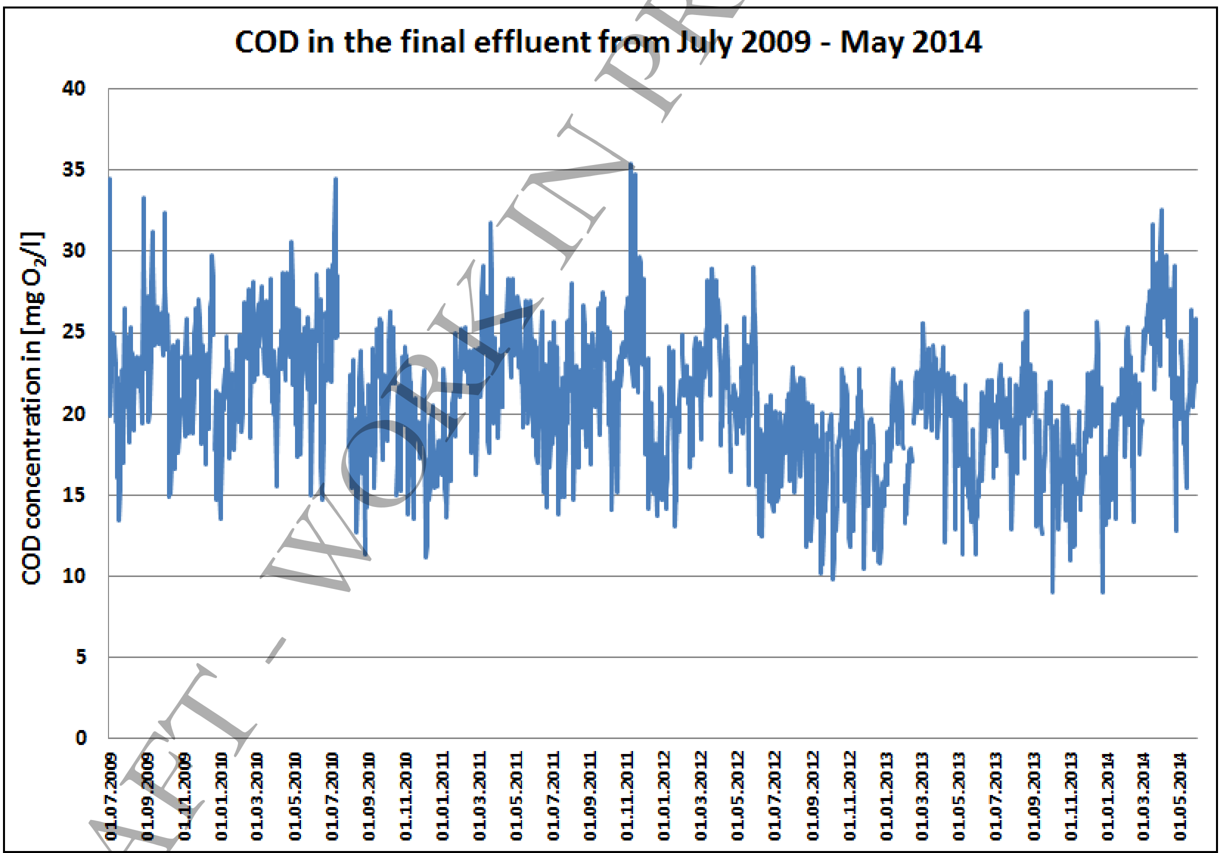

Figure 11-2: COD emission curve (values of 24-hour-composite samples) of the treatment plant "Breisgauer Bucht" set-up and operated by a grouping of 29 municipalities for the time period July 2009 – May 2014 (4 years)

The average removal efficiency of the sum of ammonia, nitrate and nitrite (inorganic nitrogen) via nitrification/denitrification is more than 80%. There are peaks for ammonia up to 2 mg NH_4-N/L which may have occurred due to rain events.

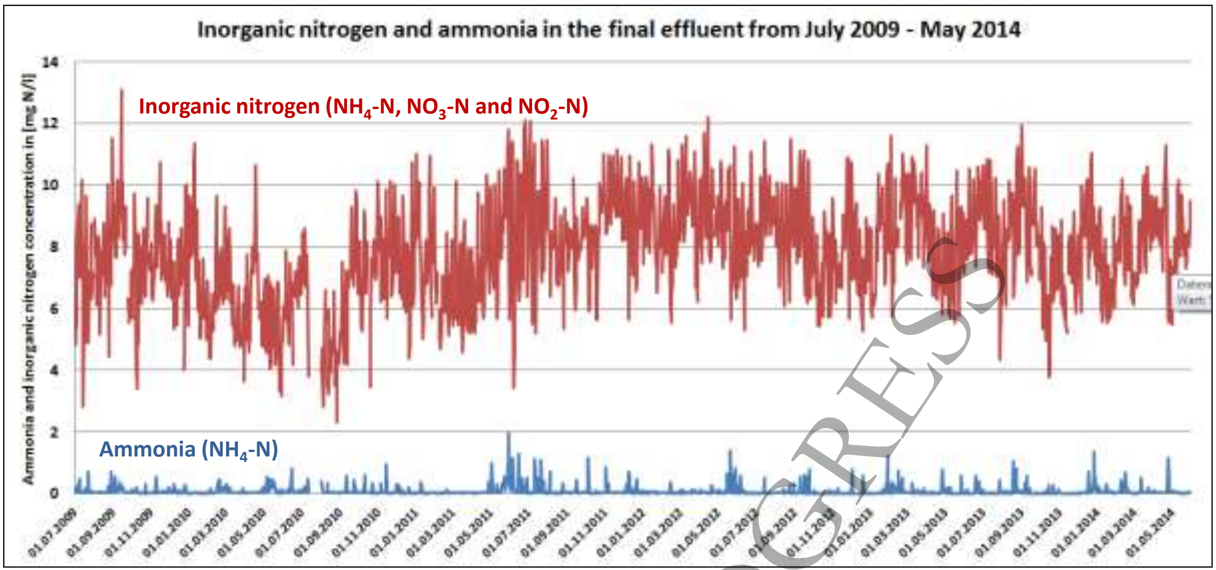

Figure 11-3: Ammonia and inorganic nitrogen (sum of ammonia, nitrate and nitrite) emission curves (values of 24-hour-composite samples) of the treatment plant "Breisgauer Bucht" set-up and operated by a grouping of 29 municipalities for the time period July 2009 – May 2014 (4 years)

The phosphorus content is reduced by co-precipitation in the activated sludge stage and the subsequent sand filtration. The values are below 0.7 mg P/L. The emission curve is curtailed because of the adjusted dosage of phosphorus-precipitating agents.

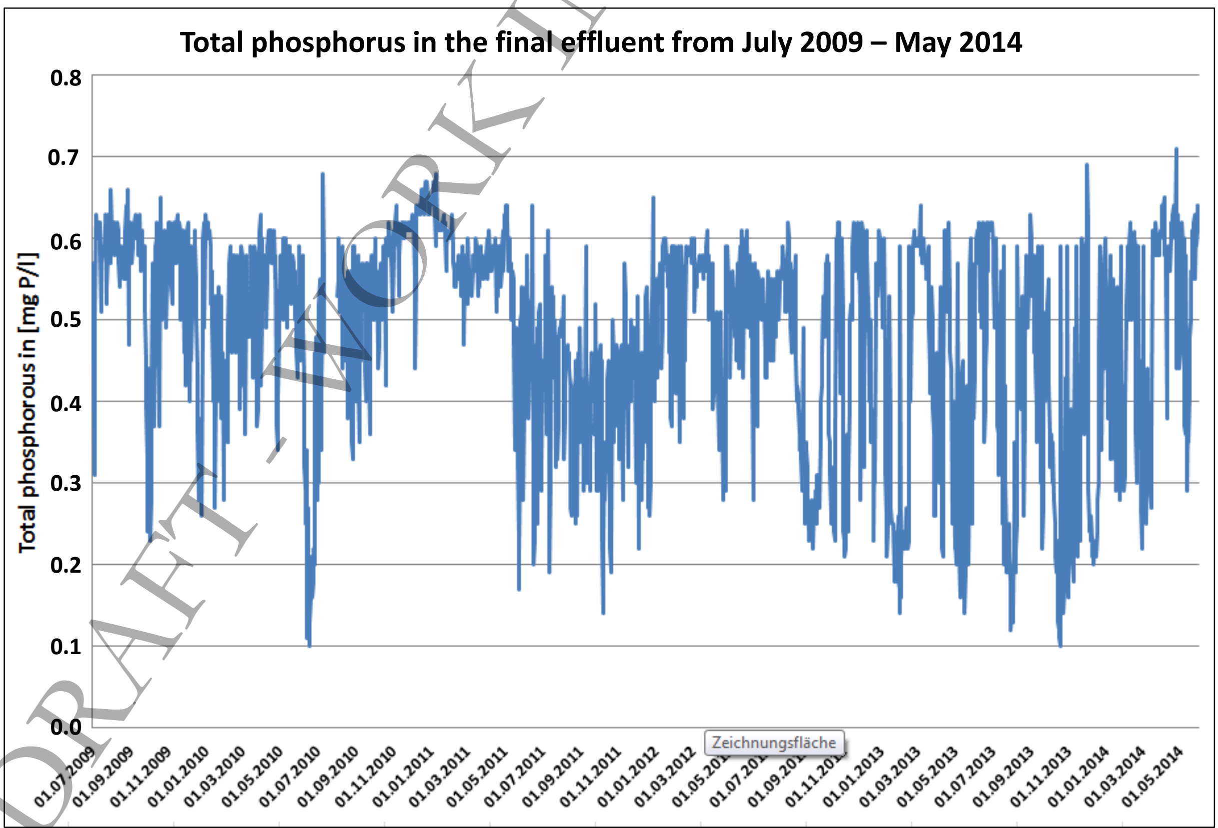

Figure 11-4: Total phosphorus emission curve (values of 24-hour-composite samples) of the treatment plant "Breisgauer Bucht" set-up and operated by a grouping of 29 municipalities for the time period July 2009 – May 2014 (4 years)

Concerning the optimisation of the energy efficiency of municipal waste water treatment plants, the following aspects are the most relevant (Haberkern et al., 2008):

- Arrangement, design and regular maintenance of aeration elements,
- Efficient control of the aeration in the activated sludge system,
- Use of highly efficient pump impellers and their regular maintenance
- Fluidically and energetically optimised stirrers,
- Separate treatment of certain internal stream (e.g. precipitation of phosphorus, steam stripping etc.).

Figure 11-5 shows the cumulative undercut frequency curves of the electricity consumption for five different size categories of municipal waste water treatment plants and target values which are achieved by a number of plants and which can be achieved by others as well. There are two different numbers: one for size categories 1-3 and another for size categories 4 and 5 (see legend of Figure 11-5). These target values are valid for waste water treatment plants with anaerobic sludge treatment. Table 11-2 contains these values together with those of other types of waste water treatment plants.

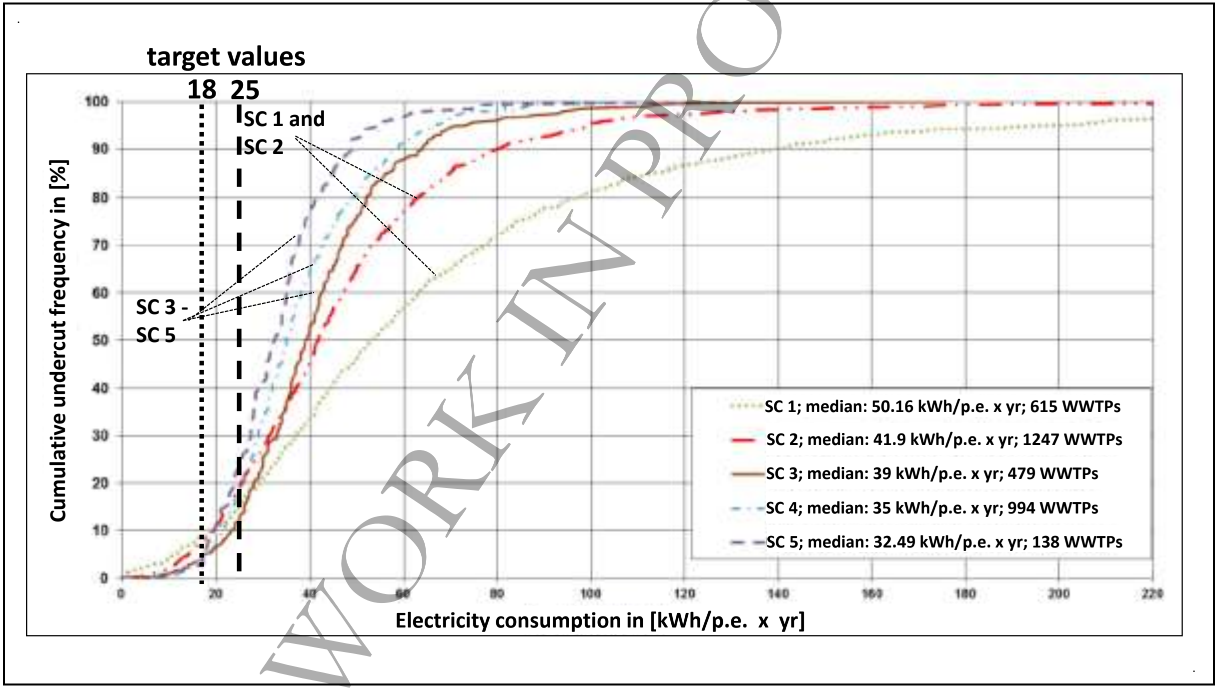

Figure 11-5: Cumulative undercut frequency curves of the electricity consumption for five different size categories of municipal waste water treatment plants (data from 3473 German treatment plants) and target values for size categories 1-3 and 4-5 (according to DWA-A 216, 2013)

Legend:
Size category 1 (SC 1): < 1000 p.e.
Size category 2 (SC 2): 1000 – 5000 p.e.
Size category 3 (SC 3): 5001 – 10,000 p.e.
Size category 4 (SC 4): 10,001 – 100,000 p.e.
Size category 5 (SC 5): > 100,000
p.e.: population equivalent; WWTP: waste water treatment plant

Table 11-2: Target values for the electricity consumption of different types of municipal waste water treatment plants (UBA, 2008; Haberkern, 2013)

Type of municipal waste water treatment plant	SC 1 and 2	SC 3 - 5
	≤ 5000 p.e.	> 5000 p.e.
	≤ 300 kg BOD_5/d	> 300 kg BOD_5/d
Total electricity consumption in [kWh/p.e. x yr]		
anaerobic sludge treatment	25	18
simultaneous aerobic sludge stabilisation	30	24
Electricity consumption for aeration in [kWh/p.e. x yr]		
anaerobic sludge treatment	14	10
simultaneous aerobic sludge stabilisation	16	12
Electricity consumption for pumping in [Wh/m^3 x m]	4	4

Applicability

This technique is applicable both to new and existing plants. Existing plants can be retrofitted. This is true for the waste water treatment as well as for the measures to minimise energy consumption and to recover energy.

Economics

For the Breisgauer Bucht waste water treatment plant near Freiburg in Southern Germany, described above, total operating costs were EUR 15.5 million in 2012, equating to EUR 0.74 per m^3. Fees charged to users of the sewage network (households, industries) are EUR 1.32 per m^3, one of the lowest in Germany (typical range EUR 1 to 3 per m^3).
The costs for energy efficiency measures usually do pay bay back with 2-5 years (UBA, 2008).

Driving force for implementation

Legal requirements, cost aspects and demands of the public due to high awareness are the most important driving forces for implementation.

Reference organisations

A considerable number of municipal waste water treatment plants in Northern and Central Europe, such as in Freiburg i.Br., Karlsruhe, Hamburg, Berlin etc. (all Germany), Copenhagen (Denmark), Amsterdam (Netherlands).

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11.2 Minimisation of wastewater emissions with special consideration of micropollutants

Description

Diffuse and point-source pollution still threaten the status of EU waters, despite the progress achieved (Blueprint, 2012) so far. A particular challenge is the emission of micropollutants[79] for which municipal waste water treatment plants are a major source (Welker, 2004; Abegglen/Siegrist, 2012; JRC, 2012; WHO/UNEP, 2013) as they cannot sufficiently be eliminated by the commonly applied techniques (primary and biological treatment) via biological degradation and adsorption to activated sludge. In addition, the possibilities to prevent the discharge of hundreds of micropollutants at source are limited. As a consequence, the application of end-of-pipe techniques is required. The minimisation of the discharge of heavily or non-biodegradable organic compounds, especially of micropollutants, comprise the following elements:

- to treat at least up to double of the dry weather wastewater influent flow (in case of rain or thawing)
- to treat the wastewater at nitrifying conditions (food-to microorganisms ratio of <0.15 kg BOD_5/kg MLSS x d), and to perform denitrification and phosphorous removal (see the BEMP on energy efficient waste water treatment achieving full nitrification)
- in case of sensitive areas[80], to remove suspended solids by means of sandfiltration (or by submerged membranes) and to significantly remove micropollutants by adequate techniques, such as adsorption to pulverised activated carbon (PAC) or oxidation with chlorine-free oxidising agents (specifically ozone). The removal of mircopollutant is at least for 90 % of the annual waste water flow; this means in case of heavy rain, part of the waste water by-passes the adsorption or oxidation plant.
- to on-line monitor organic compounds (total organic carbon), ammonia, nitrate and phosphorous in case of plant capacities of more than 100 000 inhabitants equivalents or of a daily influent BOD_5-load of more than 6000 kg respectively.

Most experience is available from plants equipped with an adsorption stage using pulverised activated carbon. It is important to note that this adsorption stage is used for the non-biodegradable organic compounds. For this purpose, the easily as well as the heavily biodegradable compounds are to be removed in the biological stage as far as possible. This requires fully nitrifying conditions (for an activated sludge system, the food-to-microorganism ratio is below 0.15 kg BOD_5/kg MLSS x d). In case of removal of the micropollutants by oxidation with ozone, the suspended solids have to be removed as far as possible by sand filtration or submerged membranes. The fact that the removal efficiency of heavily biodegradable organic compounds in an activated sludge system operated under fully nitrifying conditions is significantly better compared to activated sludge systems operated below the aforementioned food-to-microorganism ratio is shown in Figure 11-6. All the individual organic compounds analysed represent micropollutants.

[79] Micropollutants are organic compounds which are present in the aquatic environment at concentrations in the range of a few n/l to µg/l and can have an impact on fundamental biochemical processes (Abegglen/Siegrist, 2012) such as the endocrine systems. Micropollutants comprise a wide range of organic compounds, such as pesticides, biocides, pharmaceuticals, x-ray-contrast media, flame retardants etc.). All the organic priority pollutants of Annex X of the Water Framework Directive (the existing list according to (Decision, 2001) contains 33 pollutants and there is a proposal to add 15 more pollutants (Proposal, 2012)) are considered as a significant risk to or via the aquatic environment, including such risks to waters used for the abstraction of drinking water (Article 16(1) of the Water Framework Directive (WFD, 2000). The endocrine disrupting chemicals are an important part of the micropollutants (WHO/UNEP, 2013). Some of the aforementioned priority chemicals also belong to the endocrine disrupting chemicals.

[80] Sensitive areas as defined in ANNEX II of the Urban Waste Water Directive 91/271/EEC (UWWD, 1991)

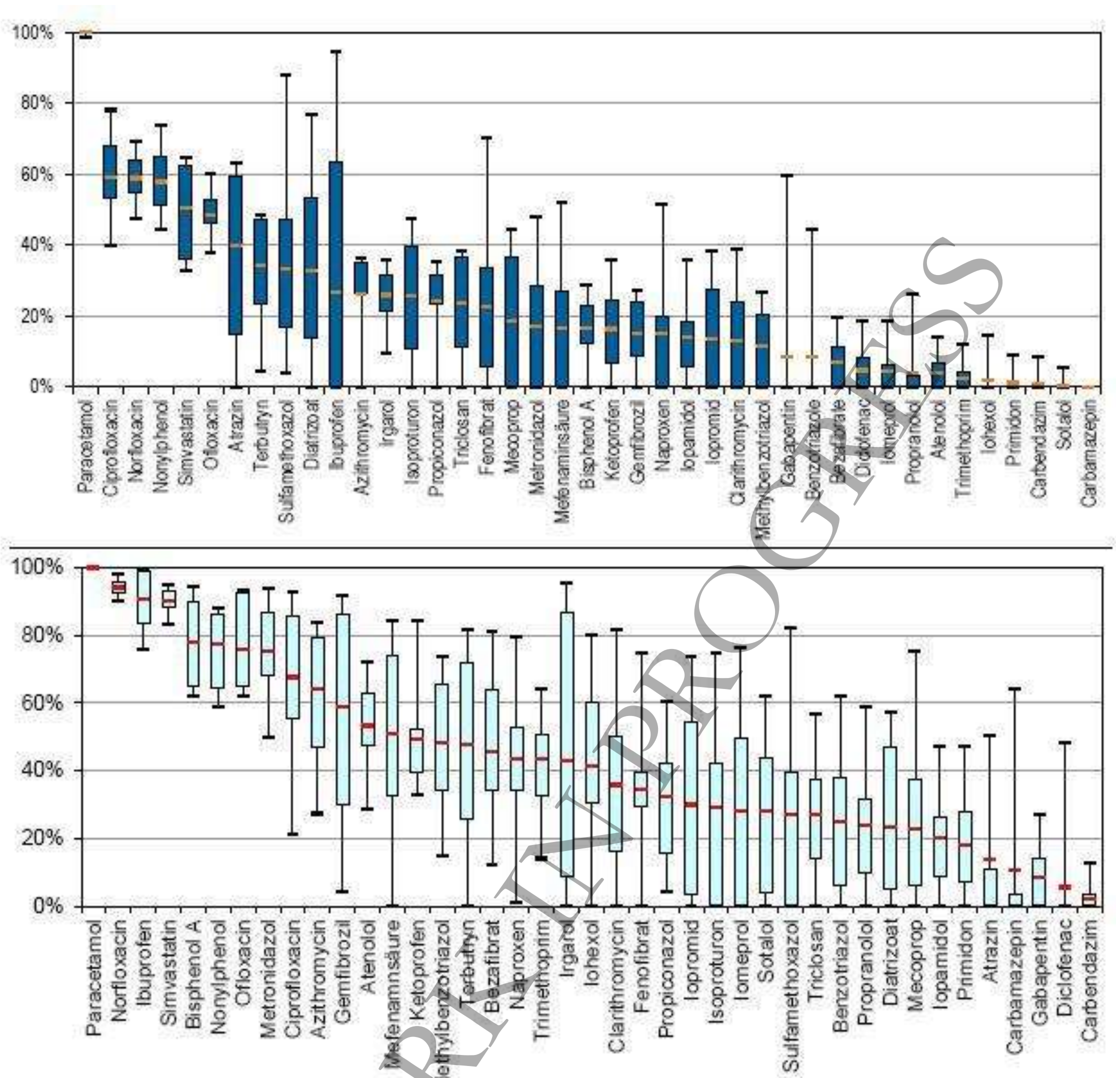


Figure 11-6: Bioelimination of micropollutants in activated sludge systems operated under fully nitrifying and under non- (or incomplete) nitrifying conditions (Abegglen/Siegrist, 2012, p 74)

The waste water from the biological stage with a BOD_5 content of less than 10 mg O_2/l (practically free of biodegradable organic compounds) is then specifically treated to remove the micropollutants. The currently most relevant techniques are the adsorption to pulverised activated carbon (PAC) in a dedicated reactor or the oxidation with ozone in a cascade reactor. Figure 11-7 shows the scheme for the adsorption technique. The pulverised activated is automatically added via a silo and a dosage system in a quantity of 10 – 20 mg/l to the contact reactor equipped with stirrers where the adsorption takes place at a retention time of half an hour and a content of activated carbon of about 4 g/l. At or just after the outlet of the contact reactor, a precipitant (usually a iron(III)salt or an aluminium salt; dosage about 2-4 mg Fe or Al/l) is added and also a polyelectrolyte to improve the aggregation of precipitates (dosage about 0.3 mg/l) (Metzger, 2012); another 1 mg Al or Fe is added after sedimentation prior to sand filtration. Then, the PAC is separated by sedimentation (retention time about 2 h) and sand filtration but it is possible to have a filtration only or to use membrane technology to completely remove the PAC from the water phase. Part of the separated PAC is returned to the adsorption stage in order to maximise its adsorption capacity and the surplus is directed to the activated sludge system where it leaves the system with the excess sludge reaching the anaerobic digestor(s). The return of the activated carbon to the biological stage significantly increases the removal efficiency. The final disposal of the laden activated carbon takes place with the anaerobically digested and dewatered, possibly also thermally dried sludge which is co-incinerated in a thermal power plant or a cement plant or in a dedicated sludge incineration plat, all operated in compliance with best available techniques according to the Industrial Emissions Directive (see also the BEMP on sludge treatment and disposal).

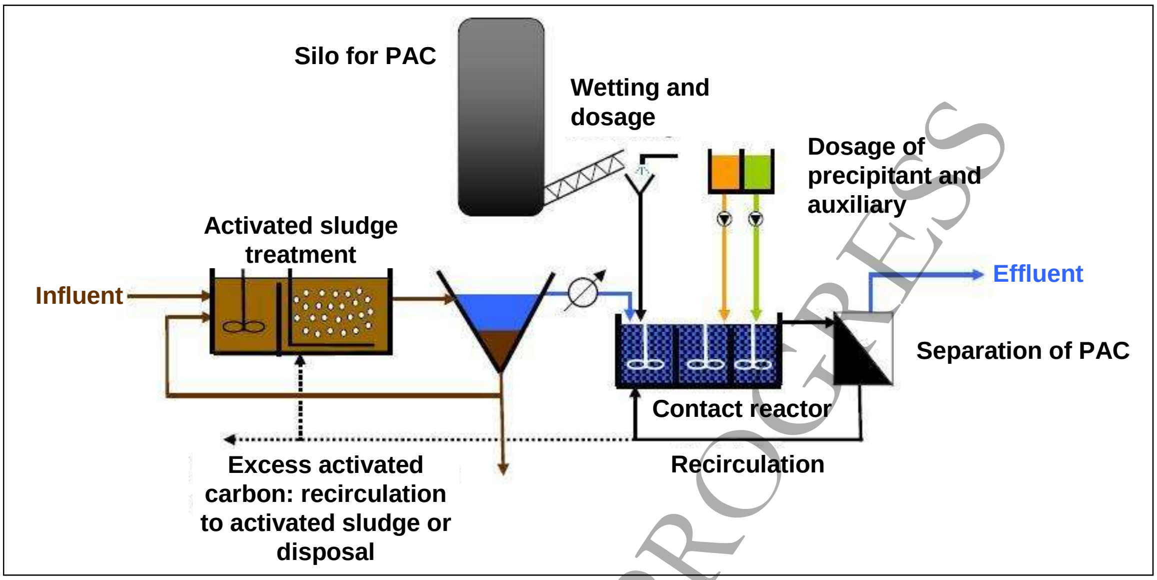


Figure 11-7: Scheme of an adsorption stage using pulverised activated carbon downstream to mechanical-biological treatment (Abegglen/Siegrist, 2012, p 121)

Another option is to add ozone to the waste water after mechanical-biological treatment (see the scheme in Figure 11-8). The content of organic compounds and suspended solids should be as low as possible in order to minimise the dosage of ozone. Ozone is produced onsite by means of silent electric discharge from air or oxygen. In a closed ozonation reactor, it is counter-currently added to the waste water flow at an injection depth of more than 4 m to completely dissolve it.

