



D2.4 FLOW Impact Assessment Tool – Guideline

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Introduction to FLOW

FLOW sees a need for a paradigm shift wherein non-motorised transport (often seen from a transport policy perspective simply as a nice “extra”) is placed on an equal footing with motorised modes with regard to urban congestion. To do this, FLOW will create a link between (currently poorly-connected) walking and cycling and congestion by developing a user-friendly methodology for evaluating the ability of walking and cycling measures to reduce congestion. FLOW will develop assessment tools to allow cities to evaluate effects of walking and cycling measures on congestion.

Our aim is for the tools to become the standard for assessing the impact of walking and cycling measures on congestion. The tools include a congestion impact assessment (including socio-economic impact, an assessment of soft measures, congestion evaluation based on KPIs and a cost benefit analysis) and traffic modelling. Current modelling software will be calibrated and customised in FLOW partner cities to analyse the relationship of cyclist and pedestrian movements to congestion. The modelling and impact assessment will identify the congestion reducing effect of walking and cycling measures. FLOW partner cities will develop implementation scenarios and action plans for adding or up-scaling measures that are shown to reduce congestion.

FLOW will target three distinct audiences, with appropriate materials and messaging for each. Cities will learn about the value and use of new transport modelling tools, businesses will be made aware of the potential market in congestion busting products and services and decision makers will be



Figure 1: Map of FLOW partner cities

provided with facts to argue for walking and cycling to be put on equal footing with other modes of transport. FLOW will meet the challenge of “significantly reducing urban road congestion and improving the financial and environmental sustainability of urban transport” by improving the understanding of walking and cycling measures that have potential to reduce urban congestion.

The communication and dissemination work in the project will disseminate FLOW outcomes and outputs to a wider group of cities and regions as well as other urban transport stakeholders across Europe through a set of supporting communication products and networking tools. The project will develop a comprehensive set of highly targeted dissemination activities including e-newsletters, website, social media campaigns, reports including the “Implementers Guide” on tools and measures for tackling congestion with walking and cycling and the FLOW “Congestion Quick Facts” for decision makers.

Executive summary

The aim of this guideline is to summarise the achieved developments of the FLOW assessment methodology, and to provide a step-by-step guidance for local stakeholders (e.g. municipalities and consultancies) towards the application of the impact assessment tool.

Currently, many cities do not have standardised evaluation methodologies for non-motorised measures. The offered FLOW assessment procedure gives the cities across Europe the possibility to better evaluate a wide range of effects across multiple disciplines. This is achieved by placing the congestion reduction potential of walking and cycling in the foreground, and at the same time covering environmental, social and economic aspects within one integrated tool. In this manner, the developed multimodal indicators are able to measure the impacts on the transport network performance, but also on the environment, society and economy for all transport modes. This innovative approach goes beyond the state of the art.

An assessment procedure typically consists of three steps. First an integrated target system was developed in the context of FLOW, referring to the objectives of the cities. This target system served as a basis for the determination of the whole set of indicators in the second step, which constitutes the core element of the developments. Depending on the local political objectives of the city, and also, whether required data is obtainable, FLOW offers different multimodal approaches for aggregating the impacts of walking and cycling measures, whereby the city can select, which suits the best to its priorities:

- Multi-criteria analysis (MCA)
- Weighted benefit analysis (WBA)
- Cost-benefit analysis (CBA)
- Qualitative appraisal (only as add-on to CBA)

The complexity of the FLOW impact assessment methodology allows to cover both qualitative and quantitative impacts that various walking and cycling measures can have. Moreover, the developed tool is applicable to both ex-ante assessments and ex-post evaluations. In this manner, effects of hard measures, such as infrastructure investments (e.g. bike lanes, cycle highways or squares), as well as soft measures (e.g. mobility management campaigns) can be both appraised.

The impact assessment tool was developed in an iterative process in close cooperation with the FLOW partner cities, where they were assigned the role of testing the appropriateness of the tool and provide feedback on the applicability of the indicators.

1. Introducing the FLOW Impact Assessment Procedure

1.1. Purpose of the guideline

The aim of this guideline at hand is to summarise the achieved developments of the FLOW assessment methodology, and to provide a step-by-step guidance for local stakeholders (e.g. municipalities and consultancies) towards its application. With the help of the developed impact assessment tool, a wide range of walking and cycling measures can be evaluated, not only in the FLOW cities, but across whole Europe.

Currently, many cities do not have standardised evaluation¹ methodologies for non-motorised measures. On the one hand, lower scale measures, especially non-motorised measures do not necessarily require proper assessment techniques, since they are often seen as “supply planning”, meaning that they will be implemented anyway, regardless of their likely impacts (e.g. proven economic efficiency). On the other hand, non-motorised measures are still often considered to be nice-to-have options. Therefore FLOW offers tailor-made assessment procedures, where the cities can select the most suitable one that reflects their political objectives. The complexity of the FLOW impact assessment methodology allows to cover both qualitative and quantitative impacts that various measures can have.

The FLOW impact assessment methodology, together with the developed impact assessment tool introduced in this document is part of the FLOW Congestion Assessment with the overall goal to better analyse the congestion reduction impacts of walking and cycling, including direct and further benefits. This overall concept includes enhanced modelling of walking and cycling travel behaviour, as well as proper depicting of their interactions also with motorised traffic in a transport simulation environment. The undertaken improvements in the transport models serve as a basis for the evaluation of the direct and further benefits of these measures.

The software development including the calibration and validation process was undertaken in cooperation with the FLOW partner cities. In a similar manner, the impact assessment tool is developed in an iterative process in close cooperation with the partner cities, in order to assure applicability.

1.2. Current state of research

The development of the FLOW impact assessment methodology started with the outlook into the currently available analysis and evaluation instruments.

The objective of the literature review was to identify innovative aspects of current congestion evaluation techniques and walking and cycling assessment tools, as well as to analyse the limitations and shortcomings of current analyses in the context of congestion and walking & cycling.

Through the desktop research, several innovative tools were identified that evaluate the impacts of walking or cycling measures. Thereby a paradigm shift can be observed, recognising that active transport modes can serve as remedies for congestion, as the improvement of walking and cycling conditions can reduce trips taken by motorised vehicles and therefore traffic congestion (corresponding to the consequence of targeted modal

¹ The words evaluation, assessment and appraisal are used as synonyms in this document, referring to the same meaning.

split). However, the majority of existing appraisals acknowledging social, health and economic benefits of walking and cycling measures still neglect the impacts on the transport network performance.

After reviewing a high number of congestion and walking and cycling assessment tools, it can be stated that no tool was found, which assesses all impacts and thereby covers the congestion reduction benefits of walking or cycling measures and assesses all wider consequences of congestion at the same time.

These findings are summarised in detail in *Deliverable 2.1: Measuring the impacts of walking and cycling on congestion - a literature review*. Building upon these findings, FLOW has prepared the following generic recommendations for the improvement of congestion analysis tools with respect to walking and cycling:

- By assessing the impacts of walking and cycling measures, provide quantifiable measurement by selected multimodal indicators, which can assess all transport modes (thus also motorised traffic).
- Offer an integrated approach for measuring both direct impacts (e.g. diminished travel time) and wider consequences (e.g. environmental, safety and health effects) of congestion reduction measures.
- Develop a methodology for monetisation of indicators with internationally accepted cost rates, in order to provide a uniform basis for applicability and comparability in Europe.
- Develop a comprehensive evaluation procedure, taking also into account investment, operating and maintenance costs beside the benefits of walking and cycling measures.

These recommendations have been directly incorporated by the elaboration of the FLOW impact assessment tool, considering the innovative aspects, but also overcoming the analysed shortcomings.

1.3. Structure and concept

The developments relied on the findings that were gathered in the desktop research phase, whereas the recognised innovative aspects were built in, and the identified shortcomings were overcome in FLOW. These aspects of the reviewed literature, including the identified benefits of walking and cycling measures and their assessment techniques are summarised in Chapter 2. The next two chapters (3 and 4) introduce the impact assessment tool in detail – first each step of the FLOW assessment methodology is introduced, outlining the target system with the selected indicators and their possible aggregation procedures; and second, all indicators are explained in separate fact sheets, including the calculation procedure with formulas and practical hints.

Since the FLOW impact assessment tool is intended to be applied with the support of the FLOW Technical Knowledge Partners in FLOW partner cities and without the support of Technical Knowledge Partners in FLOW Exchange and Follower cities, this document provides some practical advices and insights that can be useful for the application. These are summarised in the standardised fact sheets for each indicator (see above), and some important issues regarding the application are addressed in Chapter 5.

2. Assessing the impacts of walking and cycling

2.1. Walking and cycling measures in FLOW

The aim of the developed impact assessment tool is to be applied to walking and cycling measures evaluations across Europe, including the whole FLOW cities network (i.e. Partner, Exchange and Follower cities). Within

the tool development phase, the FLOW partner cities were assigned the role of testing the appropriateness of the tool and provide feedback on the indicators.

Best practices, to which the tool can be applied were gathered from across Europe. These measures were clustered into the following categories:

- Infrastructure measures for moving traffic (e.g. bike lanes, cycle highways),
- Infrastructure for non-moving traffic (e.g. bicycle stands, or benches and squares),
- Traffic management strategies (e.g. traffic signals, access restrictions),
- Mobility management (e.g. campaigns).

These already implemented measures – together with their short description and congestion reduction potential – were collected and presented in Deliverable 1.2. *A portfolio of measures – the role of walking and cycling in reducing congestion*. The portfolio describes the actual effects of different types of measures on congestion by presenting case studies of successfully implemented urban transport measures supportive of walking and cycling. The measures described have helped reduce congestion or at least have increased walking and/or cycling levels without increasing congestion.

2.2. Benefits arising from walking and cycling

By identifying the various benefits of walking and cycling measures, one can differentiate between direct benefits arising from improved walking and cycling conditions in an urban environment (e.g. infrastructure improvements, image, awareness), and indirect benefits through the achieved reduced vehicle mileage as the result of modal shift. Table 1 clusters the identified benefits into these categories.

Benefits linked to improved walking and cycling conditions (e.g. infrastructure, image, awareness)	Reduced travel time and more comfort for cyclists and pedestrians
	Increased accessibility to amenities
	Improved traffic safety for vulnerable user groups through increased visibility & safer infrastructure
	Increased mobility level through better affordability of transport for lower social classes
	Reduced energy consumption
	Reduced land consumption via sealed surface from deconstructed traffic area
Benefits linked to reduced motorised vehicle usage	Reduced GHG & other harmful emissions
	Reduced noise pollution (only gains relevance at min. 50 % of reduction of motorised traffic, therefore effect in FLOW is not depicted)
	Increased traffic safety through the reduction of motorised traffic
	Reduced mobility (thus vehicle operating) costs
	Reduced vehicle travel time through diminishing congestion level
	Improved quality of life by more social interaction and reduction of separation effect
	Improvement in private businesses via increased attractiveness of public spaces

Table 1: Various benefits associated with walking and cycling

As the table shows, some indicators can reflect both individual (i.e. user perception), and global, socio-economic impacts, as sometimes setting a clear boundary is not possible. The above introduced benefits are all assessed in FLOW within one integrated approach.

2.3. Common assessment methodologies

A typical assessment procedure consists of the following three steps:

- 1) Target system
- 2) Indicators in their original physical units (measuring the achievement of targets)
- 3) Aggregation of indicators

Depending on type and volume of the measures to be evaluated in the context of walking and cycling, different aggregation procedures can be offered, starting with simple qualitative appraisals towards multi-criteria analysis (MCA) to the highly sophisticated weighted benefit analysis (WBA), cost-effectiveness analysis (CEA) and cost-benefit analysis (CBA). The last three aggregation procedures require the transformation of original physical units into utility points or monetary units to make the different basic indicators comparable, or to determine their trade-off, respectively. Each aggregation procedure has its advantages and disadvantages, and the best fitting has to be chosen in the context of the measures and the cities. The aggregation procedures themselves are widely acknowledged, therefore not a research topic of FLOW.

In most European countries, the preparation of a CBA is mandatory by the realisation of large-scale infrastructure projects to be eligible for public funding. In a CBA all (quantifiable) considered impacts are expressed in monetary terms (following European or national guidelines) with the goal to provide a common basis for comparison of different basic variables, hence monetisation can be understood as a certain weighting opportunity. Furthermore, monetisation allows internalising the external costs by balancing the external effects with project's benefits for the whole society. Within a CBA, the effects of implemented measure are compared to the base case, without implementing the measure. As a result of the CBA, the economic efficiency of the measure is shown by calculating the benefit-cost ratio (BCR), or the net present value (NPV).

For measures promoting walking and cycling, where economic evaluations are not yet a common practice, and cities are not yet aware of all economic consequences, the appraisal of impacts can be done in an alternative manner. In case monetising the impacts is not required, or the measure has also non-quantifiable effects, conducting a WBA can be the best solution to cover as wide range of impacts as possible, where the evaluation of alternatives is based on scoring, ranging and weighting of various effects. However, the pre-requisite for the application of the WBA is that a minimum three alternatives are given for the comparison.

The applied assessment procedure mainly depends on the priorities a responsible city may have. As some impacts may be more important than others, the success of the measure may be pre-evaluated through selected indicators as kick-off criteria. As the availability of the data also significantly influences the selected appraisal, the FLOW approach offers a set of aggregation procedures – including an optimal number of indicators – that suits the best to the cities' measures and reflect the political goals in terms of emphasised effects. A further explanation can be found in Chapter 3.

2.4. Data availability

Providing all required data is a crucial aspect of every assessment, especially in the field of walking and cycling, as most cities lack extensive data on non-motorised transport modes. Since the evaluation result of the

measures mainly depends on the quality of the data, reliable and sufficient sources are needed. Depending on the indicators, data should be gathered from the following sources:

- Transport simulation models
- Local traffic counts
- Surveys and questionnaires
- National statistical institutes
- Municipal and state administration departments
- Already existing audit tools
- Previous scientific studies and research project results
- National and international online databases

Data availability may differ also according to the applied assessment technique: the pre-requisite for ex-ante assessments is a realistic estimation of future impacts, while ex-post evaluations need proper extensive monitoring over time.

3. The FLOW impact assessment methodology

The offered FLOW assessment procedure gives the cities the possibility to evaluate a wide range of effects across multiple disciplines – both in a quantitative and qualitative manner. The developed tool is able to cover the environmental, social and economic aspects, but also the impacts on the transport network performance. The developed tool is applicable to both ex-ante assessments and ex-post evaluations of all kinds of walking and cycling measures.

