



Guidelines for Sustainable Public Procurement

Pedelecs

- A Guide for Public Authorities -

Marco Torregrossa, European Partners for the Environment
Marco.Torregrossa@epe.be

Theo van Bellegem, (Former) Dutch Ministry of the Environment
bellegem@gmail.com

Brussels, 26 May 2010

Although the utmost effort has been done to improve the quality of this document, nor the EPE and neither other organisations or authors involved in this document are reliable for damages or loss of any kind resulting from the use of this document or from errors or faults contained in it.

Contents

1. INTRODUCTION

2. PRODUCT AND MARKET DEVELOPMENT

3. THE USE OF PEDELECS

4. ENVIRONMENTAL ASPECTS OF THE PEDELEC

5. OWNERSHIP AND USE OF PEDELECS IN PUBLIC ORGANISATIONS

6. PROVISIONS NEEDED BY ORGANISATIONS USING PEDELECS

7. REGULATIONS

8. ELEMENTS AND CRITERIA FOR PROCUREMENT

9. ANNEX

- **Actions/ decisions before buying pedelecs,**
- **Useful sources of information,**
- **Issues regarding to procurement of pedelecs.**

1. INTRODUCTION

In 1998, Yamaha introduced a vehicle that is now called now “pedelec” (pedal electric cycle). Using a pedelec, the rider has to move the pedals but he is supported/assisted by an electric system. The riders’ energy is combined with that of the motor. If the rider stops the motor will stop as well. In this way a pedelec is different from an electric bike where the electric motor may propulse the bike without additional energy from the rider. The pedelec can be ridden without the support of the electric system.

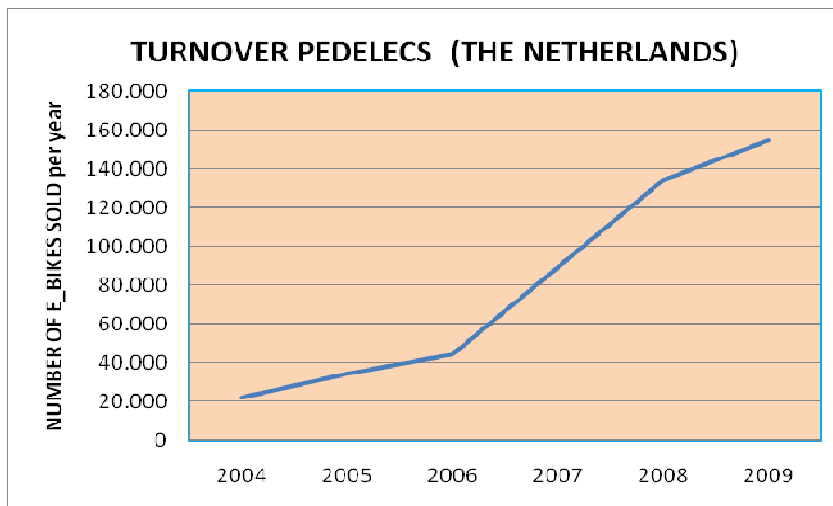
Technology available for the pedelec has gone up in performance at a high speed. New technology combined with design has sped up the market introduction and the dissemination of the pedelec. Now, after about a decade it is a reliable and environmental friendly product with a growing application. Among the users of the pedelec will be the employee of public organisations so these organisations should have information about the pedelec and its applications. In this document more information is provided in order to assist those involved in the procurement of pedelecs. The document discusses the pedelec for personal mobility. Other use e.g. for transport of goods requires other qualifications of the pedelec. It couldn’t be avoided to go into technical details discussing the pedelec. On the other hand selecting a pedelec is not only an activity focused on technology. Riding behaviour and design have an impact on the personal appreciation of a pedelec. So testing may be part of the procurement procedure. The technology of the pedelec will continue to be improved in the near future. So the procurement employee should inform about new developments. Moreover using pedelecs requires local maintenance and local service. The conclusion is that procurement of pedelecs is not a “copy paste activity” but it requires an effort of by skilled employees. In the document information is given about the development of the pedelec, its market introduction and economic aspects. As the pedelec is an environmental friendly product, much attention is paid to its environmental aspects. Public organisations may buy pedelecs but in some countries it is promoted that the employee himself owns a pedelec. This situation is enlightened in chapter 5. Public organisations with pedelecs need provisions like charging facilities, parking, repair services etc. These provisions are discussed in chapter 6. In chapter 7 the regulations regarding to pedelecs in the EU are given. Finally in chapter 8 criteria and elements for procurement of pedelecs are discussed.

PEDELEC: What’s in a name? Regarding literature on “electric bikes, pedelecs, e-bikes, electric scooters, electrically assisted bikes, electric power bike, electrically supported bikes, electrically power assisted bicycle (PAB), electrically assisted pedal cycle (EAPC) etc” the confusion in wording is terrific. In this paper we use the word pedelec in accordance with the European standard (EN 15194) and 2002/24EG for: an electrically power assisted cycle of a type with a maximum continuous rated power of 0,25 kW of which the output is progressively reduced and finally cut off as the cycle reaches a speed of 25 km/h, and of which the output is cut off at the moment the cyclist stops pedalling.

2. PRODUCT AND MARKET DEVELOPMENT

As such the bike with support is not a recently developed product. In cycling-sport the “dernie” (a bike with an engine assisting the rider) that is used as a pacemaker in track cycling was well known. But in the past it was a low developed product. After the introduction of the pedelec it took some years to develop a “grown-up” pedelec. The components of the pedelec first needed to be further optimised. So more efficient, smaller, more robust and low weight electric motors were needed. Moreover the batteries available in the past were very heavy, had an insufficient capacity (so a very limited riding range, insufficient capacity for use in hilly regions etc), long charging time, and a reduced lifetime. The lack of high quality components for the pedelecs resulted in a heavy vehicle that was rather difficult to handle. The small-scale production of the pedelecs and of its components resulted in a rather expensive product. Besides the lack of high quality components, the lack of good design was a major issue that was prohibitive for a successful market introduction of the pedelec. The lack of design resulted in a product that had no appeal at all. The pedelecs got the image of an “old people’s bike”.