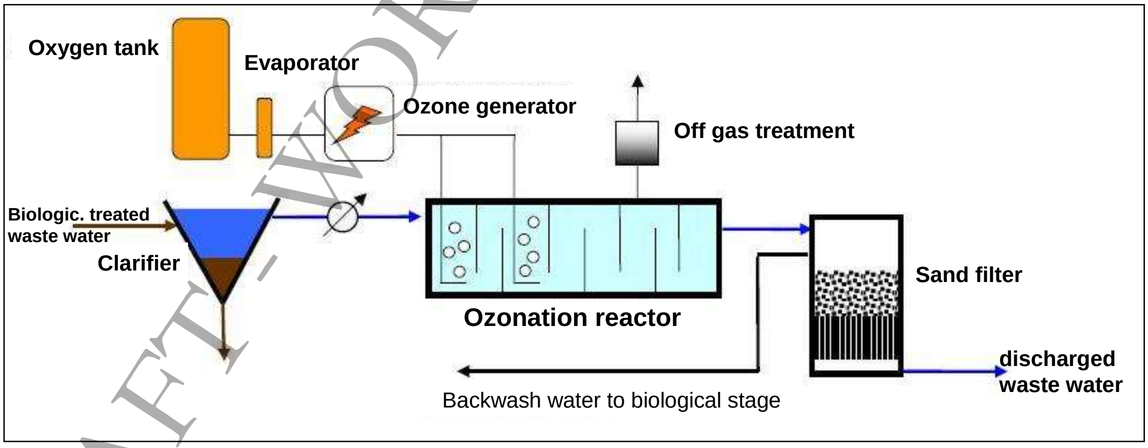


Figure 11-8: Scheme of an ozonation stage downstream to mechanical-biological treatment (Abegglen/Siegrist, 2012, p 97)

The appropriate dosage should be proportional to the dissolved organic carbon (DOC) concentration which can be achieved by means of a monitor using a signal at 254 nm (UV light absorption). It is about 0.6 g O_3/g DOC which is usually equal to 4 – 6 mg O_3/l. The oxidation depends on the chemistry of the micropollutant considered and the ozone dosage. As ozone is toxic, ozone detectors are needed and the off-gas with a residual ozone content has to be treated; it can be returned to the activated sludge system or the zone is destroyed. In the oxidation process, the organic compounds are broken down but they are not completely oxidised. Thus, the residual organics are removed in a biologically active sand filter (Figure 11-8).

Achieved environmental benefits

Most of the micropollutants are reduced with a removal efficiency of more than 80%. This is demonstrated in Figure 11-9 for the application of PAC. The efficiency for the individual micropollutants depends on their physicochemical properties. For many compounds, the removal efficiency in biological treatment is less than 10 % but more than 90 % with an adsorption stage (dosage of 15 mg PAC/l and return of excess activated carbon to the biological stage). For few micropollutants such as the X-ray contrast agents (Iopromid and Iohexol – see Figure 11-9), the removal efficiency is less than 80 %, or significantly depends on the PAC dosage and recirculation to the biological stage. It is important to note that the spectrum of micropollutants removed is broad including hundreds of compounds and their metabolites of which many cannot be analysed so far. The residual content of organic compounds is measures with sum parameters such as COD or DOC. The adsorption stage reduces the COD or DOC only by 20 – 30 % but, in general, the removal efficiency for micropollutants is much higher.
The removal of the micropollutants considerably contributes to the minimisation of adverse environmental impacts due to waste water discharge such as the impacts on the endocrine system of aquatic organisms. Further, the micropollutants removed cannot reach drinking water supply systems.

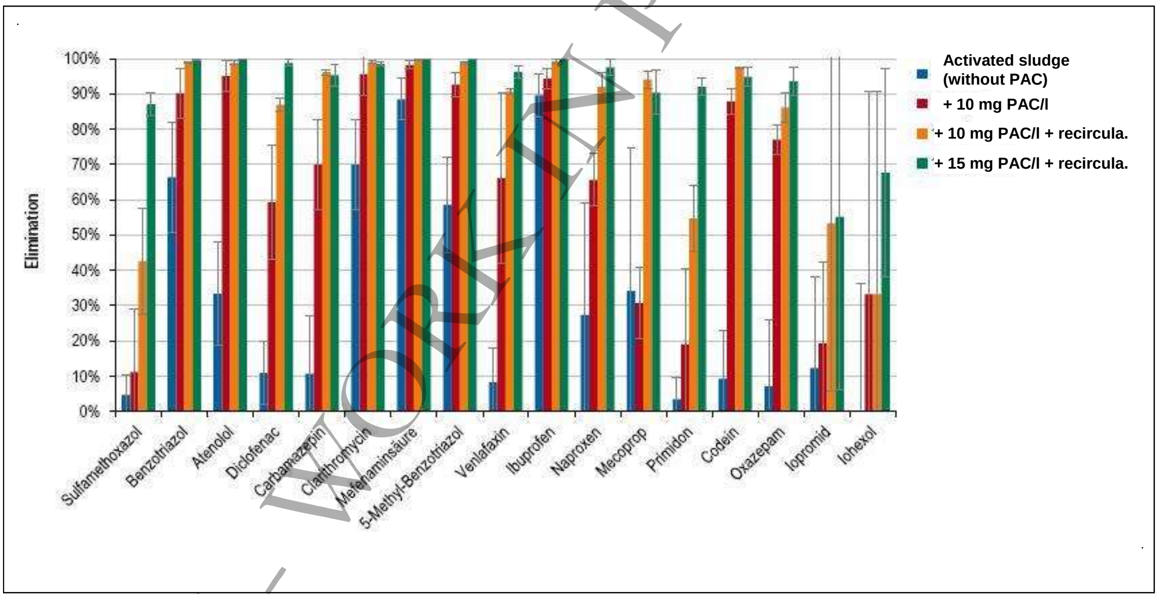


Figure 11-9: Average elimination rates of different micropollutants using pulverised activated carbon (PAC) (Abegglen/Siegrist, 2012, p 133)

Appropriate environmental indicators

The appropriate environmental indicator is the removal efficiency of the adsorption or ozonation stage determined in terms of COD or DOC. They can be easily determined whereas the analysis of individual micropollutants requires a lot of effort. E.g. where the removal efficiency for COD or DOC is more than 20 %, a removal efficiency of more than 80 % for most of the micropollutants can be expected.

Cross-media effects

The adsorption with PAC requires the production and transport of PAC which is associated with emissions of greenhouse gases and other emissions to air. This impact seems to be minor compared to the removal of micropollutants. In addition, the laden PAC has to disposed of in an environmentally friendly way such as the incineration described.

Concerning ozonation, the energy consumption for producing ozone has to be considered (about 12.5 kWh/kg O_3). With a realistic ozone dosage of about 5 g/m3, the specific energy consumption is about 8 kWh/p.e.[81]/yr which 0.06 kWh/m^3.which would increase the average electricity consumption of large mechanical-biological municipal effluent treatment plants (> 10 000 p.e.) by about one fourth (UBA, 2009).
In addition, unknown oxidation products could create an adverse impact on the natural water. However, detailed investigations did not show evidence for this fear (Abegglen/Siegrist, 2012).

Operational data

An example for a plant meeting the specifications as mentioned above under 'Description' is the municipal treatment plant 'Breisgauer Bucht' (Figure 11-10); however, it is not equipped with an adsorption or ozonation stage yet .This plant treats wastewater from an entire region, incorporating the city of Freiburg i.Br./Germany and 29 municipalities with a total 360 000 inhabitants. Plant capacity is for 600 000 population equivalents, allowing for the treatment of wastewater from industrial and other commercial activities, in addition to domestic sewage.

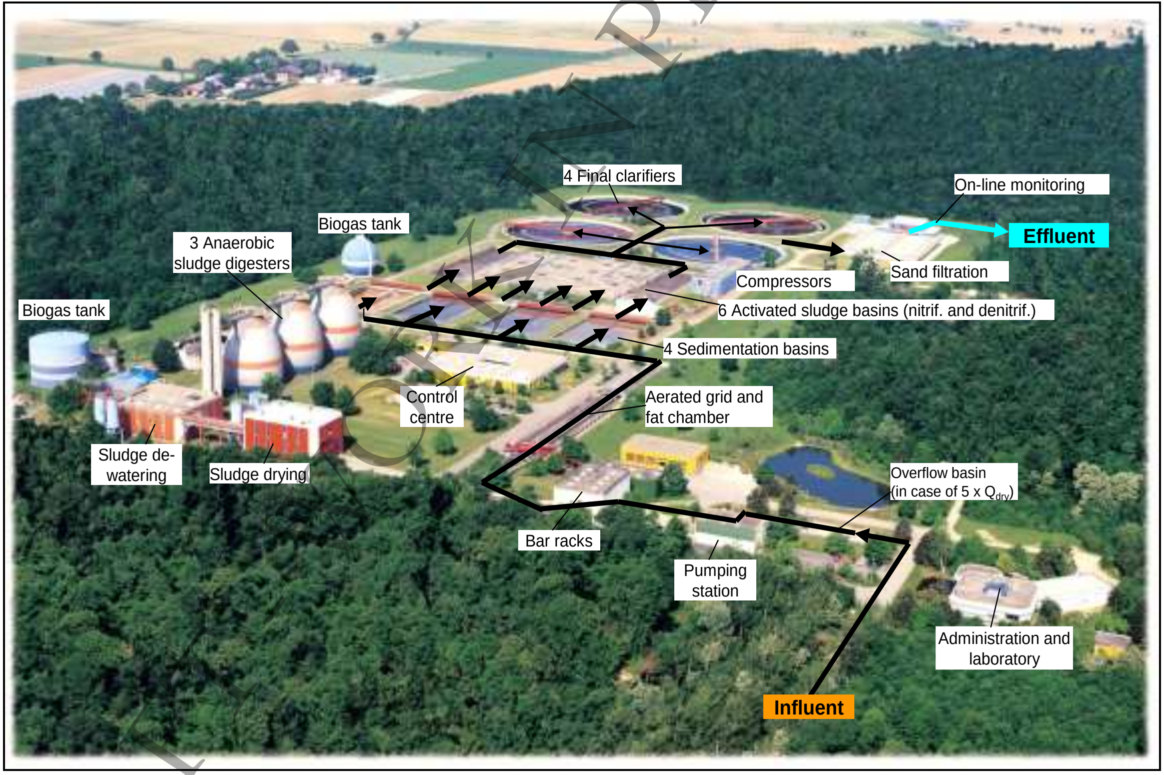


Figure 11-10: Aerial view of a best practice municipal wastewater treatment plant ('Breisgauer Bucht' near Freiburg in Southern Germany); the waste water flow is indicated (black arrows)

This plant demonstrates best performance as indicated in Table 11-3 with low variations (stable performance) as presented in for the parameter COD (Figure 11-11). As already mentioned, there is no specific treatment for micropollutants yet but could be retrofitted.

[81] P.e.:population equivalent

Table 11-3: Performance of a best practice municipal effluent treatment plant (example: treatment plant 'Breisgauer Bucht' set-up and operated by a grouping of 29 municipalities)

Parameter	**Removal efficiency in % (load in/load out)**	**Annual average concentration in mg/l**	**Min-max-values for 24-h composite samples**
BOD_5	>98	<5	no data available
COD	>90	20	9.5 – 30
Ammonia	>90	0.1	0.02 – 2.0
Sum of inorganic nitrogen compounds	>80	7	2.3 – 13
Total phosphorous	>90	0.6	0.1 – 0.7

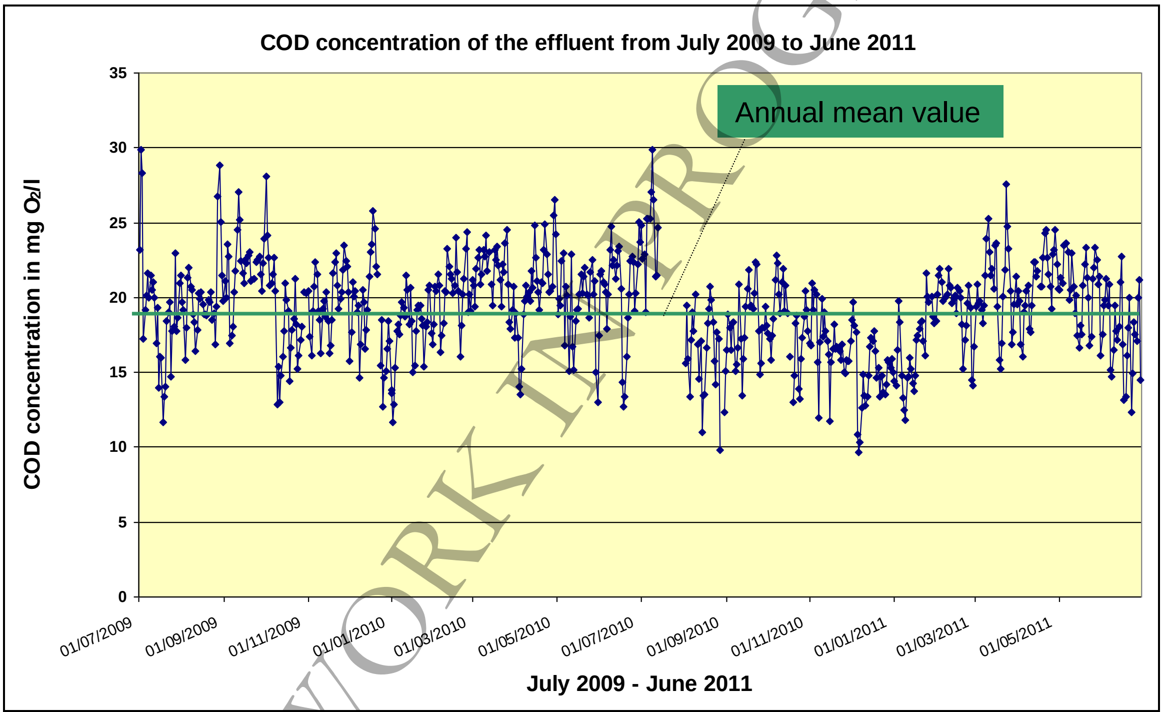


Figure 11-11: COD emission curve (values of 24 h composite samples) of the treatment plant 'Breisgauer Bucht' set-up and operated by a grouping of 29 municipalities

As a representative example for a plant equipped with a retrofitted adsorption stage, the municipal effluent treatment plant Böblingen-Sindelfingen is shown in Figure 11-12. In this plant, the waste water of two cities (Böblingen und Sindelfingen which are located in the South-West of Germany near Stuttgart) is treated (domestic sewage and waste water from industries). The waste water collection system is a combined system for domestic sewage, industrial waste water and rain water. The average influent load concerns about 140 000 inhabitant equivalents. The maximum influent flow at dry whether conditions is just below 800 l/s and at rain conditions up to 2000 l/s. The biological stage of this plant does not consist of an activated sludge system but of seven trickling filters (30 000 m^3), a subsequent tank for denitrification (2400 m^3) and four clarifiers (19 000 m3) with integrated simultaneous precipitation of phosphorous (iron chloride sulphate is added to the influent of the clarifiers). The adsorption stage is designed for a maximum flow of 1000 l/s. With this design, about 90 % of the annual influent can be treated and only under heavy rain conditions, part of the waste water by-passes the adsorption stage (Schwentner, 2012). This represents a trade-off with respect to the size of the plant, i.e. the design of the adsorption stage for the maximum flow (heavy rain conditions) would result in a plant twice the size it has now. Nevertheless, there are also adsorption plants which are designed for the maximum flow (see

Table 11-5).

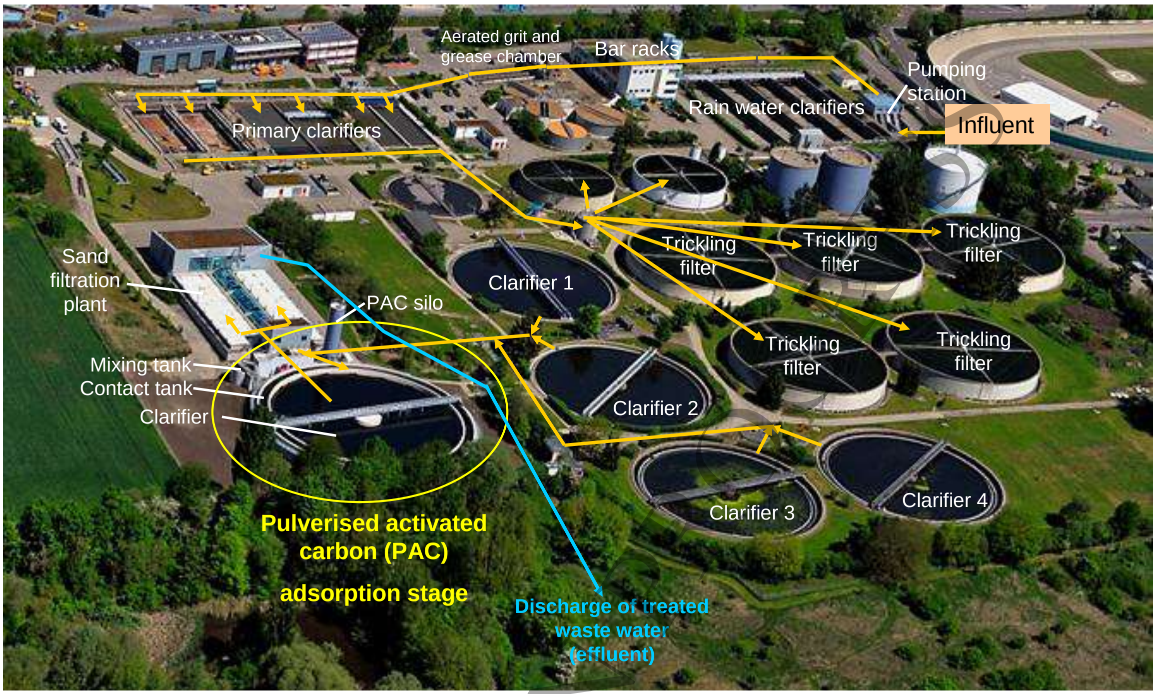


Figure 11-12: Aerial view of the municipal waste water treatment plant Böblingen-Sindelfingen with indication of the waste water flow and the adsorption stage where PAC is added

The plant meets the specifications as mentioned above under 'Description'. The performance for the classical parameters is compiled in Table 11-4, indicating a high removal efficiency for COD, ammonia and phosphorous.

Table 11-4: Performance of a best practice municipal effluent treatment plant (example: municipal treatment plant Böblingen-Sindelfingen from January 2010 to October 2012)

Parameter	Removal efficiency in % (load in/load out)	Annual average concentration in mg/l	Min-max-values for 24-h composite samples
BOD_5	no data available	<10	no data available
COD	94	25	9 - 73
Ammonia	95	1.1	0.02 – 8.4
Sum of inorganic nitrogen compounds	71	10.8	5.6 – 19.9
Total phosphorous	94	0.3	0.1 – 0.9

The retrofitted adsorption stage went into operation end of October 2011. Figure 11-13 shows the plant in more detail. From a silo, the PAC is automatically dosed to the waste water in a quantity of 10 mg/l. The dosage system is illustrated in Figure 11-14. The adsorption takes place in the reaction tank which is the outer ring of the clarifier (Figure 11-13) (in other plants, the geometry of the contact reactor can be very different); the concentration of PAC is about 4 g/l. The surplus activated carbon is directed to the denitrification tank subsequent to the trickling filters. From there, the excess biological sludge containing activated carbon is fed to the anaerobic digesters. The anaerobically digested sludge, containing acticated carbon is finally dewatered and disposed of in an incineration plant. After the adsorption, the precipitant (iron chloride sulphate – 4 mg Fe/l) and the polyelectrolyte (0.3 mg/l) are added and controlled mixing and coagulation takes place in two dedicated tanks. Another 1 mg Fe/l is added just before sand filtration. The content of suspended solids after sedimentation is about 8 mg/l, in case of maximum flow of 1000 l/s up to 15 mg/l which can be managed by the sand filtration plant. The suspended solid concentration after filtration is 3 – 4 mg/l.

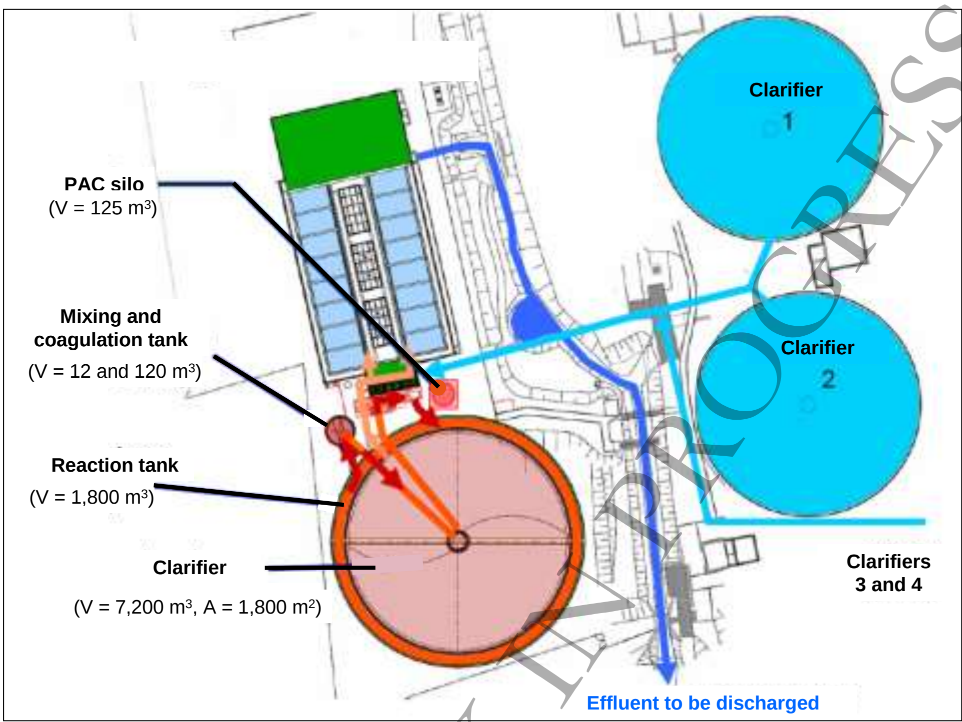
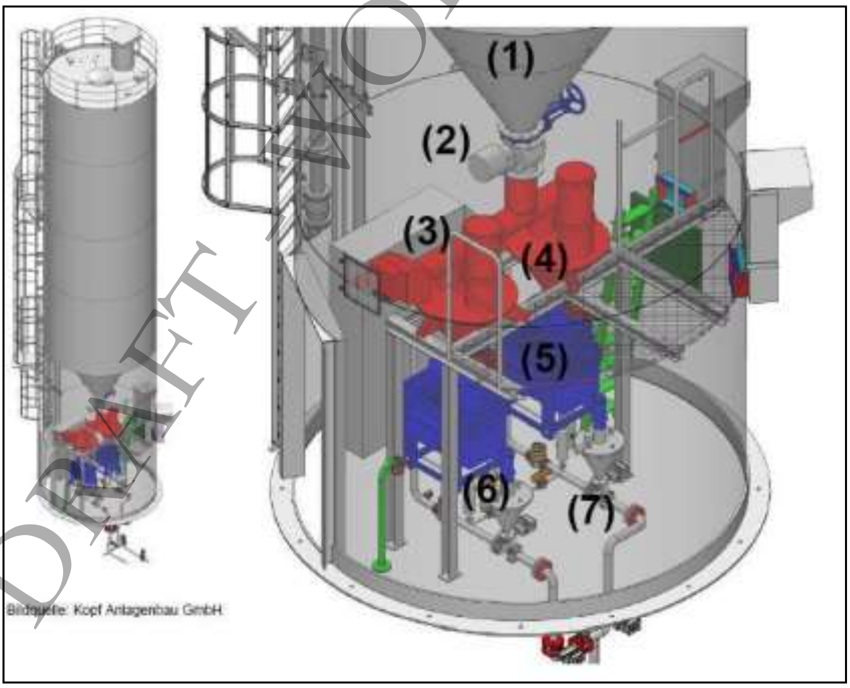


Figure 11-13: The retrofitted adsorption stage of the municipal waste water treatment plant Böblingen-Sindelfingen (Schwentner, 2012)



Legend: (1) conus of the silo, (2) rotary feeder, (3) screw conveyer, (4) feeding tank, (5) weighing tank, (6) Vortex feed hopper, (7) PAC dosage via a water jet pump

Figure 11-14: Automated dosage system for PAC

The effect of the adsorption stage is fully in line with the description above. Most of the micropollutants are removed to more than 80 % (Figure 11-15). However, there are also single micropollutants which cannot be removed such as perfluorinated surfactants (perfluorooctane sulfonate) (Kapp, 2012).