Prior to the application of the tool, one has to be familiar with the various steps of the appraisal procedure. A typical workflow of the overall assessment methodology is divided into six steps, as listed in the below figure (Figure 2):

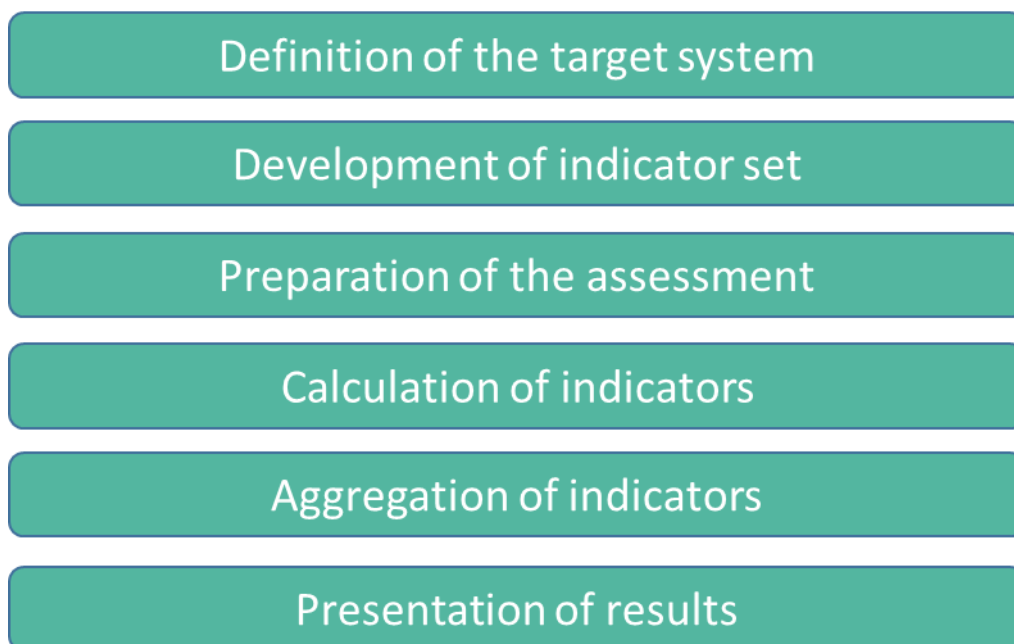


Figure 2: Five steps of the FLOW appraisal methodology

Each step is explained in detail in the following sections. Moreover, the calculation of the single indicators can be done following the instructions and explanations, including the formulas provided in the fact sheets in Chapter 4 for each indicator separately.

3.1. FLOW Target System

Based on the objectives of the cities, an integrated target system was developed in a joint interdisciplinary cooperation within work packages 1 and 2, involving congestion- and walking and cycling experts. As an outcome, the following target system has been developed (Figure 3):

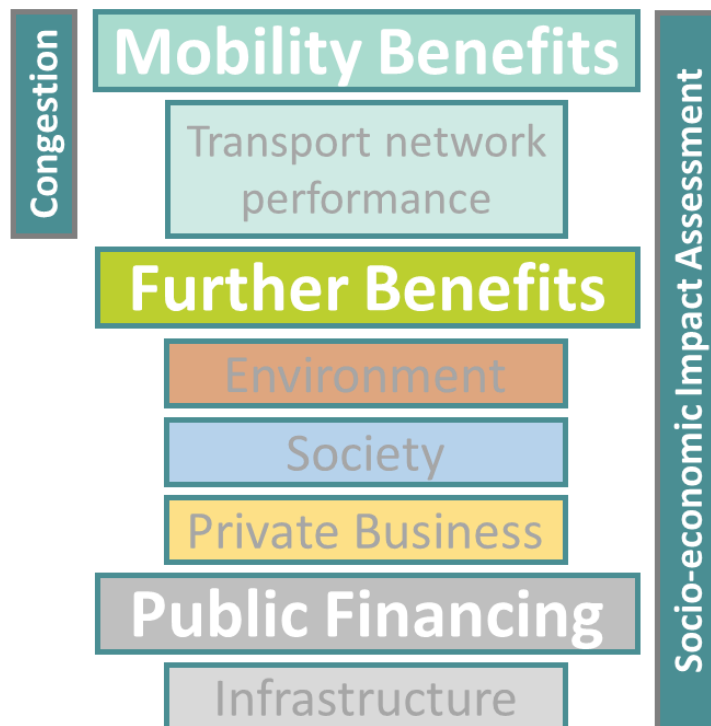


Figure 3: FLOW target system – mobility and further benefits

This target system serves as a basis for the determination of the whole set of indicators, covering all aspects of walking and cycling measures, including congestion reduction potential. As one of the key achievements of FLOW, the introduced target system already integrates the environmental, economic, social and health benefits besides the direct impacts on the transport network performance. Besides these wide range of benefits resulting from the infrastructure projects, the costs side cannot be neglected, since it plays a vital role to access public funding.

3.1.1. Target system: Public Financing

This impact area covers objectives and indicators for all costs which arise from the realisation of pedestrian or cycling infrastructure projects. These costs include the direct investment costs linked to the infrastructure (e.g. planning and construction costs, also for civil structures, costs of rolling stock and equipment, or administrative costs), as well as the yearly operating and maintenance costs. Detailed explanations of these costs are given in the following pages and in the excel sheet. Although it is possible to differentiate the various cost components, often only rough data is available.

3.1.2. Target system: Transport Network Performance

One of the most important goals of new (walking or cycling) infrastructure investments is to improve conditions on the transport network, to reduce car dependence and thereby to reduce motorised congestion. Hence by the examination of the effects of walking and cycling measures, the (positive) changes in the transport network performance have to stay in the foreground. Following the multimodal FLOW approach, the improved traffic conditions are addressed for all traffic participants individually to get a full picture of the transport network and to put walking and cycling on equal footing as motorised transport.

3.1.3. Target system: Environment

One positive consequence of a reduced vehicle mileage is the improvement of the air quality. In this context, the target to be achieved is the minimisation of environmental damage caused by motorised traffic, hence the changes of harmful air pollutants and greenhouse gas emissions in the surrounding area are measured. Amongst other factors (such as vehicle types or inclination), the emissions (and also the energy consumption) strongly depend on the actual traffic situation, as FLOW deals with the congestion reduction potential of walking and cycling measures. Four traffic states are defined, along which the environmental aspects are evaluated – these individual traffic situations are described in the single fact sheets.

3.1.4. Target system: Society

This element of the target system includes the objectives of increased traffic safety through the reduction of traffic casualties, improved health of citizens, as well as better accessibility and more social interaction throughout the society. The monetisation of social impacts happened to be a special challenge. Exact explanation and references can be found in the single fact sheets.

3.1.5. Target system: Private Business

The reduction of motorised traffic may have additional positive effects on the local economy: savings in operating and energy costs. One goal of improving the conditions for pedestrians and cyclists is to make public spaces more attractive – this positive influence of the neighbourhood may also result in additional revenues in the real estate sector.

3.2. FLOW indicators and their data needs

One of the major achievements of FLOW is the elaboration and provision of a comprehensive set of indicators, reflecting all elements of the identified target system. This final set of indicators is the result of an extensive desktop research, accompanied by several feedback rounds among the FLOW partners, who contributed to the selection relying on their expertise. More, than 100 indicators have been gathered during the research phase, which were then reduced to an optimal number.

In the selection of the indicators, some criteria have to be fulfilled: first and foremost, the indicators have to be multimodal and objective. Furthermore, they also have to be as easily measurable as possible, but also technically relevant.

As FLOW offers a multimodal assessment approach, the indicators are not only measured for cycling or walking, but also for motorised private and public transport. The impacts on urban freight are also subject of the assessment (albeit via the set of indicators that were elaborated for non-motorised measures).

With the help of these indicators, a wide range of effects can be measured, including both direct and further consequences of various walking and cycling measures aiming at congestion reduction. They can be clustered into the following two groups:

- Indicators measuring direct mobility benefits
- Indicators measuring further benefits on society, environment and economy

This classification refers to the FLOW target system. The first group of indicators measures the impacts on the transport network performance – the most important mobility benefit corresponds to the travel time – this indicator, can be assessed either on the individual traffic participants, or in the entire network. In the first case the indicators are called the key performance indicators. In the second case, the network-wide effects are measured by the so-called impact indicators.

The second group of the developed indicators is able to measure a much wider range of consequences of congestion reduction measures, including social, economic and environmental benefits.

The so-called “key performance indicators” (KPIs), together with the methodology for selection and the whole computation procedure are described in *Deliverable 1.1 FLOW Multimodal Urban Road Transport Network Performance Analysis Methodology: A Base for Analysing Congestion Effects of Walking and Cycling Measures*.

Table 2 shows the impact indicators deployed to measure the full range of effects a walking or cycling measure can have.

All indicators (whenever possible) are calculated on a yearly basis for the reference year, where the measure is considered to be fully completed. Prior to the calculation of these indicators, the time horizon has to be identified. On the one hand, this is influenced by the travel demand, whether daily or peak-hour values are available in the transport model. On the other hand, this is directly determined by the indicator itself, i.e. rents are usually given per month or year.

The computation of each multimodal indicator needs reliable and extensive data from various fields. The most basic data source for depicting the traffic-related aspects is a multimodal transport model. Depending on the cities’ objectives and the scale of the measure, it can either be a macroscopic travel demand model or microscopic transport simulation model. The calculation of some indicators uses inputs from other internationally accepted tools, such as the Health Economic Assessment Tool (HEAT) from the World Health Organisation (WHO 2014). In some other cases, parts of calculation rely on empirical data from international studies, for example published by private firms or research institutes. For the case of monetisation, international databases with country-specific national values are provided.

Number	Target System	Scope	Indicator	Transport mode	
				MT	NMT
1	Public Financing	costs of (new) infrastructure	investment costs [EUR/year - annuity]		
2			operating & maintenance costs [EUR/year]		
3a	Traffic Performance	travel time related	total travel time [person-h/year]	X	X
3b			total travel time [ton-h/year]	X	
4	Environment	GHG emission & local air pollution	total direct CO ₂ emission [t/year]	X	
5			total direct NO _x emission [t/year]	X	
6			total direct PM emission [t/year]	X	
7		land consumption	sealed surface: total new / deconstructed traffic area [-]	X	
8		noise pollution	noise pollution [-]	X	
9	Society	traffic safety	number of persons killed [no./year]	X	X
10			number of (seriously & slightly) injured persons [no./year]	X	X
11		health	health benefits based on a reduced probability of death for people who cycle/walk [no./year]		X
12		increased access	accessibility - increased access of non-motorized residents' to amenities (e.g. jobs) [-]		X
13		social interaction	separation effect [-]		X
14	Private Business	vehicle operating costs	vehicle operating costs [EUR/year]	X	X
15		energy consumption	total final energy consumption [kWh/year]	X	X
16		(monetary) attractiveness	improvement in pedestrian and cycling environment quality [-]		X

Table 2: Full set of indicators developed in FLOW

The calculation of each indicators – including the monetisation approach – occurs by means of embedded formulas in the developed MS Excel sheet. Exact instructions with further explanations, including the required data with its sources can be found in the standardised fact sheets in Chapter 4.

3.3. Preparation of the assessment

As a very first step of the appraisal development, the baselines have to be set, defining the goals and identifying the measures that meet the cities' objectives. Thereby the following issues are addressed:

- Description of measure with its reference year
- Definition of "with" and "without" cases to be compared
- Identification of scope and catchment area of the measure
- Determination of common time frame and discount rate in the reference year

The description of the measure at the beginning of the appraisal is essential, in order to see, what the selected measure is aiming at. By defining the reference year, the time frame for the evaluation is delineated, from which the measure is considered to be fully completed – all indicators with their input data have to refer to this time.

With the spatial delineation of the catchment area the boundaries are set, where the measures have an effect. Depending on the scale of the measure, the catchment area can be a smaller part of the city (i.e. small network segment with a sequence of junctions, road segments or even shared spaces), but it can also encompass the whole urban area with the boundaries of the city. The defined catchment area has to be the same for the with- and without case. By defining the “without case”, the base or reference case is set, where no measures or only the definitely fixed infrastructure projects are included that will be implemented within the planning horizon even without the walking or cycling strategy or measure to be assessed. This case is also called as the „do-nothing alternative“. The “with” case on the other hand corresponds to the case, where certain measures or combination of measures (strategies) are implemented.

The present and future benefits and costs of different projects occur at different points of time. To enable the comparison, it is necessary to transfer them to a common basis. Therefore they should be rebased to equivalent values at a common date (=price levels for discounted cash flow method). The applied price level is based on 2015. In case the socio-economic impacts of measures are assessed, thus a cost-benefit analysis is applied, one needs to define a discount rate (rate of interest) in the reference year.

3.4. Calculation of indicators

To assess the impacts of walking and cycling measures, a proper calculation procedure is offered for each defined FLOW indicator. Thereby standardised templates are provided, following the same formal criteria. A detailed explanation with the offered calculation for the indicators is summarised in Section 4.2.

3.5. Aggregation of indicators

After computing the impact indicators for the cases with- and without implementing the measure (also called Do Nothing case), they are compared to each other. In this manner, the associated benefits result from the difference of certain values in the “with”- and “without” case. In term of their effects, the indicators are clustered into two categories:

- Quantitative (and monetisable) indicators
- Qualitative indicators

Most indicators, such as actual travel time or local air pollution (e.g. NO_x) are relatively simple to measure on a quantitative basis and also to express them in monetary terms. They can feed directly the cost-benefit analysis, calculating the economic efficiency of measures. Besides the quantifiable effects, walking and cycling may have impacts that are hard or even impossible to quantify – therefore the performance of such effects are assessed in a qualitative manner, nevertheless certain utility points (hence numbers) are assigned. All indicators are calculated in the pre-determined assessment period – depending on the nature of indicator and the deployed transport model –, then extrapolated to one year by means of formulas and default values.

Depending on the local political objectives of the city, and also, whether required data is obtainable, FLOW offers different multimodal approaches for aggregating the impacts of walking and cycling measures. Thereby the city can select, which suits the best to the cities’ measures and reflect the priorities in terms of emphasised effects. As indicated in Chapter 2.3, the following aggregation opportunities of the single indicators are offered in FLOW:

- Multi-criteria analysis (MCA)
- Weighted benefit analysis (WBA)
- Cost-benefit analysis (CBA)

- Qualitative appraisal (only as add-on to CBA)

3.5.1. Multi-criteria analysis

As the most basic interpretation of results, all single indicators are calculated individually for the cases “with” and “without” implementation of measure, and these values – completed with their difference – are listed. All indicators are listed with their original units. Without having aggregated them, cities may select some indicators and interpret these changes as a result of measure analysis, referring to the political targets (e.g. if the measure of the city aims at reducing CO₂ emissions, these changes can be highlighted and shown as main benefits). Depending on the cities’ goals, one or more indicators can be given priority, so that the measure is evaluated in regard to these selected indicators as emphasized results.