The technical optimisation and a better styling and design resulted in today’s pedelecs. The designers created pedelecs that are more difficult to distinguish from a city bike. These pedelecs have technical properties, which made it a useful mode of transport. The image of “old- people’s bike” has been changed into that of “a green vehicle” and “sportive peoples bike”. This product has now achieved expanding turnovers. Information about the development of the turnover of pedelecs on the EU-level is not available. It is assumed the dissemination of the pedelec in the EU was fastest in The Netherlands. The dissemination of pedelecs evolved for the producers like a dream scenario:



The average annual growth of the turnover (in the period between 2004-2009) was more than 50%. The annual turnover of pedelecs in 2009 was seven times that of 2004. In the EU the most important markets for pedelecs are The Netherlands, Germany and Belgium. The estimated turn over on the EU-level was in 2008 about 300.000 pedelecs. In most other EU-countries the market is still in its infancy and has low market shares compared to the city

bike but shows a remarkable growth. This is demonstrated by the development of the turnover in France. In France the number of pedelecs sold in 2007 was 9700 (less than 0,5% of the total market of bikes), in 2008 the market was 15.700, (1,5% of the total market). The turnover of pedelecs in the United States in 2009 was estimated to be 150.000 and is showing a remarkable growth. In China the annual turnover is more than 10 million pedelecs. During a long period the major market for pedelecs was the private person. Later post delivery organisations introduced the pedelec on a large scale. The Royal Mail, Japanese Mail, Posti Finland and the Deutsche Post are now fleetowners with each thousands of pedelecs. The turnover figures and the widespread use demonstrate the pedelec is produced on a large scale and used under various conditions. This means there are no high risks of technological failure due to a lack of experience in production and use of pedelecs. The pedelec has become a reliable mode of transport.

3. THE USE OF PEDELECS

Purpose/use of pedelecs

As mentioned before the pedelec started its application as a bike for elderly people. The better technology and image gave impetus to new applications and new markets for the pedelec. The pedelec achieves now expansion in its use by commuters and in leisure. Timmermans et al (2003)¹ demonstrated that people having an pedelec used it almost to an equal extend for commuting, shopping and leisure. Recent research in The Netherlands² demonstrated that the use of the pedelec is expanding. More than 60% of owners that commuted used it for commuting. Besides it was used for shopping, leisure and for business contacts (15%).

The use of pedelecs depends among others on the distance to be covered. Commuters using bikes in The Netherlands covered on the average a distance of 6,3km as that of people using an pedelec was 9,8 km. So the average distance of the pedelec was 50% higher than that of the biker. It is expected that normally the pedelecs is used for distances between 1 and 20 kilometres. For shorter or longer distances other modes of transport will be used. People using pedelecs for leisure use it for longer distances.

The reason people preferred a pedelec depends on the personal situation: it appeared that various reasons were given for buying an pedelec: cover longer distances than using a bike, higher speed than a city bike, reducing use of car, environmental awareness, health, better than a bike when circumstances are unfavourable for cycling: wind, hilly area.

Analysing the various results from literature it is concluded that the pedelec differs from the city bike in its use in various aspects:

¹ Timmermans et al., World Electric Vehicle Journal 3, ISSN 2032-6653.

² Hendriksen et al, Elektrische Fietsen, TNO Kwaliteit van leven (Kvl/B&G/2008.067)

- Longer distances to cover than a bike
- Preferred under windy circumstances
- Preferred in hilly areas
- Sportier image than a car or public transport

Cost of pedelecs

Pedelecs are available in wide range of types. The price of pedelecs may be between 700 and 3000 Euro. In the range 1900-2500 good pedelecs are available. The most expensive parts of a pedelec are the frame and the batteries. The quality of the batteries is quite important (see chapter 8). The most expensive pedelecs don't need to be the best ones. In tests some average priced pedelecs performed quite well and proved to be good value for money.

The operating cost mainly consists of replacement of batteries as batteries have a limited lifetime (chapter 8). Batteries may cost 200-650 Euro (depending type, brand, capacity and quality). The energy used by a pedelec depends on the track, the pedelec, level of assistance etc. The cost of electricity was calculated by the Allgemeiner Deutscher Fahrradclub³ and appeared to be 20-40 Eurocent per 100 kilometres. If the cost of batteries is included the cost per 100 kilometres was estimated 2,50 to 3 Euro. It is clear that the cost may be different for the various situations but the data indicate that the cost of power is generally low but that the cost of batteries should be taken into consideration when using pedelecs.

4. ENVIRONMENTAL ASPECTS OF THE PEDELEC

The environmental aspects of the pedelec depend on various elements. The major one is the mode of transport that should be used if one had no pedelec. This will depend on the local situation. Vermie⁴ (2003) showed in Belgium the pedelec was used to an almost equal extent instead of cars, bikes or public transport system. In China pedelecs are used instead of public transport systems. In The Netherlands the pedelecs are a substitute for the bike (about 50%) and cars (about 40%).

The level of substitution of other modes of transport depends on the application and the distance covered. In most EU-member states it may be expected that for distances between 1 and 20 kilometres the pedelec will mainly substitute cars and public transport systems. Discussing the environmental impact we will compare the pedelec with these two modes of transport. The use of pedelecs has various environmental impacts. We may consider three stages: production, use and post use stage.

