English

Promoting Cycling for Everyone
as a Daily Transport Mode

Cycling: a daily transport mode for everyone

GIVE CYCLING A PUSH

PRESTO Cycling Policy Guide

Electric Bicycles

INTELLIGENT ENERGY EUROPE

The Project

PRESTO (Promoting Cycling for Everyone as a Daily Transport Mode) is a project of the EU's Intelligent Energy – Europe Programme granted by the Executive Agency for Competitiveness and Innovation (EACI).

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European Cyclists' Federation, Belgium
European Twowheel Retailers' Association, Belgium
Ligtermoet & Partners, the Netherlands
Promotion of Operational Links with Integrated Services, Belgium
Pomeranian Association Common Europe, Poland
German Cyclists' Federation Bremen, Germany
Free Hanseatic City of Bremen, Germany
Grenoble Alpes Métropole, France
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February 2010

Linguistic Versions

Original: English
Translation (not yet available): German, French, Polish, Italian, Croatian
This English version is available at www.presto-cycling.eu and www.etra-eu.com
If you wish to receive a designed version of this guide, please send an e-mail to f.boschetti@ecf.com and you will receive it as soon as available.

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Other PRESTO publications (available at www.presto-cycling.eu)
PRESTO Cycling Policy Guide: **Cycling Infrastructure**
PRESTO Cycling Policy Guide: **Promotion of Cycling**
25 PRESTO Implementation Fact Sheets on **Cycling Infrastructure**, **Promotion of Cycling** and **Legal Provisions for Pedelecs**

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1 Give Cycling a Push: PRESTO policy guides and fact sheets

Cycling policy is on the agenda in European cities. In recent years and decades, many local authorities have been undertaking a range of activities to stimulate cycling as a daily transport mode, because they are increasingly convinced that cycling is good for cities (also see the next chapter).

But decisions makers and those involved in implementation are faced with a lot of questions. How to develop an effective cycling policy? What will be the best approach in my city? How to provide high-quality infrastructure? How to promote cycling use and foster a cycling culture? The increasing success of the Velocity conference series testifies to the need for cycling policy knowledge and exchange of experiences. Success stories have become well-known as inspirational good practice. National and local design guides and cycling research and documentation centers are proliferating. BYPAD has become a key tool to assess and monitor cycling policy. Knowledge is becoming more abundant, but remains largely scattered and adapting it in a specific urban context is still quite a challenge for local authorities.

The PRESTO guidelines and fact sheets are the first effort to bundle **state-of-the-art European knowledge and experience on urban cycling policy** in an easily accessible format. They were developed not only to support the PRESTO cities in their cycling policy activities, but also to serve as **European reference guides**.

The PRESTO project: promoting cycling for everyone as a daily transport mode:

Five cities and a range of experts unite in developing strategies to tap the potential of cycling in cities. The cities represent a range of diverse size, location, culture and cycling tradition. All will deploy actions in three fields: cycling infrastructure, cycling promotion and pedelecs. In the course of the project, they will benefit from training sessions and expert advice. The trainings will further be developed into a set of e-learning virtual classes on cycling policy that will later be open to any interested participants.
www.presto-cycling.eu

The **4 Policy Guides** offer a clear and systematic framework to help decision makers develop a **cycling policy strategy**.

One policy guide presents a **general framework**, outlining the fundamentals of an integrated cycling policy. There are of course no one-size-fits-all answers. This is why the guide proposes to distinguish cities according their level of cycling development as **Starter, Climber and Champion cities**, and suggests approaches and packages of measures that are likely to be most effective at each stage.

Three further policy guides develop one policy area each: cycling **infrastructure**, cycling **promotion** and **pedelecs**. The first two of these outline overall principles, critical issues and decision making factors, without going into technical details. The third on focuses on the role pedelecs can play in urban transport and how local authorities and bicycle retailers can promote their use.

The policy guides are accompanied by **25 implementation Fact Sheets** giving more detailed and practical (technical) information on how to implement a selection of cycling policy measures. They are meant as a working instrument for those involved in **implementing cycling policy**.

The policy guidance offered here is meant to be of real practical use to local authorities in defining their own cycling policy strategy. At the same time, it should be considered as a work in progress and will hopefully stimulate debate, feedback and further revisions and refinement over the coming years.

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Figure 1: PRESTO Fact Sheets and Policy Guides

This is the PRESTO Cycling Policy Guide on Electric Bicycles.

This policy guideline deals with pedelecs which are equipped with an auxiliary electric motor having a maximum continuous rated power of 0.25 kW, of which the output is progressively reduced and finally cut off as the vehicle reaches a speed of 25 km/h, or sooner, if the cyclist stops pedalling only. Further details are under point 5.1.

2 Potential User Groups

Figure 2: Modern Pedelec

Source: Riese und Müller

To date, there is little research into the background of the existing clientele for pedelecs. The available studies show that the majority of pedelec users can be classified in two main groups: 65+ people and commuters. Nevertheless, the average age of pedelec buyers is decreasing. This is likely to be the result of a growing number of commuters using pedelecs and/or new target groups discovering this new means of transport.

The Dutch report "Rapport Elektrisch Fietsen – Marktonderzoek en verkenning toekomstmogelijkheden" (Electric Cycling: market research and exploration of prospects) was published in June 2008[1]. It was based on 1,448 questionnaires. At that time, 3% of the Dutch population owned a pedelec, yet over 40% of the Dutch people indicated (possible) interest in the product.

Those who used pedelecs cycled faster, more often and over longer distances. Consequently, they made less use of the conventional bike and of the car.

At the time of the research, the respondents thought that pedelecs were mainly fit for elderly and physically impaired people, whereas they found pedelecs less suitable for other target groups such as commuters or parents with young children.

[1] Hendriksen Ingrid, Engbers Luuk, Schrijver Jeroen, van Gijlswijk Rene, Weltevreden Jesse (BOVAG), Wilting Jaap (BOVAG), 2008, "Rapport Elektrisch Fietsen – Marktonderzoek en verkenning toekomstmogelijkheden".

Reason for using a pedelec	Pedelec users	Interested in using a pedelec
Conventional cycling is (too) difficult	66%	12%
Conventional cycling may become too difficult	NA	65%
To make cycling with headwind easier	52%	36%
To be able to cycle over longer distances without (much) extra effort	46%	33%
To make it easier to climb hills	29%	19%
I am not very sporty but I would like to have (some) more exercise	17%	NA
To cycle faster (less travel time) without (much) extra effort	11%	13%
As an alternative for less environmentally-friendly means of transport	10%	20%
To get to work without sweating	8%	7%
Other reasons	4%	1%
No opinion	NA	8%

Remarkably enough, one out of 5 respondents were interested in pedelecs for environmental reasons.

The respondents in the Belgian study "De elektrische fiets als duurzame mobiliteit in steden"[2] (the electric bicycle as sustainable mobility in cities) had a quite different view on the potential users of pedelecs. They were asked who, they thought, was the most typical pedelec user:

Most typical pedelec user	%
Commuters	61.4%
Elderly people	32.5%
Less sporty people who want to exercise more	24.9%
People who live in a hilly area	12.7%
Everybody	11.7%
Physically impaired people	10.7%
Sporty people	6.6%
Shoppers	5.6%
People who want to cycle without too much effort	4.6%
Employees in suits	3.6%
People who live in a flat area	3.6%
Long distance cyclists	1.5%
Students and daredevils	1.5%

In 2009, the bicycle and car accessory retail chain Halfords carried out an on-line survey[3], which received over 500 responses. 37% of the respondents would consider buying a pedelec to cycle more easily, whilst 28% was interested because it might help them to get fitter. To the question which characterisation applies best to pedelecs, 60% indicated "comfortable", 59% "easy" whereas 36% opted for "modern". According to Halfords, the average age of pedelec buyers was at that time around 50.

Since a few years, the Swiss Canton Basel-Stadt grants subsidies to pedelec purchasers, provided that they add a complete questionnaire to the subsidy request. Between 2003 and 2008 they received 634 completed questionnaires. This has allowed the Canton to draw up a profile of the average pedelec user, which was published in October 2008[4].

Pedelec users in the Canton Basel-Stadt were on average 49 years old. There was an equal distribution between men and women, but in the age group 20 to 39 women had a greater share, whereas among 65+ men were over-represented. Their level of employment was very high, unemployed pedelec users were underrepresented. Both their gross income and their education level were above average. They lived in bigger households than the rest of the Basel population.

[2] Capelle Jan, Lataire Philippe, Magetto Gaston, Timmermans Marc, "*De elektrische fiets als duurzame mobiliteit in steden*", Vrije Universiteit Brussel.

[3] http://www.tweewieler.nl/nieuws/1591/e-bike-krijgt-steeds-jonger-koperspubliek.html

[4] Schwegler Urs, et al., 2003, "*Auswirkungen elektrischer Zweiräder auf das Mobilitätsverhalten. Schlussbericht des Schweizer Projekts im Rahmen von: Electric Two-Wheelers On Urban Roads (E-TOUR, 5. Eu-Rahmenprogramm)*", University of Bern.

Nevertheless, over the research period the following changes have been observed among Basel pedelec users:
- increasing share of female buyers
- increasing average age
- decreasing level of employment
- decreasing level of education and gross income
- whereas in 2003, 98% of the buyers had a car driver's license, in 2008 that was 82%
Conclusion: the demographic mix of people who buy a pedelec is broadening.

Since a number of years, sales of pedelecs in the EU are steadily increasing. Whereas the numerical growth of the pedelec market is apparent, it is much more difficult to prove the growing popularity of the vehicle among different sections of the population. Available research clearly shows a significant interest among elderly, physically impaired and commuters. Although this means of transport is very suited for many other target groups, they have not yet been mapped in any research. Study of relevant literature allows for the distinction of the following target groups.

2.1 Car Drivers

According to the European Commission's Statistical Pocketbook 2001 "EU Energy and Transport in Figures", every European makes circa 3 trips per day of which about half are up to 3 km. Moreover, about half of all car trips are 6 km or shorter. These figures clearly demonstrate that the potential for substituting car trips by cycling is huge.

The electric bike is particularly appropriate for convincing die-hard car drivers to leave their vehicle aside for short distances because it overcomes a number of "popular" objections against cycling. As shown in the table above, interest in pedelecs springs to a large extent from the fact that cycling is made easier and more comfortable.

All research so far shows pedelecs are used as an additional means of transport without however generating additional traffic. The Swiss study "Elektro-Zweiräder - Auswirkungen auf das Mobilitätsverhalten" (Electric Two-Wheelers – Effects on Mobility) shows that the use of pedelecs resulted in 5.2% less car kilometres. What's more, the study has found that pedelecs incite people to think about routines in their transport behaviour.

Therefore, it concludes with the following recommendations: "The use of LEVs should be encouraged. (…) LEVs question the traditional approach to mobility. LEV encouragement should particularly focus on heavily motorised households."[5][6]

A 2008 special Eurobarometer on attitudes towards the environment[7] shows that European citizens attach great value to the environment and are increasingly aware of the role that the environment plays in their lives. Asked about the actions they take for environmental

[5] Schwegler Urs, et al., 2003, "Auswirkungen elektrischer Zweiräder auf das Mobilitätsverhalten. Schlussbericht des Schweizer Projekts im Rahmen von: Electric Two-Wheelers On Urban Roads (E-TOUR, 5. Eu-Rahmenprogramm)", University of Bern.

[6] LEV = light electric vehicle – the study concerns electric two, three and four-wheelers, e-bikes in this instance means any bicycle equipped with an auxiliary electric motor.

[7] European Commission, Directorate General Environment, 2008, "*Attitudes of European citizens towards the environment*", Special Eurobarometer 295.

reasons, 28% indicate choosing an environmentally friendly way of traveling (foot, bicycle, public transport). In Finland, Sweden, the Netherlands, Denmark, Slovakia and Hungary, this percentage is more than 40%. Of the EU-27 respondents, 17% indicate less car usage as an action for the environment. In Luxembourg, Finland, France, Belgium, Germany and the Netherlands more than 1 out of 4 respondents mention this action. A 2007 Flash Eurobarometer on European transport policy[8] shows that 56% of the EU-27 respondents tried to save fuel by walking or cycling more.

In conclusion, the growing concern for the environment and the rising cost of car usage clearly creates opportunities to convince car drivers of swapping their car for an electric bike for certain trips.

2.2 Commuters

Commuters opt for the car rather than for the bike as soon as they have to travel more than 7 kilometres. The average speed of an electric bike is 24 km/h, compared with 17 km/h on a traditional bike. Since electric bikes make rides easier (no transpiration) and quicker, commuter trips up to 15 km one way are within reach. Employers can incite their employees to use a pedelec for commuting, for instance by participating in existing tax incentive schemes such as allowances for commuting by bike or company bikes, by including pedelecs in mobility plans or by leasing pedelecs. In 2009, Riese und Müller[9] was the first manufacturer to offer a leasing scheme for their pedelecs. Furthermore, there are companies specialised in leasing electric bikes, such as Electric Bikes Fleet[10] (UK) or Electric Bikes Lease[11] (NL).

Pedelecs are accessible for all types of commuters. They make cycling easy, regardless of fitness level or physical condition. They enable riders to tackle hills and headwinds without minimal effort. A pedelec can easily reach an average speed of 20 km/h, which is significantly more than the average speed of cars or public transport in city traffic. They can zip to work without needing a shower on arrival. The use of a pedelec will improve their physical condition, which in turn results in fewer sick leaves.

[8] European Commission, Directorate General Energy and Transport, 2007, "*Attitudes on issues related to EU Transport Policy - Analytical report*", Flash Eurobarometer 206b.
[9] http://www.r-m.de/produkte/leasing/
[10] http://www.electricbikesfleet.co.uk/
[11] http://www.eb-lease.nl/

2.3 Parents & Shoppers

Figure 3: Parents and shoppers

Source: Giant   Source: Babboe

Carrying a child and/or full shopping bags on a bike can be quite arduous. Pedelecs solve the problem of carrying weight, whether it concerns a child in a seat on the rear carrier, bags on the front and/or back of your vehicle, a trailer, … Manufacturers begin to develop specific pedelecs for this purpose, for instance carrier cycles with pedal assistance or electric cargo bikes.

Pedelecs also allow parents and shoppers to avoid parking problems in town.