3.5.2. Weighted benefit analysis

One step further, single basic indicators with their original physical units (e.g. total travel time in the network in person-hours) are transformed, assigned a number of utility point (using utility functions, s. below), to provide a common basis for comparison. An individual (hence not necessarily objective) weighting of each variable is also possible (with weighted utility points as final results). This approach has the advantage that both quantifiable and qualitative indicators can be aggregated at the same time.

The indicator-specific weighting factors have to be determined by the city based on political goals, depending on which indicator is of higher importance. In a first step of this approach the physical units from the impact analysis are transformed into utility points by a (normally) linear utility function with scale limits of + 100 and - 100 (see Figure 4). In order to make the results comparable, the same utility function is applied to transform all indicator results to utility points. A linear function between the scale limits reflects the fact that each saved unit generates the same benefit, as diminishing or increasing marginal benefits are difficult to prove. The scale limits are normally set endogenously, meaning out of all evaluated analysis cases. This is sensible because for almost all of the chosen indicators no exogenous limits are available (exception: noise threshold for city roads). But it is necessary to note that minimum three analysis cases need to be evaluated due to this methodology and that the scale limits may change if new alternatives get evaluated at a later time.

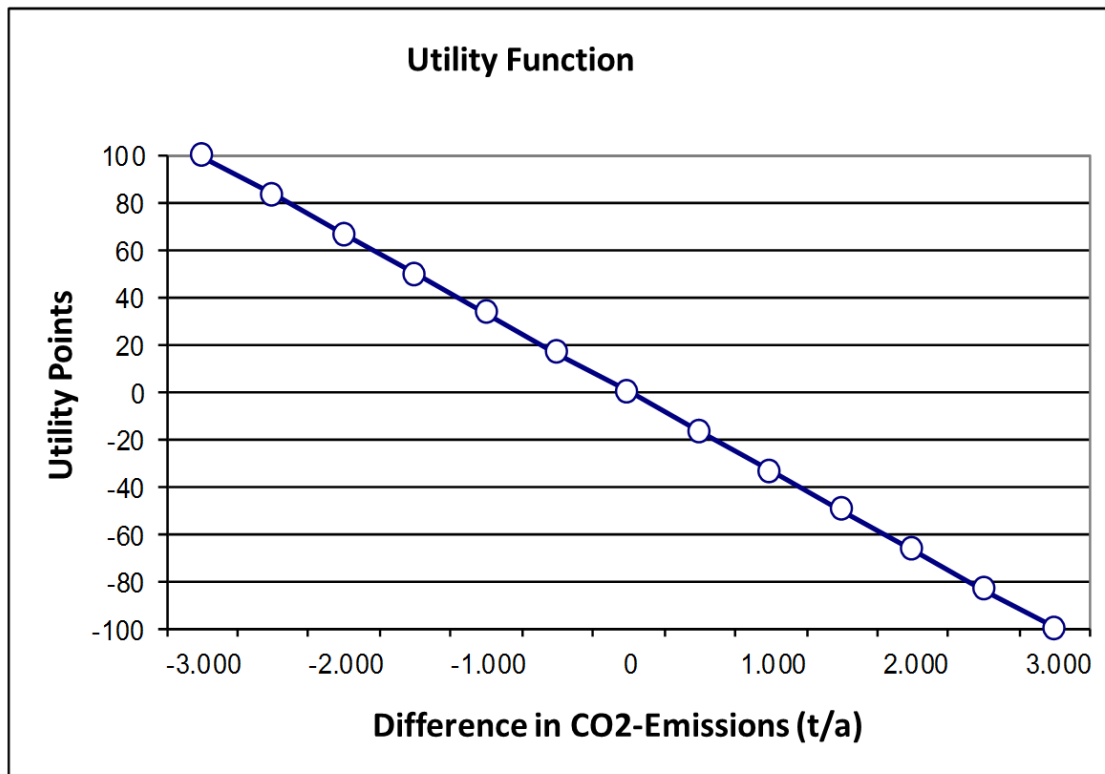


Figure 4: Example for a linear utility function

3.5.3. Cost-benefit analysis

The most sophisticated approach is to provide a cost-benefit analysis for calculating the economic efficiency of the measure. Thereby all calculated indicators are expressed in monetary terms. Goal of the monetisation is to provide a common basis for comparison of various quantifiable effects. But the expression of single values in monetary terms is an implicit weighting.

In order to avoid bias and provide an objective basis, a CBA is offered for all quantifiable and monetisable effects. The efficiency of the measures is then expressed in a cost-benefit ratio (CBR). CBA to its largest extent needs the net present value (NPV) of the benefits for the numerator and the NPV of the costs for the denominator, both of them based on indicator/cost values for each year of the assessment period. On the benefit side, according to typical planning processes benefits are calculated for a single reference year. On the cost side, the assessment period causes to calculate residual values for parts of the investment with a life time exceeding the assessment period and to take into account re-investments for those parts with a lifetime minor to the assessment period. To simplify the procedure one can use annuities on the cost side to contrast the benefits of the reference year or determine an averaged project lifetime (based on weighted annuity factors) as assessment period, which levels residual values and re-investments. Within the FLOW context it is recommended to use CBR applying costs (annuities) and benefits for a reference year. The corresponding calculation sheet is provided in the assessment tool.

The approach of FLOW for the monetisation is to provide national cost rates (reference values) in each EU country for all means of transport. This is important to calculate benefits on a realistic basis that reflect country-

specific circumstances, since the magnitude of costs linked to the infrastructure may vary also significantly. Therefore, whenever possible, FLOW attempts to provide a standard source with all national cost rates (e.g. HEATCO 2005). As such monetary values are not available for all indicators in an international database, reliable cost rates, which are only available in some countries were also taken and adjusted with a “purchasing-power-parity-factor” (PPPF) between the reference country and the country, where the assessment is undertaken, in order to make the cost rate suitable in this latter country. Monetary values are provided uniquely for the year 2015. This indicates that the older sources had to be updated to the price level of 2015. This was done with the help of the accumulated country-specific GDP per capita per year, and Harmonised Indices of Consumer Prices (HICP) measuring inflation in each Member State. The provided values are defaults values, hence recommendations that can be overwritten by more accurate local cost rates.

3.5.4. Qualitative appraisal

FLOW also measures effects that cannot be quantified (or eventually semi-quantitative). Therefore certain indicators are required, assessing these impacts on a qualitative basis. The qualitative evaluation makes use of a scaling (-2 to + 2), then to each number, an additional weighting factor is assigned. This qualitative appraisal can be incorporated into the weighted benefit analysis. In case of the CBA, they are an add-on, hence addressing the impacts that cannot be included in the CBA (as a hybrid approach).

3.6. Presentation of Results

The final result can be interpreted in three ways, depending on the applied aggregation procedure: either as a summary of the results of the weighted benefit analysis, or as a hybrid approach, the results of the cost-benefit analysis (towards a CBR) and the qualitative appraisal distinctly. Additionally, in case the city decides upon the upmost significance of selected of indicators, then the evaluation occurs based on an exact indicator value, recorded in the multi-criteria analysis.

4. Guidance through the FLOW impact assessment tool

4.1. Structure of the tool

The developed impact assessment tool is a MS Excel based spreadsheet, which allows carrying out the developed calculation procedure introduced in Section 3. Table 3 gives an overview of the 16 spreadsheets and their content.

Title	Content
1. Cover page	Basic information about the FLOW project, and legend with colour schemes for better understanding of the tool.
2. Target system	Figure about the target system defined for the FLOW purposes.
3. General project description	General measure description and country selection from a given list, where the measure is implemented.
4. Input traffic data	All required traffic data for the calculations are gathered.
5. Input monetary values	All reference values for the monetisable indicators can be found here.
6. Conversion factors	All required additional conversion factors and rates for the calculations are summarised.
7. Public financing	Indicators referring to this element of the target system are calculated.
8. Transport network performance	Indicators referring to this element of the target system are calculated.
9. Environment	Indicators referring to this element of the target system are calculated.
10. Society	Indicators referring to this element of the target system are calculated.
11. Private business	Indicators referring to this element of the target system are calculated.
12. Overview MCA	Results of the multi-criteria analysis are listed here.
13. Overview WBA	Results of the weighted benefit analysis are listed here.
14. Overview CBA	Results of the cost-benefit analysis are listed here.
15. Overview qualitative appraisal	Results of the qualitative appraisal (as add-on) are listed here.
16. Result impact assessment	Summary of the final results of the impact assessment (different offered aggregation procedures).

Table 3: Overview of the title of the single sheets in MS Excel and their content

The Excel tool is clustered into four parts following a bottom-up approach: the first part includes the cover page, developed the target system and general project description with measure details and legend for the application. The second thematic part includes the three sheets with the input data and offered conversion factors. In the third part, in sheets 7-11, the single indicators are calculated automatically, referring to the five elements of the target system. The fourth part provides an overview over all three offered aggregation

procedures, and the qualitative appraisal, as well as the overall result of the impact assessment (see

General Project Description			
Measure		Location	
Name of measure	0	City	0
Life cycle of measure	0	Population in the city	0
Description of measure	0	Currency	0
Reference year (measure fully accepted)	0	Assessment period	peak-h
Country		Germany	
Cost-Benefit Analysis of a Cycling or Walking Measure			
Result			
Sum of all Benefits	0		
Sum of all Costs	0		
BCR	#DIV/0!		
Benefits-Costs [EUR/year]	0		
Weighted Benefit Analysis of a Cycling or Walking Measure			
Weighted result (Benefit)			
Sum of Benefits [Utility]	#DIV/0!		
Qualitative Evaluation of Measure Compared to Case "Without Implementation of Measure"			
Number	Indicator	Weighted result (Benefit)	
Q1	Sealed surface: total new / deconstructed traffic area	0	
Q2	Noise pollution	0	
Q3	Accessibility - increased access of non-motorized residents to amenities (e.g. jobs)	0	
Q4	Separation effect	0	
Q1	Improvement in pedestrian and cycling environment quality	0	
Overall Evaluation of Measure			

Figure 5).

General Project Description												
Measure		Location										
Name of measure	0	City										
Life cycle of measure	0	Population in the city										
Description of measure	0	Currency										
Reference year (measure fully accepted)	0	Assessment period										
		peak-h										
Country	Germany											
Cost-Benefit Analysis of a Cycling or Walking Measure												
<table border="1"> <thead> <tr> <th colspan="2">Result</th> </tr> </thead> <tbody> <tr> <td>Sum of all Benefits</td> <td>0</td> </tr> <tr> <td>Sum of all Costs</td> <td>0</td> </tr> <tr> <td>BCR</td> <td>#DIV/0!</td> </tr> <tr> <td>Benefits-Costs [EUR/year]</td> <td>0</td> </tr> </tbody> </table>			Result		Sum of all Benefits	0	Sum of all Costs	0	BCR	#DIV/0!	Benefits-Costs [EUR/year]	0
Result												
Sum of all Benefits	0											
Sum of all Costs	0											
BCR	#DIV/0!											
Benefits-Costs [EUR/year]	0											
Weighted Benefit Analysis of a Cycling or Walking Measure												
<table border="1"> <thead> <tr> <th colspan="2">Weighted result (Benefit)</th> </tr> </thead> <tbody> <tr> <td>Sum of Benefits [Utility]</td> <td>#DIV/0!</td> </tr> </tbody> </table>			Weighted result (Benefit)		Sum of Benefits [Utility]	#DIV/0!						
Weighted result (Benefit)												
Sum of Benefits [Utility]	#DIV/0!											
Qualitative Evaluation of Measure Compared to Case "Without Implementation of Measure"												
Number	Indicator	Weighted result (Benefit)										
Q1	Sealed surface: total new / deconstructed traffic area	0										
Q2	Noise pollution	0										
Q3	Accessibility - increased access of non-motorized residents to amenities (e.g. jobs)	0										
Q4	Separation effect	0										
Q1	Improvement in pedestrian and cycling environment quality	0										
Overall Evaluation of Measure												

Figure 5: Overview of the results of the impact assessment, and a verbal (descriptive) measure evaluation

4.2. Description of single indicators – generalised template

In the following sections each selected indicator is explained in detail in a standardised own template to ease the applicability of the excel sheet. Besides the calculation, an approach for monetisation is also described for the monetisable indicators. Following points are addressed in the template:

Name of indicator	
Target system	The element of the target system is indicated here.
Description of Indicator	
Relevance	Reasons for choosing the respective indicators are given here with respect to the target system.
Definition	The meaning of the applied indicator is described.
Assessment approach	The calculation procedure for subtracting the indicator's values in case A (with measure) from case B (without measure) is defined.
Measurand	It represents the parameter value which describes the achievement of the corresponding objective, and also give information about the spatial dimension concerned by the measurand.
Calculation Procedure	
Assessed transport mode	All means of transport are listed here, for that the calculation procedure was conducted.
Calculation rules	The procedure for calculating the indicator is described here in detail.
Approach for monetisation	For the case of CBA (in case indicator is monetisable), formulas and reference values for the monetisation is provided.
Sources for required input data	The applied sources of the data, which are necessary for the calculation, are named here. (A proper reference can be found in the Bibliography.)
Further remarks	In this optional section particularities of the indicator may be explained and interdependencies with other indicators may be pointed out.

Table 4: standardised template for the detailed description of each indicator

4.3. Indicators assessing the costs of measures

Indicator: Investment Costs
Target system: Public Financing
Description of Indicator
Relevance
By investing in certain walking and cycling measures (e.g. new infrastructure elements or awareness campaigns), the city may be interested in the economic efficiency of the measure to get public funding. Therefore the associated full costs – broken down to year – have to be calculated. Within a simplified calculation procedure offered in FLOW, the investment costs are annuitized. That means that they are evenly distributed over the reconstruction period.
Definition
This indicator includes all cost components that are directly linked to the measure.