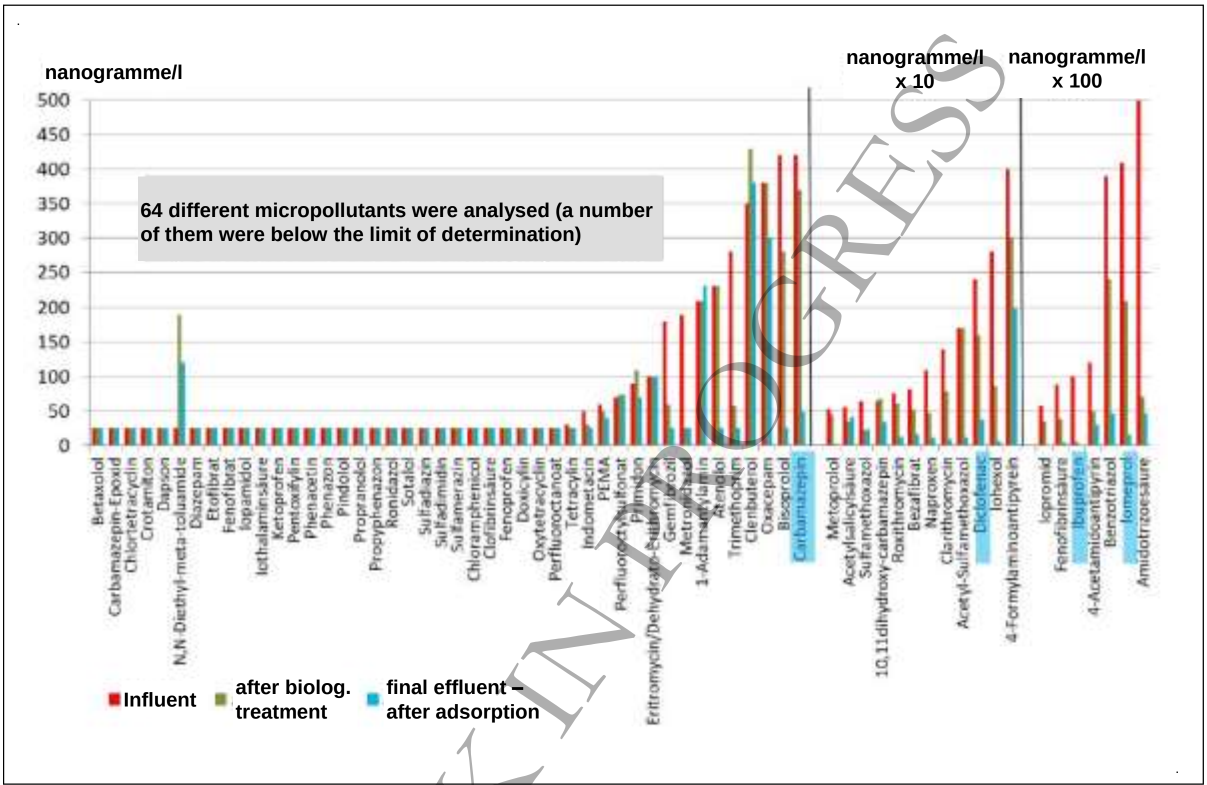


Figure 11-15: Measurement of the removal of micropollutants in the adsorption stage of the municipal waste water treatment plant Böblingen-Sindelfingen (Schwentner, 2012)

The COD is also significantly removed. The daily mean COD concentration values before and after the operation of the adsorption stage is shown in Figure 11-16. The difference of the average COD concentration of the periods before and after the adsorption stage is about 28 %. Thus, as mentioned above, the COD can be used as an indicator to determine the performance of the adsorption stage.

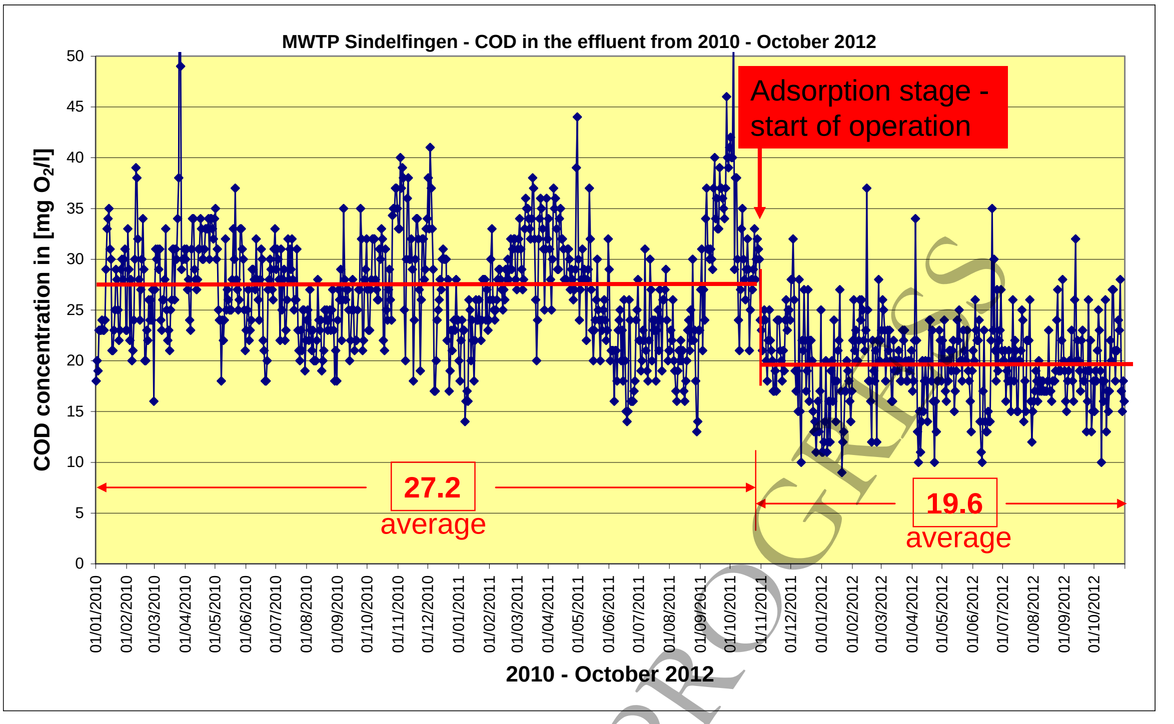


Figure 11-16: COD concentration of the discharged waste water of the municipal waste water treatment plant Böblingen-Sindelfingen with indication of the time periods before and after the operation of the adsorption stage

Applicability

The technique described is applicable to new and existing municipal waste water treatment plants (Metzger, 2010). For existing plants, there could be space constraints which can overcome by adapted mixing and reaction concepts.
As the adsorption and oxidation technique cover a very broad spectrum of micropollutants, there is no limitation for their application from this perspective. In contrast, as many micropollutants and their metabolites are still unknown or have not been analytically identified yet, it can be expected that the technique also removes most of them.

Economics

According to calculations for the Suisse situation, the operation costs for adsorption plants (including the operation of the sand filter) depend on the size of the plant. For plants with more than 250 000 population equivalents (p.e.), the operation costs are between 10 and 11 Cent/m^3, for plants between 18 000 and 66 000 p.e., the operation costs are between 18 – 30 Cent/m^3 and for small plants (< 10 000 p.e.), the figure is 37 Cent/m^3 (Abegglen/Siegrist, 2012, p 131)
The reported operation costs of real German plants are lower. For the above described municipal waste water treatment plant Böblingen-Sindelfingen, the operation costs are only 5 Cent/m3 (see Figure 11-17). This figure also contains interest and depreciation, as well as the subsidies received and the lowered waste water levy. If the subsidies received and the lowered waste water levy are not taken into account, the operation costs are 7.5 Cent/m^3.
For the much smaller plant in Kressbronn-Langenargen (30 000 p.e.), the operation costs are between 8 to 9 Cent/m3 (Götzelmann, 2012).
The estimations for the operation costs for the very carefully designed plant Ulm-Steinhäule are 10 Cent/m^3.

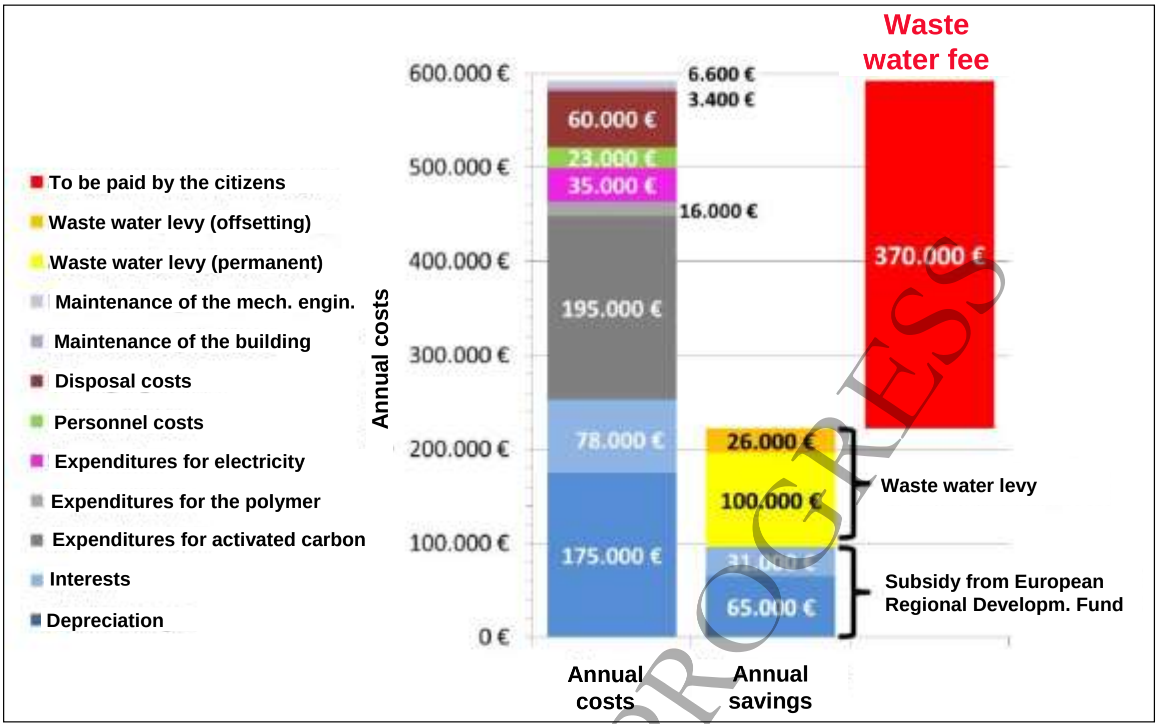


Figure 11-17: Real operation costs for the removal of micropollutants in the adsorption stage of the municipal waste water treatment plant Böblingen-Sindelfingen (Schwentner, 2012)

For the ozonation plants, the available figures also indicate that the operation costs (ozonation and sand filtration) depend on the size of the plant. For plants with more than 250 000 population equivalents (p.e.), the operation costs are between 6 and 7 Cent/m^3, for plants between 18 000 and 66 000 p.e., the operation costs are between 12 – 23 Cent/m^3 and for small plants (< 10 000 p.e.), the figure is 27 Cent/m^3 (Abegglen/Siegrist, 2012, p 107).

Driving force for implementation

There are no legal requirements but voluntary initiatives to protect the aquatic environment. The very first plants in Albstadt-Ebingen, Albstadt-Lautlingen and Hechingen (all in the Southwest of Germany) have been designed and built with respect to the combined treatment of domestic sewage and textile waste water in order to remove residual colour and heavily or non-biodegradable textile chemicals (Schönberger/Schäfer, 2003). In all three cases, the receiving water bodies are small and sensitive.

Most of the latest plants were designed and built due to small and sensitive natural water bodies such as small rivers or lakes (Lake Constance). However, the Mannheim plant discharges the treated waste water to River Rhine; nevertheless one line of the treatment plant (for about 18 % of the total annual influent) is treated (see **Table 11-5**).

Reference organisations

The adsorption of heavily or non-biodegradable organic compounds, such as micropollutants, is a proven technique and is successfully applied for more than 20 years. As mentioned above, it was first applied for the combined treatment of textile waste water and domestic sewage. Now, it is more and more applied to tackle the problems of micropollutants. The known available plants are compiled in

Table **11-5**. Where available, information concerning the size, the maximum flow, the percentage of annual waste water flow treated, the date of start of operation and the investment costs are given.

Table 11-5: Known municipal waste water treatment plants which were or will be retrofitted with an adsorption stage, status, status: August 2014 (KOMS, 2014)

City/name of the plant	Size of the plant in population equivalents	Maximum flow	Percentage of annual waste water treated	Start of operation	Investment
		[l/s]			[mio EUR]
1. In operation					
Albstadt-Ebingen	150 000	980	100	1992	
Albstadt-Lautlingen	36 000	225	100	1993	
Emmingen-Liptingen	7 5000	20			
Hechingen	57 000			1999	
Sindelfingen	250 000	1000	90	November 2011	4.3
Kressbronn-Langenargen	30 000	265	100	July 2011	3.0
Ravensburg	184 000	11000	100		
Stockacher Aach	43 000	250	90	2011	2.7
Mannheim	725 000	300 (1500 future)	18 (85 future)	April 2010	1.6
2. Under cosntruction					
Büsnau	9 680	20			
Lahr	100 000	350	> 90		
Laichingen	35 000				
Ulm-Steinhäule	445 000	2600	100		42
3. Planning/design phase					
Freiburg (Breisgauer Bucht)	600 000				
Karlsruhe	700 000		90		
Stuttgart-Mühlhausen	1 200 000		90		
Herisau (Switzerland)	34 000		95		
Wendlingen	170 000				

So far, the ozonation technique was mainly installed in Italy where there are about 100 plants. In many cases, they were erected at municipal waste water treatment plants which treat domestic sewage and textile waste water. The biggest plats were installed in Prato and Fino Mornasco (Italy).

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11.3 Anaerobic digestion of sludge and optimal energy recovery

Description

Generally, municipal waste water treatment plants contribute to about 20 % of the overall electricity consumption of the public services of a municipality or city, more than the consumption of hospitals, street lighting, water supply etc. (Haberkern et al., 2008). There is a significant potential to save energy and to increase the energy efficiency of the treatment plants (see also BEMP "Energy efficient waste water treatment achieving full nitrifying conditions"). Concerning energy recovery, the anaerobic digestion of sludge is of significant importance.

Sludge derives from primary treatment (sedimentation), called primary sludge, and from biological treatment (activated sludge system or trickling filter), called excess sludge. In addition, sludge or suspended solids results from tertiary treatment (if applied), such as precipitation of phosphorus, solids from backwashing of sand filters, powdered activated carbon or lignite coke from the removal of micropollutants (see BEMP "Minimisation of wastewater emissions with special consideration of micropollutants"); often these sludges/solids are removed from the system together with the excess sludge. Furthermore, residues originate from the bar screen and the aerated grease and grid chamber but they have to be disposed of separately.

From the carbon balances of the aerobic and anaerobic biodegradation, it can be seen that under aerobic conditions, about half of the organic compounds are transferred to biomass whereas under anaerobic conditions, this percentage is only 1-5 % as most of the organic carbon is metabolised to biogas (Figure 11-18). This is due to the different metabolism of aerobic and anaerobic microorganisms. The biogas consists to about 60 % of methane which can be used in gas motors for electricity and heat generation.

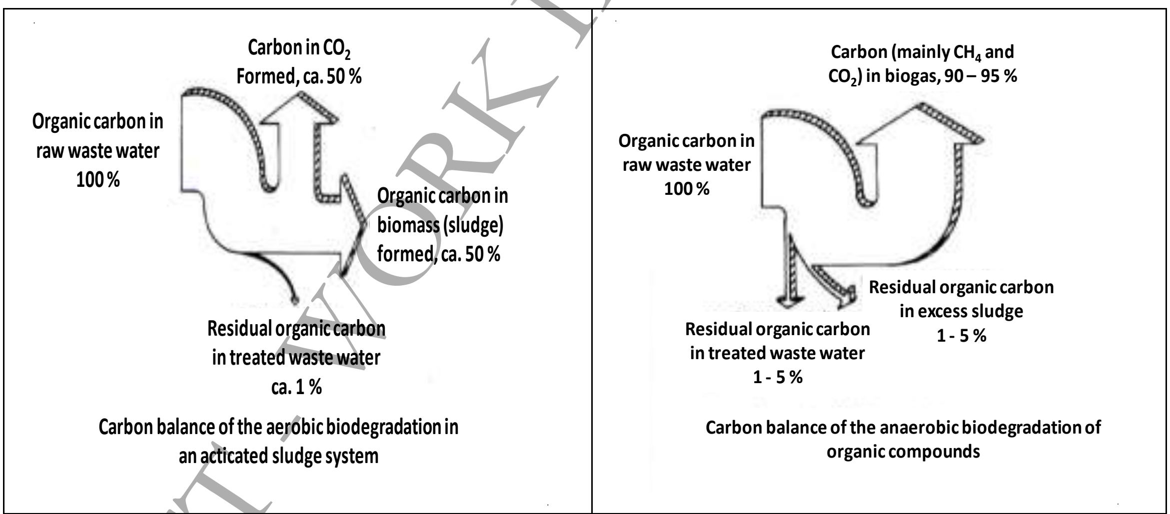

Figure 11-18: Carbon balance of the aerobic and anaerobic biodegradation process (Aivasidis/Wandrey, 1985)

The sludge is anaerobically digested in airtight tanks(see e.g. Figure 1 of the BEMP "Energy efficient waste water treatment achieving full nitrifying conditions") and the biogas formed is collected and stored to be used for on-site generation of electricity and heat in biogas motors. The usual retention time in the digestors is about 20 days. The biogas can contain elevated concentrations of hydrogen sulphide (H_2S) which can lead to sulphuric acid corrosion in the biogas motor. As a consequence, measures to reduce the H_2S content, such as addition of iron(III)salts are applied in order to precipitate H_2S as iron(III)sulphide which remains in the digested sludge.

In case of spare capacity of the anaerobic digestor(s), waste or wastewater with high organic load (> 5,000 or better > 10,000 mg COD/l), for instance from food processing industries or from distilleries (but also from other types of industries), can be co-fermented resulting in higher gas production as most of the organic compounds are converted to biogas (methane and carbon dioxide) as well as in lower sludge formation and lower electricity consumption for activated sludge aeration as the concentrates have not be aerobically treated (see Figure 11-18). Thus, the co-fermentation of biodegradable concentrates, instead of their aerobic treatment, represents a win-win-situation.

Further, the disintegration of the sludge (comminution by physical, chemical or biological processes whereby, to date, ultrasonic techniques are mostly applied) can improve the anaerobic digestion and thus increase the biogas production (Bischofsberger et al, 2005). Favourable conditions for the application of disintegration techniques are:

- short retention times in the anaerobic digestor (< 20 d),
- a content of organic solids in the sludge of higher than 55 %,
- low specific biogas yields (< 350 NL/ kg organic dry matter input),
- separate processing of primary and excess sludge,
- excess sludge thickened to about 3-6 % dry matter, and
- a low percentage of coarse and fibre matters.

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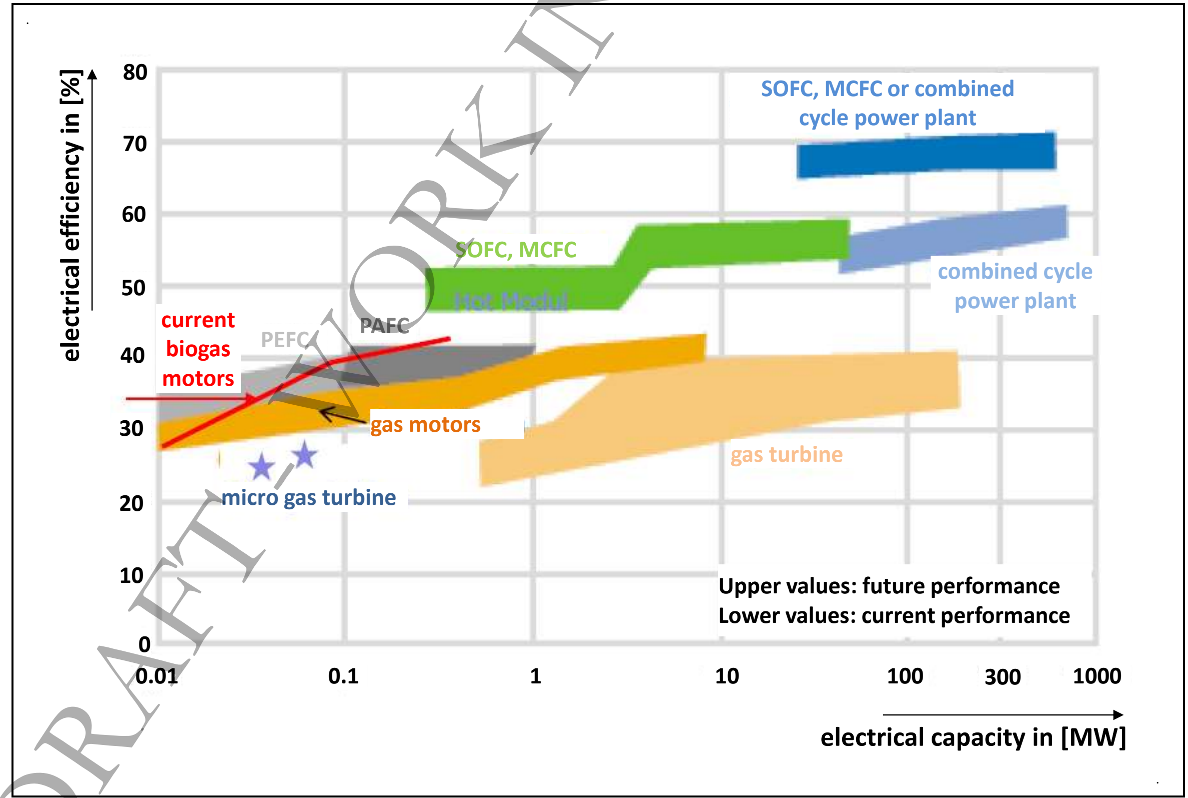
The biogas is usually used in biogas motors. Figure 11-19 shows the electrical efficiency which is between 30 and 40 %. This is low compared to other techniques which cannot be applied to biogas so far. However, the heat of the gas motors is also used for preheating the raw sludge as the temperature in the anaerobic digestors has to be maintained at around 37°C.



Legend: PEFC: Proton Exchange Membrane Fuel Cell; PAFC: Phosphoric Acid Fuel Cell; SOFC: Solid Oxide Fuel Cell; MCFC: Molten Carbonate Fuel Cell

Figure 11-19: Overview of electrical efficiencies of available power generation techniques, according to (Haberkern, 2013)

Achieved environmental benefits

Due to the high content of microorganisms and organic compounds, raw sludge is biochemically highly active. The anaerobic digestion stabilises the sludge, i.e. it significantly reduces its microbial activity.

The whole biogas produced can be used for electricity and heat generation to cover 100 % of the electricity and heat consumption of the wastewater treatment plant. This leads to reduced consumption of fossil fuel for generating electricity and consequently fewer emissions to air (CO_2, NO_x, etc.). However, in case of thermal sludge drying, a substantial part of the biogas generated is used for this process (as heat). Consequently, the percentage of electricity and heat demand of the waste water treatment plant covered by biogas produced on-site is significantly less. For instance, Figure 11-20 shows respectively the electricity consumed, generated on-site, and purchased (from the grid) of a plant with thermal sludge drying downstream of anaerobic digestion. In this case, about half of the biogas is directly used to thermally dry the sludge. Otherwise, the biogas would cover the whole electricity demand.

In Figure 11-20, the energy consumption sharply decreased in 1992 due to the replacement of the aeration of the activated sludge system with pure oxygen, produced on-site, by a conventional fine-bubble air aeration system. However, the consumption increased again due to additionally introduced treatment steps such as denitrification and sand filtration. The on-site generation of electricity started in 1998 and was steadily increased and optimised since then. Consequently, the percentage of generated electricity increased whereas the purchase of electricity from the grid decreased accordingly.

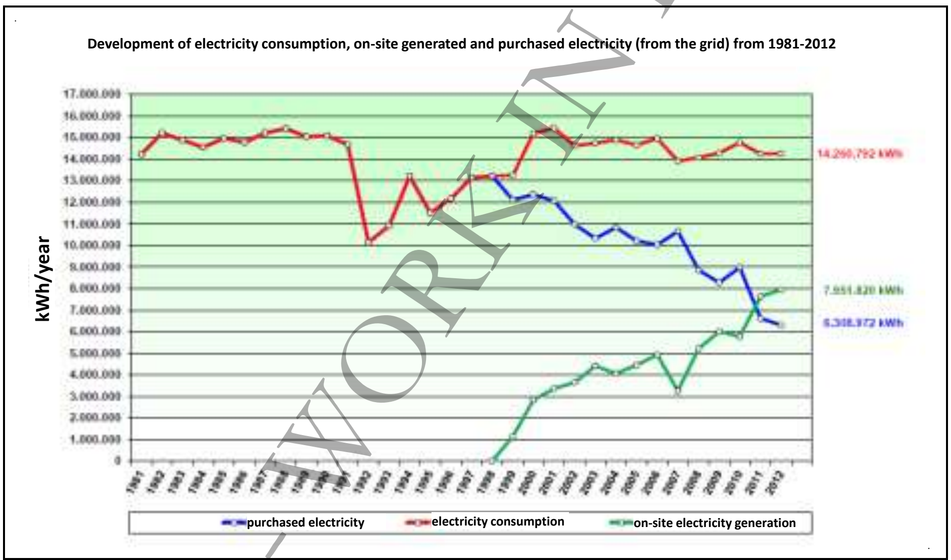


Figure 11-20: Development of the electricity consumption, the on-site generation and purchased electricity of the municipal waste water treatment plant "BreisgauerBucht" as shown in Figure 1 of the BEMP "Energy efficient waste water treatment achieving full nitrifying conditions"

Appropriate environmental indicators

The appropriate environmental indicators are:

- the percentage of self-supplied electricity and heat (with and without thermal sludge drying)
- the electrical efficiency of the biogas motor in [%]
- the specific biogas production in [NL/kg organic dry matter input]

Cross-media effects

There is no significant environmental cross-media effect known when implementing this BEMP.

Operational data

The anaerobic digestion as such is a widely known technique and is applied world-wide in thousands of plants, some of them are mentioned under the section 'reference organisations'. The optimisation of the process including the aforementioned disintegration (if promising considering a specific case) and co-fermentation is associated with higher yields of biogas and a more energy-efficient use of the biogas formed.
The potential biogas production is estimated approximately 500 NL/kg organic dry matter input equivalent to 11 Nm^3/capita and year (Haberkern et al., 2008; Haberkern, 2013).

Applicability

The technique is applicable to new and existing plants. Modern biogas utilisation in motors with high electrical efficiency can be retrofitted to existing plants. An example can be seen from Figure 11-21 where a modern gas motor (as a container module) has been installed in an existing plant.

Figure 11-21: Retrofitted gas motor in a container for the use of biogas from anaerobic digestion of sludge to generate electricity and heat at the treatment plant "BreisgauerBucht"

Considering a whole region or country, such as Germany, most of the electricity consumption of all existing municipal wastewater treatment plants takes place in big plants; e.g. the German plants with a capacity of more than 10,000 population equivalents consume about 86% of the electricity consumed by all existing plants. Consequently, the described technique may concentrate on these large plants although they are usually more energy-efficient than smaller plants (when the similar processes are compared).