Environmental impact of production and post use stage of pedelecs

³ ADFC, Information zu Pedelecs und E-Bikes, 2009.

⁴ Vermie T. *E-Tour "Electric Two Wheelers On Urban Roads" - Final Report*. Brussel, European. Com, 2003.

The production of a pedelec requires raw materials such as steel and aluminium and energy. Other modes of transport require the same resources and normally will require more of these resources. In the post use stage the pedelec is waste that is recyclable to a large extent. Special attention should be paid to the batteries (see chapter 9).

It is considered that the pedelec has both in the production phase and in the after use phase a lower environmental impact than the other modes of transport.

Environmental impact of use of pedelecs

The major environmental impacts of the use of pedelecs are: CO₂ emissions, use of resources (fossil fuels), local air quality, low noise production and a reduced claim for parking space.

- CO₂ emissions.

There are differences between the CO₂ emissions of various pedelecs. Pedelecs may be used with various levels of support, so also the way it is used has an impact on the emission. The average energy use of twelve pedelecs was 10,4 Wh/km (Timmermans). To generate this energy about 8 grams CO₂ is emitted. Comparing the pedelec with other modes of transport it should be taken into account that also those modes of transport have a wide range of emission depending on the type of vehicle and of the local circumstances. As we compared the emission of CO₂ per person per kilometre the number of people in a vehicle is an important element. We used the average data for mobility in Belgium. The CO₂ emission per kilometre based on these data per person of various modes of transport⁵ are:

| Mode of Transport | CO₂-emission gr/km/person |
|--------------------------|---|
| Cars | 130 |
| Bus | 66 |
| Tram | 23 |
| Metro | 30 |
| Train | 28 |
| Pedelec | 6-13 |

It is clear that the CO₂ emission of pedelecs is very low (the energy consumption of a car is almost twenty times higher) compared to any other mode of transport. This is the reason why the pedelec is promoted by governments and by the EU-cofinanced project Go pedelec⁶.

-Lower resource use

⁵ The data about the cars, busses, trams and trains are obtained from De Lijn, the Belgian Public Transport Organisation. Occupation level etc is based on the average situation in Belgium.

⁶ http://www.gopedelec.eu/cms/index.php?option=com_content&view=section&layout=blog&id=11&Itemid=7

The use of pedelecs requires lower quantities of resources (fossil fuels) than cars etc. The reduction of resource use is at least in the same range as the reduction of the CO₂ emission.

- Local air quality

Personal mobility (other than trains and trams) contributes to local emission of NO_x, fine dust particles, hydrocarbons and CO. Generating electricity for charging the batteries gives very low emissions, which are realised outside of the city centre. So the emission of a pedelec in city centres is nil.

- Noise reduction

The pedelec has a very low noise emission.

- Parking facilities

The pedelec needs a quite smaller place for parking than a car.

Green Image of the pedelec

The pedelec is considered as a green mode of transport. The green image may contribute to the positive attitude towards introducing pedelecs in public organisations.

Differences in energy use among pedelecs

There are differences in energy use among pedelecs. The differences depend on use, track, weight of rider, level of support, age and condition of battery, temperature etc etc. Compared to the alternatives (e.g. cars) the differences among pedelecs are small. So far there are no standard methods for comparing energy use by pedelecs that give reliable information for the different pedelecs under the different circumstances. So energy use as a criterium for procurement is still a difficult issue. Tests may provide more information.

Pedelecs and bikes

So far the pedelec was compared with cars and public transport systems. Comparing pedelecs with bikes is a complex issue. The energy conversion of electric system and of the human body and taking into account issues like the reduction of showers etc will lead to a long discussion. The result of the discussion will depend on the assumptions to be made. One may wonder whether this discussion makes sense. It is clear it will only confirm that both modes of transport are by far more environmental friendly than any other mode of transport.

Conclusions

The pedelec has an impressive lower environmental impact than cars or public transport systems. The lower impacts relates among others to climate change (about a reduction of 90-95% compared to cars), use of resources and local air quality. The differences among pedelecs in energy use are of neglect able level compared to other modes of transport.

5. OWNERSHIP AND USE OF PEDELECS IN PUBLIC ORGANISATIONS

Although in some countries the pedelec is widely used there is lack of experience with procurement of pedelecs for public organisation.⁷ The experience of mail organisations regards on pedelecs with specific applications. Those pedelecs are developed to transport a lot of goods on top of the bike and for good delivery.



Pedelecs for transport of goods are quite different from the pedelecs for personal mobility.

The lack of experience in public organisations is partly due to the fact that organisations and the employees prefer that the employees themselves buy the pedelec and get ownership of it. So most public organisations don't buy the pedelecs. Elements contributing to it are:

- **Fiscal systems**

In some countries there are fiscal incentives to promote the use of pedelecs/bikes. These systems focus on promoting the pedelec/bike for commuting and so most incentives are focused on the employee and not on the employer. There are two types of tax incentives. One type focuses on the use of the pedelec/bike and the other type lowers the cost of buying it. An example of the first type is the "fietsvergoeding" in Belgium. The compensation is free from taxation if it is lower than 0,21 Euro per kilometre. In The Netherlands a part of the money used for buying a pedelec/bike (used for commuting) is free from income tax. Italy has introduced an incentive scheme for pedelecs⁸.

- **No responsibility for employer for maintenance and supervision**

For the employer ownership of pedelecs means he had to take care of maintenance, repair, supervision, charging etc. Most employers try to avoid this trouble and cost.

- **Less problems with maintenance**

The employee that owns the pedelec will take better care of it.