According to the definition of the Guide to Cost-Benefit Analysis of Investment Projects (EC 2014), the initial investment includes the capital costs of all fixed and non-fixed assets. Thereby following cost components are considered:

- construction & planning (e.g. new cycle track)
- cost of civil structures (bridges, underpasses)
- costs of equipment (e.g. cycle parking racks, signal, bollard, lighting)
- costs of rolling stock (e.g. rental bikes)
- costs of traffic rerouting during construction
- cost of supplementary actions (permitting process, land expropriation)
- other costs (promotion etc.)

Assessment Approach

Measurand_{with case}

Measurand

EUR/year (annuity)

Calculation Procedure

Assessed transport mode

-

Calculation rules

Simplified calculation methodology is offered, where the investment costs are annualised.

The annuity of investment costs per infrastructure element is calculated as follows:

$$A_e = C_{inv,e} \cdot \frac{r}{1 - \frac{1}{(1+r)^{T_e}}}$$

Where:

A_e : annuity for cost of infrastructure element e [EUR/year]

$C_{inv,e}$: investment cost of infrastructure element e [EUR]

r : rate of interest [%] – default values are provided, which may be overwritten

T_e : life cycle of the infrastructure element [-] – default values are provided, which may be overwritten

The total investment costs over a year is calculated as a sum of all annuities for cost of the infrastructure elements:

$$A = \sum_e A_e$$

Where:

A : sum of annualized investment costs [EUR/year]

A_e : annuity for cost of infrastructure element e [EUR/year]

All investment costs exclude taxes (e.g. VAT) and indirect costs. By applying annuities, the calculation of replacement costs and residual value is not required here due to simplification reasons.

Sources for required input data
<p>The different cost components as required inputs are listed as follows (all excluding taxes):</p> <ul style="list-style-type: none"> • construction & planning (e.g. new cycle track) • cost of civil structures (bridges, underpasses) • costs of equipment (e.g. cycle parking racks, signal, bollard, lighting) • costs of rolling stock (e.g. rental bikes) • costs of traffic rerouting during construction • cost of supplementary actions (permitting process, land expropriation) • other costs (user acceptance campaign etc.) <p>For the annualization of costs, further inputs are needed:</p> <ul style="list-style-type: none"> • rate of interest • life cycle of each investment cost component <p>Each individual cost component has to be determined by the city.</p>
Further remarks
All investment cost components have to be given on (or converted to) the price level of 2015.

Indicator: Operating & Maintenance Costs
Target system: Public Financing
Description of Indicator
Relevance
Besides the investment costs, the infrastructure improvement is linked with further expenses that are associated with the maintenance and administration of an offered service on a day-to-day basis.
Definition
This indicator includes all the costs to operate and maintain the new or upgraded infrastructure or service. Cost forecasts can be based on historic unit costs, when patterns of expenditures on operation and maintenance ensured adequate quality standards (EC 2014). The costs typically include the materials needed for maintaining and repairing the assets (infrastructure, equipment or rolling stock), labour costs for the employer and other services (e.g. communication).
Assessment Approach
Measurand _{with case}
Measurand

EUR/year
Calculation Procedure
Assessed transport mode
-
Calculation rules
<p>The total operating and maintenance costs per year are calculated as a sum of all operating and maintenance costs of the infrastructure elements:</p> $C_{O\&M} = \sum_e C_{O\&M,e}$ <p>Where: $C_{O\&M}$ = total operating and maintenance costs per year [EUR/year] $C_{O\&M,e}$ = total operating and maintenance costs per year of infrastructure element e [EUR/year]</p> <p>All operating and maintenance costs exclude taxes.</p>
Sources for required input data
<p>The different operating and maintenance (O & M) cost components as required inputs are listed as follows (all excluding taxes):</p> <ul style="list-style-type: none"> • O & M costs of infrastructure • O & M costs of equipment • O & M costs of rolling stock • O & M labour costs • O & M other costs (communication etc.) <p>Each individual O & M cost component has to be determined by the city.</p>
Further remarks
All operating and maintenance cost components have to be given on (or converted to) the price level of 2015.

4.4. Indicators assessing the benefits of the measures

The benefits arise from the difference between the case with- and without the implementation of walking and cycling measures. Thereby the same calculation procedure is offered here for both cases, and at the consecutive aggregation step (see Chapter 3.5, Aggregation of indicators), the benefits are calculated by subtracting the values of the “without case” from the “with-case” (see Assessment Approach).

These benefits (hence the values in with- and without case) can be monetised – being part of the cost-benefit analysis – or transformed into utility points, hence feeding a weighted benefit analysis. Alternatively, they can also be handled as stand-alone decisive indicators based on the cities' priorities.

Indicator: Travel time
Target system: Transport Network Performance
Description of Indicator
Relevance
Travel time is one of the largest costs of transport, and travel time savings are often the primary justification for transport infrastructure investments (Litman 2013). Through the improved accessibility to amenities, travel time for each transport mode may be reduced significantly, which will result in huge socio-economic benefits.
Definition
Origin-destination travel time is understood as the whole journey time taken between a starting point A and end point B.
Assessment Approach
Measurand _{with case} – Measurand _{without case}
Measurand
person-h/year; ton-h/year
Calculation Procedure
Assessed transport mode
Motorised private transport modes (car, motorcycle) Non-motorised private transport modes (walking, cycling) Public transport (bus, tram) Urban freight (LCV, HGV)
Calculation rules
The total actual travel time in the assessment period (either in peak hour or on a daily basis) is calculated in the transport model – ideally per transport mode – and directly imported in the excel sheet. The vehicle-specific travel times are transformed in person-hours with mode- and trip purpose specific vehicle occupancy ratios, or ton-hours for urban freight, in order to provide the basis for the monetisation:

$$t_{act,pers,k,ass.per} = t_{act,veh,k,ass.per} \cdot f_{occ,k}$$

Where:

$t_{act,pers,k,ass.per}$ = total actual personal travel time in the assessment period (peak-h or day) per transport mode k [pers-h]

$t_{act,veh,k,ass.per}$ = total actual vehicle travel time in the assessment period (peak-h or day) per transport mode k [veh-h; pers-h]

$f_{occ,k}$ = mean vehicle occupancy ratio per transport mode k as a weighted average over the trip purpose [pers/veh] – default values are provided, which may be overwritten

A similar transformation of travel time for freight is not required, as it can be directly taken in its original unit:

$$t_{act,ton,j,ass.per}$$

Where:

$t_{act,ton,j,ass.per}$ = total actual travel time of transported goods for urban freight in the assessment period (peak-h or day) per transport mode j [ton-h]

The total actual personal travel times of passenger transport, as well as the travel times for urban freight in the assessment period are then extrapolated to one year:

$$t_{act,pers,k,year} = t_{act,pers,k,ass.per} \cdot N_h \cdot N_d$$

$$t_{act,ton,j,year} = t_{act,ton,j,ass.per} \cdot N_h \cdot N_d$$

Where:

$t_{act,pers,k,year}$ = total actual personal travel time per year per transport mode k [pers-h/year]

$t_{act,pers,k,ass.per}$ = total actual personal travel time in the in the assessment period (peak-h or day) per transport mode k [pers-h]

$t_{act,ton,j,year}$ = total actual travel time of transported goods for urban freight per year per transport mode j [ton-h/year]

$t_{act,ton,j,ass.per}$ = total actual travel time of transported goods for urban freight in the assessment period (peak-h or day) per transport mode j [ton-h]

N_h = extrapolation factor between assessment period and day [-] – default values are provided, which may be overwritten

N_d = extrapolation factor between day and year [-] – default values are provided, which may be overwritten

Finally, the total actual personal travel time, as well as the travel times for urban freight over all transport modes is calculated as follows:

$$t_{act,pers,year} = \sum_k t_{act,pers,k,year}$$

$$t_{act,ton,year} = \sum_j t_{act,ton,j,year}$$

Where:

$t_{act,pers.,year}$ = sum of actual personal travel times per year over all transport modes [pers-h/year]

$t_{act,pers,k,year}$ = total actual personal travel time per year per transport mode k [pers-h/year]

$t_{act,ton,year}$ = total actual travel time of transported goods for urban freight per year over all transport modes [ton-h/year]

$t_{act,ton,j,year}$ = total actual travel time of transported goods for urban freight per year per transport mode j [ton-h/year]

Approach for monetisation

The total actual travel time per transport mode (for passenger and freight transport separately) is multiplied by the mode- and trip purpose specific value of travel time savings (VTTS), and then summarised over all transport modes by means of the below formula:

$$C_{t,year} = \sum_k t_{act,pers,k,year} \cdot VTTS_k + \sum_j t_{act,ton,j,year} \cdot VTTS_j$$

Where:

$C_{t,year}$ = sum of all travel time costs per year over all transport modes [EUR/year]

$t_{act,pers,k,year}$ = total actual personal travel time per year per transport mode k [pers-h/year]

$t_{act,ton,j,year}$ = total actual travel time of transported goods for urban freight per year per transport mode j [ton-h/year]

$VTTS_k$ = value of travel time savings per transport mode k , as a weighted average over trip purpose [EUR/pers-h] – default values are provided

$VTTS_j$ = value of travel time savings per transport mode j [EUR/ton-h] – default values are provided

Based on the approach introduced in HEATCO, VTTS are disaggregated between work trips, non-work trips of passengers, as well as commercial goods traffic. This approach is recommended for the monetisation of travel time savings. The monetary factors are provided accordingly. Following components are considered in the value of time for each transport mode:

Private transport

- Work trip: calculated based on a wage-rate or cost-savings approach for employer's business (and also commercial traffic) is based on classical economic theory of marginal productivity of labour.² (World Bank 2005, HEATCO 2005). A work trip is a trip undertaken on employer's business. Thus the person making the trip is paid a wage for the duration of the trip. (World Bank 2005)
- Non-work trip: calculated based on willingness-to-pay, either upon stated preference (SP) or revealed preference (RP) surveys. The economic value of time savings for non-work trips (i.e. non-wage earning trips) is the difference between the marginal valuation of time associated with travelling and that associated with leisure (World Bank 2005).
- The monetary values for private transport are provided depending on the trip purpose. As per simplification reasons, the same values are applied for individual motorised (car, motorcycle) and non-motorised (i.e. cyclist and pedestrian) transport modes.

Public transport

² For further explanations and more sophisticated approaches please refer to World Bank 2005 and HEATCO 2005.

<ul style="list-style-type: none"> Local and inter-urban bus time savings comprise of the sum of the time savings made by the passengers and that of the driver and attendant (World Bank 2005). <p>Commercial goods traffic</p> <ul style="list-style-type: none"> The value of time is considered here via the time costs of transported goods. Value of time for urban freight does not include the hourly wage of the driver (see HEATCO 2005), since it is calculated in the vehicle operation costs as part of the drivers' personnel costs (hourly wages), in order to avoid double counting.
Sources for required input data
<ul style="list-style-type: none"> Mode-specific actual vehicle travel times per transport mode in the network in the assessment period – depending on the travel demand, either hourly or daily values [veh-h; pers-h; ton-h]: microscopic or macroscopic transport simulation model Distribution of trip purpose per transport mode: determined by the city Vehicle occupancy ratio, depending on the trip purpose [pers/veh]: determined by the city Value of travel time savings (VTTS) per transport mode [EUR/pers-h; EUR/ton-h]: HEATCO 2005 <p>The values provided in the excel sheet come from the HEATCO (2005) database with the aim of providing unique source with all national cost components. These values are recommendations. In case the user has better data source with more accurate values, the recommended values can be overwritten. Since the reference monetary values in HEATCO date from 2002, an update of costs to 2015 was needed for each country.</p>
Further remarks
<p>Taxis and Uber are considered within car traffic, rather than including them as a distinct vehicle type. Users of the impact assessment tool can default to their local rules about how to account for the driver and passenger by estimating vehicle occupancy ratio.</p> <p>There are different arguments for alternative (higher or lower) values of travel time savings for non-motorised transport modes compared to motorised modes. Due to the lack of internationally accepted evidence expressed in standardised values for the different perceptions of costs for the individual means of transport, the same values of travel time savings are applied to motorised private vehicle and walking and cycling.</p> <p>This inconsistency can be seen in two contradictory arguments while discussing special side effects of non-motorised measures. As Litman argues (2004a), when shifts from motorized to non-motorized travel result from positive incentives, additional travel time can be considered to have no cost, or may be considered a benefit by users. On the other hand – as suggested in a recent publication of the Austrian Ministry of Transport, Innovation and Technology –, the value of travel time is rated higher for non-motorised means of transport due to the “difficulty” of active transport modes. (Bundesministerium für Verkehr, Innovation und Technologie 2016).</p>

Indicator: Direct CO₂ Emission

Target system: Environment

Description of Indicator
Relevance
<p>Increasing greenhouse gas (GHG) concentration is one of the major reasons for climate change and global warming. CO₂ is the most important greenhouse gas, whereas the transport sector by burning of carbon-based fossil fuels is one of the main contributors to global warming. Reduced dependence on motorised transport modes by fostering environmentally friendly transport is an effective instrument to fight against increased GHG emissions.</p>
Definition
<p>Carbon dioxide is an odorless, colorless gas, which is the product of the combustion of carbon with an excess of oxygen; in concentrations not less than 99.0% by volume of CO₂.</p>
Assessment Approach
<p>Measurand_{with case} – Measurand_{without case}</p>
Measurand
<p>t/year</p>
Calculation Procedure
Assessed transport mode
<p>Motorised private transport modes with fossil fuel (petrol and diesel): car, motorcycle Public transport with fossil fuel (petrol and diesel): urban bus Urban freight: light commercial vehicle (LCV), heavy goods vehicle (HGV)</p>
Calculation rules
<p>The core element of the calculation procedure is the mean warm emission factors per transport mode in four traffic situations provided as weighted averages originating from the HBEFA 3.2 ³ database (INFRAS 2014). For detailed explanation, please refer to the below section “Further Remarks”.</p> <p>The direct warm CO₂ emission per transport mode in the assessment period is calculated as follows:</p> $E_{CO_2, ass. per} = \sum_k \sum_{traff. sit} \frac{EF_{CO_2, k, traff. sit} \cdot VM_{k, traff. sit}}{1.000.000}$ <p>Where:</p> <p>$E_{CO_2, ass. per}$ = direct warm CO₂ emission per transport mode k in the assessment period [t/assessment period]</p>

³ English: Handbook Emission Factors for Road Transport. German: Handbuch Emissionsfaktoren des Straßenverkehrs.