"*The cargo bicycle on its own is a great concept, but if you live in a hilly place (like I do), it can be a bit difficult to haul a hundred pounds of kids or dog food up and down those hills on a regular occasion. After we got our new (…) cargo bike, which can haul up to four kids at once, I was excited to own a whole-family transportation bike. But the ride from my home starts with a big hill. And if I was feeling less than 100%, I was just not motivated to pedal that bike full of kids up that hill. The end result was that, in the first 2 months that we had the bike, I used it about once every week or two for a weekend outing to the park or farmer's market, and that was all I could handle. (…) Then we installed an electric assist kit (…). What a difference! Suddenly it became fun to load up the bike with kids and go out for a ride. (…) We now use the bike all the time for running kids around the place. And it works great for doing errands like picking up dog food, garden mulch, and other big bulky stuff.*"[12]

This is a testimonial by Dr. Morgan Giddings, a former recreational cyclist who turned into a utilitarian cyclist upon learning about Peak Oil. After unsuccessfully attempting to work with local bike shops to obtain an electric cargo bicycle, she co-founded Cycle 9[13], a bike shop specialised in practical solutions, including cargo bikes and electric bikes that help people ride their bike more and use cars less.

2.4 Professional Groups who need to travel a Lot over short Distances

Home delivery is becoming fashionable again. Grocers, bakers, butchers, fishmongers, … redevelop this service to the customer in an attempt to distinguish themselves from their competitors and to improve their customer relations. Whereas in earlier days, they would have used a moped, today a pedelec will prove to be just as fast and effective whilst being clean and quiet. This in turn will have a positive contribution to the social responsibility of the company. In the meantime, the pizza-boys and all other food home delivery services are abandoning mopeds for the benefit of pedelecs.

[12] Giddings Morgan, "*A Quiet Revolution in Bicycles: Recapturing a Role as Utilitarian People-Movers (Part I)*", published on www.chrismartenson.com

[13] http://www.cycle9.com/

Figure 4: « Dreirad »

Source: Olaf Lange Dreiradbau

Lawyers, bankers, real estate agents, doctors and couriers are also putting pedelecs in use to make their professional trips faster, more reliable and enjoyable. During the Copenhagen Climate Conference 2009, the Avenue Hotel[14] made pedelecs available to their guests with a view to helping them "greening" their stay. This is only one of a growing number of hotels that have a fleet of pedelecs available for their clientele, which mainly exists of business people. The pedelecs allow them to get to their meetings on time. With that, new companies are emerging that offer pedelec fleets not only to hotels but also to companies, tourist businesses, local councils.

2.5 Emergency services

Figure 5: Pedelecs for professional use

Source: elektrischefietsen.com Source: Transporte del Futuro

The very first ambulance pedelec was shown at the Dutch national pedelec test day in 2008[15]. Since, several models have been introduced and purchased. They are very robust bicycles equipped with cases that hold life support equipment. They are put into action in two different situations. During large events such as concerts, fairs, sports events, the ambulance pedelec is used for first aid. Large companies where first-aiders sometimes have to walk a considerable distance to reach the injured also show interest in this vehicle. Alternatively, they are used in urban areas where either car usage is hindered or where traffic is extremely dense. A pedelec ambulance provides speed and access so that acute

[14] http://www.avenuehotel.dk/index.php?id=141
[15] http://fietsen.web-log.nl/fietsen/2008/05/wereldprimeur-e.html

first-aid can be given, even if in expectation of a four-wheeled ambulance to take the patient to hospital.

Police officers patrolling by bike are becoming a very familiar sight in more and more European cities. The bicycles are easy to manoeuvre, quiet and allow for a fast pursuit irrespective of the terrain or traffic. Apparently, police officers have some special techniques to use their vehicle as an additional weapon in their fight against crime. More importantly, bicycles contribute to their image and they are considered more approachable then their colleagues in cars.

Quite a number of voluntary firemen use a bicycle when they receive an emergency call because this is the fastest means of transport to their station. Moreover, firemen involved in prevention also use two wheels to call on visit.

There are specific pedelecs on the market for police forces as well as for firemen. They make their job easier and they speed up their interventions.

2.6 Civil Servants & Politicians

Many postal services in the EU already have pedelecs on the road, among which in Germany, UK, Finland, the Netherlands, Denmark, France, Italy and Austria. In 2009, the Belgian "De Post" has come to an agreement with WWF on 35% less CO^2 emissions by 2010. Consequently, De Post is now testing pedelecs with a view to replacing their current fleet of mopeds[16].

Of course, pedelecs for postal services need to be specifically designed for their heavy duties. Several companies have such models in their range. These extra strong pedelecs are equipped with special features such as racks and bags to carry the post, a special stand and a stabiliser to prevent the front wheel from tilting during standstills.

Pedelecs are also very well suited for civil servants and politicians who regularly have to travel short distances for work. Pedelecs allow them to ride without getting out of breath and without sweating, regardless whether the ground is flat or hilly. Moreover, the fact that they opt for sustainable mobility will have a positive influence on public opinion.

The Eco-Management Audit Scheme (EMAS) working group of the European Parliament has decided to supplement the service bicycle fleet with one pedelec in Brussels and 1 in Luxembourg as a test.

Figure 6: DG TREN Director General Matthias Ruete, Members of the European Parliament

Source: ETRA

[16] http://www.wwf.be/NL/?inc=news&newsid=728&pageid=news

2.7 65+

In 2008, 17.1% of the population in the EU-27 was aged 65+, that is 84.6 million people (source: Eurostat). Many of them become less mobile as they age. As a result of failing strength and a deteriorating condition, they are no longer capable of cycling. Pedelecs allow this age group to remain mobile and fitter for a longer time. Also, there are models available, which are specifically designed for this group, for instance pedelecs with a step-through frame and electric three wheelers.

Furthermore, pedelecs can also incite grandparents to go cycling with their grandchildren, since with pedal assistance they will be able to keep up with them.

The Dutch report "Electric Cycling: market research and exploration of prospects" shows that 89% of the 65+ people who own a pedelec, use it for recreational trips, 68% for shopping and 47% for visiting. This shows that pedelecs are effectively used as a means to safeguard their mobility and to maintain their independence and their social inclusion.

Source: www.elektrischefietsen.com

2.8 People with Health Problems

The Swiss study « Evaluation d'impact sur la santé Promotion du vélo à assistance électrique »[17] (Evaluation of the impact on health of the promotion of pedelecs) concludes that pedelec use helps to prevent cardiovascular diseases, hypertension, diabetes type II and colon cancer. As a result, pedelec use helps to reduce the general cost of the health system.

Source: Flyer

Apart from the preventative function of pedelec use, the vehicles are also extremely well suited to allow people suffering from chronic diseases to continue to exercise or to rehabilitate. This is the case for patients with multiple sclerosis, cancer, obesity, cardiovascular diseases, etc.

[17]Cantoreggi Nicola, Diallo Thierno, 2006, "*Evaluation d'impact sur la santé Promotion du vélo à assistance électrique (VAE)*", République et canton de Genève, Département de l'économie et de la santé, Direction générale de la santé.

2.9 Tourists

Cycling tourism in Europe is becoming increasingly popular. The Dutch polders, the Loire region or the cycling path along the Danube are suited for the overall majority of cyclists. The Alps, Abruzzo or the Dolomites however are reserved to the very well trained cyclists or to those who enjoy pedal assistance.

Source: Ezee

Little by little tourist businesses in hilly or mountainous regions discover the potential of pedelecs to achieve sustainable tourism. They put pedelecs up for rent, develop specific cycling routes and create spots where cyclists can charge their batteries. The Swiss manufacturer of the Flyer electric bicycles has developed the Movelo programme[18], fully organised electric bike holidays in Germany, Austria and Mallorca.

In 2009, the first edition of "La Montée Electrique"[19] (the electric ascent), more specifically of Alpe d'Huez took place. The organisers all are fanatic supporters of environmentally-friendly transport. Their event is aimed at making the electric bicycle better known as a clean vehicle that is accessible to everybody.

City trips by pedelec are bound to prosper. The organisation "Paris Charms & Secrets"[20] is probably one of the trailblazers paving the way for many more electric city tours in Europe to come.

The importance of tourism use of pedelecs for their acceptance as a utilitarian means of transport should not be underestimated. Many people have their very first pedelec experience during their holidays. Once they have been introduced to the vehicle and "felt" it, an interest may start to grow. Furthermore, tourism makes pedelecs visible.

[18] http://www.movelo.com/elektrofahrrad/
[19] http://www.la-montee-electrique.com/
[20] http://www.parischarmssecrets.com/

3 The Market

3.1 Current Market

There are no exact statistics available for the production, sales, import and export of electric bicycles in the European Union. As for EU sales however, there are various estimates.

Bike Europe, the international trade journal for the European bicycle and scooter market, published the following in their April 2009 issue: "*For the entire European Union with its current 27 member states, 2008 sales are estimated by some industry associations at 300,000 units, which seems too low considering that in Holland and Germany alone last years sales stood at about a quarter of a million units. For 2009 the industry associations are expecting sales to grow to about 400,000 units in Europe. This number again seems to be an underestimation given that in Europe's main markets, Germany and the Netherlands, public interest in e-Bikes is at high level.*"

The "Electric Bikes Worldwide Reports – 2010 Update"[21] estimates European sales in 2009 at 750,000 and has a prognosis of 1,000,000 vehicles in 2010. In any case, the European Union is now the second largest market in the world after China. The very high sales volume in China is due to the fact that a large number of cities have legally banned petrol engine mopeds and scooters. People had no other choice than to opt for electric bicycles. In China, the type that can be propelled be the motor itself largely dominates the market.

It is important to note that since 2007, growth in the EU is vigorous. Today, the European market of electric bicycles consists almost exclusively of pedelecs. As for individual member states, the following data have been published.

Austria

Pedelec sales have only started in 2009. The take-off was partly linked to the entry into the market of the Austrian bicycle manufacturer KTM.

Belgium:

There are no statistics available but the most important suppliers all confirm the success of the electric bicycle. Since 2007, Sparta, which is one of the most popular brands in Belgium reports growth of 10 to 15% a year, with a +15% prognosis for 2009. With that, sales of electric bikes are reported to increase more than other types of bikes.

Denmark

Sales in 2009 were estimated at 8,000 units.

France:

Sales in 2008 were at 15,800 units, which is a 50% improvement of the 2007 result.

Germany:

[21] Benjamin Ed, Jamerson Frank, 2010, "*Worldwide Electric Bike Reports, 2010 Update to 2009 Edition*".

In 2008, an estimated 100,000 electric bicycles were sold, which is 2.5% of total sales volume. Growth is considerable: +62.5% in 2007, +54% in 2008 and a forecasted +20% in 2009.

Italy:

Sales in 2008 are estimated at 10,000, whereas for 2009 they were expected to increase to 30,000. Sales may well be further encouraged as a result of the cycling incentive scheme. (see point 4.2).

The Netherlands:

In 2008, almost 140,000 electric bikes were sold at an average retail price of € 1,900. Thus electric bicycles have generated 1/3 of the total revenue from sales of new bikes in Holland. In the first half of 2009, sales grew further by 49% to 105,000. Average price was just over 2,000, whilst electric bikes achieved a 12% share in the total bicycle sales.

UK:

In 2009, the leading electric cycle manufacturers and distributors in the UK have formed the British Electric Bicycle Association (BEBA)[22] to provide membership services for manufacturers, distributors and dealers. According to BEBA UK electric bicycle sales hit an all-time record of over 15,000 units sold in 2009. The total value of the market was around £13 million in 2008 with sales of £25 million predicted for 2009 and a further 50% growth predicted by manufacturers for 2010.

At the 2009 Eurobike-show in Friedrichshafen[23], which is the most important international show for the bicycle industry, a total of 82 electric bicycle manufacturers exhibited. Of these, some 30 companies started off in the conventional bicycle business, whereas more than 50 companies were newcomers in the electric cycle industry. The companies were not only originating from the EU but also from the Far East and from America. Next to them, 9 battery producers were also present in Friedrichshafen.

Unfortunately it is not possible to provide reliable information as to turnover, production, import, export, nor the total number of people employed in the production of electric cycles and related components and accessories. The only possible estimate is the following. Suppose the 2009 EU sales are 400,000, as indicated in Bike Europe, at let's say an average sales price of € 1,500, then this results in a European wide revenue of almost € 6oo million.

In any case, the success of pedelecs in the Netherlands clearly shows in the statistics of EU bicycle production. In 2008, for the very first time the Dutch value of bicycle production outran the German value. It was sent up as a result of the high value of pedelecs. Compared with 2007, the Dutch value rose by 20% to € 577 million in 2008, whereas German value was € 340 million.

3.2 Future Market

It is very difficult to predict the future market of pedelecs in the European Union. Following Everett Rogers' theory on diffusion of innovation[24] (see point 4.3), the innovators constitute 2.5% of all consumers adopting the innovation, the early adopters 13.5%. Dutch population in 2009 was 16.5 million and each one of them owns at least one bicycle. Consequently, the group of innovators would be just over 400,000 people, whereas in the past few years more than 400,000 pedelecs have been sold. As a result, it is now the group of early adopters who

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[22] http://www.beba-online.co.uk
[23] http://www.eurobike-show.de/
[24] Rogers Everett, 1995, "*Diffusion of innovations (4th edition)",* The Free Press. New York.

are in the process of buying pedelecs and if their assessment of the product is positive, the famous tipping point, at which the majority rapidly adopts the innovation, is imminent. Several industry experts have stated that they expect pedelecs in the Netherlands to acquire a market share of 25 to 30% by 2015. If the majority effectively accepts pedelecs, that prognosis may well come true.

The question is however: how about pedelecs in other EU member states. Jack Oortwijn, Editor in Chief of the European trade paper Bike Europe predicts the following: "*2009 was the year of the electric bicycle. 2010 will be even more so. In those countries (Netherlands and Switzerland) where e-bikes are a trend, their popularity continues to grow. Other countries will follow in 2010, with Germany first. With that in mind, one thing is already certain: 2010 will be a better year than 2009.*"[25]

Belgium and Germany are in the stage of innovators trying out pedelecs, whereas in Denmark, France and the UK, pedelecs are in their very early stages. In quite a number of member states, notably in Eastern Europe, pedelecs are still virtually inexistent.

According to Rogers, the innovation-decision is made through a cost-benefit analysis where the major obstacle is uncertainty. People will adopt an innovation if they believe that it may yield some relative advantage to the idea it supersedes.

Source: Ezee

The Dutch example shows that growth of the pedelec market is to a large extent driven by commuters who use the pedelec because it is cheaper, faster and healthier than the car. Their cost-benefit analysis is positive and they believe traveling by pedelec offers advantages over traveling by car. The cost of car usage is increasing everywhere in the EU, whereas the problems of congestion, pollution and deteriorating public health exist in all member states. This creates a real chance for the diffusion of pedelecs throughout Europe.

Extra Energy[26] founder Hannes Neupert expects pedelec sales in Europe to round the cape of 1 million in 2010 and two million in 2012.