⁷ The experience of mail distributing organisations regards not to pedelecs for personal mobility but for good transport and delivery.

⁸ <http://www.bike-eu.com/news/3380/1st-in-eu-italian-government-spurs-bike-sales-with-incentives.html>.

- **Private use of the pedelec**

The employee prefers to own the pedelec in order to use it for private trips.

- **Rider may choose the model and type he/she prefers**

When the employee chooses his own pedelec he/she will choose the pedelec with design, size, model and colour he prefers.

- **Use of the pedelec for commuting**

In most organisations both the employer and the employee prefer that the pedelec be used for commuting. The lower parking claim by bikes and pedelecs is for the employer an important element⁹. Some employers strongly support the employee in buying a pedelec. In the city of Rotterdam the total compensation for commuting employees results into a total compensation of investments costs in three years.

An organisation considering promoting the use of pedelecs for business contact should envisage first what the best choice is in its specific situation. It is clear sometimes it may be preferred that the pedelec is owned by the employee and not by the employer or leased.

6. PROVISIONS NEEDED BY ORGANISATIONS USING PEDELECS

The use of pedelecs for business contacts and ownership of the Pedelecs requires specific provisions. A public organisation intended to use pedelecs should first think about these provision before the procurement starts.

Parking facilities

The pedelec needs to be parked overnight in a sheltered and dry place. To prevent theft or vandalism the place should have no access for unauthorised persons.

Charging facilities

Pedelecs should be charged before and after use. Some pedelecs have batteries that may be removed from the pedelec and can be charged outside of the parking facilities. Other types don't have a battery that can be removed easily and charging occurs than in the parking facility. Some organisations will prefer to charge the batteries immediately after use. This has the advantage that the batteries are charged and the pedelec is available for use at a later moment during the same day. Others will prefer to charge overnight. This is easier to organise (e.g. one person connects at five in the afternoon all batteries to the charging

⁹ In The Netherlands in some organisations more than 50% of the employees commute by bike or by pedelec.

device and disconnect them in the morning). Another reason for charging overnight is that in some countries the price of electricity is cheaper overnight.

It is recommended to have charging capacity that is able to charge more batteries at the same time if one owns more pedelecs. The capacity of the electric system needed depends on the number of batteries charged at the same time. Special attention should be given to the charging device. The connectors are not standardised. So different voltages and different polarity are used. Using the wrong charger or the wrong connector may damage the batteries and charging devices.

Maintenance and repair

Pedelecs need maintenance and repair. This requires: space, equipment and a skilled expert. Maintenance and repair may be outsourced. Some dealers will offer service contracts. If repair and maintenance are performed far from the parking facility one needs to organise transport of the pedelec. It may be preferred to organise small repair in (or next to) the parking facilities. It is strongly recommended to use for maintenance and repair entrepreneurs located nearby the parking facilities (e.g. <5 kilometre). Ways and means for maintenance and repair should thoroughly be considered before buying pedelecs because terms on maintenance and repair should be included in of the procurement process.

Supervision

Pedelecs need supervision. The supervisor regards to charging, keys of the bikes and the parking place, maintenance and repair, reservations etc.

Insurance

The legal position with respect to insurance may differ from country to country and from insurance company to insurance company. In most countries the pedelec does not need insurance. The pedelec is considered to be a bike provided the assistance of the motor is only provided till a speed of 25-kilometre/hr. Pedelecs riding at higher speeds with support may raise discussions. Moreover some pedelecs are able to ride at very low speeds (less than 6 kilometre per hour) using only the electric motor without power being provided by the biker. This is especially for making start up more easy going. This pedelec is according to some definitions not a bike but an electric bike and subjected to other insurance preconditions. In some countries (e.g. the UK) some types of pedelecs used to have a switch with which the pedelec was transformed into a vehicle that was only propelled by the motor. These vehicles are not considered to be a pedelec but an e-bike. All this may give nasty disputes about insurances. Another point to be considered is the lack of jurisprudence in most countries. It is highly recommended for a public organisation to contact its insurance company with respect to the pedelecs. As there are differences between the various pedelecs (e.g. the riding without human support at a low speed) the information should be focussed on the pedelec that is used by the organisation and not on pedelcs in general.

Apart from the legal situation it is advised to public organisations to consider taking a liability insurance for its pedelecs and the riders. As in some areas pedelecs are vulnerable for theft it may be considered to insure the pedelec and its parts (e.g. the battery) against theft.

7. REGULATIONS

Eu-regulations

In 2009, the EN 15194 standard for Electronically Assisted Cycles went into force. The mandatory status of the standard is sometimes discussed¹⁰. It is however assumed that the pedelecs in the EU must comply with this standard. The EN15194 gives specifications about safety requirements and test methods of pedelecs using battery voltage up to 48 VDC or an integrated charger with a 230 V input. The EN 15194 regards to design and assembly, electrical circuits including charging systems, batteries, electric cables and connections, measurement of maximum power, power management, maximum speed for which assistance is given by the electric motor etc. EN 15194 includes the requirements EN 14764 for mechanical parts.

As the EN 15194 regards to safety and reliability public organisations involved in procurement of pedelecs should require documents (or certificates) that prove the pedelecs offered comply with this EN 15194.

National regulations

EN 15194 regards to technical aspects of pedelecs. The use of pedelecs depends on national regulation and may be different in the various member states. The pedelec is considered to be a bike. In some countries a pedelec that can drive at a low speed without human power is not considered to be a bike but an e-bike and may require a driving license (Information derived from ADFC¹¹ for the situation in Germany). In other countries use of helmets may be required for those pedelecs. The national regulations develop often slower than technology does. Probably the authorities never had the intention to introduce driving licenses or helmets for this type of vehicles. In practice the enforcement of this type of regulations may be weak but in case of accidents these regulations may cause trouble with authorities and insurance companies. The public organisation introducing pedelecs for personal mobility should inform about the national regulations on pedelecs. Special attention should be paid to pedelecs propelled without human energy. It should be required the pedelec offered is a bike according to national regulation.