$EF_{CO_2,k,traff.sit.}$ = direct warm CO₂ emission factor per transport mode k per transport situation [g/veh-km] – default values are provided

$VM_{k,traff.sit.}$ = vehicle mileage per transport mode k in the assessment period per traffic situation [veh-km]

The total direct warm emissions are then extrapolated to 1 year of evaluation interval:

$$E_{CO_2,year} = E_{CO_2,ass.per.} \cdot N_h \cdot N_d$$

Where:

$E_{CO_2,year}$ = total direct warm CO₂ emission over all transport modes per year [t/year]

$E_{CO_2,ass.per.}$ = direct warm CO₂ emission per transport mode k in the assessment period [t/assessment period]

N_h = extrapolation factor between assessment period and day [-] – default values are provided, which may be overwritten

N_d = extrapolation factor between day and year [-] – default values are provided, which may be overwritten

Approach for monetisation

The total direct emissions are expressed in monetary terms by multiplying them with the ton-wise emission costs:

$$C_{CO_2,year} = E_{CO_2,year} \cdot CF_{CO_2}$$

Where:

$C_{CO_2,year}$ = total direct CO₂ emission costs over all transport modes per year [EUR/year]

$E_{CO_2,year}$ = total direct warm CO₂ emission over all transport modes per year [t/year]

CF_{CO_2} = emission costs of CO₂ [EUR/t] – default values are provided

All cost rates are updated to price level 2015.

Sources for required input data

- **Motorised vehicle mileage per transport mode in the assessment period in four traffic situations [veh-km]:** microscopic or macroscopic transport simulation model
- **Mean direct warm emission factors per transport mode in four traffic situations [g/veh-km]:** HBEFA 3.2 database (INFRAS 2014)
- **CO₂ emission costs [EUR/t]:** international study on External Costs of Transport in Europe (van Essen et al 2011)

Proper references can be found in Chapter 6 Bibliography.

Further remarks

By the emission calculation only the direct warm emissions are considered. The emitted CO₂ values depend on the assumed fleet mix, traffic composition, road type, and current traffic situation (i.e. speed and

saturation level). For simplification reasons and due to lack of available data in all European countries, mean German factors have been calculated based on an assumed fleet mix over all urban road types and speed limits. Mean direct warm CO₂ emission factors for each motorised transport mode are available in the following traffic situations:

- Free flow: free flowing conditions, low and steady traffic flow. Constant and quite high speed. Indicative speeds. 45-60 km/h on a road with speed limit of 50 km/h. LOS A-B according to HCM.
- Heavy: free flow conditions with heavy traffic, fairly constant speed. Indicative speeds. 30-45 km/h on a road with speed limit of 50 km/h. LOS C-D according to HCM.
- Saturated: unsteady flow, saturated traffic. Variable intermediate speeds, with possible stops. Indicative speeds: 15-30 km/h on a road with speed limit of 50 km/h. LOS E according to HCM.
- Stop+go: Heavily congested flow, stop and go or gridlock. Variable and low speed and stops. Indicative speeds. 5-15 km/h on a road with speed limit of 50 km/h. LOS F according to HCM.

The direct environmental effects are calculated for five motorised vehicle types: cars, motorbikes, light commercial vehicles, heavy good vehicles and urban bus. Pre-requisite for the sophisticated calculation procedure is the available travel demand for all listed demand strata.

Indicator: Direct NO_x Emission

Target system: Environment

Description of Indicator

Relevance

Transport sector via the combustion of fossil fuels constitutes to one of the major human-caused sources of harmful NO_x emissions. NO_x gases react to form smog and acid rain as well as being central to the formation of tropospheric ozone. An increased concentration causes irritation and damage in the respiratory organs of children and adults. Therefore the improved air quality in urban areas as a result of reduced motorised vehicle mileage would lead to a reduced risk of health damages of vulnerable road users, hence an increased quality of life on the long run.

Definition

NO_x is a generic term for mono-nitrogen oxides NO and NO₂. They are produced during combustion, especially at high temperature.

Assessment Approach

Measurand_{with case} – Measurand_{without case}

Measurand

t/year

Calculation Procedure
Assessed transport mode Motorised private transport modes with fossil fuel (petrol and diesel): car, motorcycle Public transport with fossil fuel (petrol and diesel): urban bus Urban freight: light commercial vehicle (LCV), heavy goods vehicle (HGV)
Calculation rules Similar to the CO ₂ emission calculation, the total NO _x emissions in the assessment period are computed using the mean warm emission factors from the HBEFA 3.2. database (INFRAS 2014). The direct warm NO _x emission per transport mode in the assessment period [t/assessment period] is calculated as follows: $E_{NOx,ass.per} = \sum_k \sum_{traff.sit} \frac{EF_{NOx,k,traff.sit} \cdot VM_{k,traff.sit}}{1.000.000}$ Where: $E_{NOx,ass.per}$ = direct warm NO _x emission per transport mode k in the assessment period [t/assessment period] $EF_{NOx,k,traff.sit}$ = direct warm NO _x emission factor per transport mode k per transport situation [g/veh-km] – default values are provided $VM_{k,traff.sit}$ = vehicle mileage per transport mode k in the assessment period per transport situation [veh-km] The total direct warm emissions are then extrapolated to 1 year of evaluation interval: $E_{NOx,year} = E_{NOx,ass.per} \cdot N_h \cdot N_d$ Where: $E_{NOx,year}$ = total direct warm NO _x emission over all transport modes per year [t/year] $E_{NOx,ass.per}$ = direct warm NO _x emission per transport mode k in the assessment period [t/assessment period] N_h = extrapolation factor between assessment period and day [-] – default values are provided, which may be overwritten N_d = extrapolation factor between day and year [-] – default values are provided, which may be overwritten
Approach for monetisation The total direct emissions are expressed in monetary terms by multiplying them with the ton-wise emission costs: $C_{NOx,year} = E_{NOx,year} \cdot CF_{NOx}$ Where:

$C_{NOx,year}$ = total direct NO _x emission costs over all transport modes per year [EUR/year] $E_{NOx,year}$ = total direct warm NO _x emission over all transport modes per year [t/year] CF_{NOx} = emission costs of NO _x [EUR/t] – default values are provided All cost rates are updated to price level 2015.
Sources for required input data
<ul style="list-style-type: none"> Motorised vehicle mileage per transport mode in the assessment period in four traffic situations [veh-km]: microscopic or macroscopic transport simulation model Mean direct warm emission factors per transport mode in four traffic situations [g/veh-km]: HBEFA 3.2 database (INFRAS 2014) NO_x emission costs [EUR/t]: international study on External Costs of Transport in Europe (van Essen et al 2011) <p><i>Proper references can be found in Chapter 6 Bibliography.</i></p>
Further remarks
The calculation of total direct NO _x emissions is conducted in the same manner as for CO ₂ .

Indicator: Direct PM Emission
Target system: Environment
Description of Indicator
Relevance
Transport sector is a significant contributor to particulate matter emissions, having mainly two sources from the direct vehicle operation: from fuels, and due to abrasion & resuspension from the tyres. PM affects human beings in terms of cardiovascular diseases and respiratory tract infections, it has also carcinogenic effects. PM also have impacts on climate and precipitation that adversely affect human health.
Definition
Atmospheric particulate matter (PM) are microscopic solid or liquid matter suspended in the Earth's atmosphere.
Assessment Approach
Measurand _{with case} – Measurand _{without case}
Measurand

t/year

Calculation Procedure

Assessed transport mode

Motorised private transport modes with fossil fuel (petrol and diesel), but also electric propulsion due to abrasion & resuspension: car, motorcycle
Public transport with fossil fuel (petrol and diesel), but also electric propulsion due to abrasion & resuspension: urban bus
Urban freight with fossil fuel (petrol and diesel), but also electric propulsion due to abrasion & resuspension: light commercial vehicle (LCV), heavy goods vehicle (HGV)

Calculation rules

The total recorded particulate matter emission consists of the direct emitted PM from the exhaust (internal combustion engine), and the additional PM resulting predominantly from abrasion and resuspension.

Similar to the CO₂ and NO_x emissions, the computation of the direct PM emissions in the assessment period through exhaust are based on the mean warm emission factors from the German speaking HBEFA 3.2. Database (INFRAS 2014) using the following formula:

$$E_{PM,dir,ass.per} = \sum_k \sum_{traff.sit} \frac{EF_{PM,k,traff.sit} \cdot VM_{k,traff.sit}}{1.000.000}$$

Where:

$E_{PM,dir,ass.per}$ = total direct warm PM emission in the assessment period [t/assessment period]

$EF_{PM,k,traff.sit}$ = direct warm PM emission factor per transport mode k per transport situation [g/veh-km] – default values are provided

$VM_{k,traff.sit}$ = vehicle mileage per transport mode k in the assessment period per transport situation [veh-km]

The additionally emitted PM due to abrasion and resuspension is mainly dependent from the driven vehicle kilometres, whereas no further subdivision into the different traffic situations (e.g. stop-and-go vs. free flow) is required. Furthermore, since this harmful emission component includes emissions e.g. from tyre- and brake wear, the calculation also accounts for the electric engines besides conventional propulsion.

Therefore the additional emission is calculated as follows:

$$E_{PM,add,ass.per} = \sum_k \frac{EF_{PM,add,k} \cdot VM_k}{1.000.000}$$

Where:

$E_{PM,add,ass.per}$ = total additional PM emission due to abrasion and resuspension in the assessment period [t/assessment period]

$EF_{PM,k,traff.sit}$ = additional PM emission factor due to abrasion and resuspension per transport mode k [g/veh-km] – default values are provided

$VM_{k,traff.sit}$ = vehicle mileage per transport mode k in the assessment period [veh-km]

The total direct PM emissions are calculated as a sum of warm and additional PM emissions:

$$E_{PM,ass.per} = E_{PM,dir,ass.per} + E_{PM,add,ass.per}$$

Where:

$E_{PM,ass.per}$ = total direct PM emission in the assessment period [t/assessment period]

$E_{PM,dir,ass.per}$ = total direct warm PM emission in the assessment period [t/assessment period]

$E_{PM,add,ass.per}$ = total additional PM emission due to abrasion and resuspension in the assessment period [t/assessment period]

The total warm emissions are then extrapolated to 1 year of evaluation interval:

$$E_{PM,year} = E_{PM,ass.per} \cdot N_h \cdot N_d$$

Where:

$E_{PM,year}$ = total direct warm PM emission over all transport modes per year [t/year]

$E_{PM,ass.per}$ = direct warm PM emission per transport mode k in the assessment period [t/assessment period]

N_h = extrapolation factor between assessment period and day [-] – default values are provided, which may be overwritten

N_d = extrapolation factor between day and year [-] – default values are provided, which may be overwritten

Approach for monetisation

The total direct emissions are expressed in monetary terms by multiplying them with the ton-wise emission costs:

$$C_{PM,year} = E_{PM,year} \cdot CF_{PM}$$

Where:

$C_{PM,year}$ = total direct PM emission costs over all transport modes per year [EUR/year]

$E_{PM,year}$ = total direct warm PM emission over all transport modes per year [t/year]

CF_{PM} = emission costs of PM [EUR/t] – default values are provided

All cost rates are updated to price level 2015.

Sources for required input data

- **Motorised vehicle mileage per transport mode in the assessment period in four traffic situations & total motorised vehicle mileage [veh-km]:** microscopic or macroscopic transport simulation model
- **Mean direct warm emission factors per transport mode in four traffic situations & additional emission factor due to abrasion and resuspension [g/veh-km]:** HBEFA 3.2 database (INFRAS 2014)

- **PM emission costs [EUR/t]:** PM_{2.5} in metropolitan areas is applied from the international study on External Costs of Transport in Europe (van Essen et al 2011)

Proper references can be found in Chapter 6 Bibliography.

Further remarks

The calculation of total direct NO_x emissions is conducted in the same manner as for CO₂.

Indicator: Number of persons killed in an accident

Target system: Society

Description of Indicator

Relevance

Improved cycling and walking facilities increase traffic safety. Each avoided fatality is overall a huge benefit for the whole society. More specifically perceived improvements of traffic safety can result in a higher attractiveness of cycling and walking and therefore foster mode change.

Definition

A traffic accident with bodily impact is defined as “accidents, which occurred or originated on a way or street open to public traffic; which resulted in one or more persons being killed or injured and in which at least one moving vehicle was involved (...).⁴ These accidents therefore include collisions between motorised and non-motorised vehicles too. Fatality is defined as a death arisen from a traffic accident⁵.

Assessment approach

Measurand_{with case} – Measurand_{without case}

Measurand

No. pers/year

Calculation Procedure

Assessed transport mode

⁴ See definition of Vienna Convention on Road Traffic.

⁵ Simplified accident impact definition is taken from HEATCO 2005, which was modified by removing the 30 day period, hence dying in a hospital in the consecutive 30 days is not understood as a fatal accident, but as a serious injury.

Motorised private transport (car, LCV, HGV; motorcycle, moped)

Non-motorised private transport (walking, cycling)

Public transport (bus)

Calculation rules

The number of fatal accidents per year is taken by the user directly from national statistical yearbooks (issued e.g. by the municipal police department):

$$N_{fat,year}$$

Where:

$N_{fat,year}$ = Total number of persons killed in an accident over all transport modes in a year [No./year]

Note: the number of accidents are not given in the assessment period, but already per year, hence no extrapolation factor is not needed.

As the accident figures are mostly not available in a disaggregated form for each transport mode, FLOW requires only an aggregated figure over all transport modes.

The figures should refer explicitly to the catchment area. Thus, in case the statistical data is only available in certain districts or only in the whole city, own estimation is needed.

Approach for monetisation

The costs of fatal accidents over all transport modes in a year is determined as follows:

$$C_{fat,year} = CR_{fat} \cdot N_{fat,year}$$

Where:

$C_{fat,year}$ = Costs of fatal accidents over all transport modes per year [EUR/year]

$N_{fat,year}$ = Total number of persons killed in a fatal accident over all transport modes in a year [No./year]

CR_{fat} = Cost of fatality [EUR/pers] – default values are provided

The accident costs are assumed to be the same for all transport modes.

For the estimation of the accident costs the HEATCO approach (“estimated values for casualties avoided”) was applied. Based on this, the valuing of accident risks is composed of three components⁶:

Direct economic costs of accidents:

- Medical costs, costs of property damage and administrative costs

Indirect economic costs:

- Costs of lost productive capacity

Value of safety – value of statistical life

- Valuation of lost quality of life (loss welfare due to crashes) – this is the estimation of willingness-to-pay, based on either RP or SP surveys

⁶ For more detailed explanation of the valuation methodology, please refer to HEATCO (2005).