Below is a prognosis published in the 2010 update to the 2009 edition of the Electric Bikes Worldwide Reports. These numbers include all types of two- and three-wheel cycles with an electric motor:

[25] Bike Europe, December 2009, p.2
[26] http://extraenergy.org

	2007	2008	2009	2010	2011	2012
China	21,000,000	22,000,000	21,000,000	22,000,000	23,000,000	25,000,000
India	85,000	20,000	7,500	10,000	15,000	17,500
Japan	300,000	300,000	300,000	325,000	350,000	350,000
EU	250,000	500,000	750,000	1,000,000	1,350,000	2,200,000
Taiwan	10,000	10,000	11,000	12,000	14,000	15,000
SE Asia	200,000	500,000	400,000	600,000	800,000	1,000,000
USA	120,000	170,000	150,000	300,000	400,000	500,000
Total	**21,965,000**	**23,500,000**	**22,618,500**	**24,247,000**	**25,929,000**	**29,082,500**

According to Frank Jamerson Ph.D, and Ed Benjamin, authors of the Reports, pedelec sales in Europe have been obstructed by the unavailability of funds to finance production. Pedelec manufacturers had to provide funds to support component manufacturers six months ahead of the vehicle production. However, they did not have funds available for such a long period and therefore ordered less than what the market needed. This hampered sales. Now, large European companies such as Bosch and possibly Schaeffler and Hella are preparing to enter the electric bicycle business. Their entry should contribute to eliminating the financial bottleneck and to stepping up the production of high quality European pedelecs.

In the article "The Silent Revolution", product developer Han Goes[27] predicts "that clean, silent electrified two- wheelers will cause the biggest ever revolution in the bike industry". However, he warns the bike industry. Today, most manufacturers are 'electrifying' existing bicycle concepts: Dutch city bikes, folding bikes, cargo bikes, … Goes questions this approach: "*The big question is whether this is really what the consumer is looking for, and whether bicycle companies and their product managers should try to better understand the real consumer needs for convenience, comfort, fun, speed in a modern package away from the traditional and archaic concept of the bicycle.*" He pleads for a shift from horizontal product differentiation (= apply the same concept to different groups) to vertical product differentiation (= apply the same functionality i.e. electric mobility to different concepts). He reports that some companies among which Giant, JD Components, Ultra Motor, E-Solex and Elmoto have chosen that path and consumers have shown great interest for their products. Goes warns the bike industry that if they do not opt for vertical product differentiation, they will soon be faced by huge competition from the car industry.

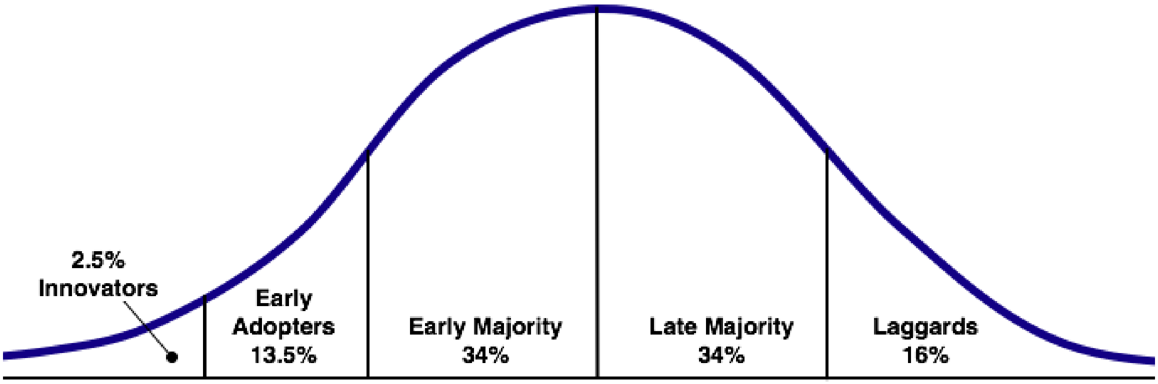
[27] Goes Han, 2009, "*The Silent Revolution*", Eurobike Show Dailies September 2009.

Source: E-Solex Source : Elmoto

3.3 How to stimulate Market Penetration

In "Diffusion of Innovation", Everett Rogers defines diffusion as "the process by which an innovation is communicated through certain channels over time among the members of a social system". Furthermore, he identifies 5 steps in the adoption process:

- knowledge: the individual becomes aware of the innovation
- persuasion: the individual becomes interested in the innovation and actively seeks information
- decision: the individual prepares a decision on adopting or rejecting the innovation
- implementation: the individual effectively uses the innovation
- confirmation: the individual assesses his information and takes a final decision



Source: Everett Rogers Diffusion of Innovations model

With that, Rogers distinguishes 5 adopter categories: innovators, early adopters (who have the highest degree of opinion leadership), early majority, late majority and laggards. When opinion leaders adopt an innovation, diffusion reaches the tipping point and the majority follows with rapid adoption of the innovation.

From this theory, Rogers concludes that there are two major ways to encourage the spread of an innovation:

1) mass media have a powerful effect as a result of spreading knowledge of innovation to a large audience at short notice;

2) A powerful way to push diffusion is to affect opinion leader attitudes. They are more trusted and have a greater influence on doing away with resistance or apathy.

To eliminate lack of awareness, the use of mass media is the most effective. Persuasion of opinion leader is the best way to change attitudes about an innovation.

Today, raising awareness on pedelecs through mass media is happening: CNN, BBC, The New York Times, The Frankfurter Allgemeine,… a lot of major television stations and newspapers have reported on the trend of electric bicycles. Sometimes, celebrities are involved to attract media attention. End of 2009, the Chinese Minister of Technology Wang Gang presented US Secretary of Energy Steven Chu with an electric bike for President Obama and one for himself.[28] Another example involving celebrities is the "Spot the E-bike" action, which Rotterdam is about to launch. If people see a celebrity on a pedelec, they are encouraged to take a photograph and send it in for publication on the dedicated website. With that they can win a prize.

Another successful tactic to get the press is to invite journalists to try out pedelecs with a view to writing a report. Furthermore, there are an infinite number of events offering opportunities to spotlight electric bicycles. At European level, Mobility Week, Green Week, EU Sustainable Energy Week, … are just a few examples of such events. Many events at local, regional or national level offer similar opportunities to raise awareness actively by organising vehicle tests, or passively, by making pedelecs available at events where participants have to cover distances, for instance from public transport locations to the event location or between exhibition/congress locations, …

Convincing people to ride a pedelec is a determining factor in the diffusion process that should not be underestimated. This can and is being done in many different ways. Extra Energy was a pioneer in this process. The organisation has been setting up test tracks for electric cycles since 1992. They started at the most important international bike exhibitions with a view to convincing the industry first and, from there on, gradually expanded their initiatives with a view to informing and persuading the general public. ETRA[29], the European trade association for bicycle dealers, regularly organises test rides for European politicians and European civil servants in order to persuade them to take electric bicycles into account in the development of policies. ETRA has used for instance TREN Day, Mobility Week and Green Week for this purpose.[30] In the Netherlands, the organisation elektrischefietsen.com holds an annual demonstration day.[31] In 2010, visitors have the opportunity to try out almost 30 different brands.

[28] http://www.chinadaily.com.cn/m/tianjin/e/2009-11/27/content_9063895.htm

[29] http://www.etra-eu.com/
[30] http://www.etra-eu.com/newsitem.asp?page=2&type=3&cat=4&id=9166377
http://www.etra-eu.com/newsitem.asp?page=3&type=3&cat=4&id=1282161
http://www.etra-eu.com/newsitem.asp?page=5&type=3&cat=4&id=1464961
[31] http://www.elektrischefietsen.com/Nationale-E-Bike-Opstapdag-2010/Nationale-E-Bike-Opstapdag-2010.html

Green Week

Mobility Week, Source: ETRA

Dealers, manufacturers and importers play a crucial role in informing people on electric bicycles and persuading them of the advantages of the innovation. Many brands as well as dealers are active and sometimes very inspired in this field. In the Netherlands, the Dutch dealer Ruud Worm has been specialising in electric bikes for 10 years. In the margin of his company, he has set up elektrischefietsen.com, a comprehensive and objective Internet site aimed at informing people on electric bicycles. Furthermore, he organises the above-mentioned national demonstration day. Finally, he offers a fully organised weekend in a B&B close to his shop, enabling people to extensively try out different pedelecs. In the Czech Republic, ekolo.cz[32] "helps open-minded individuals and companies change their city transportation habits." Their aim is to provide intensive information and training to increase the usage of electric two-wheelers in Prague and other large cities. The first ekolo.cz showroom was opened in May 2008 in Prague. They do not only sell electric bicycles but also offer hire-purchase schemes and short term rent. For companies, they have developed a special programme similar to car fleet management, FleetBike. They are also preparing a special GPS application for city bikers.

In Austria, KTM has set up an alliance with Opel offering a so-called ecoPaket.[33] Buying certain car models before a set date was rewarded with an ecoPaket, consisting of a discount card for public transport, a Garmin GPS and a € 100 voucher for a KTM bicycle. In celebration of Opel's 111th anniversary, KTM produced the Opel ecoBike "edition 111" limited to 111 pieces.

Source: Opel

The Dutch brand Sparta has established the "Ion Club"[34] (named after the brandname of their pedelecs). Members receive regular updates on their vehicle, advice on how to use and maintain it, information on new charging points, interesting cycle routes, etc. Furthermore they receive special offers and discounts for day trips or weekends, special offers for Ion

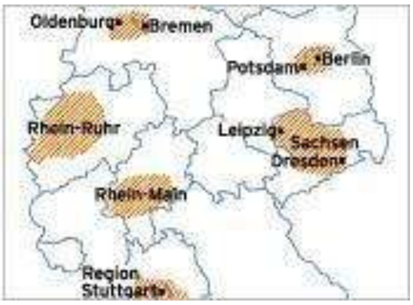
[32] http://ekolo.cz/
[33] http://www.opel.at/page.asp?id=2009122712082894IM7
[34] http://www.ionclub.nl

accessories and they can consult Ion coaches. Anybody interested in Sparta's pedelecs can use a form on the manufacturers' website to book a test-ride on-line.

It is not clear yet, to which extent pedelecs are/will be used to replace other means of transport. Some parties concerned fear pedelec use will to a large extent replace the use of conventional bicycles. In order to stimulate a changeover from other less sustainable means of transport, it is very important to have pedelec demonstrations outside the conventional cycling and/or mobility framework. As an example: in the Post-Expo 2010 in Copenhagen, there will be among other things a Zero Emission Vehicle Zone where also electric bicycles will be demonstrated.[35] Any other events focusing on sustainability, lifestyle, health, etc. are excellent opportunities to show the potential of pedelecs.

Finally, pedelec rental schemes as well as pedelec tours for tourists may also be considered as a type of demonstration initiative. It provides people with an opportunity to become aware of and to get acquainted with the vehicles, which marks the first step (knowledge) in Rogers' adoption process.

As Rogers explains, a powerful way to push diffusion is by affecting opinion leaders attitudes. This requires a more profound and fundamental approach than showing, demonstrating and testing. To affect opinion leaders' attitudes one needs to prove that the innovation offers advantages not just for individuals but also for a larger group. Perhaps, if one can prove that the innovation is useful as part of a bigger plan, for instance combating climate change or improving the quality of life in urban areas, opinion leaders will be even more disposed to adopt and promote the innovation.



A very significant example of such a bigger plan so far is Germany's programme "Modellregionen Elektromobilität in Deutschland"[36] (model regions electro-mobility in Germany) launched in 2009. With this programme, the German Transport Ministry supports 8 regions with a total of € 115 million until the end of 2011. Further support till 2020 is anticipated. The programme is aimed at accelerating the introduction of electric vehicles with a view to making Germany leader in the electric mobility market. Electric bicycles were included in the call for proposals. Of the 8 selected regions, 4 have planned activities involving pedelecs. Berlin-Potsdam will put into service a fleet through pedelec sharing (see point 5.3). Rhein-Main will integrate pedelecs in the existing mobility chains. Rhein-Ruhr will add pedelecs to existing fleets. Oldenburg-Bremen will set up a Personal Mobility Center to guarantee the introduction of electric mobility including electric bicycles. The programme is part of the National Electromobility Development Plan aimed at speeding up research and development in battery electric vehicles and their market preparation and introduction in Germany. The German Federal Government is looking to have one million electric vehicles on the road by 2020.

[35] http://www.postexpo.com/zero_emission.php
[36] http://www.bmvbs.de/artikel-,302.1092406/Modellregionen-Elektromobilita.htm

In 2009, Rotterdam has started a pedelec project as part of an integrated plan to improve air quality and accessibility.[37] The municipal services are using 25 pedelecs as service vehicles. The 15 municipal bike parkings are being equipped with battery charging points. The local council lends out 25 pedelecs, free of charge for one month, to companies that wish to stimulate sustainable means of transport for commuting. Employees can book these pedelecs on-line and try them out for one week. The commuter is expected to answer a few questions before and after the test to evaluate his experience as well as the bike. Rotterdam has carried out a first evaluation of this project. The general conclusion is: "*The potential of the E-bike is high among people who now travel by car, especially under car users with a commuter trip between the 9 and 19 kilometre. 60% think the E-bike is a transport mean by which they can fulfil their commuter trip and 40% of the car users are planning to buy an electric bike in the future. The people who commute normally by car rated the experience with the tested E-bike high and the product almost always met their expectations. However, the willingness to pay the price for an E-bike is a drawback.*"[38]

The showpiece among pedelec projects is NewRide in Switzerland, which was introduced in 2002 to support the introduction of electric bicycles and scooters.[39] It is part of SuisseEnergie, a government programme to promote energy efficiency and renewable energy. In close cooperation with municipalities, manufacturers, importers and dealers, NewRide offers a wide range of promotional activities and services: road shows, public relations, a website, product information, dealer training, dealer certification with NewRide logo, participation in regional exhibitions, …

In 2008 for instance, NewRide organised, with the collaboration of 40 municipalities, 140 dealers and 10 electric bike brands, a total of 161 road-show days. Most of these were organised in the framework of a larger event related to mobility and/or health. NewRide has experienced that road-shows embedded in larger exhibitions attract more visitors. NewRide counted some 7,000 test-rides and 24,300 visitors, whereas 1,700 test vouchers were distributed. With these vouchers, consumers can go to any NewRide dealer of their choice for a free test ride. NewRide had 2,100 pedelecs available for these events.
Since the start of the programme, the content of conversations has clearly changed. Originally, visitors mainly asked for explanations on the functioning of the vehicle. In 2008, conversations were a lot more detailed and complex. Consumers mainly asked questions about the differences between the vehicles.
NewRide's press work resulted in more than 1,000 articles. The website attracted almost 50,000 unique visitors, who downloaded 371,000 pages.[40]

Sales of electric bikes in Switzerland have finally taken off. At the start of the programme, in 2002, sales were only at 1,000 vehicles. In 2008, sales reached 13,000 units, compared with 7,000 in 2007, which is an increase of almost 86%.