Economics

The sludge from municipal wastewater treatment has to be stabilised at any rate. Then, it is best to use the technique of anaerobic digestion as it can be combined with biogas generation and thus with energy recovery to an extent that the whole electricity and heat demand can be covered if the sludge is not thermally dried. However, the investment in anaerobic digestors is significant and there is a trade-off. For plants with a capacity of more than 5,000 – 10,000 population equivalents, the anaerobic digestion of the sludge with efficient energy recovery is the preferable technical approach which pays back; however, concrete numbers are not available and differ from case to case.

Driving force for implementation

The steadily increasing energy prices are the major driving force to invest in anaerobic digestors and energy-efficient use of the biogas formed.

Reference organisations

Many municipal wastewater plants across Europe practice the anaerobic digestion of sludge from waste water treatment and do steadily invest in the improvement and optimisation of energy recovery measures (increase in the specific biogas yield) and in the energy-efficient use of the biogas formed, e.g. the plants in Freiburg, Balingen, Frankfurt, Waldshut, and Düsseldorf (all in Germany), Copenhagen/ Denmark.

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11.4 Drying of sludge and incineration according to best available technique standards

Description

Sewage sludge is a complex matrix containing (Schönberger, 1990; BUWAL, 2003, Birkett/Lester, 2003, Bayern, 2011):

- Heavy metals,
- Organic pollutants (thousands), such as endocrine disruptive chemicals, chlorinated and brominated aromatic compounds, polycyclic aromatic hydrocarbons, mineral oil-derived compounds, pharmaceuticals, disinfectants, washing agents, industrial chemicals, hormons etc.,
- Microbial pathogens.

At the same time, sewage sludge contains phosphorus, one of three elements critical to plant growth (along with nitrogen and potassium). Usually, it is sourced from phosphate rock which is a non-renewable resource, and it is thus an element of a list of 20 raw materials which are considered critical by the European Commission (EC, 20014a; EC, 2014b). According to some researchers, Earth's phosphorus reserves are expected to be completely depleted in 50–100 years and peak phosphorus production from mineral rock to be reached in approximately 2030 (Cordell et al., 2009) although another report estimates that global phosphate rock resources will last for several hundred years (Van Lauwenbergh, 2010). The amount of phosphorus in sewage sludge is significant; currently, the annual quantity of 11.5 million tonnes of sewage sludge (as dry matter) contains about 300,000 tonnes of phosphorus (Eurostat, 2009; Kabbe, 2013) which can be exploited. Firstly, the sludge is efficiently mechanically dewatered, preferably by means of chamber filter presses achieving a dry matter content of 25 – 35 %. Subsequently, the organic compounds and pollutants of the partially dewatered sludge are completely oxidised in a mono-incineration plant meeting best available techniques according to the Industrial Emissions Directive (EU IED, 2010), which are laid down in the best available techniques reference document on waste incineration (EC, 2006). Steam and electricity is generated from the incineration process and no additional fuel is required except for the combustion start-up. Finally, the phosphorus contained in the ash as the incineration residue can be recovered. For the recovery of phosphorus from municipal waste water treatment, specifically from the ash of mono-incinerated sewage sludge, different techniques have been developed such as the SESAL-PHOS Process, the PASCH Process and the ask development with and without separation of heavy metals (Seiler, 2014; Stemann/Kappe/Adam, 2014). The development is still ongoing, focusing specifically on improving the economics. Therefore, it is also proposed to store the incineration ash until the developed processes have been technically and economically optimised (DWA, 2010, Lehrmann, 2013).

Compared to mono-incineration, the co-incineration of sewage sludge in power plants, cement plants or solid municipal waste incineration plants does not allow phosphorus recovery.

For the mono-incineration, different technical options are available (Table 11-6). In most of the existing plants, the fluidised bed technology is applied (Lehrmann, 2013) which is also considered as best available technique (BAT) (EC, 2006).

Table 11-6: Comparison of different furnaces (Umweltbundesamt, 2012)

	Fluidised bed furnace	Multiple hearth-furnace	Multiple hearth cyclone catcher	Cyclone furnace
Characteristics	No mechanical moving parts and low wear	No separate pre-drying required, complex furnace design with moving parts, cooled hollow shaft	No separate pre-drying required, flexible hollow shaft, low fluidised bed volume	No mechanical moving parts and low wear, no fluidised bed material
Operating behaviour	Fast start-up and shut-down times due to short heating and cooling times, intermittent operation possible	Long heating time, continuous operation required	Medium heating and cooling times	Comparable to fluidised bed furnace, applicable to a wide range of fuels
Incineration	Low excess air level required, complete burnout above the fluidised bed only	Burnout difficult to control, insensitive to variations of feed quantity and coarse matters	Low excess air level required, good burnout control, incineration is largely completed in the fluidised bed, compared to fluidised bed furnaces, less insensitive to variations of sludge composition	Solids, long and gaseous fractions, short retention times, variable supply of primary and secondary air at different levels
Ash content in exhaust gas	High	Low	High	High
Ash discharge	Via exhaust gas and sand removal	Directly from lowest hearth	Via exhaust gas and sand removal	Via exhaust air, coarse dust at the bottom
Residues	Ash, fluidised bed material	Ash	Ash, fluidised bed material	Ash, if so coarse ash

Figure 11-22 shows the latest layout of a mono-incineration plant for sewage sludge. This plant for the incineration of the sewage sludge of all municipal wastewater treatment plants of the canton of Zurich in Switzerland will go into operation in 2015 but the illustrated technique is already successfully operated at many other sites, e.g. in Neu-Ulm/Germany since 1995 (Hiller, 2013). Considerable efforts have to be undertaken to purify the flue gases. With multi-step processes, very low emissions are achieved (see environmental benefit). However, for the time-being, the ash will be separately stored until the recovery of phosphorus from it will be more economic.

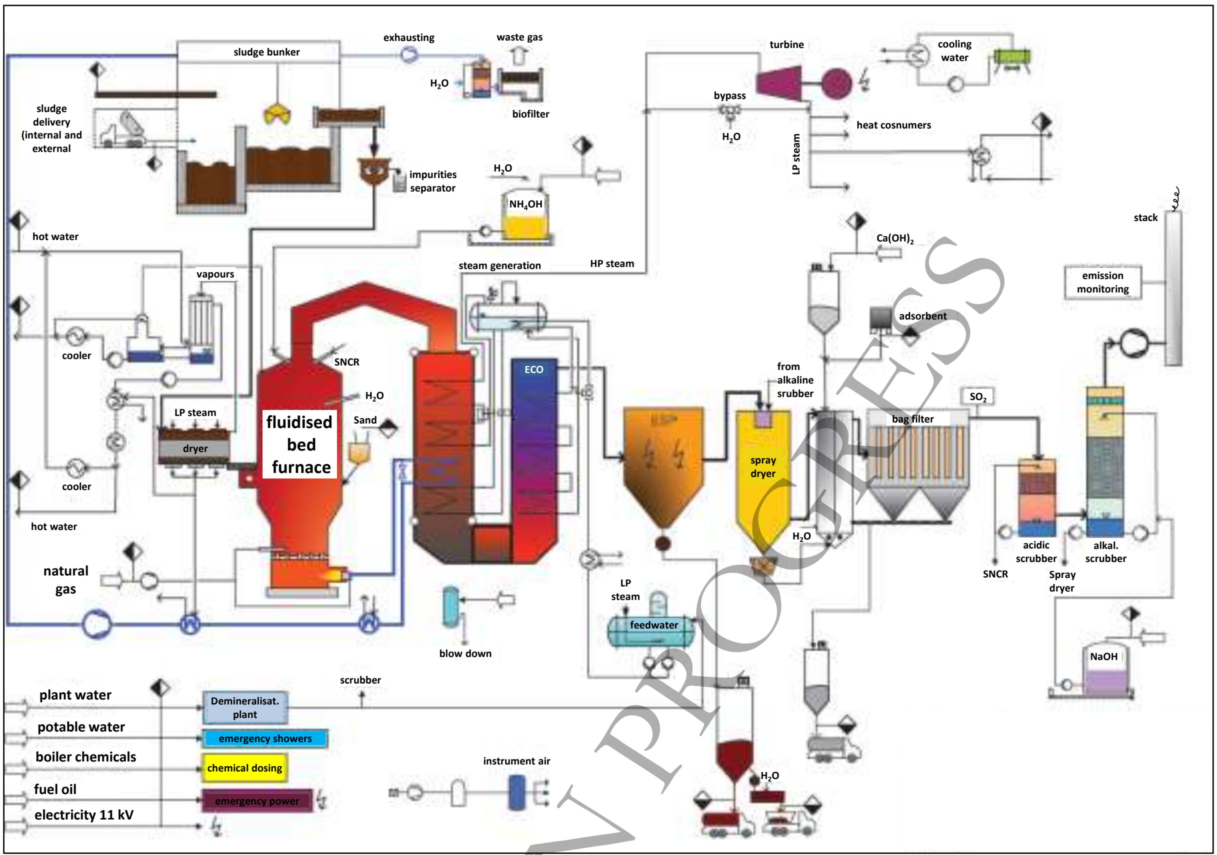

Figure 11-22: Sludge incineration plant of the canton Zurich which will go into operation in 2015 (Decker/Müller, 2014)

In case of phosphorus recovery from ash, the extracted ash could be used as a raw material in clinker production.

Achieved environmental benefits

The countless organic pollutants present in the sludge are completely oxidised. Due to efficient flue gas purification, very low emission values for the different parameters are achieved. The different applied systems (sequences) are mentioned under operational data.

Table 11-7 shows the achieved values of the sewage sludge mono-incineration plant of the city of Hamburg.

Table 11-7: Sewage sludge mono-incineration plant of the city of Hamburg - achieved average values for emission to air for the time period 2011 - 2013

Paramter	Unit	Average value	Monitoring
Dust	[mg/Nm^3]	< 0.5	continuous
SO_2	[mg/Nm^3]	< 2	continuous
NO_x	[mg/Nm^3]	< 50	continuous
TOC	[mg/Nm^3]	< 2	continuous
CO	[mg/Nm^3]	< 10	continuous
PCDD/F	[ng TEQ/Nm^3]	< 0.01	discontinuous
HCl	[mg/Nm^3]	< 1	discontinuous
HF	[mg/Nm^3]	< 0.05	discontinuous
Hg	[µg/Nm^3]	< 5	discontinuous
Cd, Tl	[µg/Nm^3]	< 0.5	discontinuous
sum of other heavy metals	[µg/Nm^3]	< 10	discontinuous

Table 11-8 gives the contents of nutrients and important heavy metals in the ash of sewage sludge mono-incineration plants from 252 measurements. For uranium and cadmium, the contents are much lower than in natural phosphate rock. Currently, there are no limits on the cadmium content of fertilisers on European level but there are in some European Member States, such as Germany (see Table 3). However, a limit of 60 mg Cd/kg P_2O_5 is currently discussed (Fertilizers Europe, 2013) to be introduced into the regulation of fertilisers (EU, 2003). In the ash of mono-incinerated municipal sewage sludge, the average phosphorus content is 90 g/kg.

Table 11-8: Heavy metal content in ashes from mono-incineration of sewage sludge and limits according to the German Regulation on Fertilisers (values for ashes from (UBA, 2014) and limits from (DE DüMV, 2012))

Parameter	unit	Minimum	Maximum	Average	Median	number of measured values	Limits according to (DE DüMV, 2012)
Na	[weight-%]	0.2	2.6	0.7	0.6	252	
Mg	[weight-%]	0.3	3.9	1.4	1.3	252	
Al	[weight-%]	0.7	20.2	5.2	4.8	252	
Si	[weight-%]	2.4	23.7	12.1	12.1	252	
P (municipal)	[weight-%]	3.6	13.1	9.0	9.1	163	
P (municipal/ industrial)	[weight-%]	2.8	7.5	4.9	4.8	69	
S	[weight-%]	0.3	6.9	1.5	1.0	252	
K	[weight-%]	< 0.006	1.7	0.9	0.9	252	
Ca	[weight-%]	6.1	37.8	13.8	10.5	252	
Ti	[weight-%]	0.1	1.5	0.4	0.4	252	
Fe	[weight-%]	1.8	20.3	9.9	9.5	252	
As	[mg/kg TS]	4.2	124	17.5	13.6	252	40
Cd	[mg/kg TS]	< 0.1	80.3	3.3	2.7	252	50[*1]
Hg	[mg/kg TS]	0.1	3.6	0.8	0.5	143	1.0
Ni	[mg/kg TS]	8.2	501	105.8	74.8	251	80
Pb	[mg/kg TS]	< 3.5	1112	151	117	252	150
U	[mg/kg TS]	1.58	25.5	5.8	4.9	252	

[*1]: For fertilisers with more than 5 weight-% P_2O_5, the limit is 50 mg Cd/kg P_2O_5 ; this value is not directly comparable with the values of ashes from incineration as it is related to P_2O_5

Recovered phosphorus reduces the sourcing of phosphate rock. As the latter is a non-renewable resource and is an element of a list of 20 raw materials which are considered critical by the European Commission, the recovery is a significant environmental benefit.

Approproate environmental indicators

The percentage of mono-incinerated sewage sludge and the percentage of recovered phosphorus present in the incineration ash are adequate environmental indicators considering a city, a municipality or a whole region.

Cross-media effects

Dust and other residues result from flue gas purification. These residues have to be carefully disposed of.

Operational data

Sewage sludge has high contents of sulphur. In order to avoid corrosion by sulphur dioxide present in flue gases, it has to be made sure that the dew point will not be reached. This requires a careful design of the whole system (wall structure, joint design, lining, insulation, selection of suitable steel etc.) (Decker/Müller, 2014).
In order to maintain a self-sustaining incineration process and to avoid the so-called adhesion phase, the air for the fluidised bed should be adequately preheated to 400 – 600°C (Decker/Müller, 2014).
With respect to low emissions to air and a complete burnout, it is important to have a uniform fuel distribution in the fluidised bed which can be achieved by means of a specific supply device (Decker/Müller, 2014).
Mechanically dewatered sludge but also completely dried sludge (water content of about 10 %) can be used for the incineration process.
For flue gas purification, different sequences of purification techniques are applied as illustrated in Figure 11-23.

Sludge incineration plant in								
Berlin/DE	furnace and boiler	Activated carbon injection	E-filter	SO_2 scrubber, lime	stack			
Bitterfeld, Wolfen/DE	furnace and boiler	E-filter	HCl scrubber	Injection of adsorbent	fabric filter	SO_2 scrubber, NaOH	stack	
Dordrecht/NL	furnace and boiler	E-filter	HCl scrubber	SO_2 scrubber, NaOH	LC fixed bed filter	fabric filter	stack	
Hamburg/DE	furnace and boiler	E-filter	HCl scrubber	SO_2 scrubber, lime	Injection of adsorbent	fabric filter	stack	
Copenhagen/DK	furnace and boiler	E-filter	Spray drier	Injection of $Ca(OH)_2$ and LC	fabric filter	SO_2 scrubber, NaOH	stack	
Mainz/DE (in planning)	furnace and boiler	E-filter	Injection of $Ca(OH)_2$ and LC	fabric filter	stack			
Moerddijk/NL	furnace and boiler	E-filter	SO_2 scrubber, NaOH	Injection of adsorbent	fabric filter	stack		
Stuttgart/DE (line 3)	furnace and boiler	E-filter	Spray drier	Injection of LC	E-filter	HCl scrubber	SO_2 scrubber, NaOH	stack
Wuppertal/DE	furnace and boiler	E-filter	HCl scrubber	SO_2 scrubber, NaOH	Injection of adsorbent	fabric filter	stack	

Figure 11-23: Different sequences of flue gas purification techniques installed at different plants for the mono-incineration of sewage sludge, based on (Gutjahr/Niemann, 2014)

LC = Lignite Coke

Applicability

The technique is applicable for existing and new waste water treatment plants. It can be retrofitted to existing plants.

Economics

The investment in a dedicated plant for the mono-incineration of sewage sludge can be significant. The investment for the plant in Zurich/Switzerland (Figure 11-22) is about 45 Million EUR.
The costs for different processes for the recovery of phosphorus from ash of sewage sludge mono-incineration plants are compiled in Table 11-9. Currently; the costs are higher than the mining and processing of phosphate rock (Herr et al., 2013).

Table 11-9: Compilation of costs for different processes for the recovery of phosphorus from ash of sewage sludge mono-incineration plants (Seiler, 2014)

	unit	SESAL-PHOS	PASCH Process	Ash development without separation of heavy metals	Ash development with separation of heavy metals
Size of the plant	inhabitants	ca. 3 mio	ca. 3 mio	ca. 3 mio	ca. 3 mio
Required investment	mio EUR	8.6	4.8	1.1	2.6
Capital costs	mio EUR/yr	0.6	0.36	0.09	0.22
Operating costs	mio EUR/yr	10.2	6.9	0.8	1.8
Total annual costs	mio EUR/yr	10.2	6.9	2.0	4.6
Generated P quantity	t P/yr	1153	1647	1830	1812
P-specific costs	EUR/kg P	7.5	4.5	1.1	2.5
spec. costs referred to waste water flow*[1]	EUR/m^3	0.0517	0.0349	0.0099	0.023

*[1]: calculated with a specific flow of 180 l per capita and day

Depending on the sequence of flue gas purification, the costs for chemicals used are between 1.3 and 1.8 EUR per tonne of dewatered sewage sludge and for the disposal of residues between 1.4 and 2.4 EUR per tonne of dewatered sewage sludge (Decker/Müller, 2014).
The disposal of the residues from flue gas purification can represent a significant percentage of total operating costs (Lehrmann, 2013).

Driving force for implementation

The rising awareness of the countless organic pollutants present in sewage sludge and the conclusion that the sludge disposal on landfills is inadequate as well as the finding that phosphorus recovery is best from ash were the main driving forces to mono-incinerate sewage sludge and to recover phosphorus from the ash or to store the ash until more economic recovery processes will be developed.

Reference organisations

Hamburg/Germany, Neu-Ulm/Germany, Zurich/Switzerland, Stuttgart/Germany, Moerdijk/Neterlands, Copenhagen/Denmark, Berlin/Germany; Dordrecht/Netherlands

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11.5 Retention and treatment of overflows from combined sewer systems and storm water from separate sewer systems

Description

Regarding the disposal of storm water and wastewater, there are basically two different types of sewer systems; the separate and the combined sewer system (see the two upper figures in Figure 11-24). In the separate system, storm water and waste water are collected and disposed of via separate sewer networks whereas in the combined system, waste water and, in case of storm or rain events, storm water is collected in one sewer network. In both cases, the most important hydraulic design element is flood protection, i.e. the sewers should be designed to avoid floods in built areas. However, the sewer systems cannot be designed for to accommodate for any magnitude of heavy rain event. On the European level, for new building areas and planned rehabilitation of built areas, it is recommended to design the sewer system in a way that at most one flood event in 10 years for rural areas is acceptable whereas the recommended frequency for city centres and industrial areas is only once in 30 years (CEN 752, 2008). The two lower figures in Figure 11-24 indicate that the two different systems can be optimised as described in the technique on environmentally friendly and more sustainable water drainage. Then, the two systems are called 'modified separate' and 'modified combined' sewer system. Consequently, this technique and the one on environmentally friendly and more sustainable water drainage have to be always considered together.

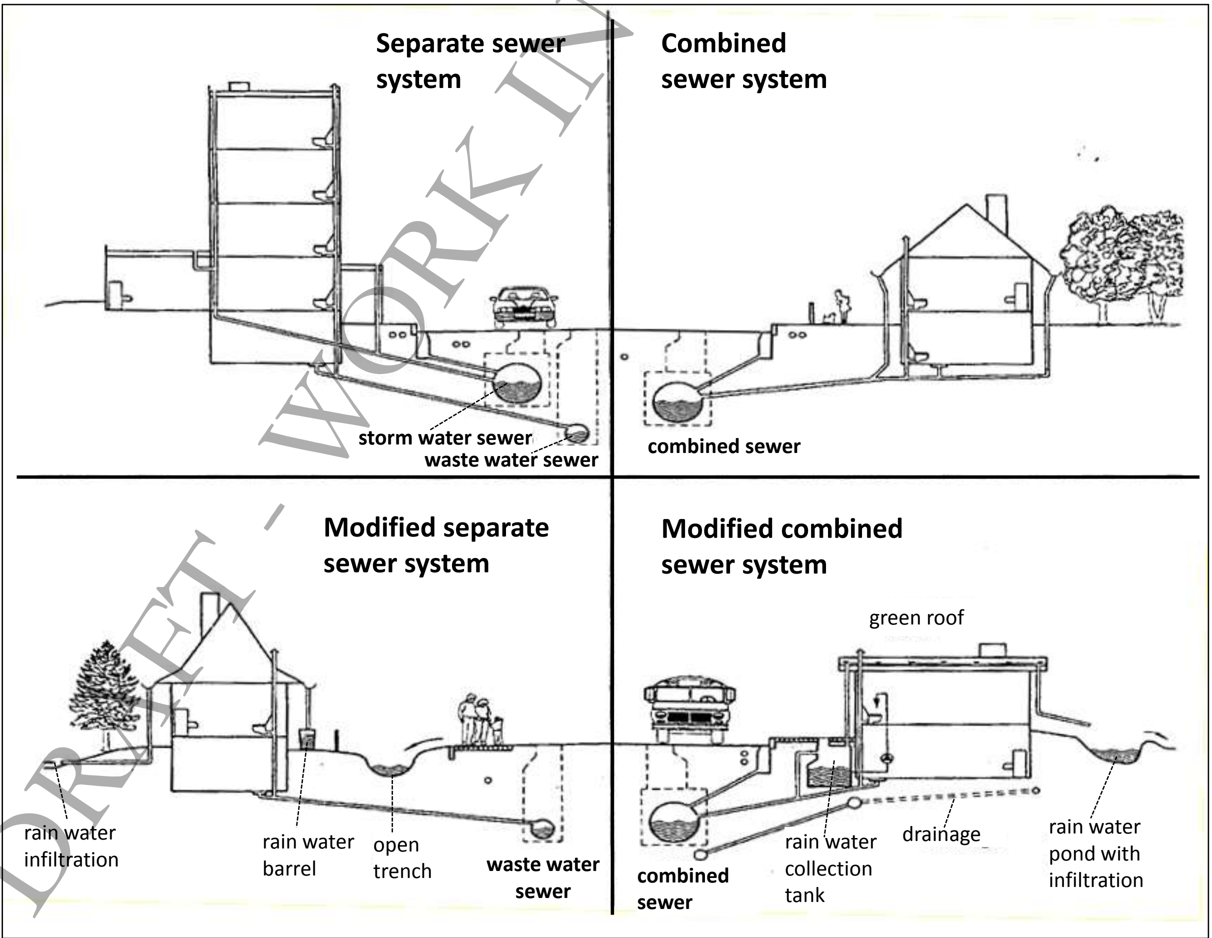


Figure 11-24: The combined and separate sewer systems as the two basic approaches to collect waste water and storm water (the two upper figures) and ways to modify (optimise) them by means of techniques on environmentally friendly and more sustainable water drainage, based on (Brombach/Weiß/Fuchs, 2004)

The two systems are compared in an idealised form in Figure 11-25. Thereby, it is assumed that the overflow from the combined system is treated, but not the storm water from the separate system (however, the latter is eventually also required depending on the degree of pollution). Also runoff which is by-passing the sewer system and is directly reaching the receiving waters is neglected. The groundwater infiltrating into the sewer is taken into account as it is a relevant part when balancing the flows. The other way round, the exfiltration of waste water/storm water is not considered. The numbers in Figure 11-25 reflect the average flow rates per hectare of impervious area in Germany but are only illustrative as the purpose of Figure 11-25 is to show the basic differences of the two sewer systems.

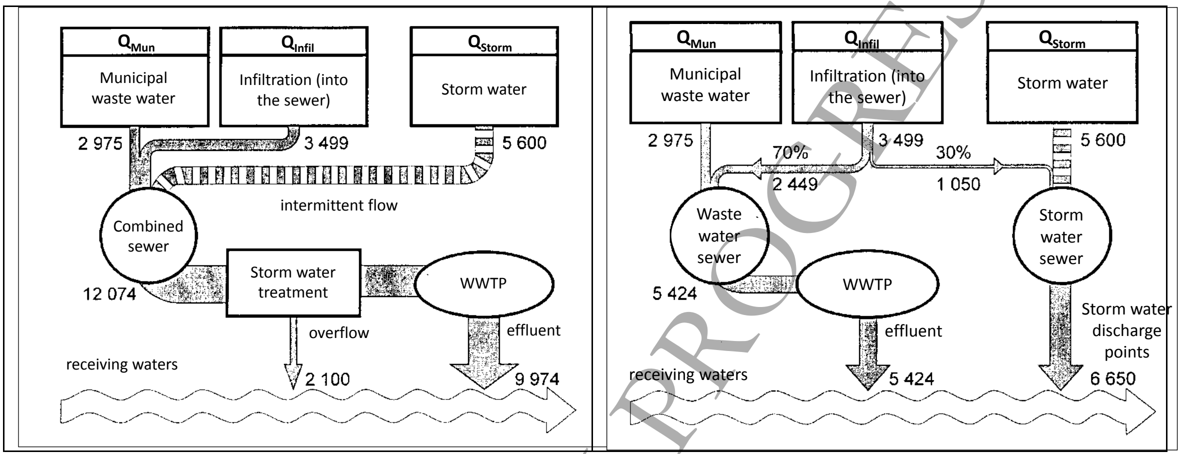
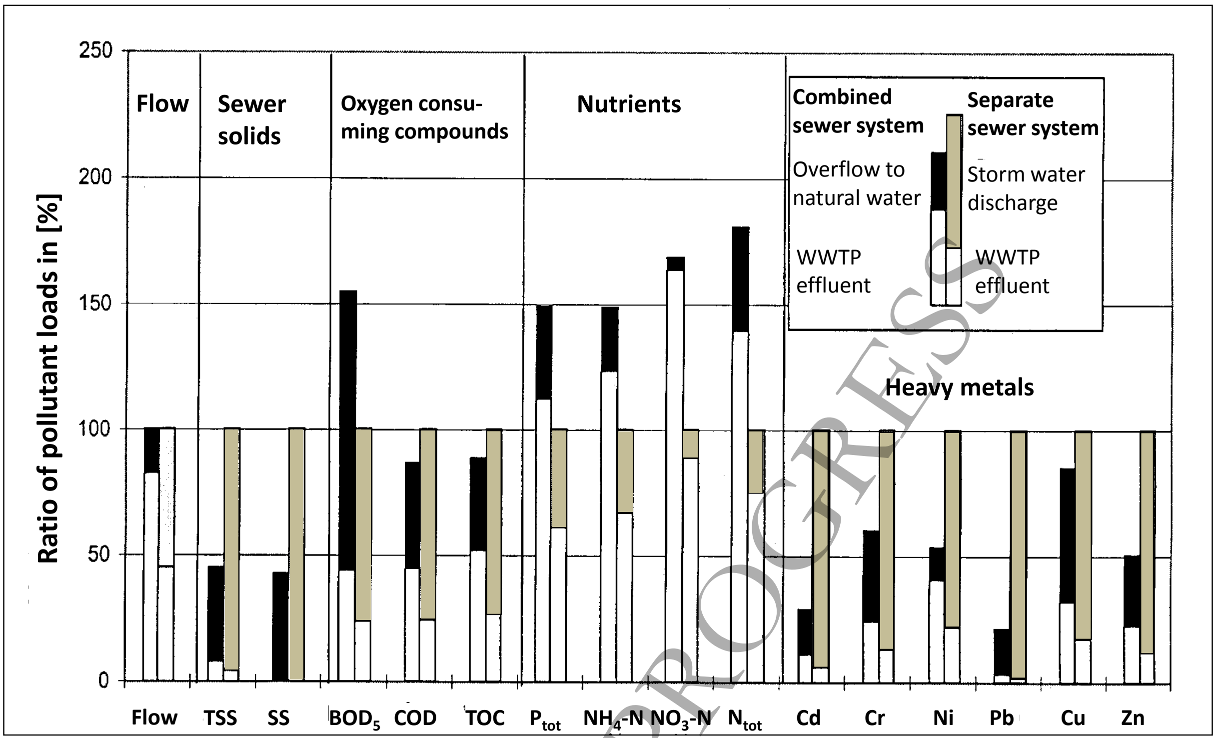


Figure 11-25: Idealised combined (left) and separate (right) sewer system with average (German) flow rates in m3/haimpervious yr, (Brombach/Weiß/Fuchs, 2004)

For the assumptions made for the calculated low rates in Figure 11-25, see: Brombach/Weiß/Fuchs, 2004

Concerning pollution load and discharge to receiving waters, based on a large database (Fuchs/Brombach/Weiß, 2004), a comparison has been made for different parameters. For better illustration, the ratios of loads are plotted rather than the absolute values. As a reference, the total load of a separate sewer system serves as 100 % for the different parameters. The white columns in Figure 11-26 indicate the load of the municipal waste water treatment plants. From the values, it can be concluded that none of the two systems is better than the other. For some parameters, lower values are achieved with the combined sewer system, and with the separate system for others. However, in many countries, preference is given to the separate sewer system in the sense that storm water with no or very low pollution should not be disposed of in combined sewers but should be locally infiltrated or directly discharged to natural waters (e.g. Denmark, Netherlands, UK, Germany, Sweden). This also means that storm water with significant pollution requires adequate treatment prior to its discharge.