The monetary factors provided here are the sum of the above mentioned three components. The applied cost rates are updated to price level 2015.

Sources for required input data

- **Total number of annual fatalities in urban areas, aggregated over all transport modes**
[no.pers]: national statistical yearbooks (input required by the user)
- **Fatal accident costs:** HEATCO D5 2005

Proper references can be found in Chapter 6 Bibliography.

Further remarks

The calculation has been radically simplified compared to the final draft based on feedbacks from the FLOW partner cities, stating to have the required statistical data for the “without-case”. Thereby a complicated estimation for using statistical accident rates can be omitted.

Indicator: Number of injured persons

Target system: Society

Description of Indicator

Relevance

The “safe participation” in social life, and also in transport is a basic right in a liveable city that has to be provided for everyone, which has a special meaning for vulnerable road users. Therefore the aim of improved cycling and walking facilities must increase also traffic safety, hence reduce the probability for injuries.

Definition

A traffic accident with bodily impact is defined as “accidents which occurred or originated on a way or street open to public traffic; which resulted in one or more persons being killed or injured and in which at least one moving vehicle was involved (...).⁷ These accidents therefore include collisions between motorised and non-motorised vehicles too.

According to the definition based on EUNET (Nellthorp et al. 1998 in: HEATCO 2005), a serious injury is understood as a casualty, which requires hospital treatment and has lasting injuries, but the victim does not die within the fatality recording period. A slight injury includes casualties, whose injuries do not require hospital treatment or, if they do, the effect of the injury quickly subsides.

Assessment approach

⁷ See definition of Vienna Convention on Road Traffic

Measurand _{with case} – Measurand _{without case}
Measurand
No. pers/year
Calculation Procedure
Assessed transport mode
<p>Motorised private transport (car; LCV, HGV; motorcycle, moped)</p> <p>Non-motorised private transport (walking, cycling)</p> <p>Public transport (bus)</p>
Calculation rules
<p>Similar to the number of fatal accidents per year (see previous indicator), the number of severely and slightly injures persons is taken by the user directly from national statistical yearbooks (issued e.g. by the municipal police department):</p> $N_{severe,year}$ $N_{slight,year}$ <p>Where:</p> <p>$N_{severe,year}$ = Number of severely injured persons over all transport modes per year [No. pers/year]</p> <p>$N_{slight,year}$ = Number of slightly injured persons over all transport modes per year [No. pers/year]</p> <p>The total number of injured persons in a year is calculated as the sum of severe and slight injuries;</p> $N_{inj,year} = N_{severe,year} + N_{slight,year}$ <p>Where:</p> <p>$N_{inj,year}$ = total number of injuries over all transport modes per year [No. pers/year]</p> <p>$N_{severe,year}$ = Number of severely injured persons over all transport modes per year [No. pers/year]</p> <p>$N_{slight,year}$ = Number of slightly injured persons over all transport modes per year [No. pers/year]</p> <p>Note: the number of accidents are not given in the assessment period, but already per year, hence no extrapolation factor is not needed.</p> <p>As the accident figures are mostly not available in a disaggregated form for each transport mode, FLOW requires only an aggregated figure over all transport modes.</p> <p>The figures should refer explicitly to the catchment area. Thus, in case the statistical data is only available in certain districts or only in the whole city, own estimation is needed.</p>

Approach for monetisation
<p>The costs of all accidents with injuries over all transport modes per year are determined as follows:</p> $C_{inj,year} = N_{severe,year} \cdot CR_{severe} + N_{slight,year} \cdot CR_{slight}$ <p>Where:</p> <p>$C_{inj,year}$ = Total costs of all injuries over all transport modes per year [EUR/year]</p> <p>$N_{severe,year}$ = Number of severely injured persons over all transport modes per year [No. pers/year]</p> <p>$N_{slight,year}$ = Number of slightly injured persons over all transport modes per year [No. pers/year]</p> <p>CR_{severe} = Costs of accidents with severe injuries [EUR/pers] – default values are provided</p> <p>CR_{slight} = Costs of accidents with slight injuries [EUR/pers] – default values are provided</p> <p>The costs of an accident are estimated based on the cost rates for fatality:</p> <ul style="list-style-type: none"> for severe injuries: 13 % of value of statistical life slight injuries: 1% of value of statistical life <p>All cost rates are updated to price level 2015.</p>
Sources for required input data
<ul style="list-style-type: none"> Total number of severe and slight injuries in urban areas, aggregated over all transport modes [no.pers]: national statistical yearbooks (input required by the user) Accident costs: HEATCO D5 2005 <p><i>Proper references can be found in Chapter 6 Bibliography.</i></p>
Further remarks
<p>The calculation has been radically simplified compared to the final draft based on feedbacks from the FLOW partner cities, stating to have the required statistical data for the “without-case”. Thereby a complicated estimation for using statistical accident rates can be omitted.</p>

Indicator: Health benefits based on a reduced probability of death for people who cycle/walk
Target system: Society
Description of Indicator
Relevance

Physical inactivity is the fourth leading risk factor for mortality worldwide (WHO 2014, in: Brown et al. 2015). Active transport, such as walking and cycling is often referred to as utilitarian physical activity, and more and more often recognised its potential to improve physical activity, hence the health status.

As a result, it has also a huge gain for the whole society, as improved health status will reduce medical costs and prolong life. So to express health benefits of increased active mobility in economic terms, an indicator is calculated based on the Health Economic Assessment Tool (HEAT) from World Health Organisation – albeit certain simplifications were applied. One of its aims is to complement existing tools for economic valuations of transport interventions, for example on emissions or congestion, hence to provide input into more comprehensive cost–benefit analyses (WHO 2014).

Definition

The benefit is based on the estimated value of reduced mortality (probability of death) due to the increased physical activity. The assessment reflects long-term activity behaviour.

Assessment Approach

Measurand_{with case} – Measurand_{without case}

Measurand

EUR/year

Calculation Procedure

Assessed transport mode

Non-motorised private transport (walking, cycling)

Calculation rules

The basic calculation methodology with basic input variables and recommended default values was completely taken from HEAT (WHO 2014). Same formula applied in both cases with and without implementation of the measure.

In order to calculate the estimated number of deaths that are prevented due to increased walking or cycling activity in a year, first the reduction in risk of mortality has to be calculated. Based on the online tool with embedded formulas, the following equation was developed for FLOW:

$$RM = \frac{(D \cdot N) \cdot 1/60}{D_{ref} \cdot 52/60} \cdot (1 - RR)$$

Where:

RM = reduction in risk of mortality either for walking or cycling [%]

D = duration of daily walking or cycling activity [minutes/day]

N = number of days activity with this duration is carried out [No.]

D_{ref} = reference duration of daily walking or cycling activity [minutes/week]

RR = relative risk of death (default value for cyclists/pedestrians)

(Linear dose-response relationship is assumed.)

The reduced risk of mortality is used to calculate the number of deaths per year that are prevented due to the certain amount of walking or cycling activity by means of following formula:

$$N_{death} = RM \cdot q \cdot p \cdot \frac{MR}{100.000}$$

Where:

N_{death} = number of deaths per year that are prevented due to the certain amount of walking/cycling activity

RM = reduction in risk of mortality either for walking or cycling [%]

q = travel demand - no of cyclists/pedestrians involved [persons]

p = proportion of cycling data attributable to the measure [%]

MR = mortality rate [no. of deaths per 100.000 persons/year] – default values are provided

The same formula applies for both before and after intervention, thus with and without implementation of the walking or cycling measure. Accordingly, the number of deaths per year that are prevented by this change in cycling/walking arises from the difference of after- and before intervention values:

$$\Delta N_{death} = N_{death,with} - N_{death,without}$$

Where:

ΔN_{death} = number of deaths per year that are prevented by the change in cycling/walking activity [No.]

$N_{death, with}$ = number of deaths per year that are prevented due to the certain amount of walking/cycling activity with the implementation of measure [No.]

$N_{death, without}$ = number of deaths per year that are prevented due to the certain amount of walking/cycling activity without the implementation of measure [No.]

Approach for monetisation

The result of increased physical activity is the maximum annual benefit reached by the respective level of cycling or walking. Overall the monetised health benefits based on a reduced probability of death for people who cycle/walk are calculated as follows:

$$HB = \Delta N_{death} \cdot C_{fat}$$

Where:

HB = health benefits based on a reduced probability of death for people who cycle/walk [EUR/year]

ΔN_{death} = number of deaths per year that are prevented by the change in cycling/walking activity [No.]

C_{fat} = cost of fatality (instead of the value of statistical life) [EUR/capita] – default values are provided

The health benefits are monetised using the value of statistical life, given by WHO in the HEAT database. However, the FLOW approach deviates from the HEAT approach at this point: instead of applying the value of statistical life, FLOW recommends to apply the same cost rates as for the monetisation of persons killed in an accident, recommended by HEATCO (2005). The application of the same cost rates helps provide consistency over the different indicators. The costs of fatalities per country are updated to the price level of 2015 by GDP growth per capita and inflation rate).

Sources for required input data

Following input data are required (input indicators and explanation are directly taken from HEAT):

- **duration of daily walking or cycling activity** [minutes/day]⁸

It describes the mean daily duration in minutes that the asked persons spend with walking or cycling. The data is recorded via surveys.

- **number of days activity with this duration is carried out** [no.]

The required data gives information about the regularity of the activity, so that the yearly amount of walking or cycling can be estimated.

- **travel demand - no of cyclists/pedestrians involved** [persons]

The travel demand includes the number of persons from the survey that regularly cycle or walk the above mentioned duration/amount.

- **reference duration of daily walking or cycling activity** [minutes/week]

Reference duration is taken directly from HEAT. Default values are based on studies (WHO 2014).

- **proportion of cycling data attributable to the measure** [%]

If data is available, it is recommended to estimate the share of induced cycling of pedestrian traffic that can be directly linked to the increase cycling or pedestrian volumes.

- **relative risk of death** (default value for cyclists/pedestrians)

Relative risk estimate for cycling – default values are given (based on studies, for more information please refer to documentation from WHO 2014) – it is applied to the amount of walking or cycling entered by the user – required for the protective benefit calculation – probability (e.g. 1-0,9=10 % less likely).

- **mortality rate** [No. of deaths per 100.000 persons/year]

⁸ In HEAT one can choose between duration, distance, and number of trips (or steps) for cycling and walking data input. The FLOW explanatory calculation recommends the daily duration.

Mortality rate⁹ is given as a crude rate of death against 100.000 inhabitants. Default values for all EU countries are provided, depending on the age of the assessed population. For the simplification of the calculations, linear dose-response curve (relationship between walking or cycling and mortality) is assumed (WHO 2014).

- **Value of statistical life** [EUR/capita] for monetisation of health benefits - HEATCO (2005) (see arguments above by the approach for monetisation)

Further remarks

Applied indicator is fully based on the HEAT approach. However, some additional input parameters are not considered due to simplification matters, or initial fix values are applied. This includes following indicators:

- *Time needed to reach full level of cycling or walking* – value is set to be 0, as time period is not known
- *Time period over which benefits are calculated* – value is set to be 1 year as default for each case
- *Discount rate to apply to future benefits* – value is set to be 0 %, as resulted benefit from this indicator is one component of the more comprehensive cost-benefit analysis

For more information about the methodology, please refer to the HEAT online tool of World Health Organization 2011, updated reprint 2014.

Indicator: Vehicle operating costs

Target system: Private business

Description of Indicator

Relevance

Additional vehicle mileage, as well as an increased length of stay due to traffic congestion causes additional operating costs for the affected road users.

Definition

The vehicle operating costs are defined as comprising the standing costs, which are invariant with distance, and operating costs, which vary with distance of the transport vehicle (HEATCO 2005). These costs are directly linked to the user.

Assessment Approach

Measurand_{with case} – Measurand_{without case}

⁹ Mortality rate is a measure of the number of deaths (in general, or due to a specific cause) in a population, per unit time, expressed in units of deaths per 1000 (or 100'000) individuals per year (WHO 2014).

Measurand
EUR/year
Calculation Procedure
Assessed transport mode
<p>Motorised private transport modes: car, motorcycle</p> <p>Non-motorised private transport modes: cycling</p> <p>Public transport: urban bus, tram</p> <p>Urban freight: light commercial vehicle (LCV), heavy goods vehicle (HGV)</p>
Calculation rules including the approach for monetisation
<p>The vehicle operating costs are composed generally of the following two cost components (see Bundesministerium für Verkehr, Innovation und Technologie 2010; HEATCO 2005):</p> <ul style="list-style-type: none"> • Standing cost components: (investment - materials costs, repair and maintenance, storage, depreciation (time dependent share), insurance, overheads, administration) • Operating cost components: personnel costs (for public commercial transport), depreciation (distance related share), • (energy costs) <p>The personnel costs for private transport (passenger costs) are calculated as part of the indicator “travel time”, through the consideration of hourly wages. The third component of the operating costs, the energy costs resulting from consumption is calculated as a separate indicator (see fact sheet for indicator <i>Final fuel and energy consumption</i>).</p> <p>The vehicle operating costs for each transport mode in the assessment period are calculated as follows:</p> $VOC_{ass.per,k} = t_{act,total,k} \cdot (f_{t,k} + f_{pers,k}) + d_{total,k} \cdot f_{d,k}$ <p>Where:</p> <p>$VOC_{ass.per,k}$ = Total vehicle operating costs per transport mode k per assessment period [EUR/assessment period]</p> <p>$t_{act,total,k}$ = Total travel time per transport mode k per assessment period in the network [veh-h/assessment period]</p> <p>$d_{total,k}$ = Total vehicle mileage per transport mode k per assessment period in the network [veh-km/assessment period]</p> <p>$f_{pers,k}$ = Personnel costs for transport mode k [EUR/veh-h] – default values are provided</p> <p>$f_{t,k}$ = Time dependent share of operating costs for transport mode k [EUR/veh-h] – default values are provided</p> <p>$f_{d,k}$ = Distance related share of operating costs for transport mode k [EUR/veh-km] – default values are provided</p>

The vehicle operating costs are calculated as the sum of the mode-specific vehicle operating costs:

$$VOC_{ass.per.} = \sum_k VOC_{ass.per,k}$$

Where:

$VOC_{ass.per.}$ = Total vehicle operating costs over all transport modes per assessment period [EUR/assessment period]

$VOC_{ass.per,k}$ = Total vehicle operating costs per transport mode k per assessment period [EUR/assessment period]

The time- and distance dependent operating costs that are calculated in the assessment period are extrapolated to one year as evaluation interval:

$$VOC_{year} = VOC_{ass.per.} \cdot N_h \cdot N_d$$

Where:

VOC_{year} = Total vehicle operating costs over all transport modes per year [EUR/year]

$VOC_{ass.per.}$ = Total vehicle operating costs over all transport modes per assessment period [EUR/assessment period]

N_h = extrapolation factor between assessment period and day [-]

N_d = extrapolation factor between day and year [-]

The original values from 2009 have been updated to the price level of 2015.