[37] http://www.rotterdamelektrisch.nl
[38] van der Eijk Wim, 2009, "*A research on the potential of the electric bike*", Master Thesis, Erasmus School of Economics, Erasmus University Rotterdam.
[39] http://www.newride.ch/
[40] http://www.newride.ch/Downloads/JB_2008.pdf

3.4 Obstacles to Market Penetration

Source: electricbike.org.uk

Pedelec sales are still obstructed by a number of factors at the level of the consumers, the business as well as the authorities.

From research, it appears that dissatisfaction among pedelec users with their vehicles is related to: range, performance, weight, price and servicing and repair costs.

As for range, a 2008 Swiss study [41] over 3 years shows that in that period battery capacity has more than doubled. As a result, even for cyclists who require a high level of assistance, battery capacity largely exceeds their real needs. The study has also established a clear relationship between quality/price and performance of the vehicle.

Manufacturers and dealers have an important role to play in dealing with this issue. The products and their range need to be diversified following the different user categories. Customers should be questioned about their intended use so that dealers can advise them on the most appropriate type of pedelec. Finally, customers need to be optimally informed not only on the actual range of their vehicle, but also on how to manage their energy use and charging batteries.

As for performance, current European legislation limits the motor output of pedelecs to 0.25 kW. ETRA has submitted a proposal to the European Commission because the limit proves to be insufficient, for instance in hilly and mountainous areas, for people suffering from obesity, for three-wheelers developed for physically impaired people, for vehicles developed to transport cargo, …[42] For cycles used in these conditions, the increase of power will have a positive effect on the safety because it will provide the cyclists far more reliability. Since the cyclist can rely on a cycle that in all conditions will perform at the required level, he will also enjoy more safety and comfort (see further details in the fact sheet).

As for price, growing sales will increase production volumes, which in turn are likely to push prices down. Nevertheless, the above-mentioned Swiss study has clearly shown that the performance of the pedelec is linked to its price/quality. Here too, manufacturers and dealers are of paramount importance. They need to inform consumers on the characteristics of the vehicles as well as on the related price/quality ratio.

Many dealers and consumers still consider pedelecs as an expensive "variation on the theme bicycle", a view which often results in a negative cost-benefit analysis and consequently

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[41] van der Eijk Wim, 2009, "*A research on the potential of the electric bike*", Master Thesis, Erasmus School of Economics, Erasmus University Rotterdam.
[42] http://www.etra-eu.com/newsitem.asp?type=3&id=7933772

rejection of the innovation. For the study "The Pedelec Market in Flanders"[43], 102 bicycle dealers filled in a questionnaire, whilst the researchers also analysed the websites of an additional 110 bicycles shops. 85% of the responding dealers were offering pedelecs or power kits. 33% of the dealers had one single brand, 51% offered at least 2 different brands. However, only 38% of the visited websites were mentioning pedelecs. The researchers concluded: "*This is much less than what would be expected from the results of responding dealers. Whether the 85% is too much because dealers who do not offer pedelecs did not take trouble to answer the inquiry, whether the dealers find it unnecessary to make publicity for these products on their websites. This may mean that most dealers are not actively promoting the pedelec. Their main concern is the ordinary human powered bicycle. (…)Although most dealers are won for the electrical assistance, they are not actively promoting the pedelec.*"

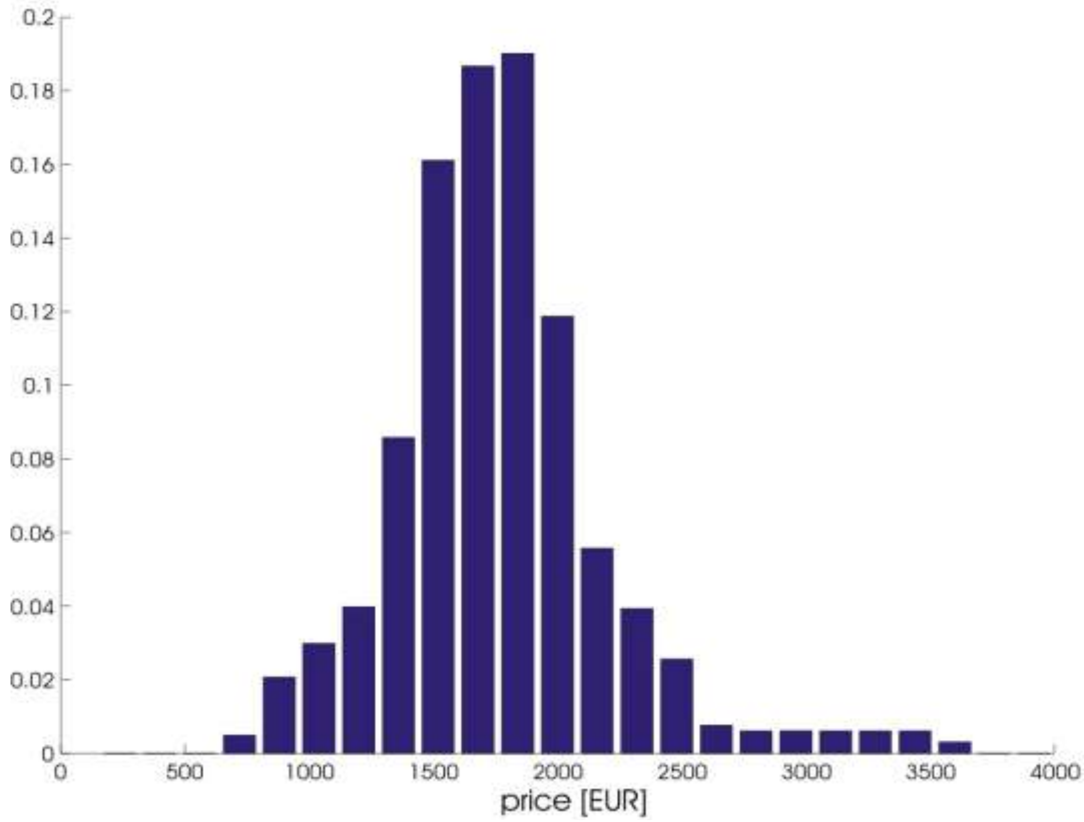


Figure 7: The distribution of offered pedelec prices in Flanders

Source: The Pedelec Market in Flanders

If pedelecs are for instance marketed as a cheap, efficient, comfortable, healthy and clean alternative for private car usage, the perception of price may well completely change. If the choice is between a second car and a pedelec, the cost-benefit anlysis will undoubtedly be positive.

[43] Cappelle Jan, Lataire Philippe, Timmermans Jean-Marc, Van Mierlo Joeri, 2007, "The Pedelec Market in Flanders".

Conventional bicycle manufacturers who entered the pedelec market logically used their existing distribution network of bicycle dealers. Pedelec manufacturers who were previously not involved in the production of conventional bicycles are more likely to use other/new distribution networks. Today, new types of companies effectively arise: mobility centres, electric vehicle shops, eco-mobility shops, … They do not profile themselves as vendors of specific vehicles, but as suppliers of cleaner, better, more sustainable … mobility solutions. The slogan on the homepage of the Spanish shop "Transporte del Futuro"[44] is "The car is no longer the best solution to travel through town". Such an approach immediately puts the price of the vehicles in a completely different perspective. As for servicing and repair costs, this factor is also largely related to perception and information. Dealers need to select suppliers who provide them with a complete offer of support. This includes training, service manuals, specialty tool and a sound warranty policy.

Furthermore, dealers need to inform their customers about their servicing and repair offer when they sell the pedelec. This allows the customer to monitor the functioning of his vehicle and to anticipate servicing, repairs and costs involved. Pedelecs with integrated software offer additional opportunities for improving servicing and repair. The software provides exact information on the use of the vehicle. As a result, on the basis of travelled distance, dealers can determine exactly when the pedelec is due for servicing. Furthermore, the dealer can adapt the performance of the vehicle to the specific use of the customer. Finally, the software also functions as an anti-theft device. Informing the customer of the details and the quality level of the servicing provided, will certainly contribute to customer satisfaction.

As for weight, battery and motor have become considerably lighter in the past few years. Today, they add around 7.5 kg to the bicycles. This is not so much an obstacle to ride the vehicle but rather to handle it, for instance to carry it on stairs, lift it on a train or a bicycle rack on a car, … The extra weight cannot be eliminated. Dealers should try to anticipate weight related problems and advise a pedelec with a removable battery.

The electric bicycle industry consists of only a few large companies and many small and even micro companies. The activities of a large number of companies are still in an R&D phase, whereas companies with effective production still have relatively high R&D costs. In the wake of the economic crisis banks have been reluctant to lend to new business ventures thus making start-up of new enterprises more difficult. Furthermore, it proves to be difficult, especially for small companies, to participate in government programmes aimed at promoting R&D, technological innovation, sustainability, … Information on these programmes does not reach the companies or they do not have sufficient staff and/or know-how to deal with applications.

Furthermore, there is too often a lack of knowledge of and interest in pedelecs among authorities who develop programmes to stimulate business activities. They do not know or underestimate the potential effects of pedelec usage on mobility, environment and public health. Furthermore, they focus on electric four-wheelers only because they believe their economic weight in terms of employment and sales is far more important than electric two-wheelers. They may also believe that public opinion is rather sensitive to the promotion of electric cars and vans than electric bicycles. Finally, because the electric bicycle industry mainly consists of small companies, many of which are in a start-up phase, their lobby is currently not strong enough to influence authorities in a structural way.

[44] http://www.transportedelfuturo.com/

A telling illustration of this is the fact that in the framework of the European Economic Recovery Plan, the European Commission has launched the European Green Cars Initiative.[45] The Commission's Research website states: "As the car industry is a major employer, any major disturbance to the industry risks affecting the economic and social fabric of Europe. This is why the European Commission made the car industry a key focus of its recovery package, presented in November 2008. At the same time, today's environmental imperatives mean that we need to encourage all road transport stakeholders to move towards more sustainable transport. The European Green Cars Initiative responds to both these needs. It provides financial support to research into the green technologies that will propel our cars, trucks and buses in the near future – spending on research today to correctly meet the demands of tomorrow."[46] Despite the proven demand for electric bicycles, the Commission totally disregards this vehicle in the European Green Cars Initiative.

The lack of attention on behalf of the authorities results in legislation that overlooks electric two-wheelers and thus stunts the growth of the market. Two examples to illustrate this situation. Whilst a growing number of local, regional and national authorities allocate funds to the co-financing of pedelecs, the vehicles are subject to the standard VAT-rate of minimum 15%, which is in some cases (for instance Scandinavia) as high as 25%. Numerous appeals on the European Commission and the member states for the application of the reduced rate have fallen on deaf ears. It does not seem logical to submit environmentally friendly vehicles to the same fiscal regime as polluting means of transport.

In April 2009, European Parliament and Council have adopted Directive 2009/33/EC on the promotion of clean and energy-efficient road transport vehicles.[47] As a result, authorities have to comply with a number of rules aimed at guaranteeing the purchase of clean and energy-efficient vehicles. The Directive does not cover two-wheelers and is therefore a missed opportunity to make authorities aware of and interested in electric two-wheelers. Consequently, they can continue to issue tenders for combustion engine mopeds and motorcycles which through their technical requirements actually exclude electric two-wheelers, as is the case today.

[45] http://www.green-cars-initiative.eu/
[46] http://ec.europa.eu/research/transport/info/green_cars_initiative_en.html
[47] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:120:0005:0012:en:pdf

3.5 Infrastructure

The above-mentioned TNO study "Electric Cycling: market research and exploration of prospects" concludes that a higher number of electric bicycles on the road will require the necessary attention for infrastructure. A larger number of electric bicycles may require adapted infrastructure such as more "cycle motorways", more secure and high quality parking facilities and battery charging points.

As far as cycle roads are concerned, a distinction needs to be made between segregated cycling infrastructure and integrated cycling. For quite a number of pedelec users (i.e. commuters), speed is a main factor. Therefore, it seems logical that on segregated cycling infrastructure, they will try to maximise speed. As a result, cohabitation of conventional and electric bicycles and in this particular instance traffic safety will have to be monitored. If the proportion of pedelecs becomes considerable, it is very likely that infrastructure well have to be adapted, for instance by making cycle lanes and tracks broader and by widening bends.


Source: Fietsfilevrij

In the Netherlands, the Dutch Cyclists' federation, regional authorities and the Ministry of Transport have set up a cooperation aimed at convincing car drivers to commute by bike. For that purpose they have developed the project "FietsFilevrij" (Cycle out of traffic jams)[48], which is about improving existing cycle routes that run parallel with congested roads. People are prepared to cycle to work if it involves a distance between 0 and 15 km. The availability of fast and comfortable routes is precisely one of the reasons for car drivers to switch to cycling. Such "cycle motorways" are perfect for pedelecs. Therefore, an increase of commuters on pedelecs can be expected on these routes. In 2010, the Flemish Minister of Mobility has announced the construction of cycle motorways in Flanders.[49]

As for integrated cycling, traffic calming and speed management of motorised transport will be of the essence, so that pedelecs are enabled to follow the flow of traffic. 30 km/h allows them perfectly well to amalgamate with cars, motorcycles, vans, … Given the fact that pedelecs usually move faster, bus lanes may well be very suitable for combined use.

In view of the value of pedelecs, users' expectations with regard to parking facilities will be higher. There will be a growing demand not only for more sheltered, secured/guarded parking but also for facilities that hold little risk of damaging the pedelecs.

Charging a pedelec battery is a very simple operation, which only requires a normal power point. In most cases, it is perfectly possible to charge the battery at home for the required trips. Nevertheless, the availability of charging points outside the house adds to the comfort

[48] http://www.fietsfilevrij.nl
[49] http://www.fietsersbond.be/nieuws/pers/fietssnelwegen

of the user. It makes it less likely that he will run empty. As a result he needs not to worry and if necessary, the external power points can increase the range of the pedelec.

Networks of external charging points for pedelecs are developing at a rapid pace. In the Netherlands, iohotspots[50] offers more than 400 free charging points throughout the country. They are located in restaurants, hotels, bicycle shops, museums, … The iohotspots website offers these businesses additional advertisement opportunities.

Source: Eneco

In cooperation with Eneco, a supplier of green electricity, Sparta has developed the NRG-spot[51], suitable for all types of electric vehicles. However, the spots have a special plug allowing Sparta Ion owners to charge their battery without the charger.

Apart from these individual external charging points, there are also collective charging stations, which are installed for instance in garages of apartment buildings, car parks, … The Californian company Coulomb Technologies sells charger stations for electric vehicles to, for instance cities, public institutions and flat owners and operates the internet portal www.chargepoint.net[52]. Customers can log in and locate available charger stations. The business model is as follows: 80% of the participation fee goes to the operator of the charger station to cover his energy costs, maintenance and profit, and the remaining 20% to Coulomb for operating the internet portal. Coulomb has found that 80% of electric vehicle users want to charge more than once a day and that most vehicles are parked for 23 hours per day, but most parking spaces have no connection to electricity. That's why they believe there is a need for public charger stations, where the vehicle can charge while the owner sleeps or works.