Legend
TSS: total suspended solids, SS: settleable solids; BOD_5: biochemical oxygen demand in 5 days; COD: chemical oxygen demand; TOC: total organic carbon; P_{tot}: total phosphorus; NH_4-N: ammonia as N; NO_3-N: nitrate as N; N_{tot}: total nitrogen, Cd: cadmium; Cr: chromium; Ni: nickel; Pb: lead; Cu: copper; Zn: zinc; WWTP: waste water treatment plant

Figure 11-26: Comparison of pollution of the combined and separate sewer system for different parameters; all loads are standardised setting the total load from a separate system (discharges from storm water and waste water treatment plants) as 100 % (Brombach/Weiß/Fuchs, 2004)

For organic compounds (pollutants), the comparison of the two systems can be further detailed as in Table 11-10, which shows estimations for some relevant organic compounds.

Table 11-10: Estimated percentages of the annual load which is discharged to receiving waters via combined sewer overflows - in [% compared to the quantity discharged via WWTPs], based on (Welker, 2005)

	Individual compounds	Estimated percentages of the annual load which is discharged to receiving waters via combined sewer overflows - in [% compared to quantity discharged via WWTPs]
1.	Compounds mainly originating from surfaces	
1.1	Heavily biodegrdable compounds	
	Polycyclic aromatic hydrocarbons (PAH)	18 - 30
	Diethylhexylphthalate (DEHP)	
	4-Nitrophenol	
	Isoproturon	
2.	Compounds manly originating from waste water	
2.1	Easily biodegradable	
	Estradiol	21
	Nitrilotriacetate (NTA)	22
	Linear alkylbenzenesulfonates (LAS)	59
2.2	Non- or heavily biodegradable	
2.2.1	Low or non-solubility in water	
	Nonylphenol	6
	Tributyltin (TBT)	7
2.2.2	High solubility in water	
	Ethinylestradiol	1.4 - 3.5
	Ethylene diamin tetraacetate (EDTA)	
	Cyclophosphamide	

In the future, more and more organic pollutants will be detected and considered in storm water and waste water disposal and treatment (e.g. Ellis et al., 2013; Gasperi et al., 2014).

For both, the combined and separate sewer system, it appears to be best environmental management practice

- to implement environmentally friendly and more sustainable water drainage (see the following BEMP on sustainable urban drainage systems) in order to reduce the flow in combined and separate sewers, and to locally infiltrate storm water; this also means to disconnect already developed impervious areas from the sewer (e.g. Sieker et al., 2006; Geiger/Dreiseitl, 2009);
- to minimise combined sewer overflows by means of the aforementioned local infiltration, including the disconnection of already developed areas (impervious pavements), the retention of combined waste water (mixture of waste water and storm water) in dedicated tanks, and increased capacity of waste water treatment plants for combined sewer flow (considering the waste water treatment plant and storm water management, especially combined sewer overflows, as a whole, i.e. in an integrated way) in order to limit overflows to situations of unusually heavy rainfall (Merscough/Digman, 2008; ECJ, 2012),
- in case of combined sewers, to treat the overflow of the retention tanks by means of fine screens (4 - 6 mm) and sediment tanks, and, depending on the water quality of the receiving water concerned, by soil retention filters or other techniques with similar removal efficiency of suspended solids, COD, heavy metals and organic pollutants,
- in case of separate sewers, to treat the storm water depending on its level of pollution, and, as indicated above, to directly discharge storm water with no or low pollution; for this purpose, the areas of a municipality have to be systematically categorised according to their pollution.

When considering storm water management objectives, the preservation of groundwater and baseflow characteristics, the prevention of undesirable and costly geomorphic changes in watercourses, prevention of flood risk potential, protection of water quality, and maintenance of appropriate abundance and diversity of aquatic life and opportunities for human beneficial uses should also be taken into account (Marsalek, 2013). In addition, the impact of climate change on the sewer systems, especially the possible occurrence of more heavy rain events, has become an intrinsic element of storm water drainage and treatment, specifically the disconnection of impervious areas from combined sewers (Villarreal et al., 2004; Emschergenossenschaft, 2005; Myerscough/Digman, 2008; Semadeni-Davies et al. 2008a; Semadeni-Davies et al. 2008b; Schmitt, 2011, Emschergenossenschaft, 2012; City of Hamburg, 2012; Emschergenossenschaft, 2013; City of Hamburg, 2014; Togersen et al., 2014).

Concerning the disposal of storm water as runoff from impervious areas, it is required to systematically assess all areas with respect to their pollution potential. It has been demonstrated to be an adequate approach to have three categories (as laid out in Table 11-11 below).

Table 11-11: Requirement for the treatment of storm water depending on the level of pollution of impervious areas (Schmitt, 2012; Sieker, 2012)

Assessment of the contamination	Description of impervious area (examples)	Requirement of treatment
Category I Low contamination	Green roofs, roofs and yards in residential areas, cycling and walking paths, roads with an average daily traffic volume of less than 2000 cars	No specific treatment required
Category II Moderate contamination	Roads with an average daily traffic volume of more than 2000 cars, yards and parking areas in commercial and industrial areas	Treatment required in principle
Category III High contamination	Roads in industrial areas with significant air pollution, special areas, aircraft parking areas	Discharge to a WWTP or treatment

		with comparable efficiency

Available treatment techniques for the treatment of storm water are compiled in Figure 11-27. They are grouped into central end-of-pipe techniques and decentralised techniques at source. Practical details about most of the mentioned techniques are compiled in (Sommer et al., 2014). Some of the decentralised techniques are described in the BEMP on environmentally friendly and more sustainable water drainage.

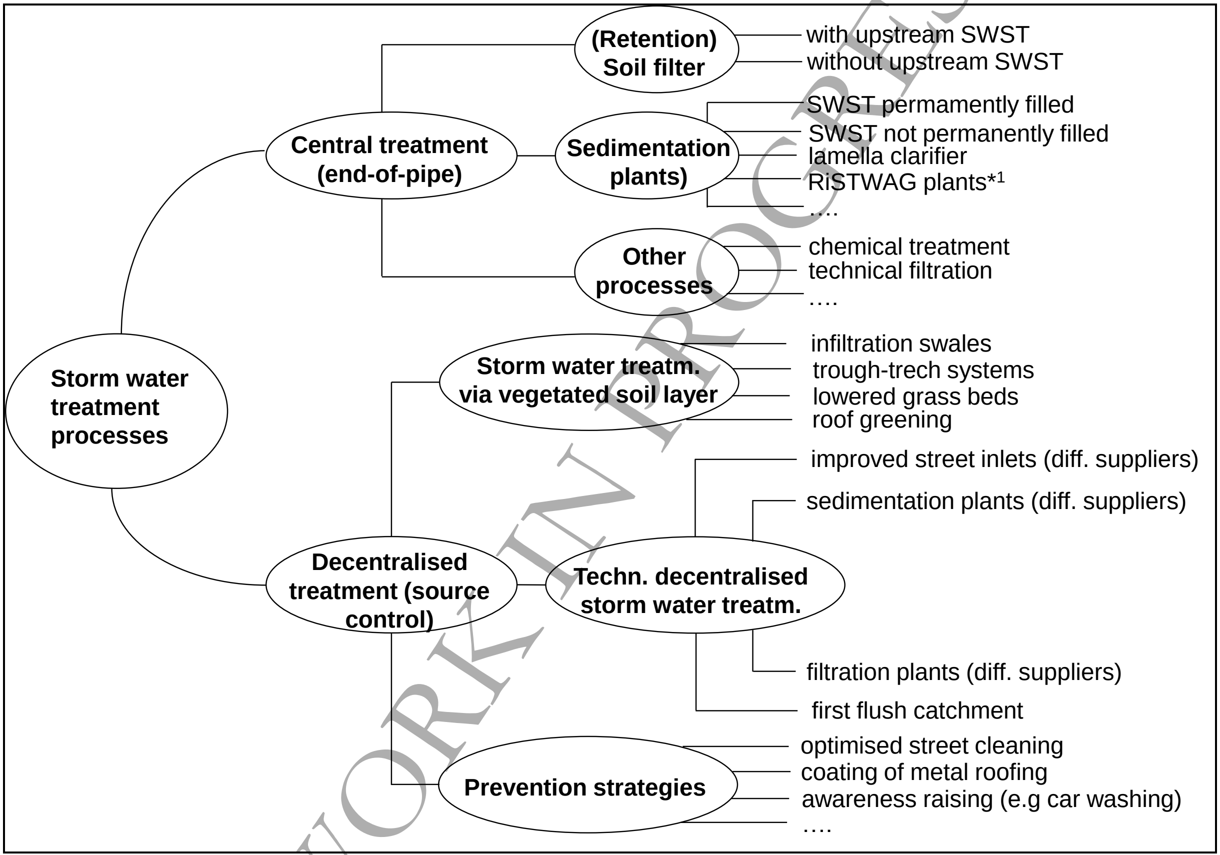


Figure 11-27: Overview of different techniques for the treatment of storm water, according to (Sieker, 2012)

No individual technique fits for all applications. The individual circumstances determine the selection of the suitable technique (Sieker et al., 2008; Sommer et al., 2014).

Achieved environmental benefits

The main environmental benefits are the reduction of water pollution (reduction of oxygen consuming compounds, heavy metals and organic pollutants) and the improvement of the water quality as well as the local water balance in case of decentralised systems.

Figure 11-28 shows the overflow duration for about 100 tanks for the treatment of combined sewer overflows in Central Europe (Germany) over a time period of some years. With the techniques described, the overflow duration is short or very short which is associated with an improvement of the quality of receiving waters.

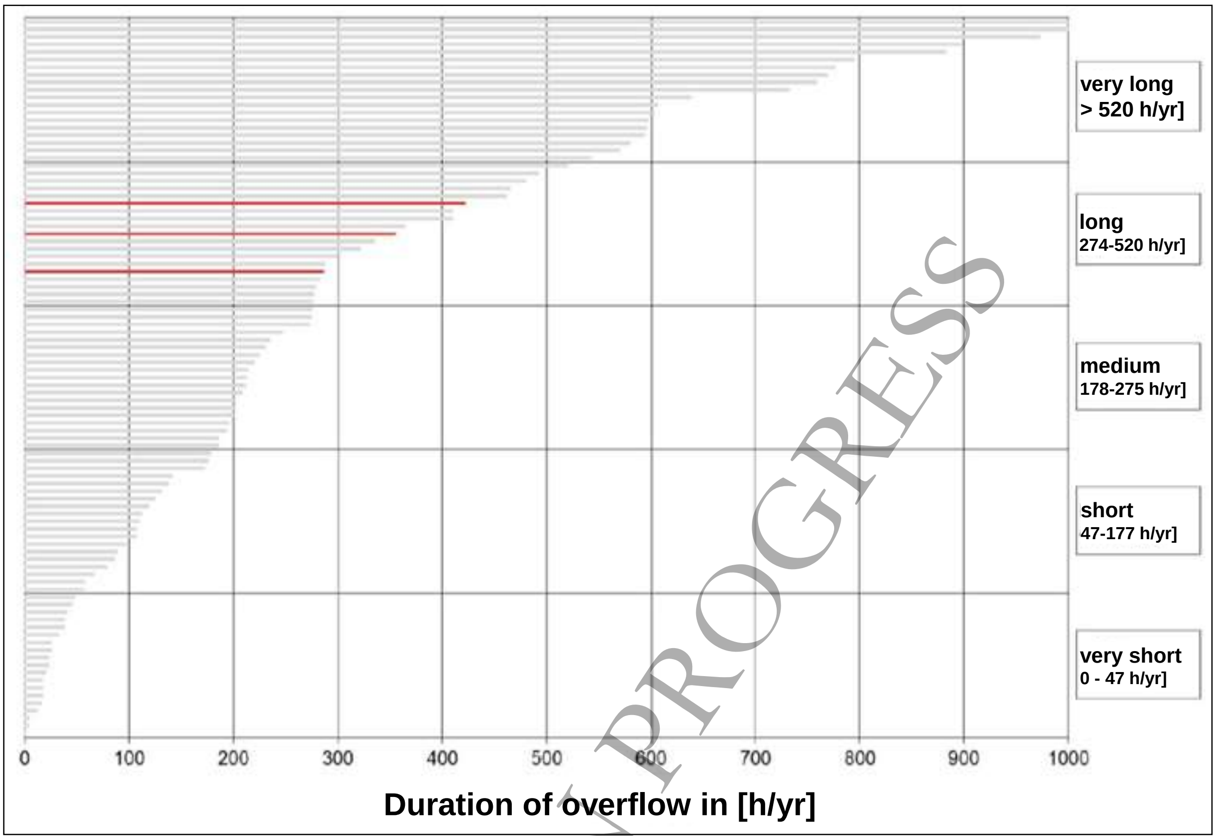


Figure 11-28: Annual overflow duration of about 100 tanks for the treatment of water of combined sewers, (Nichler et al., 2012) – example for Central Europe (Germany), the data were collected over a time period of some years

Appropriate environmental indicators

For combined sewer systems, appropriate indicators include: the frequency, duration and estimated quantity of overflows as well as, considering the total connected impervious area, the ratio of pollutants discharged via waste water treatment vs. storm water overflows, measured for total suspended solids, COD and heavy metals.

For separate sewer systems, appropriate indicators include: the percentage of impervious areas with moderate and high contamination from which storm water is adequately treated, in relation to the whole area which needs treatment.

For both systems, considering the whole impervious area, the percentage of disconnected area with decentralised disposal/treatment is also a suitable indicator.

Cross-media effects

For decentralised techniques, filter media may result as a waste. However, this does not appear to be an important cross-media effect.

Operational data

The optimisation of combined and separate sewers by means of the aforementioned techniques represents a joint task which means that planners of any infrastructure, such as traffic or drainage planners and landscape architects need to work in close co-operation to develop suitable and affordable technical solutions. This approach also includes the awareness that urban flood protection is not only the task to be fulfilled by the sewer system but is an element of integrated thinking (Schmitt, 2011; Waldhoff et al., 2012).

Decentralised systems require maintenance which depends on the local circumstances, such as
- storm intensity (first flush)
- size of the connected area (quantity of solids)
- vegetation in the surroundings (leaves, seeds, blooms, fruits etc.)
- pollination
- traffic volume
- grit from winter services
- construction traffic, especially in case of earthwork
- agricultural traffic and green cuttings on neighbouring property (Koch, 2010; Knippenberg/Werker, 2014)

The required maintenance of central systems is more homogeneous and does not depend on that many factors.

For the central treatment of storm water from combined and separate systems, the frequency, duration and estimated quantity of overflows should be recorded and evaluated on an annual basis.

Applicability

There is no technique that fits all applications (Sommer et al., 2014). In principle, it is required to distinguish between developed and new areas. Whereas in new areas, the spectrum of applicable techniques is broad, in developed areas the local conditions have an impact on the technique to be selected, such as
- position in the urban area
- existing subsurface infrastructure
- condition of the existing infrastructure (road gullies, shafts, sewer etc.)
- pollution of the area considered
- topography
- requirements on the discharged water
- initial level of pollution of the receiving water considered.

In case of decentralised techniques with disconnection of impervious areas, the information and involvement of individual owners is important. The same is true for the space availability for trenches, swales, etc..

Retention soil filters are recommended for both combined sewer overflow and storm water as runoff from impervious areas. Figure 11-29 shows an example.

Figure 11-29: Retention basin (sedimentation) and retention soil filter for the disposal/treatment of storm water

The space requirement for retention basins is relatively high. Thus, retention soil filters require a base area of about 100 m^2/ha (Sieker, 2012). When adding the enclosure, intake structure and operating building, the space requirement of a central retention soil filter is between one and two per cent of the connected area. For existing impervious areas, this space is often not available. Another limitation is the fact that soil retention filters need a height difference of about 1 – 2 metres which is not always available (Sieker, 2012). Consequently, the applicability of retention soil filters can be limited.

Economics

The costs for retention soil filters are comparatively high; the costs are about 1000 EUR/m2 filter area or about 7.50 EUR per square metre connected impervious area (Sieker, 2012).
Depending on the type of decentralised technique, the investment costs are between 0.1 and 8 EUR/m^2 connected impervious area (Sommer et al., 2014).
Decentralised techniques are not more expensive than central systems but the total costs depend on the required intensity of maintenance (Koch, 2010; Knippenberg/Werker, 2014).

Driving force for implementation

The improvement of the quality of receiving waters is a major driving force, but also legal requirements are also in force in the different Member States, as well as the judgment of the European Court of Justice (ECJ, 2012) concerning the limitations of spills from storm water overflows of combined sewers.

Reference organisations

Many cities and municipalities in the UK (e.g. London), Germany (e.g. Freiburg and Karlsruhe) and other EU Member States apply the aforementioned techniques. In the German federal state North Rhine Westphalia, many cities and municipalities are frontrunners, especially with respect to separate sewers. In this state, the Emschergenossenschaft (Water Management Association of the Emscher Basin) is a frontrunner, both for combined and separate sewers. Hamburg is also implementing many of the described techniques. The city of Karlsruhe is prioritising the treatment of combined sewer overflows according to the results of their impact on the quality of receiving waters.

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11.6 Sustainable urban drainage systems

Description

From the historical point of view, most cities started on the water management path by ensuring water supply and over time they incorporated additional measures such as sewerage, drainage, and more recently pollution abatement and natural resource protection. The ideal end point of the sustainable transition framework is the water-sensitive city, a city where water management is adaptive, multi-functional and aligned with the principles of urban design (Figure 11-30).

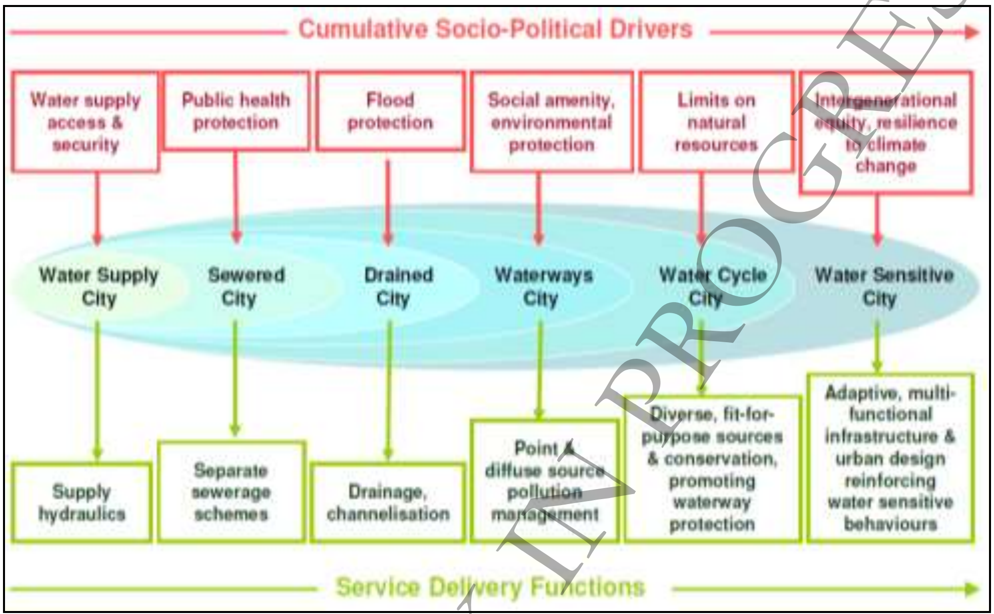


Figure 11-30: A framework for the transition of water management towards more sustainability (Brown et al., 2009)

In the USA, this transition is a substantial part of the so-called low impact development (LID), in Australia of the water sensitive urban design (WSUD) and in the UK of the sustainable urban drainage system (SUDS) (Marsalek, 2013). In the EU, the Water Framework Directive (EU, 2000) also asks for this transition towards a water sensitive city. Consequently, there is a need for an integrated approach within the urban water cycle (EC, 2012).

An important impact of urban development is the reduction of permeability of the land surface by replacing free ground (permeable) with impermeable roofs, roads and paved zones, which have to be drained through piping systems in order to collect and to discharge the runoff water (Figure 11-31). The phenomenon of increased impervious surface is known as land or soil sealing, which occurs not only as a consequence of the reduction of infiltration but also because of the removal of the green coverage, which decreases evapotranspiration. This can be defined as "the destruction or covering of soils by buildings, constructions and layers of completely or partially impermeable artificial material (asphalt, concrete, etc.)" (EC, 2011).

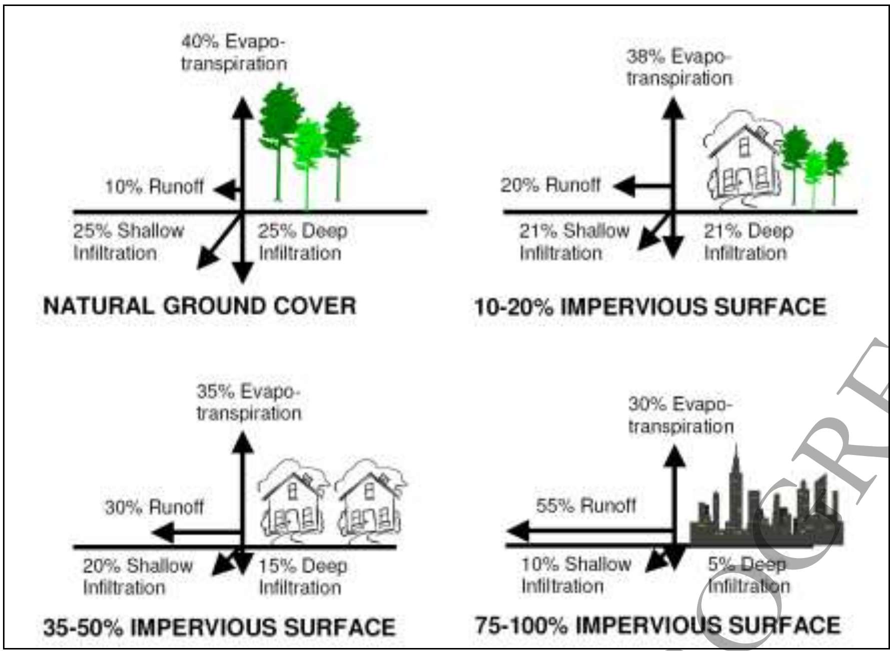


Figure 11-31: Impact of impervious area on hydrologic flows (Dane Waters, 2009)

In general, drainage systems should be considered in local, regional and national policies, allowing the following characteristics:

- the drainage system is part of a holistic approach for the management of the water environment, which should be based on river basins.
- it integrates quantitative and qualitative objectives. Thus, all discharge activities of urban runoff will need to be managed in order to avoid damages on the receiving environment (e.g. surface waters).

The impervious surface, used for human activities, is an important source of chemical pollution, where, in addition, natural filters have been removed. Chemical pollutants may be present in runoff, such as rain water from roads with heavy traffic or from contaminated areas of industrial sites, spillages, solid depositions on roofs, animal faeces, sediments from erosion etc. (Welker, 2005).This is associated with the following impacts (Woods-Ballard et al., 2007):

- Changes to stream flow: fast urban area drainage with reduced infiltration triggers the increase of runoff volumes, i.e. discharges which are orders of magnitude higher than those from natural sources.
- Changes to stream morphology: widening channels to accommodate for increased runoff would increase erosion, increasing sediment in natural water ways and exposing trees' roots. Stream banks may be eroded as well.
- Impacts to aquatic habitat: e.g. by washing away biological communities, impacting on riparian vegetation, sedimenting solid deposits, reducing oxygen levels, reducing water quality, etc.
- Impacts on water quality: reduced oxygen levels, increased sediments, increased eutrophication, increased pollutants and toxic chemicals, etc.

In addition, climate change impacts on water resources will reduce the availability of fresh water, increase evaporation, increase the periods of intense rainfall (with higher erosion impacts), increase the amount of pollutants fed to water ways, increase flooding, and increase the amount of untreated wastewater discharged to the environment. Relevant policy approaches regarding best practices are shown in Table 11-12.