Source for required input data

- **Vehicle mileage per transport mode in the assessment period [veh-km]:** microscopic or macroscopic transport simulation model
- **Vehicle hours per transport mode in the assessment period [veh-h]:** microscopic or macroscopic transport simulation model
- **Vehicle operating costs [EUR/veh-km; EUR/veh-h] per vehicle – without fuel costs:**
 - Standing cost components, operating cost components, personnel costs taken from the Austrian Guideline for Cost-Benefit Analyses in the transport sector¹⁰ (Bundesministerium für Verkehr, Innovation und Technologie 2010).
 - Operating costs for e-vehicles and pedelecs: due to the lack of data, own values have to be applied by the user (computation is already prepared)

Indicator: Final energy consumption

Target system: Private Business

¹⁰ German: Nutzen-Kosten-Untersuchungen im Verkehrswesen

Description of Indicator
Relevance
<p>The energy consumption in the transport sector still constitutes to 32 %¹¹ of the total yearly energy consumption (EEA 2015), therefore the increased share of non-motorised transport modes will not only lead to individual cost savings, but also to reduced dependence on non-renewable energy-resources.</p>
Definition
<p>Final energy consumption covers all energy supplies to the final consumer for all energy uses. It is usually disaggregated into the final end-use sectors: industry, transport, households, services and agriculture (EEA 2013). This indicator addresses the fuel and electricity consumption resulted from direct vehicle operation.</p>
Assessment Approach
<p>Measurand_{with case} – Measurand_{without case}</p>
Measurand
<p>kWh/year</p>
Calculation Procedure
Assessed transport mode
<p>Motorised private transport modes (fossil fuel and electric propulsion): car, e-car motorcycle Non-motorised private transport modes: cycle, pedelec Public transport: urban bus, e-bus, tram Urban freight: light commercial vehicle (LCV and e-LCV), heavy goods vehicle (HGV) <i>Cyclists and pedestrians are assigned 0 by default.</i></p>
Calculation rules
<p>The total energy consumption in the assessment period is calculated for all vehicles including conventional (fossil fuels) and electric propulsion. Therefore different formulas have to be applied due to the different basic units.</p> <p>Similar to the emission calculations, the total final fuel consumption of vehicles with fossil fuels are computed using the mean warm consumption factors from the HBEFA 3.2. database (INFRAS 2014).</p> <p>Thereby the final fuel consumption per transport mode in the assessment period is calculated as follows:</p>

¹¹ Figure as an EU-28 average final energy consumption by sector and fuel given by the European Environmental Agency, referring to year 2013.

$$F_{ass.per,k} = \sum_{traff.sit} \frac{F_{FC,k,traff.sit} \cdot VM_{k,traff.sit}}{1.000}$$

Where:

$F_{ass.per,k}$ = final fuel consumption per transport mode k in the assessment period [kg/assessment period]

$F_{FC,k,traff.sit}$ = mean final fuel consumption factor per transport mode k per traffic situation [g/veh-km] – default values are provided

$VM_{k,traff.sit}$ = vehicle mileage per transport mode k in the assessment period per transport situation [veh-km]

The total final electricity consumption per transport mode in the assessment period [kWh/assessment period] is calculated in a simplified way, as different traffic situations are not considered anymore:

$$E_{ass.per,k} = F_{E,k} \cdot VM_k$$

Where:

$EC_{ass.per,k}$ = final electricity consumption per transport mode k in the assessment period [kWh/assessment period]

$F_{EC,k}$ = mean final electricity consumption factor per transport mode k [kWh/veh-km] – default values are provided

VM_k = vehicle mileage per transport mode k in the assessment period [veh-km]

The final fuel consumptions per transport mode are transformed to kWh, and then their sum is added to the sum electricity consumption to extrapolate them together to 1 year of evaluation interval:

$$EC_{ass.per} = \sum_k F_{ass.per,k} \cdot f_{conv,kWh} + \sum_k E_{ass.per,k}$$

Where:

$EC_{ass.per}$ = final energy consumption over all transport modes in the assessment period [kWh/assessment period]

$F_{ass.per,k}$ = final fuel consumption per transport mode k in the assessment period [kg/assessment period]

$E_{ass.per,k}$ = final electricity consumption per transport mode k in the assessment period [kWh/assessment period]

$f_{conv,kWh}$ = conversion factor from kg to kWh for fuel type – diesel and petrol [kWh/kg] – default values are provided

The share of engine type – whether diesel or petrol – has to be estimated by the user in the respective field in the Excel sheet. The yearly final energy consumption is calculated as follows:

$$EC_{year} = EC_{ass.per} \cdot N_h \cdot N_d$$

Where:

EC_{year} = final energy consumption over all transport modes in a year [kWh/year]

$EC_{ass.per}$ = final energy consumption over all transport modes in the assessment period [kWh/assessment period]

N_h = extrapolation factor between assessment period and day [-] – default values are provided, which may be overwritten

N_d = extrapolation factor between day and year [-] – default values are provided, which may be overwritten

Approach for monetisation

The final fuel consumption costs per transport mode per year are calculated applying the fuel prices and conversion factors:

$$C_{F,year,k} = \frac{F_{year,k}}{f_{conv,l}} \cdot CF_{fc}$$

Where:

$C_{F,year,k}$ = final fuel consumption costs per transport mode k per year [EUR/year]

$F_{year,k}$ = final fuel consumption per transport mode k per year [kg/year]

$f_{conv,l}$ = conversion factor from kg to l for fuel type – diesel and petrol [kg/l] – default values are provided

CF_{fc} = cost factor of fuel consumption – fuel prices for petrol and diesel [EUR/l] – default values are provided

The share of engine type – whether diesel or petrol – has to be estimated by the user in the respective field in the Excel sheet.

Similarly, the costs of final electricity consumption per transport mode in a year are calculated:

$$C_{E,year,k} = E_{year,k} \cdot CF_{ec}$$

Where:

$C_{E,year,k}$ = final electricity consumption costs per transport mode k per year [EUR/year]

$E_{year,k}$ = final electricity consumption per transport mode k per year [kWh/year]

CF_{ec} = cost factor of electricity consumption transport mode k [EUR/kWh] – default values are provided

(No conversion factor is needed for the electricity consumption.)

The total final energy consumption costs are calculated as a sum of costs of final fuel consumption and electricity consumption.

$$C_{EC,year} = \sum_k C_{F,year,k} + \sum_k C_{E,year,k}$$

Where:

$C_{EC,ass,per}$ = final energy consumption costs over all transport modes per year [EUR/year]

$C_{F,year,k}$ = final fuel consumption costs per transport mode k per year [EUR/year]

$C_{E,year,k}$ = final electricity consumption costs per transport mode k per year [EUR/year]

All applied costs (i.e. fuel and electricity prices) exclude taxes, levies and VTA. All prices are updated to price level 2015.

Sources for required input data
<ul style="list-style-type: none"> • Motorised vehicle mileage per transport mode in the assessment period in four traffic situations [veh-km]: microscopic or macroscopic transport simulation model • Mean final fuel consumption factors per transport mode in four traffic situations [g/veh-km]: HBEFA 3.2 database (INFRAS 2014) <p>(Due to the lack of unique source for all e-vehicles, required input was gathered from more sources.)</p> <ul style="list-style-type: none"> • Mean final electricity consumption factor for e-cars and e-LCVs: own findings from PTV within the frames of the German research project iZEUS • Mean final electricity consumption factor for e-buses: Final report on supporting Hybrid- and electro buses (Grütter 2014) • Mean final electricity consumption factor for pedelecs: Pedelecs homepage (2014) • Fuel costs: <ul style="list-style-type: none"> ○ Prices of fuel per litre (with tax & excise duty): fuel prices Europe (2016) ○ Road and fuel excise duties to deduct from the gross fuel prices: database of European Environmental Agency (2016) • Electricity costs (without taxes): Eurostat database <p><i>Proper references can be found in Chapter 6 Bibliography.</i></p>
Further remarks
<p>The reason for considering the energy consumption apart from the operating costs as a separate indicator is to provide a detailed approach, while considering the impact of the different traffic situations.</p> <p>The computation of total final fuel consumption was conducted in the same manner as for CO₂ emission calculation.</p>

4.5. Descriptive Indicators

On the below factsheets, the descriptive indicators are described in detail, which are chosen to assess the non-quantifiable effects of walking and cycling.

Indicator: Sealed surface – total new / deconstructed traffic area
Target system: Environment
Description of Indicator
Relevance
Nowadays a high percentage of urban land is used for transport infrastructure. Due to city expansions, this percentage is even increasing.

An integrated settlement and transport planning that also aims at the creation of pedestrian and cycling-friendly structures, can help to minimise the required space for transport infrastructure, since pedestrians and bicycles have significantly lower space requirements than car traffic. The so “re-gained” surfaces can be provided for other usages and depending on the new usage, contribute to the environmental and social quality of the city.

Definition

Since the pure consumption of land is reflected and monetised in the investment costs, the indicator “sealed or deconstructed traffic areas” is meant to address the social and environmental aspect of land consumption.

Assessment approach

Measurand_{case with-without}

Measurand

Weighted utility points: qualitative, weighted assessment

Calculation Procedure

Assessed transport mode

Non-motorised transport (walking and cycling)

Calculation rules

The formalised assessment is explained in the following steps, including an explanatory case:

- Identification of areas where measure either causes land consumption, or “re-gain” the land
- Identification of impact of either land consumption or “re-gain” on surrounding areas.
E.g. does the measure enable the deconstruction of parking lots or roadway and more importantly does the re-gained space get used in a more social way (recreation, green space, gastronomy)? Can an expansion or construction of areas for motor traffic be made redundant? For the evaluation of this indicator, the size of the area and the subsequent / alternative use within the urban context needs to be included in the assessment.
- Evaluation of impact by relative change of the indicator in a typical year of the operation phase. The project case (“with measure”) is compared directly with the reference case (“without measure”). The maximum range of quality change is +/- 2, see formalised assessment below.
- Definition of weighting factor related to the importance of this indicator in the municipal context
- Multiplication of qualitative assessment with municipal weighting factor

Please use the following scheme for a formalised assessment:

Formalised Assumption	Explanation for formalised assessment

+2 major positive impact	Scope, location and / or quality of the released/deconstructed area are such that they lead to a <u>significant improvement</u> of residential and / or urban quality
+1 positive impact	Scope, location and / or quality of the released/deconstructed area are such that they lead to an improvement of residential and / or urban quality
0 No relevant impact	not relevant / not known, meaning no space gained / consumed
-1 negative impact	Consumption of land for walking or cycling infrastructure, will have a small negative impact on the urban quality because of their size, location and / or quality
-2 major neg. impact	Consumption of land for walking or cycling infrastructure, will have a <u>significant negative</u> impact on the urban quality because of their size, location and / or quality

The assessment result is gained by multiplying the different single values (assumption and weighing factor) to weighted utility points, which represents the difference to the base case.

Required input data
<ul style="list-style-type: none"> Information on dismantling or consumption of areas related to bicycle or pedestrian measures Information on quality of previous or subsequent use
Further remarks
-

Indicator: Noise pollution
Target system: Environment
Description of Indicator
Relevance
<p>Noise does not only disturb people, it can also, depending on its duration and level, cause serious health effects, e.g. cardiovascular diseases, cognitive impairment or sleep disturbances which can lead to a loss of productivity and put a burden to the health care system (EU 2018).</p> <p>The combined effect from greater urbanisation, that means more people exposed to traffic noise, and from increased traffic volume makes noise a very relevant indicator to monitor.</p>
Definition
Noise is undesirable, unpleasant or harmful sound. While sound is precisely measurable as a physical phenomenon (above), noise is a subjective sensation.
Assessment approach

Measurand _{case with-without}										
Measurand										
Weighted utility points: qualitative, weighted assessment										
Calculation Procedure										
Assessed transport mode										
All motorised modes (public, private and commercial)										
Calculation rules										
<p>The formalised assessment is explained in the following steps, including an explanatory case:</p> <ul style="list-style-type: none"> • Identification of areas where measure either causes reduction or increase of noise levels • Identification of impact of either reduction or increase of noise levels. E.g. does the measure reduce noise significantly – or even beneath national target values or set limits - in an area where no people live but by deviation of traffic increases noise levels – even to a lesser extend - in areas where many people are affected? This could be the case by implementing a pedestrian zone in a street where only shops are but no one lives. But by shift from motorized modes to non-motorised modes in sufficient quantities (see further remarks) noise levels could be reduced without the displacement effects sketched above. • Evaluation of impact by relative change of the indicator in a typical year of the operation phase. The project case (“with measure”) is compared directly with the reference case (“without measure”). The maximum range of quality change is +/- 2, see formalised assessment below. • Definition of weighting factor related to the importance of this indicator in the municipal context. • Multiplication of qualitative assessment with municipal weighting factor. <p>Please use the following scheme for a formalised assessment:</p> <table border="1"> <thead> <tr> <th>Formalised Assumption</th> <th>Explanation for formalised assessment</th> </tr> </thead> <tbody> <tr> <td>+2 major positive impact</td> <td>Extent of noise reduction leads to a <u>significant improvement</u> of inhabited areas. For estimation of impact noise maps according to END might be helpful if available for at least for case before measure is implemented (see further remarks). Please take also into account possible noise pollution effects of traffic deviations caused by the measure (see calculation rules above for explanation).</td> </tr> <tr> <td>+1 positive impact</td> <td>Extent of noise reduction leads to an <u>improvement</u> of inhabited areas. END might be helpful if available for at least for case before measure is implemented (see further remarks) Please take also into account possible noise pollution effects of traffic deviations caused by the measure (see calculation rules above for explanation).</td> </tr> <tr> <td>0 No relevant impact</td> <td>not relevant / not known, meaning verifiable change in noise/sound levels</td> </tr> <tr> <td>-1 negative impact</td> <td>Extent of noise increase leads to a <u>negative</u> impact on inhabited areas See comments above</td> </tr> </tbody> </table>	Formalised Assumption	Explanation for formalised assessment	+2 major positive impact	Extent of noise reduction leads to a <u>significant improvement</u> of inhabited areas. For estimation of impact noise maps according to END might be helpful if available for at least for case before measure is implemented (see further remarks). Please take also into account possible noise pollution effects of traffic deviations caused by the measure (see calculation rules above for explanation).	+1 positive impact	Extent of noise reduction leads to an <u>improvement</u> of inhabited areas. END might be helpful if available for at least for case before measure is implemented (see further remarks) Please take also into account possible noise pollution effects of traffic deviations caused by the measure (see calculation rules above for explanation).	0 No relevant impact	not relevant / not known, meaning verifiable change in noise/sound levels	-1 negative impact	Extent of noise increase leads to a <u>negative</u> impact on inhabited areas See comments above
Formalised Assumption	Explanation for formalised assessment									
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+1 positive impact	Extent of noise reduction leads to an <u>improvement</u> of inhabited areas. END might be helpful if available for at least for case before measure is implemented (see further remarks) Please take also into account possible noise pollution effects of traffic deviations caused by the measure (see calculation rules above for explanation).									
0 No relevant impact	not relevant / not known, meaning verifiable change in noise/sound levels									
-1 negative impact	Extent of noise increase leads to a <u>negative</u> impact on inhabited areas See comments above									