The UK initiative Park and Charge[53] allows users of electrically powered two-wheelers and cars to store their vehicles in a safe and secure location and to connect them to a supply of electricity. The Park & Charge system uses smart technology that recognises the voltage requirements of any battery-powered vehicle, ensuring a safe and efficient powering-up process. Most electric bikes can take a full recharge in less than four hours, at a cost of less than 10p a time.

[50] http://www.iohotspots.nl/
[51] http://www.iktekenervoor.nl/?cid=146
[52] http://www.coulombtech.com/
[53] http://www.parkandcharge.com/

Sanyo has announced the installation of its "Solar Parking Lot" incorporating solar panels and lithium-ion battery systems in combination with pedelecs.[54] The "Solar Parking Lot" is a perfectly independent and clean system eliminating the use of fossil fuels. The clean power generated from the solar panels installed on the roof is stored to be used to recharge 40 pedelec batteries and to illuminate the parking lot lights.

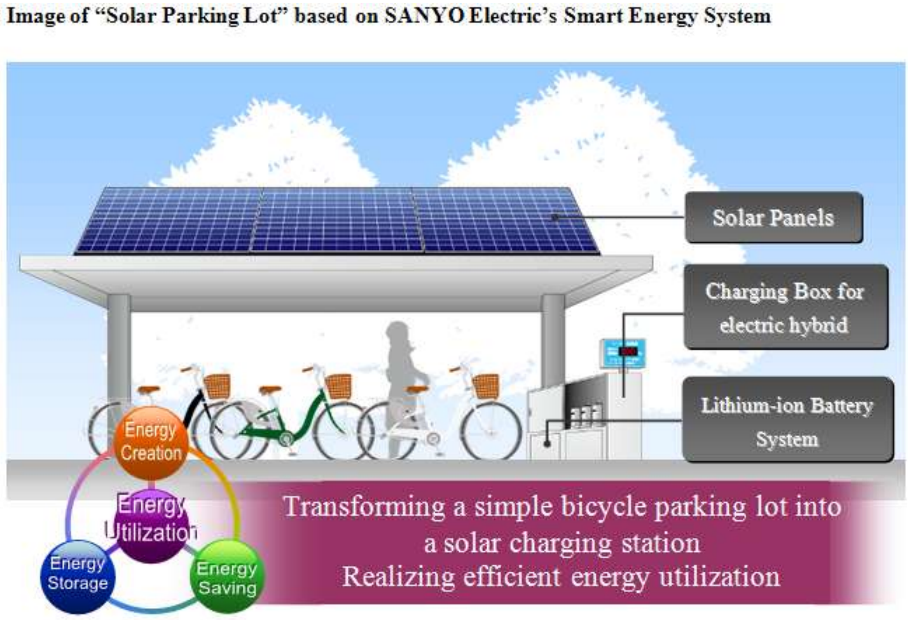


Figure 8: Solar Parking Lot

Source: Sanyo

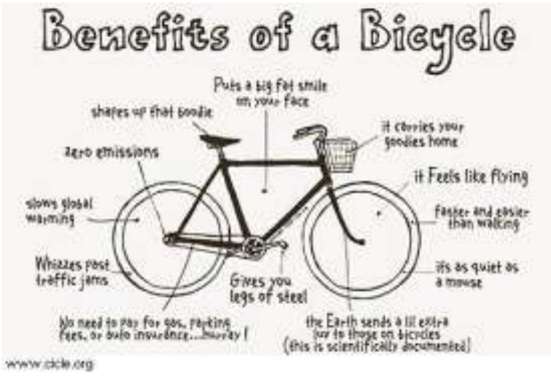
An alternative to charging points are the battery exchange systems. Stuttgart has tried out a pedelec rental system where the users exchanged their empty battery for a full one by means of vending machines. This test has shown that battery exchange systems are too expensive if done with independent infrastructure. This system may however prove to be useful for fleets, for instance for postal or courier services with a very high and almost continuous usage of the vehicles.

[54] http://sanyo.com/news/2009/11/30-1.html

4 Opportunities

4.1 Effects of Pedelec Use

Today, millions of people suffer from air pollution, traffic congestion, failing traffic safety, noise, bad health, … while our entire planet is under threat as a result of climate change. These are major problems for which cycling can be part of the solution; a part, which so far, has been greatly underestimated. Just one example: findings of the Dutch Cyclists' Federation show that if all car journeys up to 7.5 km would be replaced by cycling trips, CO^2 emissions would decrease by 2.4 million tons per year. That is 6% reduction of Dutch car traffic emissions and 1/8th of the Dutch objectives in the framework of the Kyoto Protocol.[55]



Electric bikes are in this context a very important issue. They produce no emissions, no noise and they use very little energy at very low cost. They cause no "external costs", they allow avoiding congestion and parking problems. They also assure mobility of elderly people and people with health problems, they benefit public health in general and therefore reduce medical costs. They also contribute to sustainable tourism.

4.1.1 Public Health

The WHO report "Transport, environment and health"[56] states: "*A total of 30 minutes of brisk walking or cycling a day, on most days, even if carried out in ten- to fifteen-minute episodes, reduces the risk of developing cardiovascular diseases, diabetes and hypertension, and helps to control blood lipids and body weight. This evidence is mostly from studies in middle-aged, white males, but the few studies in women, young people and the elderly point in the same direction. This is new evidence and especially useful for public health, as it was previously thought that only vigorous, uninterrupted exercise, such as jogging, could provide such benefits. While the benefits of physical activity increase with the intensity and frequency of exercise, the greatest come when people who have been sedentary or minimally active engage in moderate activity. In addition, moderate physical activity is a more realistic goal for most people and carries a lower risk of cardiovascular or orthopaedic complications than vigorous activity. It is therefore safer to recommend for the general population.*"

[55] http://www.fietsersbond.nl/urlsearchresults.asp?itemnumber=1
[56] Dora Carlos, Phillips Margaret, 2000, "*Transport, Environment and Health*", WHO Regional Publications, European Series, No. 89.

The pedelec fits perfectly well in this scenario. Whether the vehicle is used for shopping, commuting, work, recreation, it offers a perfect opportunity for regular, moderate activity as part of a daily routine.

The benefits of cycling to work are further corroborated by a recent TNO research that shows that sick leaf among cycling employees is on average 7.4 days per year as opposed to 8.7 days for employees who do not cycle.[57] What's more: the longer the traveled distance and the more frequent the employee cycles, the less he is on sick leaf. If the number of Dutch cycling commuters could increase by 1%, this could result in ± 27 million euro cost reduction.

The VUB study "The electric bicycle as sustainable mobility in cities" includes research into the effect of pedelec use on the health of the cyclist. Twenty carefully selected people were checked before and after the test period on their maximum oxygen intake and maximum power output. They also underwent blood and lactate tests. For 6 weeks, they had to use the pedelec at least 3 times to commute over a minimum distance of 6 km (single trip). "*The results clearly showed that the intensity used by the subjects in the study, was sufficient to improve general condition. Regular physical activity has positive effects on an individual's health and functional capacity. Therefore increasing the physical activity level of the general population is one of the key issues in today's health promotion. In this respect the conclusion remains that the electric supported bicycle can help overcome the barrier towards physical activity, for those who will benefit the most in terms of health related fitness.*"

The Dutch study "Electrically assisted cycling as a novel device for meeting the physical activity guidelines: energy expenditure, heart rate and power output"[58] confirms the findings of the VUB study: the intensity of cycling on a pedelec is sufficient to improve the fitness level.

According to the Dutch study "Electric Cycling: market research and exploration of prospects", in the next few years, the Dutch government wants to achieve an increase of 1% in the group of people who meet the "national norm for healthy exercise", i.e. minimum 30 minutes a day on minimum 5 days a week of moderately intensive exercise. According to the study this can be achieved by pedelec use only. If the number of pedelecs increases substantially, the effects would be even bigger.

The study has also found that the number of Dutch people who are overweight may decrease as a result of stimulating the use of electric bikes. The exercise involved comes down to additional burning of calories. Among commuters, a decrease of 0.1 to 0.2 kg a year is possible, whereas the bodyweight normally increases by 0.5 kg a year. Consequently, stimulating the use of electric bikes may contribute to keeping a healthy bodyweight.

At an average speed of 22 km/h with average assistance, the cyclist uses 80% of the energy he would use on a conventional bicycle.

As stated under point 2.8., pedelecs also contribute to the prevention of certain diseases and they may allow people with health conditions to become active again and/or stay active.

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[57] TNO onderzoeksresultaten, 2009, "*Regelmatig fietsen naar het werk leidt tot lager ziekteverzuim*".
[58] Hendriksen IJM, Simons M, van Es EM, 2008, "*Electrically assisted cycling as a novel device for meeting the physical activity uidelines: energy expenditure, heart rate and power output*", Medicine & Science in Sports and Exercise.

4.1.2 Environment, Energy and Energy Efficiency

According to the EEA report "Climate for a transport change"[59], total EU-27 CO2 emissions between 1990 and 2005 would have fallen by 14% instead of 7.9% if transport sector emissions had respected the same reduction trends as society as a whole.

As far as CO_2 emissions are concerned, according to New Ride, every electric bicycle on the road results in 900 km less car kilometres per year.[60] The European Union has a stated objective to reduce CO_2 emissions from new passenger cars to an average of 120 grams per kilometre by 2012.[61] Consequently, if this objective is to be achieved, every electric bicycle that avoids the above-mentioned 900 km car kilometres should yield a reduction of 108 kg CO_2 per year. Following these calculations, the 140,000 electric bicycles sold in 2008 in The Netherlands may have resulted in 15,120 tons less CO_2, whereas the estimated 400,000 to 500,000 electric bicycles sold in the EU may have resulted in 43,200 to 54,000 tons less CO_2.

Based on the same assumption as above, i.e. 1 pedelec avoids 900 km of car usage, the estimated half a million pedelecs sold in the EU in 2008 prevented the use of 38.25 million litres of petrol, which equals € 42.75 million. It also saved 337.50 kWh electricity, which equals € 55.96 million. That results in a total saving of almost € 100 million.

According to Eurostat, the price of household electricity in the first semester of 2009 was € 16.58 per 100 kWh for the EU-27.[62] Thus to recharge a 200 watt-hour pedelec battery would cost only € 0.033. A pedelec might travel 60 km with one charge so the cost per km would only be € 0.00055. For a combustion engine four-wheel vehicle, fuel cost per km would be around € 0.095. Thus, the pedelec is 172 times less costly for fuel than a combustion engine four-wheel vehicle

As for the electricity needed to charge the batteries, much depends on the type of power plant supplying the energy. The table below states CO^2 emissions per type of energy source:

Energy source	CO^2-emissions (gram / kWh)
Wind	9 - 25
Water	8 - 33
Sun (PV-system)	50 - 60
Nuclear energy	3,5 - 100
Biomass	0 - 540
Gas	350 - 450
Coal	850 - 1000

*Source: www.milieucentraal.nl[63]

[59] European Environment Agency, 2008, "*Climate for a transport change - TERM 2007: indicators tracking transport and environment in the European Union*", Report No 1/2008.
[60] Schneider Bernhard, "*Energieeffizienz lohnt sich – für die Umwelt und fürs Portemonnaie*", New Ride
[61] http://ec.europa.eu/environment/air/transport/co2/co2_home.htm
[62] http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-QA-09-048/EN/KS-QA-09-048-EN.PDF
[63] http://cgi.milieucentraal.nl/pagina.aspx?onderwerp=Duurzame%20energiebronnen

In the case of a 200 watt-hours battery, producing the energy to charge the battery will lead to 0 CO^2 in the best case (biomass) and 0.17 to 0.2 kg in the worst case (coal). As a result, if the charge allows for 60 km range, this vehicle will in the best case cause no CO^2 emission at all, whereas in the worst case it will cause over a 100 km trip 0.333 kg of CO^2. For comparison, a car with a CO^2 emission of 0.12 kg per kilometre will emit 12 kg of CO^2 over 100 km.

The last but not the least environmental advantage of pedelecs is that they produce hardly any noise.

4.1.3 Mobility

The Australian Bureau of Transport and Regional Economics has found that the primary cause of congestion in Australia is private automobile use.[64] The Bureau also found that the cost of *avoidable* congestion in 2005 was almost € 6 billion. Avoidable congestion is described as situations where the benefits to drivers of travel in congested conditions are less than the costs imposed on other members of the community. This cost is composed of: business time costs (€ 2.28 billion), private time costs (€ 2.22 billion), extra vehicle operating costs (€ 0.76 billion) and extra air pollution (€ 0.7 billion).

Commuter cycling reduces the cost of congestion by approximately € 40.47 million per year. Therefore encouragement of cycling is a cost effective response to the challenge posed by traffic congestion. This is all the more true since congestion intensity is at its greatest in the areas most suitable for cycling – urban areas, where trip distances are likely to be shorter.

The Dutch report "Electric Cycling: market research and exploration of prospects" has found the following mobility effects of pedelec use:

- Whereas Dutch bike commuters travel on average 6.3 km to and from work, with an electric bike, that distance increases to 9.8 km.
- For more than half of the trips up to 4 km, Dutch people use a bike. With an electric bike, people will choose the bike for more than half of the trips up to 6 km.
- As a result, the total distance cycled in Holland is expected to increase by up to 10%.
- The total distance cycled by commuters in Holland is expected to increase by up to 20%
- The use of electric bikes will to a considerable extent substitute short car trips.
- The decrease of car usage will not have an influence on the queues, but accessibility within cities may well improve



The Swiss study "Electric Twowheelers – Effects on Mobility" recorded the mobility patterns of light electric vehicles, including pedelec buyers both before the purchase and a year later by means of on-board logbooks and mobility journals. The results were verified by supplementary interviews and additional data obtained on the mobility patterns of the

[64] Cycling Promotion Fund, 2008, "*Economic Benefits of Cycling for Australia*"

respondents. A total of 179 on-board logbooks were evaluated and a total of 192 surveys using mobility journals were carried out.

The inquiry focused on the following issues:

- How do LEVs influence mileage?
- To what extent do LEVs replace other means of transport?
- For which purpose are LEVs mainly used?

The study found the following results for pedelecs. They were mainly used for commuting. They replaced different modes of transport, i.e. conventional bikes, cars, public transport. Although they were initially purchased as additional vehicles, they did not seem to generate new mobility. They resulted in 5.2 % less mileage with private motorized transport.