8. ELEMENTS AND CRITERIA FOR PROCUREMENT

¹⁰ Http: [www: endless-sphere.com/forums/viewtopic.php](http://www.endless-sphere.com/forums/viewtopic.php)

¹¹ ADFC, Information zu Pedelcs un E-bikes, Bremen 2009.

Although in some countries the pedelec is widely used there is lack of experience with procurement of pedelecs. The experience of mail organisations regards on pedelecs developed to transport goods on top of the bike and for good delivery. This document is written for organisations that want to use the pedelec for personal mobility.

Lady's bike or gentleman's bike

Most pedelecs are available as a lady's and as a gentleman's pedelec. The difference between the two types is more than just the lack of the top tube (crossbar). The distance between the handlebar and saddle may be different as well. The choice to make may depend on the person that will use the bike. When more persons use the pedelecs it is advised to prefer lady's bikes. Some types have lady's pedelecs that are smaller than the gentleman's pedelecs.

Frame size

There are various frame sizes. The wrong frame size may lead to back pain and unsafe situations, as the driver should be able to have its feet on the ground if necessary. The best method to determine the frame size is to use the length of the legs.

Determination of frame size

Stand barefoot against a wall. Measure the inseam by having a book between the legs pressed up to the pelvic bone. Mark with a pencil on the wall the position of the top of the book. Measure the distance from the floor. Multiply the inseam (in cm) by 0,65= frame size in cm. (Attention: frame sizes are sometimes expressed in inches)

To determine what is most comfortable a test ride is recommended.

Frame type

A pedelec may be used without support. The frame should be designed in a way pedalling is efficient and easy. This means scooter like pedelecs should be avoided.

Painting of the frame

Painting of the frame or parts of the frame should be performed in an environmental friendly way. So use of organic solvents and highly toxic compounds should be avoided. Reference could be made to National guidelines for green procurement regarding to painting.

Stem and handlebar

Multi-position handlebars and adjustable stems are widely used. These devices allow adjusting the pedelec to personal preference. The availability of those devices makes sense if

the systems are adjustable easily (and without specific tools) and if the pedelecs are used for longer distances e.g longer than 25 kilometres).

Front suspension/ shock absorption

Most pedelecs have a the front wheel with a shock absorbing fork in order to reduce shocks from uneven tracks. Taking into consideration the increase of the riding comfort and riding stability such a device is recommended.

Saddle

If women and men use the pedelec the saddle should have a shape that fits well for both. If it is used by persons with various lengths it is recommended to require that the saddle height may be changed without using a tool. Gel-type of saddles are generally considered to be comfortable.



Example of an easy adjustable saddle

Luggage rack

Although this documents regards to pedelecs for personal mobility some transport of goods may occur. A luggage rack with a load up to of 15 kilo and a strap should be required.

Support stand

As a pedelec is heavier than a bike a good support stand is required. It may be considered to require the support stand should be able to support the pedelec on a slope.

Weight

The average weight of a city bike is 15-20 kilos. The weight of a pedelec is 20 – 35 kilos. The higher weight of the pedelec is caused by the heavier frame construction, the motor and the

the battery. The high weight reduces riding comfort, riding stability and energy efficiency. Besides a heavy pedelec may be difficult to be transported. For transporting pedelecs special carriers may be used that are fixed on the towbar. The weight allowed on a towbar may be limited by the producer of the car or by law. To reduce weight it is recommended to require an aluminium frame (moreover these frames are resistant to corrosion). Frames of reinforced carbon fibre have a very low weight. These frames are very expensive so they are not recommended for our target group. As discussed later the type and capacity of the battery have an impact on the weight of the pedelec. A smaller capacity of the battery means a lower riding range so optimising to a low weight should be done without reducing the battery capacity. A pedelec with a high weight should be avoided. Good quality pedelecs with a weight lower than 30 kilos are available.

Gearing systems

The rider of the pedelec should be able to use it at high and at low speed. The use under different circumstances requires a good gearing system. Based on tests it is advised to have six or more gears. Fewer gears may be troublesome under difficult circumstances (climbing the Mont Ventoux). More gears are not required. (There are pedelecs available with 21 gears.) There are two types of gearing device: the hub-gear and the derailleur gearing system. Both systems are of good quality. The hub gear may be used to change gears while the bike stands still. The derailleur system requires for changing gears that the bike is riding. If you stopped in a high gear and you have to start (uphill) it is useful to be able to change gear without riding. In a test of the Dutch Consumers Organisation¹² people preferred the hub-gear for this reason. People who use the pedelec at a high frequency may be accustomed to stop using a low gear. The type of gearing system in a pedelec often depends on the location of the motor. The motor may be located in the front wheel. Then the nave of the rear wheel offers enough space to locate the hub gear. If the motor is in the nave of the rear wheel there is no space in this nave to locate the gearing device and a derailleur is than the only solution.

Location of the motor

In a pedelec two types of motors may be used. The hub motor, which is in the nave of the rear wheel or in the front wheel and a motor located near the bracket (e.g. crank motor).

¹²<http://www.consumentenbond.nl/>



The hub motor in a rear wheel (left) and in a front wheel (right)

Both types have some advantages and some disadvantages. It is considered that the motor located near or in the pedal axis provides a more stable riding. The modern hub motor is light and the impact on the riding properties is lower than in the past. If the traction of the motor is transmitted by the chain to the rear wheel it appears that the wear of the chain and of the chain wheels increases remarkably and a more frequent e.g every 8000 kilometres replacement of this parts is required (Timmerman). This is a rather expensive repair.