Table 11-12: Relevant policy approaches regarding best practices to avoid soil sealing and improve water drainage (EC, 2011)

Measure	Development
Reduction of urban sprawl (e.g. Austria)	• New spatial planning regulations to improve land use efficiency: (i) Building permits with expiration date, (ii) contracts between municipalities and land owners and (iii) real estate funds at provincial level. • New funding schemes for housing to improve intensification of settlements • "Soil efficient" business developments
Reuse of brownfield land (e.g. Belgium)	Brownfield Covenant: agreement between the regional (in this case, the Flemish) government and one or more private or public parties which lays out arrangements in order to promote a smooth and efficient realisation of a brownfield project
Protection of the best agricultural land and landscape fragmentation (e.g. Czech Republic)	Three policy documents which protect the utilisation of green land inside and outside city boarders and give priority to inner urban developments: namely, the building code, the act on nature conservation, and the act on the protection of agricultural land. This also translates in the improvement of water drainage by: • High quality soils in the outer city belt are protected by the act on the protection of agricultural land. • Green areas are protected within city boarders • Priority is given to the development of abandoned areas (brownland, i.e. old industrial estates) instead of developing green land.
Management of flood risks (e.g. Germany)	Example in Saxony: building activities in flood risk areas are banned, retention zones were extended, soil sealing rates in flood risk area are being monitored with the aim of avoiding any increase in sealing, meanwhile desealing of abandoned developed land is encouraged.
Water drainage (e.g. Ireland, UK)	Proposals for housing estate development or for the development of a large number of houses in a particular area, shall be required to submit a flood impact assessment and proposals for a so-called sustainable urban drainage system (SuDS)

The use of overarching approaches can be considered as a best environmental management practice on land planning. Surface water drainage systems, developed in accordance to a sustainable development policy, managing environmental risks resulting from urban runoff and contributing to environmental enhancement, have the best example on the developed "Sustainable Drainage Systems" (SuDS) philosophy in the UK (Woods-Ballard et al., 2007). This is an exemplary approach, consisting of a three-way concept (improve water runoff quality, optimise water quantity and maximise amenity and biodiversity), replicating, as closely as possible, natural drainage of sites before development. Apart from the evident environmental benefit, it has a cost justification, as the need for large flow attenuation and flow control structures is to be effectively minimised.

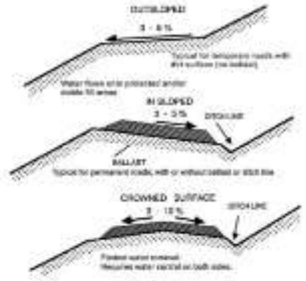
Management hierarchy for water drainage management, given also by SuDS, usually refers to the techniques which should be preferred in a new development, e.g.:

- **Prevention**: good design practices and site housekeeping measures prevent runoff and pollution, e.g. rainwater harvesting or dust removal. Overall prevention policies should be considered as a technique for that.
- **Sourcecontrol**: highly polluted (or large amounts of) runoff should be controlled at their source, for instance, green roofs or car parks.

- **Site control**: control of water flows on site, for instance, piping water flow to infiltration or detention basins. This is also called decentralised runoff management (Sieker et al., 2007; Sieker et al., 2008).
- **Regional control**: to send excess runoff water to a pond or to a wetland, shared by several sites.

Techniques to be consider for environmentally friendly drainage systems are listed in Table 11-13 and are referred to improve water quality or to affect water quantity. This table is also reflecting the position at the management hierarchy and the main benefit to be achieved on water quality or quantity control.

Table 11-13: Techniques to be considered as best environmental management practice for water drainage systems, based on (Sieker, 2004; City of Hamburg, 2006; Woods-Ballard et al., 2007)

Technique	**Description**	**Type of management**	**Main benefit**	**Picture**
Water butts, site layout and management	Good housekeeping and good design practices.	Preventive, source control	Increase water infiltration. Possible benefits on water quality and biodiversity.	
Pervious pavements	Allow inflow of rainwater into underlying construction/soil	Preventive and source control	Avoid pollution and increase infiltration.	
Filter drain	Linear drains/trenches filled with a permeable material, often with a perforated pipe in the base of the trench.	Conveyance and source control.	Allows conveyance and detention and avoids water pollution.	

Technique	Description	Type of management	Main benefit	Picture
Swales	Shallow vegetated channels that conduct and/or retain water and permit infiltration when un-lined. Filter for particulates.	Conveyance, source control and site control	Allows conveyance, detention, infiltration and reduce pollution.	
Filter strips	Vegetated strips of gently sloping ground designed to drain water evenly from impermeable areas and filter out silt and other particulates	Pretreats and allows source control.	Improves water quality.	
Ponds	Depressions used for storing and treating water. They have a permanent pool and bankside emergent and aquatic vegetation.	Site control. Regional control.	Detention and harvest water. Improves quality.	
Wetlands	Like ponds, but the runoff flows slowly but continuously through aquatic vegetation that attenuates and filters the flow. Shallower than ponds.	Site control. Regional control.	Detention and harvest water. Improves quality.	

Technique	Description	Type of management	Main benefit	Picture
Soakaways	Subsurface structures that store and dispose of water via infiltration	Site control.	Infiltration. May improve water quality.	
Infiltration trenches	As filter drains, but allowing infiltration through trench base and sides	Site control. Source control.	Infiltration and detention. May improve water quality.	
Infiltration basins	Depressions that store and dispose of water via infiltration	Site control. Regional control.	Detention and infiltration. May improve water quality.	
Green roofs.	Vegetated roofs reducing runoff volume and rate	Site control. Regional control.	Detention.	
Bioretention areas	Vegetated areas for collecting and treating water before discharge downstream or to the ground via infiltration.	Site control. Source control.	Detention and infiltration. Improves water quality.	

Technique	Description	Type of management	Main benefit	Picture
Sand filters	Treatment devices using sand beds as filter media.	Pretreatment and site control	Detention and improves water quality.	
Silt removal devices.	Manhole and/or proprietary devices to remove silt.	Pre-treatment	Improves water quality.	
Pipes and storage.	Conduits and accessories as conveyance measures.	Conveyance and site control.	Conveyance and detention.	

Achieved environmental benefits

The described environmentally friendly and more sustainable water drainage approach and the techniques and technologies that are associated with it deliver a number of environmental benefits. The retention, detention and infiltration of storm water reduce peak discharge and prolong the lag time of urban runoff during high precipitation events. This provides flood control and helps to prevent erosion, siltation and high turbidity in streams and rivers as is typically caused by conventional drainage channels due to the high velocity discharge of large volumes of storm water into receiving water bodies. Many aforementioned techniques treat storm water to various degrees by removing pollutants such as oils, metals and nutrients through natural treatment processes within vegetation, soils and ponds. This improves water quality in receiving water bodies thereby protecting ecosystems and recreational facilities. They also reduce the impact of urbanization on the natural water cycle. The impact of soil sealing is mitigated through systems designed to increase rainfall infiltration to underlying aquifers (de-centralised systems). Such groundwater recharge also provides an additional source of water supply, reducing the need to abstract (and often treat) water from other sources

Appropriate environmental indicators

The following indicators can be used:

- The percentage of a defined area, e.g. a residential or commercial area, where rain water is not directly drained but retained within the area site by means of the techniques described in Table 11-13.
- The estimated annual percentage of rain water which is retained in a defined area.

Cross-media effects

The increase of infiltration rates in urbanised areas frequently produces an undesired cross effect: groundwater contamination and soil pollution. Rainwater is usually polluted when it is in contact with the urban area, increasing the concentration of heavy metals, taking away organic compounds as lubricating oils, and dragging along suspended solids. Although some of the aforementioned techniques are based on vegetation have filtering capabilities, special attention should be paid to the infiltration of polluted water. For rainwater management, there are devices that include an automatic valve that conducts heavily polluted water produced during the first minutes of a storm to the sewerage.

Operational data

Table 11-14: Performance of several water drainage systems elements

Water drainage element	Environmental performance	Reference
Pervious surface: grass-concrete surface	Run-off coefficient of 0.05 (compared to 0.78 for the same surface made of concrete). Pollutant concentration was higher from the run-off of the pervious surface but with a significant lower pollutant load. Soil was able to retain 75 % of phosphorus, 70-80 % of nitrogen and high percentages of heavy metals.	(Day et al., 1981) acc. to (Pratt, 2004)
Pervious surface: permeable concrete (15 - 24 % unsealed voids) and porous	Geotextile layer was applied. Small migration of pollutants was found. Heavy metals are located next to the surface. Able to retain most of the fine particles. Higher concentration of nitrite, nitrate, ammonia and chlorides in water run-off was detected compared to conventional pavement.	(Hogland et al., 1990) acc. to (Pratt, 2004), (Castro-Fresno et al., 2013), (Sanudo-

Water drainage element	Environmental performance	Reference
mixture surfaces and pervious pavements		Fontaneda et al., 2014)
Pervious surface: grass concrete grid compared to conventional pavement	Run-off peak from grass grid was about 10 % of the run-off of conventional pavement (21.6l L/s for grass grid and 223.6 L/s for asphalt)	(Smith, 1984) acc. to (Pratt, 2004)
Pervious surface: impact on soil pollution.	Several studies show that soil is able to retain heavy metals with no significant impact on groundwater. Some results from different sub-bases show great removal efficiency for lead, cadmium, copper and zinc. Therefore, for a high groundwater table, it is advisable to build drainage techniques other than only infiltration. Oil is mostly retained and degraded (60 - 90 %), although soil can become saturated (although not a main problem as it is evenly spread over time).	(Pratt, 2004;Dierkes et al., 2002; Bond, 1999)
Settling basins	Removal of suspended solids by 70 %.	Chocat et al., 1999 (Pratt, 2004)
Infiltration basins	Contamination of soil particulates with oil and heavy metals was detected, although they may be within legal limits.	(Chocat et al., 1999) acc. to (Pratt, 2004)
Swales and filter strips	Removal efficiencies higher than 70 % of suspended solids are achievable. Also, heavy metals are retained, although some nutrients are accumulated when using swales. These should be regarded as a transport mechanism to other treatment processes. A number of swales in Scotland reduced the water run-off up to 53 %, reducing considerably the water peak flow and reducing significantly pollution load.	Several authors, acc. to (Pratt, 2004)
Detention basins	Efficiencies higher than 78 % on the removal of suspended solids and a slightly increase of dissolved solids is detected. BOD, TOC and COD is removed with an efficiency of 60 - 80 %. Nitrite is increased and re-suspension of some pollutants takes place.	Several authors, acc. to (Pratt, 2004)
Detention ponds	Detention ponds, usually designed only for hydraulic control, can have a great influence on water quality. Nevertheless, BOD is removable by 45 % and suspended solids by 80 %. This can be achieved through shallow ponds, well oxygenised in the interface between water and sediments. Heavy metals can be reduced by up to 93 %	(Jefferies et al., 2001) acc. to (Pratt, 2004)
Filter drains	Filter drains are effective traps for water quality during storm events, usually higher than 90 % for heavy metals.	Several authors acc. To (Pratt, 2004)
Infiltration trenches and soakaways	A study shows the comparison of a conventional catchment and an infiltration one. Differences show groundwater recharge in the traditional system from 464 to 751 mm/year in the infiltration, while surface run-off varies from 660 to 161 mm/year and evapotranspiration varies from 524 to 735 mm/year. Nevertheless, water quality is a main concern in the	(Imbe et al., 2002)

Water drainage element	Environmental performance	Reference
	design of water infiltration devices and should be coupled with other treatment techniques.	

Applicability

The described techniques can be applied to new construction developments. In principle, they can also be retrofitted to existing built areas but there are often constraints (space, costs etc.) which do not allow their implementation or only to a limited degree.

Economics

Environmentally friendly and more sustainable water drainage techniques are often more cost-effective to install and maintain than conventional ones; for example, a comparison of a centralised (sewer) versus a decentralised (swale) solution found a cost of €19 versus €17/m2 (Sieker, 2010). Moreover, reducing the amount of storm water inflow into wastewater treatment plants (in cities with combined sewer systems) allows these to operate more cost-effectively. A study carried out by the US Environmental Protection Agency concluded that environmentally friendly drainage techniques produce cost savings in the range of 15 up to 80 %, which is attributed to lower site grading and preparation costs and lower costs for paving and storm water infrastructure (EPA, 2007). Nevertheless, the application of best techniques for drainage do not always produce cost savings, as it depends on the amount of infrastructure needed and the availability of natural drainage systems, and whether it is normally planned for several sites in the same local area. Also, the preparation of soil, the availability of space and connectivity to municipality network may require additional efforts.

In general, the use of more natural driven drainage requires less materials and less conveyance infrastructure, which also require lower installation costs. As for other environmentally sound techniques, it is necessary to implement a life cycle cost perspective when implementing water drainage techniques. According to (Woods-Ballard et al., 2007), this approach gives an overview to the developer of the long-term investment required, while implementing robust decision-making procedures due to enhanced knowledge of techniques. Also, this can be integrated in a long-term risk assessment, which may modify the site management plan. The implementation of techniques such as those covered by SUDS will benefit from gained expertise, further reducing uncertainties.

Correct planning of environmentally friendly and more sustainable water drainage techniques should, therefore, take into account whole life cycle costs. Figure 11-32 outlines the magnitude of the different costs.

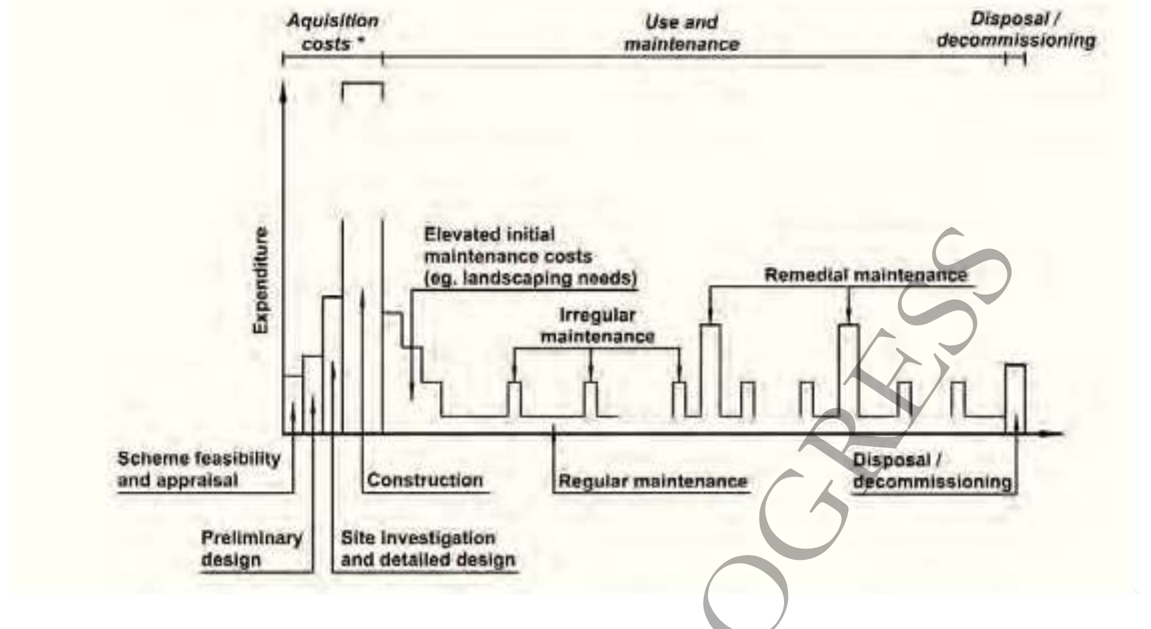


Figure 11-32: Life cycle expenditure profile (Woods-Ballard et al., 2007)

Many factors can affect the construction of a drainage system, such as soil type, groundwater management, design criteria, availability of space, hydraulic control characteristics, etc. A range of costs are shown in Table 11-15. This includes construction costs in addition to actual installation, materials, erosion and sediment control during construction, planting and landscaping.

Table 11-15: Water drainage construction and regular maintenance costs (Woods-Ballard et al., 2007)

Drainage element	**Construction cost, EUR**	**Regular maintenance cost (annual), EUR**
Filter drain, per m^3 stored volume	130 - 180	0.3 - 1.5 (per m^2)
Infiltration trench, per m^3 stored volume	70 85	0.3 - 1.5 (per m^2)
Soakaway, per m^3 stored volume	>130	0.15 (per m^2)
Permeable pavement, per m^2 surface	40 - 50	0.6 - 1.5
Infiltration basin, per m^3 detention volume	10 - 20	0.15 - 0.4 (per m^2)
Detention basin, per m^3 detention volume	20 - 30	0.15 - 0.4 (per m^2)
Wetland, per m^3 treated volume	30 - 40	0.15 (per m^2)
Retention pond, per m^3 treated volume	19.5 - 32.5	0.6 – 2 (per m^2)
Swale, per m^2	10 - 20	0.15
Filter strip, per m^2	5 - 20	0.15

Driving force for implementation

There are a number of drivers for the implementation of environmentally friendly drainage systems, especially those gathered under the term sustainable drainage system. In general, these systems drive implementation in several ways:

- Environmentally:
  - To prevent adverse effects of climate change, that will have an impact on the availability of fresh water. This, combined with increase pressure to water

resources, will produce also undesired effects because of groundwater availability and pollution.
  - To prevent storm events, that will be more frequent, with high rainfall peaks. Improved drainage should also allow avoiding erosion, thereby reducing water pollution and flood risks.
  - To preserve and create new habitats, while protecting species.
  - To recharge groundwater at the same time of maintaining or increasing its quality.
  - To fulfil regulations, national, regional or local, in line with the Water Framework Directive (EU, 2000).
- Economically:
  - To reduce downstream flooding and, therefore, preventing property damage.
  - To increase the real estate value through the aesthetic value of created amenities
  - To reduce the conventional drainage system costs
- Socially:
  - To create public spaces and to increase quality of life.

Reference organisations

Berlin/Germany (City of Berlin, 2007), many cities and municipalities in the UK (see (Woods-Ballard et al., 2007), Hamburg/Germany, Copenhagen/Denmark, Nantes/France, Melbourne/Australia, Perth/Australia

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12 BEST ENVIRONMENTAL MANAGEMENT PRACTICES FOR GREEN PUBLIC PROCUREMENT

Chapter structure

This chapter is intended to guide public authorities in Green Public Procurement (GPP).

Chapter introduction

Public procurement is an internal process of a public administration which allows the purchase of products and services. Some of the main activities in which public administrations are engaged, for instance social housing, public transport, education, libraries, leisure, waste collection, emergency services, etc. are often based on public procurement. This is thus a key area for most public authorities at different levels.

Each year European public authorities spend the equivalent of 16% of the EU Gross Domestic Product on the purchase of goods, such as office equipment, building components and transport vehicles; services, such as buildings maintenance, transport services, cleaning and catering services and works. It's worth noting that for most public authorities, construction and renovation activities and running costs of buildings represent a major share of annual expenditure, in some cases over 50%.

In order for public administrations to become more environmentally-friendly, green public procurement brings significant positive environmental change (due to the size and scope of activities of public authorities) but can also lead to a series of other benefits, most importantly a more efficient, effective and sustainable service delivery for citizens' quality of life. Above all, green public procurement can efficiently use, and partly significantly save, financial resources. Moreover, thanks to GPP, public administrations can improve their reputation by demonstrating a commitment to environmental protection. Other benefits form GPP include the improvement of internal operations to become more efficient and the possibility to drive environmental innovation within the private sector.

GPP can shape production and consumption trends and a significant demand from public authorities for "greener" goods will create or enlarge markets for environmentally friendly products and services. By doing so, it will also provide incentives for companies to develop environmental technologies.

Technique portfolio

One of the ways through which public administrations can exert the most influence on the private sector is through public procurement, which is the purchasing of products and services. When public procurement takes into account environmental criteria for the selection of the product or service purchased, public authorities are able not only to save money and improve their environmental performance, but also to positively influence the behaviour of products, works and service providers as well as to set a positive example throughout the wider community.

In most European public authorities procurement is a relatively decentralised process involving many individuals in different departments. Even where central purchasing units exist, some procurement responsibility is still allocated to staff in other units. In such situation ensuring the implementation of green procurement requires effective communication between and within departments, and also the setting of clear priorities. Public procurement is an activity with substantial consequences in terms of environmental impact, reaching out all municipal services and activities. The most efficient way to use the potential of GPP is clearly to promote the integration of green procurement actions into the management systems that are increasingly used in European local authorities to provide a useful framework for coordinating environmental and sustainable activities[82]. In the BEMP presented in this chapter, an operational plan for establishing GPP policies is presented in detail.

[82] http://leap.iclei-europe.org/index.php?id=29

12.1 Systematically include environmental criteria in all public procurement

Description

Public administrations can introduce environmental criteria for their procurement of products and services. This has the benefit of reducing the environmental impact of the public authority but also to influence, increase the awareness and provide example to citizens. Environmental criteria can be introduced in the technical specifications of any tender and when evaluating the proposals received, the public administration can consider as a criteria the life-cycle cost of the product or service and not the initial investment for its purchase. Despite the perception that green products are more expensive, research has found little difference in the life-cycle costs of green versus non-green products (Rüdenauer et al., 2007).

A public administration which plans to introduce environmental criteria in procurement can find useful information referencing to the EU Green Public Procurement (GPP)[83]. Environmental criteria for a broad range of products are available and regularly updated. The Commission has identified ten "priority" sectors for GPP. These have been selected on the basis of the importance of the relevant sector in terms of the scope for environmental improvement; public expenditure; potential impact on the supply side; example setting for private or corporate consumers; political sensitivity; existence of relevant and easy-to-use criteria; market availability and economic efficiency.

The priority sectors are:

1. Construction (covering raw materials, such as wood, aluminum, steel, concrete, glass as well as construction products, such as windows, wall and floor coverings, heating and cooling equipment, operational and end-of-life aspects of buildings, maintenance services, on-site performance of works contracts)
2. Food and catering services
3. Transport and transport services
4. Energy (including electricity, heating and cooling coming from renewable energy sources)
5. Office machinery and computers
6. Clothing, uniforms and other textiles
7. Paper and printing services
8. Furniture
9. Cleaning products and services
10. Equipment used in the health sector

The environmental criteria developed within the EU GPP can be used by public administrations for the tendering processes without investing relevant time and resources.

How to implement GPP in public administrations

The introduction of GPP may require, especially at the beginning and depending on the size and structure of the public administration, considerable investment of time and resource from the staff. In order for a GPP policy to be successfully implemented, it is very important to define what the main objectives of the policy are (which sectors, departments, products, services should be addressed and why) and also to seek for a link with possible complementary policies (e.g. a policy fostering innovation). A GPP policy consists of a clear policy statement and of an operational implementation plan (action plan). The high level policy statement provides the commitment framework for GPP implementation, outlining the key goals and targets which the authority aims to meet, and against which progress can be evaluated. The operational plan,

[83] http://ec.europa.eu/environment/gpp/index_en.htm

instead, should provide an in-depth description of how the goals of the policy will be met in practice (European Commission, 2008).

A suitable well-structured GPP action plan should contain the following operational elements:

- Include clear targets, priorities and timeframes: The introduction of a GPP action plan can begin with pilot projects focusing on certain departments, products or service groups. This can help verify internal capacity and testing providing companies and eventually may facilitate the public administration towards the formulation and implementation of the GPP action plan.
- The choice of priority intervention areas should primarily be implemented based on potential environmental impacts, budgetary considerations and market influence potential. Targets are set with the aim of assessing progress and of communicating both within and outside of the organisation. Targets can cover overall procurement (for example the percentage of tenders or tender values that include GPP criteria), be specific to products or services or be operational (for example providing GPP training and/or information). For inexperienced authorities it is recommended to begin with products or services, which are easy to understand and whose environmental impact is easy to assess.
- Indicate the scope of the purchasing activities covered.
- Indicate overall responsibilities for implementing the policy.
- Include a mechanism for appropriately monitoring performance against targets, which should ideally include information on the environmental impact of procurement decisions.
- Acting fairly, i.e. applying internal market principles[84].

The aforementioned elements are required for the formulation of an operational GPP action plan, but the whole methodology and the logic sequence are summarised below (**Error! Reference source not found.** summarises the logic sequence of the presented methodology).

Local public administrations can follow an appropriate process for the implementation of GPP operational action plans (Procura$^+$, 2007). This methodology is based on 5 principles (summarised in Table 12-1): i. preparation, ii. target setting, iii. develop action plan, iv. implement action plan and v. monitoring progress and report results. In the following paragraphs each of the aforementioned steps are further explained (Procura$^+$, 2007).

Table 12-1: Operational plan of a GPP (Procura+, 2007)

Stages	What to do	How to do	Comments

Preparation	• Carry out an inventory:
	  ◦ covering the whole authority or just certain departments?
	  ◦ which product/service groups to focus on
		• Inventory, including procurement table/scoreboard
		• Defined scope for the activity
			• Select a range of possible product/service groups and departments to involve
			• Carry out inventory for this range of product/services groups
			• Select which of the product/services groups to be covered and departments to involve

Target setting	• Set targets tailored to the specific interests and capacities of the examined authority through: • Market research, external advice from	• Prepare the targets	• Any number of products/services groups can be included and a single authority can be covered

[84] The market principles are: i. efficiency, ii. equal treatment, iii. transparency and iv. genuine competition (European Parliament).

Stages	What to do	How to do	Comments
	experts/stakeholders and considering organizational factors.		
Development	• Plan activities and assigning responsibilities		• Actions that must be included: • tendering • training • internal communication
Implementation	• Implement the actions described in the plan	• Procurement of more sustainable products/services	
Monitoring progress and reporting results	• Asses and report on achievements • Review the targets	• Procurement table/scoreboard • Internal review	

<u>Preparation</u>

It is very important to carry out a preliminary research (inventory) in order to identify the actions that have to be taken and also to clearly define which parts of the organisation(s) will be covered and eventually which product/service groups or works will be addressed. The selection of the products/services groups and departments is taken based on the level of the skills and resources available for procurement implementation, the local environmental priorities, the budgetary importance of certain products/service groups and the commitment levels of different departments within the authority. Regarding the inventory process, it is important to carry out a survey of the organisation arrangements for the procurement activities covered (whether centralised/decentralised, which people and departments etc.).

Some more practical information about the selection of the product/services groups are listed below (Procura$^+$, 2007):

- Products will likely be easier to start with than services, as environmental/social demands are more easily integrated into tendering;
- Start with a product where environmental/social criteria will be most straightforward – e.g. IT equipment, paper, cleaning products, food;
- Think about products demonstrating the highest financial savings over the lifecycle (typically energy-consuming products), or with relatively small levels of spending (such as paper or cleaning products);
- Consider products where environmental labels are already available – e.g. EU Ecolabel

<u>Setting targets</u>

The clear and well-structured targets and objectives may result in attracting funds and/or political support for the implementation of the GPP action plan. The targets can be set by market research (what is available on the market and at what cost) and by getting advice form stakeholders and experts. In general, there should be some short or long-term targets depending on the size of the procurements and on the scheduled projects (Procura$^+$, 2007).