The study results lead to the following recommendations:

- The use of LEVs should be encouraged. Beside the environmental impact, the reduced space demand and, for e-bikes, the health aspect must also be taken into account. LEVs question the traditional approach to mobility.
- LEV encouragement should particularly focus on heavily motorised households.
- Major questions, such as the long-term effects on mobility patterns and the lifespan of the vehicles are still open. Targeted monitoring of the most important questions could help assess potentials more precisely.

Increasing number of pedelecs on the European roads will probably raise the issue of road safety. It is proved again and again that the more cyclists, the less accidents. Pucher and Buehler state: "*There is also reason to believe that more cycling facilitates safer cycling. The phenomenon of 'safety in numbers' has consistently been found to hold over time and across cities and countries. Fatality rates per trip and per km are much lower for countries and cities with high bicycling shares of total travel, and fatality rates fall for any given country or city as cycling levels rise (Jacobsen, 2003).*"[65] There is no reason to believe that the trend would be different in the case of rising numbers of pedelecs.

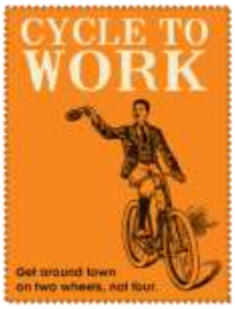
The only element that may require more watchfulness is the cohabitation between pedelec users with conventional cyclists and pedestrians because of the higher average speed pedelecs usually develop.

4.2 Fiscal Incentives

Some local authorities and member states are trying to stimulate the use of bicycles in general and of pedelecs in particular by means of fiscal incentives. A few examples:

Many years ago, Holland introduced a law allowing employers to give their employees a bike, tax-free, up to an amount of € 749. The Dutch trade association for bicycle dealers is lobbying for an increase of this tax-free amount so that it can also easily cover pedelecs. In 2008, 240,000 so-called company bikes were sold, i.e. almost 1 out of 5 new bikes, at an average price of € 836. Holland has 18 million bicycles for 16 million people. The bicycle accounts for 26% of all trips.

[65] Buehler Ralph, Pucher John, 2008, "*Making Cycling Irresistible: Lessons from The Netherlands, Denmark and Germany*", Transport Reviews, Vol. 28, No. 4, 495–528.



In Belgium, the law allows employers to pay employees, who cycle to work, a tax-free fee of currently € 0.20 per cycled kilometre. Paying the fee is a favour, not a legal obligation. Research by the Belgian mobility department has shown that if a company pays the fee, cycling increases considerably. The number of cyclists rises from 6.3% to 9.5%, that is +50%.[66] Furthermore, employers can give a bike/pedelec to their employees as a benefit in kind. Following a recent Parliamentary decision, these company bikes are now also tax-free. What's more, in contrast to Holland where there is a limit of € 750, in Belgium there is no limit to the value of the company bike and the employer is also allowed to compensate his employee for the parking and maintenance costs of the bike.

In 2005, the UK government launched the "Cycle to Work" tax incentive scheme.[67] Employers can lend bicycles/pedelecs to their staff as a tax-free benefit on condition that the vehicles are mainly used to go to and from work or for work-related purposes. The employee pays back the loan with a salary sacrifice, allowing him to benefit from tax and national insurance relief. At the end of the lending period he 'buys' the bike for a nominal sum.

In 2009, the Italian Ministry of Environment set up a subsidy scheme for the purchase of bicycles or electric two-wheelers. The total budget of € 19 million resulted in the sales of an extra 127,000 bicycles/pedelecs.[68]

Austria's klima:activ programme is aimed at reducing greenhouse gas emissions with 13% between 2008 and 2012 compared with 1990. As part of that programme, Austria co-finances the purchase of pedelec fleets with a maximum of 10 vehicles. The initiative is

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[66] Federale Overheidsdienst Mobiliteit en Vervoer, 2005, "*Diagnostiek Woon-Werkverkeer van 30 juni 2005*".

[67] http://www.dft.gov.uk/pgr/sustainable/cycling/cycletoworkguidance/
[68] http://www.bike-eu.com/news/3647/italians-sell-57-000-bikes-in-5-days-with-incentive-scheme.html

reserved to companies, local, regional and national authorities, tourist organisations and tourist companies and NGO's. The subsidy amounts to € 200 per vehicle or € 400 if green electricity is used. To promote the programme, the environment minister climbed the Großglockner, Austria's highest mountain by pedelec. Several Austrian regions and local councils have set up incentives for private individuals who buy an electric two-wheeler. Salzburg has the highest subsidy, up to € 400 plus € 100 for green electricity. Oberösterreich offers € 300 plus € 150 and Steiermark € 250.[69]

In 2009, the Paris Council has voted to extend the existing subsidy on the purchase of electric scooters to electric bicycles.[70] This decision complies with the city's strategy for improvement of mobility, public health, and the fight against air pollution and noise. The subsidy amounts to 25% of the purchase price with a maximum of € 400. It applies to all Parisians, whilst the duration of neither the measure nor the budget is limited.

At European level, there is no coherent integrated programme aimed at stimulating electric two-wheelers in general and pedelecs in particular. In November 2008, the President of the European Commission has announced the European Green Cars Initiative as one of the three Public Private Partnerships of the European Economic Recovery Plan. The objective of the initiative is to support R&D on technologies and infrastructures that are essential for achieving breakthroughs in the use of renewable and non-polluting energy sources, safety and traffic fluidity. Beyond providing loans through the European Investment Bank, the PPP European Green Cars Initiative is making available a total of one billion EUR for R&D through joint funding programmes of the European Commission, the industry and the member states. These financial support measures will be supplemented by demand-side measures, involving regulatory action by Member States and the EU, such as the reduction of car registration taxes on low CO_2 cars to stimulate car purchase by citizens.

Despite its name the Green Cars Initiative is not only for passenger cars. Under the Green Cars Initiative, the topics include research on trucks, internal combustion engines, bio-methane use, and logistics. However a main focus is on the electrification of mobility and road transport. Nevertheless, the Green Cars Initiative does not include two-wheelers. In June 2009 the European Commission held an Expert Workshop seeking to understand the landscape of ongoing initiatives at national levels in Europe related to development of fully electric vehicles and the required infrastructure.[71] At this meeting, Polis stressed the need to

[69] http://www.escooterstore.at/819_Foerderungen_fuer_Elektrofahrraeder.html
[70] http://www.bike-eu.com/news/3646/paris-grants-euro-400-subsidy-on-e-bike.html
[71] European Commission, 2009, "*Report on a European Commission Workshop: European Commissions' and Member States'R&D Programmes for the Electric Vehicle*", Draft Version 1.0 / 15 November 2009.

consider all modes of transport when talking about electrification. So far this advice has not been followed.

The Directorate-General for Energy and Transport will support a large European "electromobility" demonstration project on electric vehicles and related infrastructure with a total budget of around € 50 million as part of the Green Car Initiative. This does not include electric two-wheelers.[72]

Under point 4.4 we indicate another missed opportunity as two-wheelers were not included in Directive 2009/33/EC on the promotion of clean and energy-efficient road transport vehicles.

In 2009, ETRA, together with the industry associations COLIBI and COLIPED have made an appeal to the Commission for a European strategy on tax incentives for cycling. In 2002, the European Commission presented a new strategy on the taxation of passenger cars in the European Union. The Commission analysed existing passenger car taxation systems and explored ways to remove the tax obstacles to free movement of passenger cars within the Internal Market. The 3 organisations said it was now time for a European analysis of cycling prohibitive taxation systems as an impetus for a new strategy on tax incentives for cycling in the European Union. The European Commission has not responded.[73]

4.3 Rental Schemes

There are different ways of renting pedelecs. The most simple system is a fleet of rental vehicles, owned and operated by a company such as a bike shop, a hotel, a public transport company, … This is the most widespread and fastest growing system and it is producing some innovative derivatives.

The German initiative eBike Rent[74] offers an online-platform where customers can find a pedelec rental station and book a vehicle on-line. Renters are bicycle shops, hotels, touroperators, ... The initiative is currently being expanded to other member states.

It appears that public transport companies show a particular interest in pedelec rental systems. They see a potential for making public transport more attractive and efficient by combining it with sustainable individual transport modes such as pedelecs.

Source: martenwallgren.blogspot.com/

[72] http://ec.europa.eu/transport/urban/vehicles/road/electric_en.htm
[73] http://www.etra-eu.com/newsitem.asp?page=2&type=1&cat=4&id=4433406
[74] http://www.ebikerent.eu

The Austrian city of Salzburg offers the holders of an annual season ticket for the Salzburg Stadtbus the possibility to rent an electric bicycle at a very low rate.[75] Furthermore, customers can use city charging stations free of charge.

In 2009, the German government has awarded € 27 million to the city of Stuttgart as co-winner in the national competition for innovative public bicycle rental schemes. In cooperation with DB Rent GmbH, the city is developing an electric version of the Call-A-Bike system.[76] The objective is to further increase cycle usage in the hilly city and to promote the combination of public transport and cycling. The award money will be used to develop a pioneering rental system for pedelecs with integrated charging stations. The new pedelec system will be built in stages, starting early 2010 and should include a total of 3,000 pedelecs. The University of Stuttgart will scientifically monitor the implementation of the pedelec rental scheme. The scientists will focus on the impact of the scheme on urban mobility.

As part of the German programme "Modellregionen Elektromobilität", the region Berlin-Potsdam is developing "BeMobility".[77] The objective is to promote the combined use of public transport and pedelecs. A pilot project will be launched in Autumn 2010 involving 50 pedelecs. Customers can book a vehicle with their mobile or with a special card. To charge the batteries only renewable energy will be used.

The classical public bike system, making vehicles available in the streets usually by means of unmanned stations, seems not easily transferable to pedelecs. There are several issues to deal with. The problem of the battery could be solved in two ways: distribution of spare batteries through vending machines or integrating a charging system in the station. Brian Mcallister has for instance designed a system in which the bike will charge via its two locking points when it is docked.[78] Apart from the battery, there are the issues of theft, maintenance of the vehicles and power supply for the stations.


Source: Brian Mcallister

[75] http://www.oekonews.at/index.php?mdoc_id=1041533
[76] http://www.stuttgart.de/item/show/273273/1/9/367170?
[77] http://www.deutschebahn.com/site/bahn/de/unternehmen/konzernprofil/im__blickpunkt/bemobility.html
[78] http://www.yankodesign.com/2009/06/11/dual-system-bike/

5 The Vehicle

Figure 9: 1947 Bowden Fiberglas electric Bicycle

5.1 Definitions and Legal Aspects

Electric bicycle and/or LEV (Light Electric Vehicle of weight less than or equal to 400 kg) is a term, which covers two different concepts of vehicles with an auxiliary electric motor. On the one hand, there are cycles equipped with an auxiliary motor that cannot be exclusively propelled by that motor. Only when the cyclist pedals, does the motor assist. For these vehicles types the term “pedelec” is more commonly applied. On the other hand, there are cycles equipped with an auxiliary electric motor that can be exclusively propelled by that motor. The cyclist is not necessarily required to pedal. These vehicles are generally called E-bikes.

Pedelecs and E-bikes are not always two-wheeled. There are vehicles with 3 or 4 wheels. Legal definitions always have the term “cycles” in order to cover all vehicles, irrespective of their number of wheels.

European legislation stipulates that only pedelecs “which are equipped with an auxiliary electric motor having a maximum continuous rated power of 0.25 kW, of which the output is progressively reduced and finally cut off as the vehicle reaches a speed of 25 km/h, or sooner, if the cyclist stops pedalling”[79] are classified as bicycles. For these vehicle types, the European standard EN 15194 (EPAC – Electrically Power Assisted Cycles) has been implemented.

E-bikes and pedelecs of which the motor output exceeds 0.25 KW and/or the motor assists beyond 25 km/h are classified as mopeds. They have to comply with the type-approval

[79] Directive 2002/24/EC of the European Parliament and of the Council of 18 March 2002 relating to the type-approval of two or three-wheel motor vehicles and repealing Council Directive 92/61/EEC, article 1(h)

legislation as laid down in Directive 2002/24/EC and all accompanying Directives. Full details on all legislation governing pedelecs and E-bikes are in the fact sheet "Legal Framework".

This policy guideline deals with pedelecs which are equipped with an auxiliary electric motor having a maximum continuous rated power of 0.25 kW, of which the output is progressively reduced and finally cut off as the vehicle reaches a speed of 25 km/h, or sooner, if the cyclist stops pedalling only. The term electric bicycle is a generic name for all bicycles equipped with a motor, i.e. both pedelecs and E-bikes.

5.2 Technical Elements

5.2.1 The Bicycle Section

As a result of the pedal assistance, the design and construction of the bicycle frame of an electric bicycle requires significant adaptation and reinforcement to withstand the non-linear exerted forces that result from the pedal assistance. It is imperative that components such as brakes, rims, tyres and the frame are able to withstand the exerted forces. In order to comply with EN 15194 (see Fact Sheet on the Legal Framework) electric bicycles have to pass more demanding tests than city and trekking bicycles, which are subject to EN 14764.

The main features of the bicycle section are as follows:

Frame: usually made of aluminium, which is a light and rustproof material. Quite a number of electric bicycles have a low step-through frame, which is convenient for urban usage. It permits easier mounting, especially if the cyclist is carrying a child or loads or if the cyclist has physical impediments.
A number of users are primarily interested in exercising on their bicycle and therefore prefer a very lightweight bicycle. For this purpose, manufacturers could utilise a reinforced carbon-fibre frame, which is extremely light. Reinforced carbon fibre frames are an expensive option. Consequently carbon-fibre based electric bicycles are currently only produced in small quantities. All that is reflected in their price-level.

Gears: since the introduction of indexed shifting, changing gears is very accurate and simple either by pushing a button or turning a handle. The gears are either integrated in the hub or external. There are gear hub systems with 3, 4, 5, 7, 8, 9 and even 14 gears integrated and shielded from dirt, humidity, damage, … Alternatively the bicycle is equipped with 2 derailleurs for up to maximum 30 gears. There are also systems, which combine a gear hub

with a derailleur.
Although not generally in use yet, electronic shifting has been invented: a computer automatically selects the gear that fits your cadence. You control the system from a "dashboard" which also includes traditional cycling computer functions such as speed, distance, time, etc. …

In recent years, NuVinci introduced an innovative and "ground-breaking" gear control system to the (electric)bike world. This system can be compared with the Variomatic, the continuous variably transmission system which DAF developed in the fifties. A set of rotating spheres transfers torque between two "rings". Tilting the spheres changes their contact diameters on the rings, allowing an endless progression of speed ratios. This results in smooth, seamless and continuous transition to any ratio within its range.

Brakes: are either integrated in the hub or they are the classical external V-brakes, a very powerful variation on the cantilever-theme. By means of a power modulator, one can adjust their braking force. Alternatively, there are hydraulic brakes, very powerful, user-friendly and reliable.