The difference between the two motors is also that the hub motor has no gearing device (there is a gearing for the transmission of the traction of the pedals but not for that of the motor). The hubmotor should cover the total range of speeds required. At low speeds some of the hubmotors have a lower support than the geared other type of motor. Hubmotors are improving but buying a pedelec one should pay attention to this issue (support level at low speed when starting). A disadvantage of a geared motor is that gearing means loss of energy. The loss of efficiency may be about 15%.

The hubmotor is further expanding in the market and is dominant in pedelecs for personal mobility. It is expected that (for the time being) other motors will keep a good position in pedelecs for transport of goods.

Batteries

Types of batteries

In theory there are four different types of batteries. Sealed lead (Pb) batteries, Nickel metal hydrid batteries, Lithium-ion batteries and Nickel Cadmium batteries. Nickel cadmium batteries are no longer available in Europe due to their negative environmental impact.

The price of batteries is very important for the total price of the pedelec. Sealed lead batteries are cheapest but are very heavy. Pedelecs with these batteries are often the cheapest pedelecs. If charmed by the low price of lead batteries, one should realise that its life span is two to three times shorter than that of the other types of batteries. The heavy lead batteries make the pedelec heavy and the handling of the pedelec more difficult. This is even worse if the battery is located at a high place in the bike. Nickel metal hydrid (NiMH) batteries are lighter, have a higher energy density, but are more expensive than lead

batteries. Lithium ion batteries are lighter, have a higher energy density but are more expensive than the NiMH batteries. The sealed lead batteries should be avoided. It is recommended to require that the producer will accept that old batteries are returned (at an acceptable price) and will process them in an environmental friendly way.

Lifespan of batteries

A lot of research is focused on batteries and progress in quality of batteries is made. So far the lifespan of batteries is shorter than that of a pedelec. Replacement of batteries is an impressive cost. Guarantees pertaining to the lifespan of batteries should be part of the terms in procurement. Batteries should be stored in a way they cannot be stolen easily if the bike is parked outside. On the other hand it should be possible to change batteries at low cost if they are at the end of lifetime.



A Lithium ion battery pack of 2,5 kg that may easily be changed.

The lifespan of batteries depends (among others) on intensity of use, the way it is used and the age of the battery. The lifespan of batteries is given by the number of charging and discharging cycles (CDc). The lead batteries have the lowest lifespan (about 200 CDc). The lifespan of the other batteries is two to three times higher. These batteries may have a longer lifespan but they lose capacity in such a way that the driving range is reduced to much after about 500 to 600 CDcs. One of the nasty properties of batteries is aging. It will gradually lose quality and will at the end discharge slowly and have a lower capacity. So the driving range will decrease. The life span of a battery due to aging is about five years.

Level of charge gauge

The pedelec should be provided with an indicator of the level of charge of the battery. The indicator should be visible while riding.

Deep discharge protection system

Deep discharge of a battery may be harmful for it. The pedelec should be provided with a system that prevents deep discharge in a way it switches off the electric system at a certain level of discharge. Pedelecs may have a rebooting system in order to start up the electrically system. Rebooting may be possible without charging the discharged battery. Continued use

of a discharged battery by repeated rebooting may result in a very deep discharged battery and have detrimental effect on its lifetime. The riders should be instructed to avoid this.

Changing batteries

The way the batteries are changed may in some situations be a decisive issue in the procurement. There are batteries that may be changed easily. This means the batteries may be changed in a place inside without taking the bike inside. In some situations this is important. Another advantage of this system is one may use a spare battery which may be important if one wants to ride longer distances than the driving range of a single battery. The last argument is gradually less important because the driving range of modern pedelecs is at a higher level than in the past. In the frame incorporated batteries are better protected against humidity, mechanical damage, and theft. The disadvantage of the easily changeable batteries is that these batteries are very “visible” stored which is disliked by some people. The incorporated batteries are less visible so it is difficult to distinguish the pedelec from a city bike. The exposed easy changeable batteries should be protected against theft in a good way. Taking the battery out when parking is not always attractive as these batteries may be rather heavy and people don’t like carrying it with them during a meeting (or shopping). So protection against theft needs serious attention. In most cases the place for charging the battery will be the decisive issue when choosing the system: a (hidden) fixed or an exposed quick-change battery.

Charging time

The charging time of batteries is important if the biker travels distances that are longer than the driving range. Then a quick charging is wanted. The modern pedelec has a charging time (from total discharge to full charge) between 2 and 6 hours¹³. A shorter charging will result in a partly charged battery. It should be taken into account that smaller batteries (batteries with a lower capacity) often have a shorter charging time. So quick charged batteries may have a more limited driving range and need to be charged more frequently. It is important to consider the use that the organisation will make of the pedelecs. Most trips will be shorter than twenty kilometres. A modern pedelec may cover two times this distance. For most organisations an extra full charging cycle will never be required for one trip or on one day. So the charging time is of less importance unless pedelecs with a short driving range (which is not recommended) are bought.

Charging batteries

The connecting of the batteries with the charger should be easy and quick without risks of mistakes. In The Netherlands a public charging grid is developed and contains already about 450 charging spots¹⁴.

Assistance

¹³ In exceptional cases batteries with longer charging times are offered.

¹⁴ www.iohotspots.nl

In practice one may distinguish three situations in which the support by the electric system is important: support on a flat area, support uphill and support when starting. Most pedelecs offer acceptable assistance uphill and on a flat area. Remarkable differences are seen when starting. It may depend on the local circumstances and the person riding the bike to what extent the assistance in starting is relevant. Testing the pedelec is the best way to experience the difference between the various pedelecs that are offered.