<u>Development</u>

At this stage all the recommended actions and measures to be taken and how the targets are achieved are described. Ideally, the GPP action plan should contain the political commitment made by the public administration preparing the plan, including the targets set, a description of the assigned responsibilities, a description of the implemented measures and procedures, a number of relevant progress indicators and a sound timeframe (Procura$^+$, 2007). The actions in the plan should be carefully described in order for each target set to be met. On top of that, other actions like training and communication must also be incorporated to the plan.

An important factor that influences the success of the GPP action plan is the staff training. Therefore it is important to ensure that the responsible staff carrying out specific tasks already has the appropriate skills or needs a special targeted training (Procura[+], 2007).

Regarding the tendering process, the environmental criteria introduced should be identified properly by, for instance, market research of the available options. Therefore, these environmental criteria can be incorporated into actual tender documents and then the opportunities for joint procurement inside the organisation must be identified. The joint procurement opportunities may result in cost and administrative resources savings (Procura[+], 2007). The last important step is the publication and evaluation of the received bids followed by signature and management of the contracts. Setting up a procurement contract implies several steps, which are presented below (European Union, 2011):

- *Defining the subject matter of the contract*, most often to obtain a description of the product, service or work. Carrying out a needs assessment is also crucial to the definition process, sometimes enabling avoiding the purchase.
- *Setting up measurable technical specifications* within the contract. Technical specifications can refer to existing environmental criteria (for example the EU Ecolabel) and can be formulated in terms of environmental performance levels of a material, product, supply or service.
- *Specifying materials and production methods* within a tender is possible as long as this fits into the legal framework surrounding procurement. For example, a tender can specify a type of material to be used, or a certain percentage of recycled material, or the exclusion of certain hazardous substances. In order to comply with the non-discrimination principles, it is in this case important to refer to existing legislation (for example the RoHS Directive for hazardous substances) or EU ecolabels and GPP criteria. Tenders can also specify production methods while again bearing free competition rules in mind.
- *Using variants* allows tenderers to submit alternative proposals that meet the same minimum requirements that have been set in the tender. The evaluation of the tender bids is done against the same criteria for all submitted bids.
- *Using already available eco-labels and GPP criteria in technical specifications*.
- *Verifying compliance*: the evidence that will be required to determine compliance should be laid out in the tender documentation. Compliance verification can often be complex and require technical expertise, but there are other ways to do so without it, for example by obtaining evidence of compliance with mandatory EU legislation (such as the RoHS Directive), by relying on eco-labelling as evidence, or by checking environmental product declarations to check compliance with specifications.

In selecting suppliers and service providers, certification under an Environmental Management System (EMS) such as EMAS or ISO 14001 can be legally used in tendering, although such certification cannot be mandatory.

<u>Implementation</u>

During this stage it is assessed the share of procured sustainable products/services. In light of that, staff is trained properly in order to improve the results achieved. At the same time, the public administration can inform citizens and suppliers about the results of GPP (Procura[+], 2007).

<u>Monitoring progress and reporting results</u>

Setting milestones during the elaboration of the GPP action plan helps public administration to assess whether the targets previously defined have been achieved, any problem faced is identified and solutions developed. Table 13.1 below shows an estimated evaluation for the milestones for each of the aforementioned stages (Procura[+], 2007):

Table 13.1. Milestones of a GPP action plan (Procura+, 2007)

Stages	Milestones (months)
Preparation	4-8
Setting targets	1-6
Development	12-24
implementation	3-6
Monitoring	4-8

In order to monitor efficiently the GPP action plan, public administrations can establish a dedicated working group involving representatives from different departments and ensure that they have the necessary cross-cutting competences to draft a strategy, including (European Union, 2011):

- ✓ Project management skills: to manage the staff, work flow and budget;
- ✓ Technical skills: in order to effectively assess new technologies, precisely identify needs and interact with the market (a simple market research to be informed about upcoming products is a start);
- ✓ Legal skills: to ensure market engagement activities and tendering procedures are legally compliant.

If the above mentioned competencies are not found in-house, public administrations can seek for external assistance and thus other tools can be used such as (Smart SPP Consortium, 2011):

- ✓ Government Agencies: Certain Agencies may exist to provide support relating to innovation or energy efficiency.
- ✓ Sectoral technological centres, professional associations and other public administration organisations.
- ✓ Research institutes and consultancy services.
- ✓ National/international networks which can provide expertise.
- ✓ Procurement agencies: it can be an option to contract out the whole, or part of the action to a procurement agency operating on behalf of the public administration.

Reporting and communication of results achieved plays an important role among staff and citizens in order to raise their awareness.

Achieved environmental benefits

The implementation of this BEMP is associated with significant environmental benefits, depending on the products and service purchased and the environmental criteria used. Therefore, the environmental benefits achieved vary considerably, e.g. from reduced emissions to air and water, to reduced waste generation.

Appropriate environmental indicators

An appropriate environmental performance indicator for this BEMP is:

- Green public procurement procedures: expressed as *(number of tenders referring to environmental criteria)/(total number of tenders)*; the tenders should be disaggregated by product categories: buildings, furniture, electronic appliances, cleaning products, food, paper products, etc.

Other indicators which may be used to assess the use of the most common environmental criteria are:

- Green paper used in the municipal offices: expressed as *(number of green paper reams)/(total number of paper reams)*; the definition of green paper refers to paper having a reduced environmental impact e.g. recycled paper, paper with EU Ecolabel logo.

- Organic food served by municipal canteens: expressed as (*number of meals with organic food)/(total meals served)*; organic meals served by municipal canteens should disaggregate into: partially organic meals and organic meals
- Local's authority green fleet: expressed as *(number of low emission vehicles)/(total number of vehicles)*; low emission vehicles are considered the vehicles fueled by LPG or natural gas or are hybrid, equipped with low resistance tires etc.

Cross-media effects

There are no cross media effects from the implementation of this BEMP.

Operational data

When public administrations decide to introduce environmental criteria in their purchasing of products and services, they can identify the ones with the most relevant environmental impacts and where environmental criteria are already available or easy to assess. For instance, if the public authority wish to reduce CO_2 emissions, it can implement GPP when buying windows and insulation, heating cooling and ventilation systems, indoor and outdoor lighting systems, transportation of goods and people, energy consuming office equipment, energy management systems for buildings. All of these products should meet high energy efficiency standards (European Union, 2011). If the public administration instead would like to support small local scale producers, food and catering services can be procured introducing environmental criteria. Here the procurer can give preference to fair trade labels and catering providers using organic products. Cleaning products and services are another area easy to be procured with already existing green labels and criteria.

Below some examples from the real implementation of different GPP cases are presented[85].

<u>Windows and insulation, heating cooling and ventilation systems and energy management system for buildings</u>
The headquarters of the District Authority of Weiz (Austria) are located in an office building built in 1964. Due to new requirements concerning function, fire protection and energy demand, a comprehensive renovation has been carried out. Renovation measures include a new innovative façade system, mechanical night cooling with the existing air condition system and a circulating heat exchanger based on air. Following renovation the building is planned to achieve a very high energy standard (which is A+ in the Austrian energy certificate) – the reduction of the energy demand for heating and annual CO_2eq emissions per m^2 is about 80%. After the renovation (end of June 2011) detailed energy monitoring will be carried out to evaluate planned renovation measures.
<u>Indoor and outdoor lighting system</u>
The City of Budapest (Hungary) replaced the lighting system of the "Liberty Bridge", one of the key crossing points over the Danube, and an iconic site within central Budapest. More than 800 light fittings were installed to provide Liberty Bridge's ornamental lighting, 584 of which are LED lights. This amounts to installed power of 40.7 kilowatts, of which the LEDs account for 13.1 kilowatts. The project was carried out in 2009 at a cost of €1.66 million. The estimated life expectancy of the ornamental lighting installed is 15 years and 30 years for the street lighting. This longer lifespan means lower replacement rates, bringing considerable direct and indirect economic benefits and reduced waste. Replacing the lamps is difficult and costly due to their mounting on the bridge and the disruption to traffic, and these costs have been avoided. The savings on electricity compared with the original concept (which used halogen lighting) are estimated at €40,000 per annum, with total savings of €100.000 per annum.
<u>Transportation of goods and people</u>
Frankfurt am Main (Germany) placed environmentally enhanced services in public transport. 20% (3.3 million km/a) of the public bus transport was tendered. Within a pilot-tendering

[85] All the case studies summarized above are available in an extended version from: http://www.sustainable-procurement.org.

throughout the EU, incentives for offers considering enhanced environmental busses were set. The contract was awarded to ALPINA, a tenderer from Bad Homburg (Germany). The new busses went into service in December 2006. 32 standard-size-buses, 17 midsized-buses and 2 Minibuses came into operation. Except for the Minibuses, all these EEV-standard (EEV = Enhanced Environmental Friendly Vehicle) vehicles are diesel powered. Therefore in Frankfurt/Main operates the largest diesel powered EEV- standard bus fleet. By using EEV busses, the tendered transport performances will result in a significant reduction of air- and noise pollution. Compared to today's emission limits, particulate matter emissions will decrease to around 20% and those of nitrogen oxides to around 50%. Even compared to the EURO V standard nitrogen oxides are reduced clearly. Noise is reduced by 3dB(A) for both categories of busses. These drastic reductions of noise- and air pollution results in additional costs of less than 0,07 €/km.

Energy consuming office equipment, paper and printing services

The Central Project Management Agency (CPMA) acts as the central purchasing body in Lithuania. CPMA has implemented GPP criteria in its frameworks for office IT equipment (including desktops, laptops, displays and imaging equipment), stationery and office supplies (including toner cartridges, light bulbs, paper products and writing implements) and printing and copying paper. In total, there are over 60 different product specifications offered in an online catalogue for purchasing organisations to choose from. Buyers are able to easily find green products as they are specially marked in the catalogue. Thanks to the simplified procedures and intense competition, one of the main concerns regarding the price of environmentally friendly products was solved. Major discounts for all product groups have resulted in reasonable prices for green products too. An impressive share of contracts in which green products were purchased can be observed: 61% for IT equipment, 76% for office paper and 49% for stationery products. The most popular green products are desktop computers and notebooks.

Food and catering services

Rome (Italy) supports organic agriculture and organic food chains, food safety and nutritional balance, and encourages good environmental performance of current and potential suppliers through its school meal service. Since 2001, Rome has employed an incremental approach to designing its food and catering tenders and its food service, to gradually make these more sustainable and innovative. As a result, organic food accounts for 69% of all food served in Roman schools, except meat, fish and cold cuts. The switch to organic has raised the average cost of a meal by 8% (that is €0.40). Rome's approach has improved the market in terms of sustainability and quality. Companies are now aware that they face a public administration which calls for strict compliance with all the requirements specified in tenders – they therefore take the bidding process very seriously and are encouraged to improve their own performance.

Furniture

In 2005, the city of Cognac (France) decided to replace its obsolete street furniture with wooden furniture. Analysis of the product revealed that the furniture was made from Moabi – a rare and endangered wood species, often smuggled from the Congo and Cameroon. Since then, the City of Cognac requires compliance with certain eco-label criteria when purchasing products that are derived or contain wood. During 2010 and 2011, wood for construction, wall panels and door units have been purchased, which are certified with the PEFC label, as a minimum. The successful tenderer was a local wood provider. Sustainability criteria have not had a negative economic impact for Cognac. On the contrary, the city actually saved 5% in purchasing costs compared to the same purchase carried out in the previous year, which did not include the sustainability requirements.

Cleaning products and services

The Municipality of Reykjavik (Iceland) conducted an analysis on the cleaning habits in its facilities. This study showed that the cleaning frequency in the City Council's buildings could be considerably reduced, generating positive results for the environment and the City's budget. Furthermore, by cleaning the offices during office hours, staff reacted more positively about the quality of the cleaning service provided, despite the lower frequency. The City Council also engaged in purchasing non-allergenic, readily biodegradable and free of high concentrations of volatile organic compounds cleaning products, certified by the Nordic Swan Eco-label, thus lowering its environmental impacts.

Applicability

GPP is applicable to all types and sizes of public administrations. However, public administrations of considerable size have more financial and staff resources to be dedicated to GPP, resulting in a potentially higher implementation for the procurement of services and products. For small public administrations, joint procurement with other public administrations is a viable solution that allows knowledge and costs sharing. Guidance for GPP is becoming more common, making the process easier to implement for local authorities.

Economics

Often, the perception is that applying higher environmental standards will lead to important cost increases. Research has found little difference in the life-cycle costs of green versus non-green products (Rüdenauer et al., 2007).

Driving force for implementation

In addition to the environmental benefits listed previously, the following points are also drivers for the implementation of GPP within public administrations (European Union, 2011):

- GPP as a driver of innovation: Procurement programmes, particularly large ones set by big cities or groupings of smaller ones, can push for sustainable innovation in service delivery or product manufacturing by setting high standards, "providing industry with real incentives for developing green products and services – particularly in sectors where public purchasers represent a large share of the market (e.g. construction, health services, or public transport)." For example, public bodies such as Transport for London or the London Metropolitan police have invested in electric vehicles for their own use as a way to stimulate the uptake of electric vehicles throughout the capital.
- GPP as a cost-reduction tool: "GPP may also provide financial savings for public authorities – especially if you consider the full life-cycle costs of a contract and not just the purchase price. Purchasing low-energy or water saving products for example, can help to significantly reduce utility bills. Reducing hazardous substances in products can cut disposal costs."
- GPP as a way to boost confidence in public administrations: Having a green procurement policy can create a positive, environmentally-friendly and open reputation for an organisation, and lead to improved relations with businesses, civil society and citizens.
- GPP as a means for improving working conditions: Many of the criteria and requirements of GPP contain provisions that directly or indirectly improve the health and working conditions of public sector employees.

Reference organisations

- ICLEI – Local governments for sustainability is a website where more information about GPP can be found and list of experienced municipalities: http://www.iclei.org/
- Procura^{+} provides information about the implementation of GPP policies as well as examples of cities, which have already implemented them: http://www.procuraplus.org/
- European Commission have developed GPP criteria; more information can be found: http://ec.europa.eu/environment/gpp/toolkit_en.htm

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13 BEST ENVIRONMENTAL MANAGEMENT PRACTICE FOR ENVIRONMENTAL EDUCATION AND DISSEMINATION OF INFORMATION

Introduction

Sustainable development is a process of societal change that cannot be implemented top-down by a public administration. It requires that all members of society (citizens, businesses, associations) contribute to it and implement their share of the transition to sustainable management practices. For instance, the role of citizens is absolutely key in achieving results in reducing the emission of greenhouse gases (transportation, buildings), waste management and air pollution within a municipality.

Environmental education is thus a central aspect of the process of change towards sustainable development. It is based on building awareness and identification with personal living environments. Therefore it is not merely the conveyance of knowledge but a process of action-oriented, political learning (PROEUROPE, 2005).

In more practical terms, environmental education is both about raising awareness on how to save resources and limit damage to the environment (e.g. explaining the importance of separating waste at source) and about creating emotional links between people and nature (e.g. discovering and enjoying natural spaces close to citizens' homes). These actions have also benefits that go well beyond the environmental aims. For instance, several studies have reported a clear relation between human health and activities in open urban spaces; the outcome of a study of eight European cities showed that people who live in areas with abundant green open space are three times more likely to be physically active and 40% less likely to be overweight or obese (Ellaway et al., 2005; Hudeková and REC Slovakia, 2009). Likewise, the school children who have access to, or even sight of, the natural environment show higher levels of attention than those without these benefits (Velarde et al., 2007).

Besides environmental education, local public administrations can also play an important role in providing information related to the (local) environment and how to protect it to citizens and businesses. This includes but is not limited to the proper dissemination of the environmental policies and plans formulated by the municipality and the concrete actions implemented and their results. Also very important is the provision of information on applicable legislation, available incentive schemes, etc. which can trigger sustainable choices by businesses and citizens.

It should be mentioned that environmental education, awareness raising and provision of information on some specific environmental aspects are already addressed by other BEMPs in this document. In particular, concerning energy, Section 3.4.2 deals with the provision of information and advice services to citizens and businesses, whereas Section 3.4.1 outlines some approaches to communication to the public and stakeholder engagement.

Technique portfolio

The BEMP (Section 13.1) deals with the environmental education and information for citizens and businesses by public administration. The main elements of environmental education schemes are discussed and best examples from local public administrations are presented.

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13.1 Environmental education and information for citizens and businesses

Description

Environmental education plays a key role in the effectiveness of putting in practice the principles of sustainable development. In terms of content, environmental education encompasses a variety of areas ranging from practical advice about environmental protection and the efficient utilisation of the natural resources, to information about the local natural ecosystems and their conservation (PROEUROPE, 2005). It can be aimed at awareness raising, behavioural changes or, also very important, reconnecting with nature.

Local public administrations are in a key role for providing environmental education and information to citizens and businesses. Indeed they are both the level of public administration closest to citizens and business and those in charge of implementation of crucial environment-related policies, public services and concrete measures in fields such as waste management, energy planning, air quality, mobility…

Most often environmental education/information schemes run by local public administrations have the following objectives (PROEUROPE, 2005; Uttke, 2012; CEA, 2015):

- Fostering public awareness of environmental problems
- Providing practical information on the everyday contribution that citizens and businesses can make to environmental protection and efficient utilisations of resources
- Creating new patterns of behaviour among different groups within the society
- Inspire citizens to get to know and appreciate the local environment and reconnect with nature
- Stimulating an understanding of the environmental interdependence between urban and surrounding rural and natural areas
- Providing information on legal (and other) environment-related provisions and on incentives to go beyond legal obligations (e.g. incentives for energy efficiency)
- Organising educational seminars, conferences, workshops for the general public or specific groups of citizens or businesses professionals on specific aspects (e.g. energy efficient buildings)

The environmental education and information schemes can be organised and run internally by the public administrations, i.e. using in-house resources, as well as relying on civil society or external companies. An example of use of in-house human resources is the recycling officers employed by several city councils to explain how to separate waste at the household level. An example of relying on civil society is the "environmental education centre" set up and funded by the municipality of Rome (Italy) and run, on behalf of the municipality, by a consortium of local environmental associations (CEA, 2015).

One representative widespread example of educating citizens comes from the waste management field. Citizens and businesses play a crucial role in ensuring waste separation which is a key step to make the system more sustainable. The experience shows that campaigns in this area, especially based on household level personal interaction, can be very effective in modifying people behaviour. Moreover, even an education programme focused on a specific aspect, such as waste separation, can have a broader effect by increasing environmental awareness of people and encouraging them to take further measures to protect the environment.

An approach which is often successful is providing environmental education at or in cooperation with schools and at vocational training establishments. This has not only the potential to have a positive effect on the children's and young adults' interest and knowledge of the environment, but also to have those messages conveyed by the children and young adults to their whole family. Therefore a much broader audience and effect can be reached.

Another effective approach is the creation of environmental education centres. These can be placed in or close to natural areas and act as a link between citizens and the green space thanks to talks, guided tours, etc. In touristic places, they can also play a very important role in informing and raising awareness of tourists (e.g. about the importance of conserving the dunes for a municipality responsible for a natural coastal area).

Achieved environmental benefits

The environmental benefits of providing environmental education and information to citizens and businesses depend on the specific issues tackled and on the effectiveness of the programme. In several instances the benefits are long term, such as for actions targeted at school students or programmes aimed at behavioural change, but can be very significant.

Appropriate environmental performance indicators

The environmental performance indicators for this BEMP are:

- Implementation of an environmental education strategy (Y/N)
- Operation of an environmental education centre (Y/N)
- Number of citizens reached directly and indirectly by the environmental education programme or centre
- Presence of a municipal service or agency for environment-related information for businesses (Y/N)
- Number of companies having been provided environment-related information by the municipal service or agency

Operational data

PROEUROPE
PROEUROPE is the European organisation representing the national producer responsibility systems engaged in the selective collection and recycling of packaging waste. It developed a full environmental education scheme with focus on waste aspects covering the entire education chain, starting from pre-schools, to vocational training establishments ending up to comprehensive consumer communication measures (PROEUROPE, 2005).

City example: Warrington, United Kingdom
A waste education centre was established in Warrington to show how the different waste streams are recycled and reused. Visitors to that centre find out about the wide variety of materials that can be recycled in their area and how different fractions are collected, treated and recycled. This stimulates them to make a difference by better separating waste at home to ensure better recycling. The centre organises educational sessions for the local schools and community groups.

City example: Bristol, United Kingdom
The council of Bristol has run communication campaigns through print, web and social marketing channels including working with local social groups and local communities in order to inform citizens about waste management. Also some local social enterprises were involved. An example of educational material used is illustrated in Figure 13.1 (EU Green Capital Award, 2015).

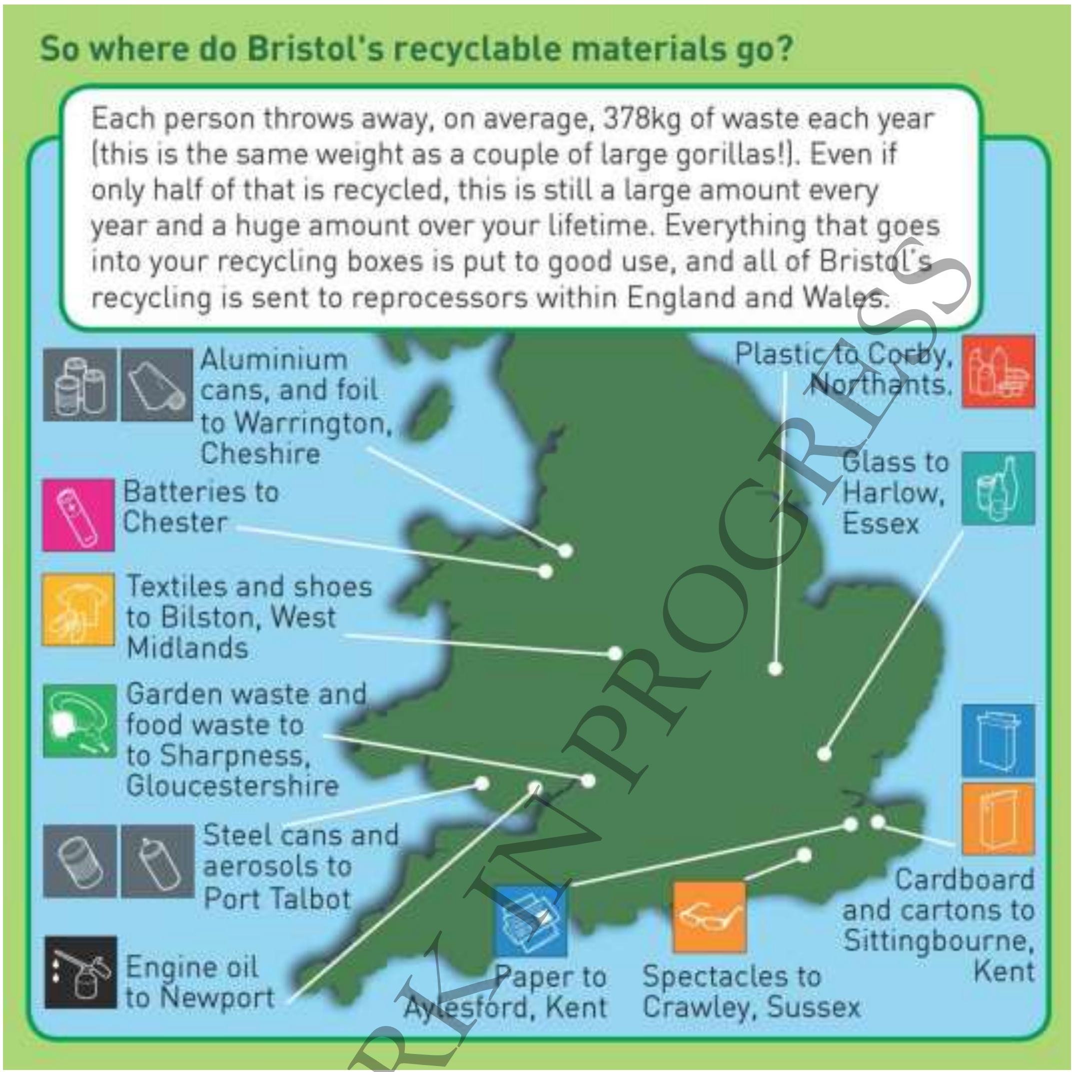

Figure 13.1. Citizen communication materials about destinations of recyclable materials (EU Green Capital Award, 2015)

<u>City example: Barcelona, Spain</u>
The municipality of Barcelona introduced an action plan regarding environmental education in cooperation with ICLEI (Local Governments for Sustainability). The plan identified schools as the main education vehicle and provided for the permanent support to teaching staff through personalised advice, online communication, specific training and coordination with municipal management areas, the city districts, and other stakeholders. Teachers can also participate in networks of schools and other organisations and are given a methodological guide to orient the progress of the participants with clear milestones over the school year.

<u>Case study: CENEAM, Spain</u>
Spain's National Environmental Education Centre (CENEAM), based in Segovia, provides professionals with specialised information and tools to develop environmental education programmes and activities. The centre offers also guided tours and direct educational programmes for schools and citizens. Among the programmes for citizens, the programme "Green Homes" is aimed at all those people who want to improve their environmental behaviour in the domestic setting. It includes information meetings, educational materials, and personal consultation service (CENEAM, 2010).

<u>Further city examples from different European cities</u> (Beatley, 2000)

- Leicester, UK, built an environmental community centre which attracts citizens thanks to an environmental shop, bulletin board and ecological café serving organic ingredients which are (when possible) from local farms.

- Heidelberg, Germany, opted for environmental education to citizens based on targeted decentralised awareness campaigns. The decentralised approach consists in soliciting community-level actors and individuals to get out the message. This has proven more effective in the long run. A practical example is the distribution of energy-saving light bulbs by local hardware store owners who become knowledgeable advocates.
- In Kolding city, Denmark, each school adopts a natural space, analyses the ecological condition and contributes to restore and improve it through actions like tree planting and placement of more rocks. The city also takes measures to inform farmers about the environmental impacts of their operations and observed changes in the farming practices implemented towards more sustainable ones.
- In Hairaken, Finland, students learn about the ecology of the region in schools and act as stewards for twelve different ecological areas in the city.
- Several cities, e.g. Copenhagen and Berlin, have prepared booklets presenting ecological walking tours of the city which highlight urban ecology and energy innovations in the city.

Applicability

This BEMP is easily and fully applicable by all the public administrations. Those lacking internal capacity and/or resources can look into partnering with other organisations with similar aims active on their territory (such as environmental NGOs).