Stem: adjustable stems have become very popular. They allow modifying the height and/or the angle of the handlebar. Certain models can be adjusted without any tools. Adjustable stems contribute to comfortable cycling. Thread-less headsets are less suitable for electric bicycles because they usually do not allow adjusting the height of the handlebar to match the size of the cyclist.

Handlebar: On most electric bicycles, the cyclist has an upright position, hence an upright handlebar. If the bicycle is used for longer distances, then a multi-position handlebar is advisable. This allows the rider to hold the handlebar in many different positions, thus enhancing the comfort and reducing fatigue.

Saddle: Gel saddles are now widely in use. The gel is industrially applied under the saddlecloth in view of distributing the cyclist's weight in an optimum manner. Leather saddles are making a comeback. They have the advantage that, after a while, they mould themselves to fit the particular anatomical shape of the rider. Furthermore, they are porous and able to breathe. Leather saddles require maintenance. To keep the leather supple, it requires regular oiling.

Lighting equipment**:** thanks to the introduction of LEDs (light emitting diodes) dynamo free battery systems are now widespread. In the case of traditional bulbs, energy is more and more supplied by hub dynamos instead of traditional rim dynamos. Hub dynamos have a much better performance, are less vulnerable, thus much more reliable.
A growing number of head and taillights are equipped with sensors. As a result, the light switches automatically on at dusk or in bad weather. Also, these lights continue to function when you stop for a short period, for instance at traffic lights.

Shock absorption: aluminium electric bicycles are equipped with a front suspension fork because aluminium is not a springy material. Therefore, the fork is meant to absorb the shocks resulting from uneven road surface. Although such a fork adds to the weight of the vehicle, it provides the rider with more comfort, with improved overall balance and control over the bike. In view of the fact that electric bicycles can reach significantly higher average speeds than conventional bicycles, a front suspension fork becomes even more relevant. The fork should be adjustable so that suspension can be adapted to the weight of the rider and to the type of terrain.

Bell: just as conventional bicycles, electric bicycles hardly produce any noise. Other road users, especially pedestrians, often cannot or do not hear them coming. Since electric bicycles can easily reach higher speeds than conventional bicycles, the presence of a bell on the vehicle is all the more important.

5.2.2 The Motor

The motors used in electric bikes are Direct Current (DC) types that operate with a power supply, the battery, which is also a DC power source. Electricity in homes is Alternating Current (AC).

Most DC motors used in electric bikes are of the brush-less type whereas brush type motors use graphite brushes that switch current in the windings. Brush-less motors use permanent magnets of the Neodymium-Iron-Boron type invented at General Motors Research Laboratories in 1982 and now used worldwide in most DC motor applications, including the disk drive in personal computers. The Neodymium magnet, also called REM (Rare Earth Magnet), is the most powerful allowing the motor to be lighter and smaller than older designs that used ferrite magnets.
An important functional issue for motors is that brushes wear out, thus limiting the motor's life. A brushless motor will last much longer than a brush type motor – with the only limiting factor being the life of the bearings, or in some cases the Hall effect sensors. These are transducers that vary their output in voltage in response to changes in a magnetic field.

Motors that have fewer parts, such as brush-less, sensor-less designs are both less expensive to build and have fewer failure points. Sensor-less motors require more sophisticated electronics, but are very simple in their construction. The most common failure point of such motors is the bearings.

The most common pedelec motor currently on the market is the hub motor located in the hub of either the front or the rear wheel. There are Japanese pedelecs that use a motor mounted near the sprocket that is mechanically coupled, via gears, to drive the sprocket.

Hub motors use a space that is not otherwise used by a conventional bicycle design – making the addition of a motor easy and elegant. This seems to be accepted by bike companies and consumers on an intuitive basis. Additionally, the hub motor wheel that simply bolts into place in a normal bicycle frame reduces the need for engineering or design changes, and fits into the assembly / sourcing processes of the normal bicycle industry. However, hub motors, due to their confined space and the complexity of adding internal, changeable gears, are less efficient than a bottom bracket drive – and cost slightly more.

Rear hub motors seem to be the most logical solution, but it must be possible to mount gear clusters for the human powered bicycle chain – an extra cost. Front hub motors are simpler to design and install. They give the bicycle two-wheel drive as the human power is always applied to the rear wheel. Front wheel drive bikes, when properly designed, ride as well as rear wheel drive bikes.

Manufacturers of hub motors for pedelecs can be found in Europe, Asia and North America. Around 95% of all pedelecs use hub motors. Most pedelec motors in Europe range in power output between 0.25 and 0.4 kilowatts. Designs of motors for pedelecs will continue to improve to increase torque performance and efficiency as well as to reduce size and weight.

Electric motors for four-wheel electric vehicles are sized from 50 to 100 kilowatts. Thus a pedelec motor is in comparison quite small compared to a four-wheel vehicle motor or engine. Hence the pedelec is truly miniature user of energy compared to four-wheelers.

There are a number of controller design options to manage the motor. A pedelec equipped with a speed sensor will require the rider to pedal a few strokes before the motor starts. The EN 15194 standard permits for pedelecs from 0 to 5 km/h, that the motor can provide the main power for propulsion. When the speed exceeds 5 km/h the pedals most be utilised and current is progressively reduced until the bicycle reaches a speed of 25 km/h. Hence, an accurate current and speed sensors are required. Furthermore, bike riders often want a little boost when they set off or when they are slowing down to climb a hill. For this, torque sensors are most suitable.

5.2.3 The Battery

The sealed lead-acid battery (VRLA - Value Regulated Lead Acid) is currently the dominant battery used in electric bicycles in China where the emphasis is on low cost. However, electric bicycles made in China for the export-market are mostly equipped with Lithium Ion (Li-ion) and in some case Nickel Metal Hydride (NiMH) batteries that are both lighter weight and operate up to 2,000 recharge cycles. The Nickel-Metal-Hydride (NiMH) battery is also used in China and in around half the pedelecs sold in the European Union. Their performance however is significantly reduced in cold weather and they need to be fully discharged regularly to maximise battery life. The other half of pedelecs in Europe is equipped with a Li-ion battery.

The majority of past safety relevant issues with regards to lithium-ion batteries, which put a question mark over their suitability for electric bike applications, have been for the most part solved. Responsible cell and pack manufactures that utilise a minimum form of charge-load management electronics and pass the appropriate tests e.g. UN Recommendations on Transport of Dangerous Goods (see Fact Sheet) appear to have no serious problems. Li-ion batteries have a narrow and defined “window” of operation, if the cell or pack deviates outside this operational window, they can enter an unstable operational condition. Hence, Li-ion batteries of all types must be equipped with the appropriate battery management system (BMS) to maintain the cell and/or pack parameters (voltage, current, temperature) within its stability window. There are numerous Li-ion cell types on the market to choose from. However, in this framework, we will limit commentary to the three most widely used Li-ion varieties in the electric bike sector.

The most common Li-ion cell on the market is the lithium nickel manganese cobalt oxide (Li-NMC) with a nominal voltage of 3.6 V per cell. This cell offers a good mixture power to energy. Li-NMC cells perform well at low temperatures, and generally have a good safety record. The most common all round cell type is the 18650 design, which is produced on a scale of hundreds of millions per year, at low cost, and at a high manufacturing quality.

The second most commonly produced Li-ion based cell type on the market is the cell Lithium-Polymer (Li-Po) type with a nominal voltage of 3.3 to 3.6 V per cell. This type can consist of a number of chemistries. This cell type offers significant advantages in packing design/form and in high power applications. However, it often has the disadvantage of limited availability and high costs due to limited production. It can be considered a specialist battery.

The third place contender for the most common Li-ion cell type for electric bicycles applications is lithium iron phosphate (*$LiFePO_4$* or *LFE*) with a nominal voltage of 3.3 V per cell. This cell type is considered the safest of Li-ion family. It exhibits considerable electrical and thermal stability if the cell deviates outside its normal operational window. However, at present compared with the Li-NMC and Li-polymer cell types, the LFE cells have considerably lower nominal voltage, energy densities, and higher production cost.

Regardless of the cell type, all Li-ion cells require a minimum level of electronic management and charger safety management. The responsibility for the implementation of cell/pack electronic safety measures and certification lies with the electric bike manufacturer and not the cell manufacturer.

Batteries for pedelecs are now typically produced at 24 V, 36 V, and with a few exceptions 48 V, whereas most Chinese electric bicycles operate at 12 V (lead-acid batteries). The single cell nominal voltage of: lead-acid = 2.1 V, NiMH = 1.2 V. Li-ion 3.3 -3.6 V. Consequently, 6 cells are required for a 12 V lead acid battery, 20 cells for 24 V NiMH, and 8 to 6 cells for 24 V Li-ion. The fewer cells for Li-ion is an advantage since these batteries will have fewer failure points and lower assembly demands. Large four-wheel "automotive" electric vehicle manufacturers construct battery packs that include many multiple-cell modules with voltage as high as 336 to 600 V that results the assembly fourteen to twenty five, 24 V batteries in series respectively.

Batteries are rated in two forms: rated current capacity Ah (amp-hours) and/or rated energy Wh (watt-hours). For example, 10 Ah means the battery can provide 5 amps of current for 2 hours or 2 amps of current for 5 hours. The electric "rated" power, in watts, as produced by a battery, is a product of battery voltage and amps that flow into the motor to which the battery is connected. Multiplying the battery's nominal voltage by the battery's Ah rating yields the number of rated watt-hours ($Wh = V_{nom} \times Ah$ e.g. nominal 24 V x rated 10 Ah = 240 Wh), this is a unit of the energy storage capability of a battery.

The major difference between lead-acid, NiMH and Li-ion batteries is the storage capability measured in Watt-hours of energy per unit weight (Wh/kg). The Wh/kg for lead-acid is around 30, for NiMH around 90 and Li-ion around 120 or higher. Thus for the same weight, Li-ion will have around four times the energy of a lead-acid battery that means the pedelec will travel four times further with the Li-ion battery. Li-ion would also have less volume.

How much energy should a pedelec battery carry? The average "healthy" cyclist can pedal with a mechanical effort of around 100 watts at 15 km/h. So if one wants to ride 2 hours with a battery one will need 200 watt-hours of energy to maintain the 15 km/h speed with the battery-motor drive unit. Actually it will take more battery energy since there are losses in the system to overcome.

Most pedelecs carry battery energy capacity (watt-hours/kilogram) of 250 watt-hours (China mainly) to 800 watt-hours or higher for pedelecs in Europe and North America. The range will vary depending on the weight of the rider, the terrain, speed, battery age and how aggressive the rider uses the pedelec. Reliable manufacturers quote ranges from 40 to 60 km (36 V - 500 Wh systems). Some pedelecs are standard equipped with a spare battery that doubles the range of the vehicle.

Cost is another important element for batteries and that is generally specified as €/Wh, the cost in Euro per unit of energy or rated Wh. Lead-acid batteries are currently priced around 30 €/kWh, NiMH and Li-ion at around 300 to 600 €/kWh, a factor of ten to twenty difference. This explains the big price difference between electric bikes with lead-acid and those that use NiMH or Li-ion. It is expected that the price of Li-ion will decrease as more Li-ion batteries are put into production for four-wheel and light electric vehicles.

Manufacturers will use more automation at all levels of materials and cell production that will provide high quality, reliable and less costly batteries. A replacement battery would cost from two to three times the above-mentioned prices; that would include battery pack fabrication, distribution and shipping costs. Furthermore, it is unlikely that the €/Wh cost of Li-ion batteries will ever come on par or fall below the cost of lead acid batteries. This is mainly due to the intrinsic design requirements of Li-ion batteries i.e. BMS, cell manufacturing complexity, and raw material sourcing. These costs are not present or relevant for lead acid based systems.

The most realistic long-term €/Wh cost target for Li-ion systems is closer to 200 – 250 €/Wh. Replacement batteries would in specialist cases i.e. Li-polymer packs cost from two to three times the above-mentioned prices; that would include battery pack fabrication, distribution and shipping cost.

Source: Powaride

As pedelecs are usually torque sensor controlled, the sophistication of the software in the controller is also a factor. Note: higher voltages allow the motor to operate with more torque, and at higher RPM. This leads to more battery cells. Hence, there is a trade off in cost versus performance. The higher voltage systems require a more costly battery, but deliver significantly better performance (higher fun factor).

Most pedelecs have an indicator of the state of battery charge that informs the rider when the battery needs to be recharged. This is called a "state-of-charge" (SOC) meter. Since, the vast majority of battery accidents occur during the charging procedure. It is essential to use a dedicated charger that is both electrically and mechanically coded for the specific battery on the electric bike i.e. two-way charger to battery communication, with the exchange of the essential battery parameters: (1) battery ID, (2) nominal battery voltage, (3) charge end voltage, (5) maximum allowable charge capacity in Ah, (6) charge timeout. If any one or all of these parameters are not fulfilled, then the charger procedure will not be started.

Using the wrong charger can have several consequences. The battery may suffer from overcharge, and overheat, which can result in the battery management system shutting down, perhaps permanently. Or in a hardware "fire" fuse blowing. Or in damage to the cells that will result in a dead battery. Or in a battery that never reaches full charge, or in subtle cell damage that reduces range and performance. In extreme cases, the wrong charger can result in a fire or explosion. There are efforts in the EU to standardise chargers and connectors. More can be learned about this at www.energybus.com**.**

Useful charge of a battery is generally programmed to run from 20% to 90% SOC. Thus when the SOC goes below the 20% mark, the battery indicator will show need to recharge. Some controllers will allow more than one level of energy use. The basic idea is that the controller will limit the current to increase range or battery life. There is a wide variation of controller designs to optimise performance and battery life.

Battery location is an important style and safety issue. With lead acid batteries, their heavy weight requires a location as low as possible to offer a safe centre of gravity. Lithium Ion cells are quite light, allowing them to be mounted under luggage racks, or inside frame tubes, or in other locations. The most common locations in the EU today are in a plastic box under the rear luggage rack, or inside the main down tube of the bike.

The life span of a battery of an electric bicycle can be expressed in a number of complete discharge cycles. A real life span for lead batteries is approximately 200 cycles. The lifetime for NiMH batteries and for Li-ion batteries are in the range of 500 complete cycles. Next to the life span expressed in cycles, the battery also has a limited life in absolute time. Typically, the ageing of the battery becomes more and more noticeable after about five years because the useful energy capacity starts to drop significantly (below 80% of its rated capacity) and the self-discharge of the battery increases.

5.2.4 The Electricity

The power for the pedelec comes from the battery that needs to be recharged periodically from an electricity source. Household electric power is used for this purpose. The European household electricity is 230 volt AC and that has to be changed to 24V, 36V or if required 48V DC. This is done in a box separate from the pedelec or is sometimes incorporated into the pedelec's electronics that use a transformer to lower the voltage and a rectifier to change the AC current to DC current. The circuit automatically adjusts the charging current to provide the optimum charging cycle for the particular materials in the battery.