Another issue for testing is the constant level of support. It appeared some pedelecs don't have a "smooth" constant level but slight variations in support are being felt when pedalling which may give an inconvenient feeling.

Assistance level

A pedelec may be used at different support/assistance levels. The rider should be able to switch between the various levels: e.g. maximum support, less support and no support.

Display and controlling system

A modern pedelec has a speed meter, a trip meter, an odometer, and an indicator for charging levels, an indicator of the level of assistance, a switch for light. The display should also be clear in sunlight.

Braking system

A pedelec requires a good braking system. Brakes on both the rear wheel and the front wheel should be required. Brakes may be provided with a device that stops the assistance by the electric system when using the brakes. A new development is regenerative braking. In this type the braking energy is converted to electric energy that is used to charge the battery. Experts have divided opinions about it. Some pretend it is a device with a positive impact on the driving range. Others pretend the device adds more weight to the pedelec and so its energy saving contribution is marginal. They point to the cost of the regenerative braking. They claim the system is not worth the obtained efficiencies. In other vehicles like buses the regenerative braking system is a general applied system that really contributes to the energy efficiency. The economy of the regenerating brakes for pedelecs is questionable. The cost of power for a pedelec is very low (20-40 Eurocent/100km). Assumed in its lifetime (e.g. ten years) a pedelec is used for 50.000 kilometres an increase of efficiency of 2% has an economic value of about 2 to 4 Euro. So it is questionable if a regenerative braking system is an economical attractive proposition even if higher increases of efficiencies may be achieved. The conclusion is that the regenerative brake will reduce energy need and increase riding range under certain conditions. In other circumstances its impact may be neglectable. There is a lack of data that are suitable for various situations. So far the economics of the regenerative brake are questionable.

Driving range

The driving range of a pedelec depends on track, speed and speed variations, starting and stopping, weight of rider, age of battery, level of assistance, wind etc. This makes the driving range of pedelecs a difficult issue. The driving ranges given by the producers are often optimistic. So far no uniform methods for measuring the driving range are used. But even if those methods were used the variety of circumstances in practice would limit the value of the results. However the driving range is important for most users. The best way to get information on driving ranges is testing various types of pedelecs under the same conditions on the same track. To give an impression of the ranges the result of a test of 12 pedelecs¹⁵ is used:

| | Range average | Min. and Max. Range of tested pedelecs |
|-----------------|---------------|--|
| Full support: | 44,7 km | 28-57 km |
| Lowest support: | 59,6 km | 39-79 km |

The importance of the driving range should not be exaggerated. The public organisation should have a clear view of the trips (with full assistance of the electric system) that should be made by the pedelec. In most organisations the trip (single) will be less than ten kilometre and trips of twenty (single) kilometre will be rare. In those situations even the pedelec with an average range will cover the needs in almost all situation. If once a longer distance should be covered a lower assistance level may be used. The driving range of the producer may be an indication for the range but as mentioned testing is the best. If one is not able to test various pedelecs some advice may be given. Most pedelecs with a low weight and a NiMH or a Lithium ion battery of a capacity 250 Wh capacity (or higher) will have a range of more than 35 kilometre (with fully assistance).

Light

The rear light and the front light of pedelecs are vulnerable for damage. The lowest damage may occur to those systems in which the lights are incorporated in the frame or protected by a good construction.



A rear light that is well protected against mechanical damage.

¹⁵ <http://www.plusonline.nl/geldenrecht/artikelen/artikel/1301/e-bike-de-testresultaten>

It is advised to take halogen or led lamps (these lamps have long life time and low energy use) that use electricity from the battery. Changing the lamps should be possible in a simple way without using tools that are not common. According to information provided by the ADFC¹⁶ the power for the light should not be derived from the batteries in Germany.

Theft

A pedelec is sometimes parked on a public place. It is necessary to protect it from theft. There are mechanical and electronic protection systems of good quality available. Special attention should be paid to the resistance of the expensive battery against theft. An additional chain lock may be advised to connect the bike with an unmovable object.

Manual

The pedelec should be delivered with a good manual that in the native language of the rider. The manual should contain information on: technical specifications, riding, maintenance, simple repair like changing lamps etc. It is important the manual gives instructions and advice for charging in the right way in order to obtain a long life span of the battery.

Spare parts

It is important to have quick access to spare parts. Maximum delivery times for batteries etc may be part of the procurement terms. Another requirement is the time spare parts will remain available. The provider should guarantee that batteries suitable for the pedelec would remain available during at least six years or longer as a pedelec may have a longer depreciation period of ten year.

Service agreements for maintenance and repair

If the organisation doesn't have a technical section it is recommended to have a service agreement. The distance between the repair place and the parking place of the pedelecs should be limited. The response time should be less than e.g. half an hour as a pedelec may fail while making a trip. (See the previous chapter).

Guarantee

Guarantee against possible defects other than failure due to traffic accidents, wear, etc should be required. Guarantee periods for electrically systems (other than the battery) should be given for at least 2 years, for frames 5 year, for painting 3 year. Special attention should be given to the battery. Suppliers may be reluctant with respect to guarantee for batteries. As a battery slowly loses quality by using (even under favourable conditions) a full guarantee may not be expected. It is a matter of negotiation. Providers should guarantee a capacity level of the battery during a certain period (e.g. 70- 75% of its rated capacity after one year). Other ways to express guarantee is using the covered distance as an indicator e.g.

¹⁶ Based on the Strassenverkehrs-Zulassings-Verordnung Par. 67.

10.000 kilometres. Some providers are willing to offer guarantee for two or even three years.