<p>-2 major neg. impact</p>	<p>Extent of noise increase leads to a <u>significant negative</u> impact on inhabited areas See comments above</p>	
<p>The assessment result is gained by multiplying the different single values (assumption and weighing factor) to weighted utility points, which represents the difference to the base case.</p>		
<p>Required input data</p>		
<ul style="list-style-type: none"> Information on sound/noise levels in areas related to the measures before and after implementation of the measure most likely in dB (A) (e.g. from strategic noise maps), see further remarks Information on affected persons 		
<p>Further remarks</p>		
<ul style="list-style-type: none"> Sound levels are expressed in decibels (dB) on a logarithmic scale. A logarithmic scale is used since it lies closely to the human perception of the amplitude of acoustic waves. Since the human ear does not have the same sensitivity for all frequencies, a so-called A-weighting is used and the resulting sound pressure level is expressed in dB (A). The Environmental Noise Directive (END/ Directive 2002/49/EC) is the main EU instrument to identify noise pollution levels and to trigger the necessary action both at Member State and at EU level. The Directive applies to noise to which humans are exposed, particularly in built-up areas or quiet areas in an agglomeration (e.g. parks) and noise-sensitive buildings (schools, hospitals). It requires Member States to prepare and publish, every 5 years - starting from June 2007, noise maps and noise management action plans for e.g. agglomerations with more than 100,000 inhabitants and major roads, railway and airports. The noise maps – also called strategic noise maps – (EU, 2002). END requires the provision of exposure data in 5 decibel bands (55–59 dB L_{den}, 60–64 dB L_{den}, 65–69 dB L_{den}, 70–74 dB L_{den}, > 75 dB L_{den}). Whereas L_{den} is: day, evening and night level. High noise levels' are defined in the 7th EAP as noise levels above 55 dB L_{den} and 50 dB L_{night}, and 55 dB L_{den} is the EU threshold for excess exposure (EEA, 2014). Increasing or decreasing a given dB value by 3 dB is equivalent to doubling or halving the sound intensity. If, for example, the traffic noise was reduced by a reduction of the maximum permissible speed by 3 dB, this would be equivalent to the effect of halving the traffic volume. And 3 dB would be minimum change in noise levels that can be perceived by a person's hearing. A change of 10 dB corresponds to the sound perception of the person doubling or halving the volume and this would correspond with a 90% reduction of traffic volumes (BUWAL 2003). 		

Indicator: Accessibility - increased access of non-motorized residents' to amenities (e.g. jobs)
Target system: Society
Description of Indicator
Relevance
Due to its low cost walking and even more cycling - taking its comparatively larger radius of action into account - are particularly suitable to enable all but esp. the non-motorised - residents, participation in public life.
Definition
Since the indicator travel time reflects the time aspect of accessibility and its monetary value, this indicator addresses the availability of high quality routes to amenities for pedestrians and cyclists and therefore aspects of comfort.
Assessment approach
Measurand _{case with-without}
Measurand
Weighted utility points: qualitative, weighted assessment
Calculation Procedure
Assessed transport mode
Non-motorised transport (walking and cycling)
Calculation rules
<p>The formalised assessment is explained in the following steps, including an explanatory case:</p> <ul style="list-style-type: none"> • Identification of impact of walking or cycling measure on accessibility of non-motorized residents. E.g. does the proposed measure lead to a better/safer route to amenities like schools, jobs, supply or recreational facilities. • Evaluation of impact by relative change of the indicator in a typical year of the operation phase. The project case (with measure) is compared directly with the reference case (without measure). The maximum range of quality change is +/- 2, see formalised assessment below. • Definition of weighting factor related to the importance of this indicator in the municipal context • Multiplication of qualitative assessment with municipal weighting factor <p>Please use the following scheme for a formalised assessment:</p>

Formalised Assumption	Explanation for formalised assessment	
+2 major positive impact	Proposed measure leads to a <u>significant improvement</u> in accessibility of amenities (e.g. schools, sub-centres,) for non-motorised residents. This can be either due to improvement of already existing routes to amenities, or establishment of high quality routes to additional amenities.	
+1 positive impact	Proposed measure leads to an improvement in accessibility of amenities (e.g. schools, sub-centres,) for non-motorised residents. This can be either due to improvement of already existing routes to amenities, or establishment of high quality routes to additional amenities.	
0 No relevant impact	not relevant / not known, meaning no changes in accessibility	
-1 negative impact	Proposed measure leads to a deterioration in accessibility of amenities (e.g. schools, sub-centres,) for non-motorised residents (esp. children and senior citizens).	
-2 major neg. impact	Proposed measure leads to a <u>significant deterioration</u> in accessibility of amenities (e.g. schools, sub-centres,) for non-motorised residents (esp. children and senior citizens).	
The assessment result is gained by multiplying the different single values (assumption and weighing factor) to weighted utility points, which represents the difference to the base case.		
Required input data		
<ul style="list-style-type: none"> Information on locations of relevant amenities, e.g. schools Information on previous quality of routes and infrastructure 		
Further remarks		
-		

Indicator: Separation effect

Target system: Society

Description of Indicator

Relevance

Traffic spaces and the traffic on them have a strong influence on structure and shape of a city and its social quality. For example, they cannot only connect green and settlement areas, but – under heavy use by vehicles – also disconnect (separation effect). This can result in altered spatial activity patterns. Thus more remote local amenities or recreational areas are being preferred to the ones close by, because the way to the nearest site is perceived as uncomfortable due to essentials crossings of busy streets. Additionally, the recreational areas can be limited in their functions, due to strong noise pollution. Since a liveable city

should organise traffic in a way that pedestrians do not encounter undue restrictions, the separation effect of traffic spaces also needs to be taken into account.

Definition

Since the time consumption for pedestrians associated by the separation effect of streets reflected and monetised by indicator travel time, this indicator is meant to address the social aspect of separation.

Measurand

Weighted utility points: qualitative, weighted assessment

Calculation Procedure

Assessed transport mode

Non-motorised transport (walking)

Calculation rules

The formalised assessment is explained in the following steps, including an explanatory case:

- Identification of impact of walking or cycling measure on separation effect of busy streets.
E.g. does the proposed measure lead to a relevant reduction in motorised traffic.
- Evaluation of impact by relative change of the indicator in a typical year of the operation phase. The project case (with measure) is compared directly with the reference case (without measure). The maximum range of quality change is +/- 2, see formalised assessment below.
- Definition of weighting factor related to the importance of this indicator in the municipal context
- Multiplication of qualitative assessment with municipal weighting factor

Please use the following scheme for a formalised assessment:

Formalised Assumption	Explanation for formalised assessment
+2 major positive impact	Proposed measure leads to a <u>significant reduction</u> of motorized traffic in locations with already high pedestrian volumes and high demand of pedestrians willing to cross the streets or locations with „pedestrian potential“ due to proximity of residential and recreational areas.
+1 positive impact	Proposed measure leads to a reduction of motorized traffic in locations with already high pedestrian volumes and high demand of pedestrians wanting to cross the streets or locations with „pedestrian potential“ due to proximity of residential and recreational areas.
0 No relevant impact	not relevant / not known, meaning no changes in separation effects
-1 negative impact	Proposed measure leads to an increase of motorized traffic in locations with already high pedestrian volumes and high demand of pedestrians wanting to cross the streets or locations with „pedestrian potential“ due to proximity of residential and recreational areas.

-2 major neg. impact	Proposed measure leads to a <u>significant increase</u> of motorized traffic in locations with already high pedestrian volumes and high demand of pedestrians wanting to cross the streets or locations with „pedestrian potential“ due to proximity of residential and recreational areas.	
The assessment result is gained by multiplying the different single values (assumption and weighing factor) to weighted utility points which represents the difference to the base case.		
Required input data		
<ul style="list-style-type: none"> Section-wise changes of traffic volumes before and after implementation of measure Information on streets with high pedestrian volumes and/or high pedestrian crossing demand Information on streets with pedestrian potential 		
Further remarks		
-		

Indicator: Improvement in pedestrian and cycling environment quality	
Target system: Private business	
Description of Indicator	
Relevance	
Making space for pedestrians and cyclists more attractive has not only a direct benefit for the direct users, but it may have a positive side effect on the surrounding environment. In this manner, the improved safety, accessibility and attractiveness of public spaces may result in a value uplift of commercial and residential real estate, which reflects citizens' preference for attractive neighbourhoods, and which produces economic benefits for private businesses or individuals.	
Definition	
This indicator assesses the qualitative improvement of the public realm as an additional benefit of walking and cycling infrastructure investments.	
Assessment approach	
Measurand _{case with-without}	
Measurand	
<ul style="list-style-type: none"> Weighted utility points: qualitative, weighted assessment 	
Calculation Procedure	

Assessed transport mode	
(walking and cycling indirectly)	
Calculation rules	
<p>The formalised assessment is explained in the following steps, including an explanatory case:</p> <ul style="list-style-type: none"> • Identification of public spaces, where the walking or cycling measure affects the neighbourhood, indicating additional developments in street view (e.g. surrounding buildings, or lighting provision of streets). • Identification of impact of measure, thus improvement of the pedestrian and/or cycling environment. E.g. does the proposed measure lead to increased personal security on the streets and squares. • Evaluation of impact by relative change of the indicator in a typical year of the operation phase. The project case (with measure) is compared directly with the reference case (without measure). The maximum range of quality change is +/- 2, see formalised assessment below. • Definition of weighting factor related to the importance of this indicator in the municipal context • Multiplication of qualitative assessment with municipal weighting factor <p>Please use the following scheme for a formalised assessment:</p>	
Formalised Assumption	Explanation for formalised assessment
+2 major positive impact	Very high standards in the overall environment, with the majority of street components designed to current best practice. The environment is aesthetically pleasing and efforts have been made to foster a sense of place with high quality materials used throughout. Good access and egress is possible with plenty of space to cater for all user types with no-to-limited conflict with motorised vehicles: where this does occur, pedestrians and/or cyclists have priority over vehicles. High levels of perceived personal security present including good lighting provision and high natural surveillance providing an environment that people feel safe within and are happy to spend significant periods of time in.
+1 positive impact	Reasonably high standards in the overall environment: some of the street components have been designed to current best practice with quality materials used for most of the area. The environment is aesthetically pleasing with some sense of place. Improved access and egress possible with sufficient space to cater for all user types with limited conflict with motorised vehicles: where this does occur, pedestrians and/or cyclists have priority over vehicles in most instances, especially where vehicle flows are high. Good levels of perceived personal security present including good lighting provision and natural surveillance providing an environment that people feel safe within and are happy to spend time in.
0 No relevant impact	An average score would be gained by a reasonably well maintained area that had pleasant and durable materials and some good provision of public space. Overall it would not be an unpleasant place to be. Attempts have been made to minimise conflict with motorised vehicles and where vehicle flows and speeds are high these conflict points provide pedestrian and/or cyclist priority. The provision would be generally adequate for the flows encountered with reasonable natural surveillance and adequate lighting provision.
-1 negative impact	The environment is relatively poor and may include deteriorating buildings, use of low quality materials and/or proximity to a main traffic corridor that creates noise or spray that is likely to lessen the overall quality. Space is insufficient to cater for all users at all times, with periods of congestion resulting in some conflict with access / egress points restricted at times. Conflicting movements between pedestrians and/or cyclists and motorised vehicles can occur that to the most vulnerable users may feel

	threatening or uncomfortable. Perceived feelings of personal security may be low due to a lack of or poor lighting provision, low user flows and/or low levels of natural surveillance.	
-2 major neg. impact	The environment has harsh or uncomfortable surroundings that may include decaying buildings, poor materials used throughout and/or proximity to a major traffic corridor creating excessive noise or spray. Space is insufficient to cater for users resulting in conflict and limited access / egress points. Severe conflicting movements can occur between pedestrians and/or cyclists and motorised vehicles that are likely to feel threatening /uncomfortable. Perceived feelings of personal security may be low due to lack of or poor lighting provision, low user flows and very little natural surveillance.	
The assessment result is gained by multiplying the different single values (assumption and weighing factor) to weighted utility points which represents the difference to the base case.		
Required input data		
<ul style="list-style-type: none"> Information on streets and public spaces with improved quality of the pavement, lighting conditions, and overall personal security Information on previous quality of the infrastructure, lighting provision and security on the public spaces 		
Further remarks		
<p>The qualitative evaluation is a derivation of the quantified improvement in pedestrian environment quality calculated from PERS and CERS audits methods developed by TRL (this is the weighted change in scores for four PERS Link criteria – lighting, personal security, quality of environment, maintenance). This quantified improvement is furthermore an input variable for the more complex calculation procedure of the British “Valuing Urban Realm Toolkit“, provided by Transport for London (TfL). This evaluates the value uplift of buildings resulted from the pedestrian or cyclist improvements. For more precise calculation, including all further considered components, please refer to the guidelines for the application of PERS and CERS audits (TRL 2014), as well as to the latest version of the “Valuing Urban Realm Toolkit Guideline“, or to the paper of Sheldon et al. (2010).</p>		

5. Application of the impact assessment tool in partner cities

In the second half of the project, the Flow partner cities have applied the assessment methodology and tool to evaluate the various impacts of their walking and cycling measures. all results, including the lessons learned can be found in Deliverable 3.4 Local Implementation Scenarios and Action Plans.

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