Economics

The cost for organising educational schemes and trainings for citizens by the public administration is relatively low comparing to the outcomes. As an example, in the case of waste management, the cost of effective education of citizens can be easily paid back by lower waste management costs if the amount of the residual waste becomes significantly lower.

Furthermore, the construction of environmental education centres may have positive effects for the local economy, such as attracting more tourism to the area.

Driving forces for implementation

Different driving force may lead to the implementation of this BEMP. In some instances, the environmental education/information schemes may be part of a broader sustainability plan or policy. In other cases, these can be the result of the need or willingness to reach a certain target or objective (sometimes because dictated by regulation) where the active engagement of citizens or business is key (e.g. reaching a certain level of separated waste collection). Finally, there are cases where these actions start from the willingness to promote a natural place (such as a reserve or park) and engage citizens with it.

Reference organisation

Several municipalities run effective environmental education/information schemes. Some examples are:

- Barcelona, Spain
- Bristol, UK
- Leicester, UK
- Rome, Italy

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14 EMERGING TECHNIQUES

According to the IED directive (2010/75/EU), an emerging technique is 'a novel technique for an industrial activity that, if commercially developed, could provide either a higher general level of protection of the environment or at least the same level of protection of the environment and higher cost savings than existing best available techniques'. A similar understanding can be transferred to non-industrial sectors, such as public administration, to identify measures/actions that are not yet fully implemented but have a large potential. In this chapter attention is turned to emerging techniques and approaches in a rather broad sense: not only technical challenges, but also political, economic, social, cultural and ethical, as are the challenges that public administration face.

Ecosystem services approach

The scope of planning for public administrations is closely linked to the emerging approaches on ecosystem services. Ecosystem services describe the interactions between the physical environment and human societies. Ecosystem services are classified as ‘provisioning, socio-cultural, regulating and supporting’ types of services.

Typically, local policy makers have to provide multiple services simultaneously. These include: public infrastructure, water and waste management, promoting local economic development, education and health care. Their challenge is to maintain and improve the quality of life for citizens when financial resources and capacities are often severely limited.

By making use of the concept of ecosystem services, local policy makers can fully utilise nature’s assets for local development. They can make good use of available instruments and procedures (Environmental or strategic Impact Assessments; Cost-Benefit Analysis for public infrastructure; local and regional tax incentives); develop new instruments to improve biodiversity related decision-making (Payment for Ecosystem Services (PES), Reducing Emissions from Deforestation and Forest Degradation (REDD) pilot scheme and Clean Development Mechanism projects); advocate environmental concerns at higher policy levels. Ecosystems become therefore building blocks for public administrations planning. Integrating the Ecosystem services approach into planning can also lead to a sustainable response to climate change.

ICT-enabled governance for smart cities

Effective governance of local European public administrations today is fundamentally undermined by urban complexity, whereby the high degree of interconnectedness and multiple interactions between socio-economic and environmental factors in a territorial context create major barriers to the effective implementation of sustainable urban development. The proactive governance of cities and the delivery of more sustainable compact cities offer substantial opportunity for the application of enhanced intelligence in urban management, to produce an effective basis for assessment of urban complexity, and decision-making support (Urban API, 2014).

ICT-enabled governance is particularly emerging to “1. Simplify and improve the internal administrative operations of government and their relations with other bodies involved in public management and service delivery; 2. Facilitate public service interaction between government, citizens and other stakeholders, thus enabling better citizen participation and overall monitoring and evaluation of decision-making processes and their implementation and 3. Ensure inclusiveness and equal opportunity for all” (JRC, 2011). ICTs bring a significant change in public administrations' governance, particularly in terms of improved communication and information services, as well as offering the potential to provide urban planners with the tools and intelligence needed to actively manage the urban environment.

Smart grids

Smart grids could fundamentally change the architecture of the conventional electricity grid, shifting mass production and centralised control to smaller sources and decentralised information. While no consensual definition of "smart" grids is broadly accepted, two key

features distinguish smart grids from the electricity infrastructure prevalent today: information and decentralisation.
The ability to transmit information (either through the grid itself or through a parallel network e.g. the internet or GSM communication) enables producers and consumers to transmit real-time data on usage and pricing and help optimise the operation of the whole network. This better match of supply and demand increases efficiencies through reduced losses and can e.g. allocate production to the most climate-friendly sources.
The second feature is a paradigm shift from top-down, centralised electricity production in single-point sources (or consolidated, even in the case of PV or wind farms) to a model where the producers are as numerous, and often the same, as the electricity consumers, typically homes or businesses (with an array of technologies e.g. PV, fuel cells, storage batteries, wind turbines etc.). The coordination of not just demand but also supply between thousands or millions of decentralised facilities is enabled by the ability to transmit real-time information between these network points, creating a dynamic marketplace for power with much broader scope for reaching an allocation optimum.

The first step towards a smart grid, still within today's top-down centralised distribution model, is the widespread deployment of so-called "smart" electricity meters, i.e. able to send and receive information about the status of the grid, typically the instant load which concretely impacts the spot price. Users can then determine dynamically according to their established preferences whether to adapt their consumption. This approach – termed demande response – is already possible today and being deployed in many countries worldwide, either at the level of the meter or also sometimes for each individual appliance consuming electricity.
The second step will be enabled by the economies of scale for small-scale electricity production technologies as mentioned above, which will create a liquid market for electricity sale into the grid. This has been introduced with the ever increasing deployment of PV panels for instance, although in many countries the feed-in system is rather rigid and does not yet facilitate real-time optimisation of the grid efficiency.

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15 CONCLUSIONS

This document identifies the most important environmental aspects, direct or indirect, relevant to local public administrations. The report presents the best environmental management practices dealing with these identified aspects, including also sector specific environmental indicators which allow tracking sustainability improvements. The following table lists all the BEMPs presented in the document, including some details on their applicability, the environmental performance indicators applicable for each of them and, finally, also the identified benchmarks of excellence. As mentioned in the Preface of the document, the benchmarks of excellence represent the highest environmental standards that have been achieved by organisations implementing each related BEMP, however, they are not targets for all organisations to reach but rather a measure of what is possible to achieve (under stated conditions) that public administrations can use to set priorities for action in the framework of continuous improvement of environmental performance.

Table 15-1: BEMPs, environmental performance indicators and benchmarks of excellence

BEMPs for sustainable offices			
BEMPs	**Applicability**	**Benchmarks of excellence**	**Most relevant environmental performance indicators**
1) Managing and minimising energy consumption	BEMP applicable to all public administrations. BEMP specific for office buildings.	N/A	Energy consumption in office buildings per floor area and year ($kWh/m^2/yr$)
2) Managing and minimising water consumption	BEMP applicable to all public administrations. BEMP particularly relevant in areas prone to water stress due to their geographical location.	Water consumption in office buildings is lower than 6.4 m^3/employee/year	Water consumption in office buildings per employee and year (m^3/employee/year)
3) Managing and minimising waste production	BEMP applicable to all public administrations. The different fractions in which waste is segregated should reflect the local waste management policy.	Zero waste sent to landfill Total waste generation in office buildings is lower than 200 kg/employee/yr	Waste generation in office buildings per employee and year (kg/employee/yr)
4) Minimising consumption of paper and consumables	BEMP applicable to all public administrations.	Copier paper used is 100% recycled or certified according to an ISO-type-I ecolabel. Paper consumption is lower than 15 sheets/employee/working day	Paper consumption per employee and year (sheets/employee/working day)
5) Minimising the environmental impact of commuting and business travel	BEMP applicable to all public administrations. However applicability of specific measures will vary depending on the local situation, such as geographical setting and availability of public transport.	Engagement tools for promoting sustainable commuting for employees are implemented and promoted Carbon budgeting is implemented for all business travel Video conferencing facilities are available to all staff and their use is monitored and promoted	• Total CO_2e emissions from business travel (kg CO2e) • Total CO_2e emissions from business travel per full time equivalent (FTE) employee (kg CO_2e /FTE) • Carbon intensity of business fleet/vehicles (g CO_2e /km) • Percentage staff commuting by sustainable transport modes > 3 times per week (% sustainable modes/total)

6) Minimising the environmental impact of canteens and coffee bars	BEMP applicable to all public administrations that have internal canteen or coffee bar facilities.	N/A	• Percentage of low impact food options served (e.g. locally-sourced, low-meat, seasonal, organic) (% low impact/total purchase volume) • amount of food waste generated per meal served (g/meal) • Percentage of food waste sent for anaerobic digestion (% sent for AD/total tonnes food waste)
7) Minimising the environmental impact of meetings and events organisation	BEMP applicable to all public administrations.	N/A	• Suppliers with recognised events management system (e.g. ISO20121) (%/total contract value) • % accommodation with a recognised sustainable certification scheme (e.g. EMAS, EU Ecolabel, Green Tourism, Business Scheme, ISO20121) (%/total hotel nights)
BEMPs for sustainable energy and climate change			
BEMPs	**Applicability**	**Benchmarks of excellence**	**Most relevant environmental performance indicators**
8) Establishing an inventory of energy consumption and emissions of the territory of a municipality	BEMP applicable to all public administrations.	N/A	• Total annual carbon emissions of the municipality (tCO_{2e}) and per inhabitant ($kgCO_{2e}$/pers) • Annual energy consumption per inhabitant (kWh/pers)
9) Establishing and implementing a municipal energy and climate action plan	BEMP applicable to all public administrations.	N/A	• Total annual carbon emissions of the municipality (tCO_{2e}) and per inhabitant ($kgCO_{2e}$/pers) • Annual energy consumption per inhabitant (kWh/pers)

10) Establishing and implementing a strategy for climate change adaptation within the territory of the municipality	BEMP applicable to all public administrations. The specific adaptation strategy should be developed in relation to the local context and respond to the projected climate change impacts of the region.	N/A	• Likelihood of serious adverse weather effect (e.g. likelihood of flooding: 1 in 300 years) • Percentage of homes and businesses protected as a result of the strategy • Cost savings as a result of the measures implemented in the strategy
11) Implementing energy efficient street lighting	BEMP applicable to public administrations managing directly or indirectly (through a public or private company) the provision of street lighting.	Street lighting energy consumption per street kilometre is lower than 6 MWh/km yr	- Annual energy consumption for street lighting per inhabitant (kWh/pers yr) - Annual energy consumption for street lighting per street kilometre (MWh/km yr)
12) Improve the energy efficiency of public buildings	BEMP applicable to all public administrations that own or manage public buildings. However construction techniques should adapt to the environment, climate and surroundings of the building location.	For new builds, the building is designed according to the Passive House standard or equivalent, with an energy need for heating and cooling lower than 15 kWh/m^2/yr and a total primary energy use lower than 120 kWh/m^2/yr. For existing buildings, the building is retrofitted according to the Passive House standard or equivalent, with an energy need for heating and cooling lower than 25 kWh/m^2/yr and a total primary energy use lower than 132 kWh/m^2/yr. The building's final specific heat load for heating or cooling is lower than 10 W/m^2, according to the definition of the Passive House standard or equivalent.	Energy consumption per floor area and year (kWh/m^2/yr)

13) Improving the energy efficiency of social housing	BEMP applicable to all public administrations responsible for social housing. However construction techniques should adapt to the environment, climate and surroundings of the building location.	For new builds, the building is designed according to the Passive House standard or equivalent, with an energy need for heating and cooling lower than 15 kWh/m^2/yr and a total primary energy use lower than 120 kWh/m^2/yr. For existing buildings, the building is retrofitted according to the Passive House standard or equivalent, with an energy need for heating and cooling lower than 25 kWh/m^2/yr and a total primary energy use lower than 132 kWh/m^2/yr. The building's final specific heat load for heating or cooling is lower than 10 W/m^2, according to the definition of the Passive House standard or equivalent.	Energy consumption per floor area and year (kWh/m^2/yr)
14) Achieving energy efficiency in public buildings through ESCo models	BEMP applicable to all public administrations that own or manage public buildings. Municipalities with a limited budget to be invested for energy retrofitting and/or limited expertise among their employees may consider the ESCo model particularly suitable and relevant.	N/A	Energy consumption per floor area and year (kWh/m^2/yr)
15) Improving the energy performance of existing public buildings through monitoring, energy management and fostering of behavioural change	BEMP applicable to all public administrations.	N/A	• Energy consumption per floor area and year (kWh/m^2/yr) • Percentage of staff engaged and who continue to be engaged after one year of the launch of an awareness campaign • Hours of environment-specific training provided (/employee /year)

16) Implementing district heating and/or district cooling networks	BEMP applicable in all regions with relevant heating or cooling demand, and especially when planning new developments (public or private) or redesigning the energy system of a considerable number of public buildings within a limited area.	N/A	• CO_2 emissions of the system providing heating or cooling, before and after the implementation of district heating/cooling (or compared to an alternative system for new developments)
17) Implementing on-site renewables and mini-CHP on public buildings and social housing	The suitability for implementing a renewable energy or low carbon system on a particular site depends on numerous factors. However, there should be a solution applicable to most situations.	Electricity consumption in public buildings is 100% met by on-site renewable energy generation. Water heating in public buildings/social housing is 100% provided by on-site renewable heat generation.	• Renewable energy generation per internal floor area (kWh/m^2year) • Share of total energy needs met by on-site renewables (%) • Share of total energy needs met by locally generated low carbon energy (%) • On-site generation of renewable electricity out of the total electricity consumption of the building (%) • Percentage of water heating provided by on-site renewable heat generation (%)
18) Imposing higher energy efficiency standards and renewable energy requirements in land use planning for new-built and buildings undergoing major renovations through local building regulations and planning permissions	BEMP applicable to public administrations responsible for giving building permits, planning developments and having the possibility to set local building regulations. These depend heavily on the national legal framework.	N/A	• Establishment of regulations imposing higher energy efficiency standards and renewable energy requirements (Y/N) • Level of energy performance required by the local building code (kWh/m^2/year)
19) Exemplary role of the public sector	BEMP applicable to all public administrations.	N/A	• Delivery of flagship/demonstration schemes and buildings (Y/N) • Achievement of ambitious level of performance across all buildings and activities of the public administration (Y/N).

20) Information and advice services on sustainable energy for citizens and businesses and public-private partnerships	BEMP applicable to all public administrations.	N/A	• Delivery of information and advice services (Y/N) • Support of low carbon pilot projects, e.g. through public-private partnerships (Y/N).
21) Thermographic surveying of municipalities' built environment	BEMP applicable to all public administrations.	High-resolution (<50cm) recent (<5 years) thermographic data is available for 100% of the built area on the territory of the municipality.	• % of the built area of the municipality covered by thermographic surveying • potential energy savings identified (kWh / heating season) (or €/heating season)
BEMPs for mobility			
BEMPs	**Applicability**	**Benchmarks of excellence**	**Most relevant environmental performance indicators**
22) Enacting a Sustainable Urban Mobility Plan	BEMP applicable to all public administrations.	N/A	• Modal share of journeys (% of journeys made by car, motorbike, public transport, cycling and walking) • Accessibility of public transport (Number of people living within 300 metres from an urban public transport stop with a minimum frequency of 15-20 minutes.)
23) Fostering cycling and walking through cycling infrastructures, bike sharing schemes and promoting walking	BEMP applicable to all public administrations, regardless of climate and topography.	The city has a modal split for cycling of 20% or higher OR the city has in-creased its modal split of cycling with at least 50% during the last five years. At least 10% of the cities investment in transport infrastructure and maintenance is dedicated to cycle infrastructure. The city has a modal split for walking of 20% or higher OR the city has in-creased its modal split of walking with at least 50% during the last five years.	• Modal share of journeys (% of journeys made by car, motorbike, public transport, cycling and walking) • Total length of cycle infrastructure (cycle lanes, cycle tracks), in total (km) and in relation to the length of the total road network (km cycle lanes/km roads) • The city has a dedicated policy and measurable goals to increase walking/cycling that is politically adopted (Y/N).

24) Implementing a large scale car sharing schemes	BEMP applicable to public administrations administering large urban areas.	At least 8 privately-owned cars were replaced by every vehicle in the car sharing operator's fleet At least 1 shared car available per 2,500 residents	• Number of car sharing users per 10,000 inhabitants • Number of registered users per car sharing vehicle • Mileage driven by car sharing users • Number of privately-owned cars replaced by every vehicle in a car sharing operator's fleet
25) Integrated ticketing for public transport	BEMP applicable to all public administrations with a considerable influence on the public transport system.	At least 75% of trips are paid for by the integrated ticket	• Percentage of trips paid for by the integrated ticket • Number of public transport users who would have used private motorised transportation in the absence of an integrated ticketing system (normalised by total population in the catchment area)
26) Improving the uptake of Electric Vehicles in urban areas	BEMP applicable to all public administrations. However, this BEMP is targeted to cities in which short driving distances are the norm.	N/A	• Percentage of electric vehicles on the road compared to total vehicles • Percentage of electric public fleet compared to total public vehicles • Public charging points per inhabitants
27) Fostering passenger intermodality	BEMP applicable to all public administrations.	Share of sustainable modes of transport used in the city (e.g. walking, cycling, bus, tram, train) > 60%	• Modal share of journeys (%) • Average number of bicycle rack spaces at public transport stops per average daily passenger throughput. • Percentage of people who live within a reasonable radius from high-frequency public transport stops that combine walking/cycling with public transport (%). • Intermodal journey planning software includes walkable and cyclable journey legs (Y/N).

28) Implementing a congestion charge	BEMP applicable to cities with high traffic congestion.	Concentration of air pollutants (PM10, Ammonia and Nitrogen Oxide) are reduced by 10% (on average) within the congestion charging area, compared to the situation without the congestion charge. Vehicular access of non-exempt vehicles to the congestion charging area is reduced by 20% compared to the situation without the congestion charge. Speed and punctuality of public transport services are improved by 5% compared to the situation without the congestion charge.	• Modal share of journeys (%) • Percentage of reduction in air pollution. • Percentage of reduction in vehicular access to the congestion charging area. • Percentage of increased average speed and punctuality of public transport vehicles in the congestion area.
29) Limiting free parking spaces in cities	BEMP applicable to all public administrations.	On-street parking spaces are between 80 percent and 90 percent occupied during 90 percent of all business hours The city has no minimum parking requirements for new developments and has a formal policy to incrementally remove any previous parking requirements from existing developments.	• Modal share of journeys (%) • Percentage of available parking spaces during business hours
30) Implementation of logistic service centres	BEMP primarily applicable to cities with highly congestioned city centre which receive a high volume of deliveries via heavy duty vehicles.	40% reduction in CO_2 emissions from delivery vehicles in the service area compared to the situation without the logistic service centre 75% reduction in the number of delivery trips per day to the service area compared to the situation without the logistic service centre	• Emissions of CO_2 from delivery vehicles in the area served by the logistic service centre • Number of delivery trips per day in the service area

BEMPs for land use			
BEMPs	**Applicability**	**Benchmarks of excellence**	**Most relevant environmental performance indicators**
31) Limiting urban sprawl into green spaces and agricultural land	BEMP applicable to all public administrations.	N/A	• Percentage of artificial surfaces (i.e. any kind of impermeable built-up area: buildings, roads, any part with no vegetation or water) ($km^2_{artificial\ surface}/km^2_{total\ surface}$) • Percentage of new built-up area over total built-up area at the beginning of the period considered
BEMPs for green urban areas, nature and biodiversity			
BEMPs	**Applicability**	**Benchmarks of excellence**	**Most relevant environmental performance indicators**
32) Establishing and implementing a local biodiversity strategy and action plan	BEMP applicable to all public administrations.	N/A	• Percentage and number of native species (including also the kind of the species e.g. birds, butterflies etc.) in the urban area • Percentage of natural and semi-natural areas compared to the total urban area • Green space per inhabitant ($m^2_{greenery}$/inhabitant) – distinguished into urban, semi-urban, rural areas.
33) Creating blue-green networks	BEMP applicable to all public administrations.	N/A	• Percentage of green and blue urban areas (km^2green and blue areas/km^2total area) • Recreational green urban areas (RGUA) per inhabitant (km^2_{RGUA}/inhabitants) • Application of blue measures within a city e.g. storm-water management, eco-hydrological measures (Y/N).

34) Fostering the deployment of green roofs and integration with renewable energy generation	BEMP applicable to all public administrations.	Use of materials for green and brown roofs that can be recycled 100% e.g. drainage and water reservoir mat, crushed brick, split logs and branches. Use of local supplies that support the conservation of the local biodiversity	• Percentage of the green roofs surface out of the total surface of an urban area ($m^2_{green\ roof}/m^2_{urban\ area}$) • Percentage or number of buildings with green roofs in the given urban area
35) Giving new environmental value to derelict green areas and fringe areas	BEMP applicable to all public administrations.	N/A	• Compilation of a plan regarding the environmental management of the green areas within an urban area (Y/N) • Implementation of specific measures/actions e.g. biking lanes or pathways to access the green areas according to the plan (Y/N) • Percentage of green spaces in the fringe/derelict areas (%) • Number of Ecosystem Services categories (according to the UN millennium assessment) where progress has been recorded
BEMPs for local ambient air quality			
BEMPs	**Applicability**	**Benchmarks of excellence**	**Most relevant environmental performance indicators**
36) Improving local ambient air quality	BEMP applicable to all public administrations. It is more relevant for cities with low air quality.	N/A	• PM10 daily and annual average concentrations ($\mu g/m^3$) • PM2.5 daily and annual average concentrations ($\mu g/m^3$) • NO_2 daily and annual average concentrations ($\mu g/m^3$) • O_3 daily and annual concentrations ($\mu g/m^3$)

BEMPs for noise pollution			
BEMPs	**Applicability**	**Benchmarks of excellence**	**Most relevant environmental performance indicators**
37) Monitoring, mapping and reducing noise pollution	BEMP applicable to all public administrations. It is more relevant for cities with high noise pollution on their territory.	N/A	• Percentage of noise levels measurements exceeding local limit values (% out of total number of measurements) • People exposed to noise levels exceeding local limit values (% out of total population) • People exposed to night noise levels affecting health according to WHO limits (% out of total population)
BEMPs for water consumption			
BEMPs	**Applicability**	**Benchmarks of excellence**	**Most relevant environmental performance indicators**
38) Deploying full water metering at the household/final user level	BEMP applicable to all public administrations.	The penetration rate of water meters at household or final user level is >99% In areas with limited water availability (at least for part of the year) water meters at household/final user level are smart meters. All new buildings are equipped with water meters (smart meters in areas with limited water availability).	• Penetration rate of water metering (% households/consumers or % water consumption covered by metering). • Percentage of smart meters out of total water meters in use. • Reduction in water use by final users after installation of water meters and/or smart meters
39) Minimising water leakages from the water distribution system	BEMP applicable to all public administrations.	The Infrastructure Leakage Index (ILI) is lower than 1.5	• Percentage of water loss out of system input volume (%) • Infrastructure Leakage Index: calculated as Current annual real losses (CARL) / unavoidable annual real losses (UARL)

BEMPs for wastewater management			
BEMPs	**Applicability**	**Benchmarks of excellence**	**Most relevant environmental performance indicators**
40) Energy efficient waste water treatment achieving full nitrifying conditions	BEMP applicable to all public administrations managing waste water treatment. The technique is applicable both to existing and new wastewater treatment plants.	The removal efficiencies achieved are: for BOD_5: > 98 %, for COD: > 90 %, for ammonia: > 90 %, for total organic nitrogen compounds: > 80 %, for total phosphorus : >90% The electricity consumption is: ○ <18 kWh/p.e. yr for municipal waste water treatment plants with a size of more than 10,000 p.e. ○ <25 kWh/p.e. yr for municipal waste water treatment plants with a size of less than 10,000 p.e	• Concentrations in the discharged final effluent or removal efficiencies of COD, BOD_5, ammonia, total nitrogen and total phosphorus • Electricity consumption (kWh/kg BOD_5 removed) • Electricity consumption per volume treated (kWh/m^3 of wastewater treated) • Annual electricity consumption per person equivalent (KWh/p.e. yr) • Percentage of electricity and primary energy covered by internal supply (with biogas etc.)
41) Minimisation of wastewater emissions with special consideration of micropollutants	BEMP applicable to all public administrations managing waste water treatment. The technique is applicable both to existing and new wastewater treatment plants.	Average removal efficiency of micropollutants of more than 80 %.	• Removal efficiency of the adsorption or ozonation stage determined in terms of COD or DOC.
42) Anaerobic digestion of sludge and optimal energy recovery	BEMP applicable to all public administrations managing waste water treatment. The technique is applicable both to existing and new wastewater treatment plants.	Use 100 % of self-supplied electricity and heat for municipal wastewater treatment plants with a size of more than 10,000 p.e. without on-site thermal sludge drying, and 50 % in case of on-site thermal sludge drying.	• Percentage of self-supplied electricity and heat (with and without thermal sludge drying) • Electrical efficiency of the biogas motor (%) • Specific biogas production (NL/kg organic dry matter input)
43) Drying of sludge and incineration according to BAT standards	BEMP applicable to all public administrations managing waste water treatment. The technique is applicable both to existing and new wastewater treatment plants.	N/A	• Percentage of mono-incinerated sewage sludge in a given area (city, municipality or a whole region) • Percentage of recovered phosphorus present in the incineration ash in a given area (city, municipality or a whole region)

44) Retention and treatment of overflows from combined sewer systems and storm water from separate sewer systems	The applicability of this BEMP is highly influenced by local conditions (e.g. new-built or existing infrastructures, geographical conditions)	N/A	• For combined sewer systems, ratio of pollutants (total suspended solids, COD and heavy metals) discharged to water bodies from waste water treatment vs. storm water overflows (%) • For separate sewer systems, percentage of impervious areas with moderate and high contamination from which storm water is adequately treated (%) • Percentage of disconnected urban area with decentralised disposal/treatment of storm water (%).
44) Sustainable urban drainage systems	BEMP applicable to all public administrations, mostly for new developments.	N/A	• Percentage of a defined area, e.g. a residential or commercial area, where rain water is retained rather than drained (%). • Estimated annual percentage of rain water which is retained in a defined area (%).
BEMPs for green public procurement			
BEMPs	**Applicability**	**Benchmarks of excellence**	**Most relevant environmental performance indicators**
45) Systematically include environmental criteria in all public procurement	BEMP applicable to all public administrations.	100% of procurement activities for paper offices, cleaning agents, work clothes, laundry services, printing services, tissue paper, copy paper, fleet management include environmental criteria in the technical specifications.	• Number of tenders referring to environmental criteria out of total number of tenders (%) disaggregated by product categories.

BEMPs for environmental education and dissemination of information			
BEMPs	**Applicability**	**Benchmarks of excellence**	**Most relevant environmental performance indicators**
46) Environmental education and information for citizens and businesses	BEMP applicable to all public administrations.	N/A	• Number of citizens reached directly and indirectly by the environmental education programme or centre • Presence of a municipal service or agency for environment-related information for businesses (Y/N)