9. ANNEX

ACTIONS/DECISIONS BEFORE BUYING PEDELECS

1. Should organisation or employee own the pedelec?
2. What trips are made? How many trips of 2-20 kilometre a day will be made?
3. How many pedelecs are wanted?
4. What types are wanted: Lady/Gentleman/frame size?
5. Is a suitable parking facility available?
6. Is a charging facility in the parking facility possible?
7. Maintenance and repair: outsourcing yes or no?
8. How will the supervision be organised?
9. How will we organise support for the pedelec in the organisation?
10. Cost estimate: Investment cost, annual cost.

USEFUL SOURCES OF INFORMATION

1. Tests.

A lot of organisations (e.g. national cyclist federations, consumers organisations etc) organise tests. Most of those test are available either in national or local publications or on the web. Using this test it should be taken into account that:

- The technology is rather fast developing. Test older than two years have a limited value as these don't include recent products.
- Be keen on the issues tested and the criteria used. Those may be different from the criteria of the public organisation.

2. Labels.

So far there is no labelling system at the European level.

3. Websites.

Some organisations have websites that provide useful information on pedelecs. The enumeration is not complete but may contain information and links to national organisations and producers.

- WWW.ECF.com : this is the site of the European Cyclists' Federation. On the site links to national federations and other organisations are provided.
- WWW.velo-city2009.com/index-nl.html : a site of a group of European cities that cooperate to promote the use of bikes and pedelecs.
- WWW.extraenergy.org : site gives producers information, test results etc.
- WWW.ETRA.com : site of the European Twowheelers Retailers' Association. It has links to national members.

| ISSUES REGARDING TO PROCUREMENT OF PEDELECS | |
|--|--|
| Requirements should be adapted to the specific use of the pedelec. | |
| ISSUE | ADVICE |
| Definition | pedelec in accordance with the European standard (EN 15194) and 2002/24EG for: an electrically power assisted cycle of a type with a maximum continuous rated power of 0,25 kW of which the output is progressively reduced and finally cut off as the cycle reaches a speed of 25 km/h, and of which the output is cut off at the moment the cyclist stops pedalling. |
| EU-legislation | Require a certificate that proves the pedelec is in accordance with EN 15194 |
| National regulation | Require declaration that the pedelec is according to the national regulations a bike. |
| Styling/design | If applied: mention the design requirements (resemblance with a city bike). |
| Riding behaviour | High quality is wanted. Test panel for final choice? |
| Price | Price range: 700- 3000 Euro. In the segment 1900-2500 Euro good pedelecs are available. |
| Price Battery | Price range 200-650 Euro |
| Type of bike | Type of bike: lady or gentlemen type, depends on user. If mixed use then ladies is recommended. |
| Size of bike | Size depends on users (determination of size Chapter 8). |
| Frame type | Pedalling without support should be effective and convenient: e.g. no scooter type |
| Painting of frame | The painting of the frame should be according to high environmental levels. |
| Front Wheel suspension | The fork of the front wheel should be provided with a shock absorbing suspension . |
| Saddle | Depends user. If mixed use the saddle should be convenient for ladies. Saddle adjustment without tool. |
| Luggage rack | Provide with strap and an load up to e.g. 15 kg. The load may depend on specific requirements. |

| | |
|-----------------------|--|
| Support stand | Good support stand. If wanted require the stand should support on a slope and /or with the luggage rack packed. |
| Weight | Low weight is preferred. Weight lower than 30 kg may be required. |
| Gearing system | Six gears or more for pedalling traction system |
| Support | Motor not more than 0,25Kw, not less than 0,23Kw. |
| Support | Three modes of support/assistance: low, medium, full and no support |
| Support | No support/assistance without pedalling |
| Support when starting | Test for support level when starting. Avoid gearing system for motor when possible. |
| Support when riding | The support should be "smooth" and at a constant level when pedalling at a constant level. |
| Battery return | Old batteries should be accepted by the company at no additional cost and should be recycled in an environmental friendly way. |
| Batteries | No sealed lead batteries, No Ni-Cadmium batteries. Nickel metal hydrid (NiMH) or Lithium ions batteries. |
| Capacity of batteries | Depends on wanted range: good capacity is 250Wh or more. |
| Changing batteries | Depends on wanted charging place: Easy removable batteries required if charging is not in parking place |
| Charging | Connecting battery to charger easy and quick without risk of mistakes |
| Charging time | Depends on use. Less than 6 hrs for full charge . |
| Lifespan battery | Require guarantee: at least two years, or 10.000 kilometre. |
| Battery protection: | Mechanical protection: the battery should not be damaged when bike falls. |
| Battery protection | Battery should have a deep discharge prevention system. |
| Battery protection | Battery should be protected from theft: electronic system, or mechanical system. |

| | |
|----------------------------|---|
| Display controlling system | Indication of: level of charge, speed meter, trip meter, odometer , assistance level switch, switch for light. |
| Backing system | Two brakes of high quality |
| Driving range | Depends on use of pedelecs: a range of 40 kilometre is a technical achievable requirement. |
| Light | In accordance with local regulation. Preferred: battery for energy supply, led or halogen lamps. Well protected against mechanical damage. |
| Protection against theft | Electronic and or mechanical locking system. |
| Manual | Language. Etc see chapter 8 |
| Maintenance and service | If maintenance and service are outsourced: Contract should contain: transport of pedelecs, repair and time for response or distance from the parking place. |
| Spare parts: | The company quarantees the availability of spare parts during at least six years. |
| Guarantee | Requirements: Electric system: 2 year, battery 3 year, frame 5 year, painting 3 year |
| Test riding | The company should offer a pedelec for testing: range, driving comfort, support at starting etc. |