Battery recharge time varies with battery size and charger efficiency. The bigger the watt-hours storage, the longer it takes to recharge. Typical recharging times vary between 3 and 5 hours on 230V European home power.

5.3 Vehicle Offer and Trends

The very first consumer groups to become interested in electric bicycles were elderly and physically impaired people. Their preference was a classic, inconspicuous vehicle that looked as much as possible like a conventional bicycle and preferably had a low step-through frame. As a result, most of the electric bicycle manufacturers who first entered the market originated from conventional bicycle production and focused on integrating motor and battery in existing bicycle design, in many cases classic women's bikes.

That is for instance the case for the Accell Group, today one of the market leaders of pedelecs. Other conventional bicycle producers who are currently playing a role in the electric bicycle market are among others Biria, Diamant, Epple, Gazelle, Giant, Heinz Kettler, Helkama, Kalkhoff, Pantherwerke, Riese & Müller, Schwinn, Trek, ...


Source: Accell

In the last few years, the market is gaining momentum. On the one hand, new consumer groups become interested in electric bicycles and on the other hand, technical developments result in new products, which are appealing to these new groups. Furthermore, more and more European cities start to discourage private car usage and encourage more sustainable means of urban transport. The electric bicycle is an excellent alternative for car trips, whether these trips are for commuting, professional reasons, shopping, delivering goods, transporting children, tourism, leisure, …

As a result, new manufacturers enter the market, manufacturers who were previously not involved in the production of conventional bicycles and who are developing electric cycles for specific purposes and the corresponding user groups. Among them are Bion-X, Clean Mobile, Currie, OHM Cycles, Ultra Motor,Watt World.

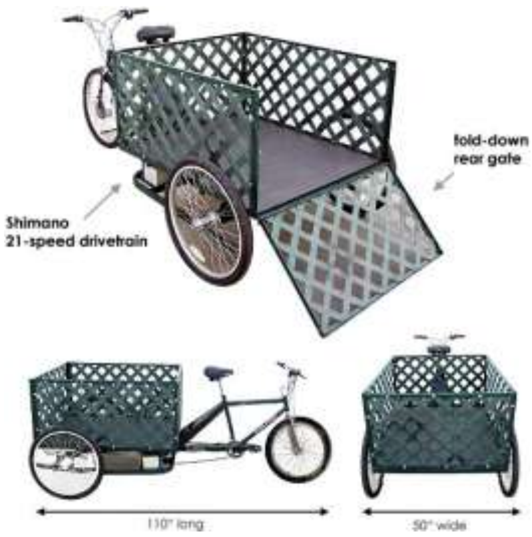
One of the "oldest examples" of such a new entry is Flyer, a Swiss company that started to produce electric bicycles in 2001 and now has a prominent position in the market. They have traditional city models but also a tandem, a folding bike, a carbon bike, a sports series and a very compact city bike. They continue to broaden their offer, but for the EU they are restricted as a result of current legislation.

Source: Flyer

Another example of a "new entry" is Karbon Kinetics a UK based company founded by someone who previously worked for McLaren Cars. The company has developed the world's lightest production electric bicycle, which does no longer look like a conventional bicycle and which is aimed at 25 to 45 year old city professionals and their families. JD Components is a Taiwanese component manufacturer who has developed a pedal assisted bicycle with a very unique design and a lithium-polymer battery. Main Street Pedicabs is producing electric cycles in pedicab, truck, and delivery van configurations.

Source: Ultra Motor

Source: Karbon Kinetics



Source: Pedicab

Source Dahon

Source: Hase

Finally there are companies that, before entering the electric bicycle market were addressing a niche market with special products, and now add an electric version to their offer. Dahon, specialises in folding bicycles and has now introduced a first electric folder. HP Velotechnik is a specialist recumbent manufacturer who also develops electric recumbents. Hase has launched an electric version of its Pino tandem, which is a combination of a conventional and a recumbent bike. Utopia specialises in trekking bikes for cycling tourists. They have designed the eSupport, an electric kit to equip their existing range with electric pedal assistance.

Clean Mobile specialises in power-trains for cargo and load transport to 300 kg in combination with fuel cells (e.g. postal delivery) and off-road vehicles (mountain bike). Consequently, today there is an abundant range of models and designs available. Cargo bikes, recumbent bikes, folding bikes, mountain bikes, trekking bikes, … all become available with electric pedal assistance.

A growing number of these vehicles have a unique appearance, which is a long way off the classical bicycle concept. What's more, manufacturers are becoming increasingly aware of the need to adapt their specifications to the specific use they are intended for. For instance, the requirements of a commuter using his bike for a daily sporty ride to and from work of, say, 15 km are completely different from the requirements of a postman who daily pushes a heavy load for several hours. The difference will not only pertain to the technical characteristics of the bicycle, but also to the performance of the electric assistance. The range and the output of the battery for instance will be far more important to the postman than to the commuter.

Another important development is that electric power is not only used to assist the cyclist with pedalling but also to charge other appliances. The Biologic Reecharge by Dahon and the E-werk by Busch & Müller allow for the recuperation of power from a hub dynamo. This power can be used to charge cycling computers, mobiles, GPS, Ipods, etc. The Copenhagen Wheel has an electric motor that recuperates kinetic energy generated through braking and stores it in a battery. The cyclist can use the energy whenever he requires a little push in the back. By means of a series of sensors and a Bluetooth connection with the cyclist's telephone, the Wheel can monitor the speed, distance and direction of the cyclist. The system can gather information on pollution and show you the healthiest route. It also has a "smart" lock. If there is an attempt to steal the bicycles, the owner receives a warning by sms.

The Copenhagen Wheel

Source: Gruber Assist

Gruber Assist is a very small and lightweight drive assist that supplies a boost on demand. It was originally designed to help mountain bikers in difficult climbs. As the Copenhagen Wheel shows, the concept of sporadic boosts may well be useful in various circumstances and for different types of cyclists.

Many people ask questions about, and are attracted to, the idea of an electric bike that can regenerate, or recharge itself. The idea behind this is that since an electric motor can be easily used as an electric generator, then using the electric motor in a "regenerating" mode could recharge the batteries either on down hills, or by the rider's pedalling effort.

In theory, this is possible. But in reality, there are a number of factors that diminish the usefulness of this concept. First, there are efficiency losses in the motor, the wiring, the controller, and particularly in the ability of the battery to accept a charge (most batteries simply cannot accept as much energy as the regenerating motor can create on a long downhill). That means that only a small percentage of the energy created by the down hill run, or the rider's effort will make it back into the battery as useful energy that can propel the bike.

The motor must be able to be run by the mechanical effort of the wheel turning, which means that usually only a direct drive motor can be used. Also, the controller and battery management system must be configured for regenerating. So there is some extra cost, and some limits to what equipment can be used.

The amount of energy recovered by even the most efficient systems, under ideal conditions, amounts to only a few meters of extra range per trip, at best. Finally, to recharge the battery by pedalling is an arduous effort for all but the strongest of riders. Not really a practical idea. Carrying a charger and using it on the way is much more practical. Or pedalling more while on the bike. Even mild effort while pedalling will greatly extend range by decreasing the demand on the battery.

6 References

6.1 Bibliography

- Benjamin Ed, Jamerson Frank, 2010, "*Electric Bikes Worldwide Reports, 2010 Update to 2009 Edition*".
- BOVAG and the RAI Association, 2009, "Sustainability Agenda for Bicycles – Working towards a fully-fledged role of cycling in the transport sector".
- Buehler Ralph, Pucher John, 2008, "*Making Cycling Irresistible: Lessons from The Netherlands, Denmark and Germany*", Transport Reviews, Vol. 28, No. 4, 495–528.
- Bundesamt für Umwelt, Wald und Landschaft (BUWAL), Sektion Verkehr und verschiedene Autoren, 2004, "*Elektro-Zweiräder, Auswirkungen auf das Mobilitätsverhalten*".
- Burger Michael, 2008/2009, "*Gestalterische Studie eines motorunterstützten Fahrrades für den urbanen Raum*", diplomarbeit.
- Cantoreggi Nicola, Diallo Thierno, 2006, "*Evaluation d'impact sur la santé Promotion du vélo à assistance électrique (VAE)*", République et canton de Genève, Département de l'économie et de la santé, Direction générale de la santé.
- Capelle Jan, Lataire Philippe, Magetto Gaston, Timmermans Marc, "*De elektrische fiets als duurzame mobiliteit in steden*", Vrije Universiteit Brussel.
- Cappelle Jan, Lataire Philippe, Timmermans Jean-Marc, Van Mierlo Joeri, 2007, "The Pedelec Market in Flanders".
- Cappelle Jan, Lataire Philippe, Matheys Julien, Timmermans Jean-Marc, Van Mierlo Joerig, 2009, "*A Comparative Study of 12 Electrically Assisted Bicycles*", World Electric Vehicle Journal Vol. 3.
- Cycling Promotion Fund, 2008, "*Economic Benefits of Cycling for Australia*".
- Die Bundesregiering, "*German Federal Government's National Electromobility Development Plan".*
- *"Directive 2009/33/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of clean and energy-efficient road transport vehicles".*
- Dora Carlos, Phillips Margaret, 2000, "*Transport, Environment and Health*", WHO Regional Publications, European Series, No. 89.
- European Commission, 2009, "*Report on a European Commission Workshop: European Commissions' and Member States'R&D Programmes for the Electric Vehicle*", Draft Version 1.0 / 15 November 2009.
- European Commission, Directorate General Energy and Transport, 2001, "*Statistical Pocketbook EU Energy and Transport in Figures*".
- European Commission, Directorate General Energy and Transport, 2007, "*Attitudes on issues related to EU Transport Policy - Analytical report"*, Flash Eurobarometer 206b.
- European Commission, Directorate General Environment, 2008, "*Attitudes of European citizens towards the environment*", Special Eurobarometer 295.

- European Environment Agency, 2008, "*Climate for a transport change - TERM 2007: indicators tracking transport and environment in the European Union*", Report No 1/2008.
- Federale Overheidsdienst Mobiliteit en Vervoer, 2005, **"***Diagnostiek Woon-Werkverkeer van 30 juni 2005***".**
- Giddings Morgan, "*A Quiet Revolution in Bicycles: Recapturing a Role as Utilitarian People-Movers (Part I)*", published on www.chrismartenson.com
- Goes Han, 2009, "*The Silent Revolution*", Eurobike Show Dailies September 2009.
- Guggenbühl Hanspeter, 2009, "*Das grosse Rechnen*", Das Velojournal, E-Bike-special 3/2009.
- Haefeli Ueli, Hofmann Heidi, Meier Eugene, Moreni Gianni, Schwegler Urs, 2003, "*Changes in the mobility pattern of households due to the introduction of electric vehicles*", paper presented at the 10th International Conference on Travel Behaviour Research, Lucerne, August 2003.
- Hendriksen Ingrid, Engbers Luuk, Schrijver Jeroen, van Gijlswijk Rene, Weltevreden Jesse (BOVAG), Wilting Jaap (BOVAG), 2008, "Rapport Elektrisch Fietsen – Marktonderzoek en verkenning toekomstmogelijkheden".
- Hendriksen IJM, Simons M, van Es EM, 2008, "*Electrically assisted cycling as a novel device for meeting the physical activity uidelines: energy expenditure, heart rate and power output*", Medicine & Science in Sports and Exercise.
- Rogers Everett, 1995, "*Diffusion of innovations (4th edition)",* The Free Press. New York.
- Schneider Bernhard, "*Energieeffizienz lohnt sich – für die Umwelt und fürs Portemonnaie*", New Ride
- Schneider Bernhard Schneider, 2008, **"***E-Bike Reichweitentest, Alltagstauglichkeit von Elekrobikes, Schlussbericht*", Bundesamt für Energie.
- Schwegler Urs, et al., 2003, "*Auswirkungen elektrischer Zweiräder auf das Mobilitätsverhalten. Schlussbericht des Schweizer Projekts im Rahmen von: Electric Two-Wheelers On Urban Roads (E-TOUR, 5. Eu-Rahmenprogramm)*", University of Bern.
- TNO onderzoeksresultaten, 2009, "*Regelmatig fietsen naar het werk leidt tot lager ziekteverzuim*".
- van der Eijk Wim, 2009, "*A research on the potential of the electric bike*", Master Thesis, Erasmus School of Economics, Erasmus University Rotterdam.
- Vermie Ton, 2002, "*E-Tour - Electric Two-Wheelers on Urban Roads*", January 2000 – December 2002, final report.

6.2 Links

- http://ec.europa.eu/eaci/: Executive Agency for Competitiveness and Innovation
- http://ec.europa.eu/dgs/energy_transport/index_en.htm: Directorate-General Energy and Transport
- www.beba-online.co.uk: British electric bicycle association
- www.bemobility.de: pedelec rental service in Berlin-Potsdam organised by DB
- www.bike-eu.com: European trade-paper for the bicycle business
- http://www.bmvbs.de/Verkehr-,1405.1091796/Nationaler-Entwicklungsplan-El.htm: German National Electromobility Development Plan
- www.citelec.org: CITELEC is the Association of European Cities interested in Electric Vehicles
- www.civitas-initiative.org: The CIVITAS Initiative helps cities to achieve a more sustainable, clean and energy efficient urban transport system
- www.electribikee.com: news, reviews and information on electric bicycles
- www.electricfantastic.nl: the Rotterdam pedelec project
- www.elektrischefietsen.com: information site on electric cycling in the Benelux
- www.energybus.com: European initiative to standardise chargers and connectors
- www.etra-eu.com: European trade association for twowheel retailers
- www.extraenergy.org: NGO focusing on information, promotion and testing of light electric vehicles around the globe
- www.fietsfilevrij.nl: improvement of cycle routes to convince car drivers to commute by (electric) bike
- www.gopedelec.eu: EU Intelligent Energy project aimed at raising awareness about pedelecs among citizens and municipal decision makers
- www.levassociation.com: global trade association for the light electric vehicle industry
- www.ebwr.com: information about Electric Bikes Worldwide Reports
- www.newride.ch: Swiss programme for the promotion of electric two-wheelers
- www.pedelecs.co.uk: UK information site on electric bicycles
- www.presto-cycling.eu: EU Intelligent Energy project aimed at promoting cycling for everyone as a daily transport mode
- www.polis-online.org: network of European cities and regions from across Europe, which promotes, supports and advocates innovation in local transport

6.3 Acknowledgements

This policy guide has been made possible thanks to the highly appreciated expert advice of Ed Benjamin, Ton Daggers, John de Roche, Eddie Eccleston, Frank Jamerson, Sidney Kuropchak and Ruud Worms.