GoPedelec!

Go Pedelec! Go easy!

Supported by INTELLIGENT ENERGY EUROPE

IEA INTERNATIONAL ENERGY AGENCY HYBRID & ELECTRIC VEHICLE IMPLEMENTING AGREEMENT

OVERVIEW

AIM This *GoPedelec* handbook offers an introduction to the subject of pedelecs and their potential for society and the economy, to their promotion as products, and to their problems and opportunities.
This work aims to assist in the making of correct, that is well informed, purchase decisions and to provide ideas, inspiration and real-world examples for the further dissemination of pedelecs in wider society.

TARGET AUDIENCE Both individuals and organizational decision-makers who want to learn more about pedelecs.

FORMAT This brochure draws on the Pedelec Magazine from *ExtraEnergy e.V.* and it has a hybrid format which combines articles with the classic elements of a handbook. It also contains examples from the real-world experiences of *GoPedelec* projects in the form of best practice case studies and examples from external experts.

STRUCTURE The publication is divided into six thematic sections: Markets & Trends, Technology, Buying, Promotion, Health & Environment, Standards & Regulations

Markets & Trends

This chapter will explore the economic potential of the pedelec employing current and forecast market data, all in the context of the ongoing digital revolution. (Design) trends and market segments hitherto not widely recognized but with remarkable growth potential demonstrate what the pedelec might in future become.

Technology

The pedelec belongs to the wider circle of Light Electric Vehicles (LEVs). A glossary gives an overview of the most important vocabulary of e-mobility and is followed by detailed evaluation of the electrical components of a pedelec.

Buying

Here customers will find practical tips on buying a pedelec and general information about tests and prices. How to evaluate test reports and key specifications, notes of caution to observe and what it's best to test for yourself: it leads step by step to the right pedelec.

Promotion

Pedelec promotion through the provision of test rides is at the heart of the *GoPedelec* project. Experience and best practice with a variety of target groups is underpinned by diffusion theory, demonstrating that the pedelec is a technology on its way to wider acceptance.

Health & Environment

This chapter covers the ecological credentials of the pedelec, considering its potential to reduce CO2 emissions, and discussing its sustainability over the entire product lifecycle. In a further report the pedelec is introduced as an ideal training device for enhancing health.

Standard & Regulations

This is the most political chapter, dealing as it does with standardisation and efforts towards harmonisation at the European and national levels. Laws and standards are explained, and harmonisation measures recommended. Alongside practical tips you will find suggestions and inspiration for a political approach through which the pedelec can reach its full, rightful potential.

BEST PRACTICE

FLTR Gerhard Ablasser, head of the EU Ofice of the City of Graz; Waltraud Schmid, Head of Sector Energy Efficiency Unit, EACI (supporters of the *Go Pedelec*! framework project); Federal President Gregor Hammerl; Federal Minister for Land and Forests, Environment and Water, Niki Berlakovich; Federal Minister for Science and Research, Dr. Karlheinz Töchterle; National Assembly Congressman Hermann Schultes.

Welcome

Pedelecs are playing an ever more significant role in our everyday mobility. Among the many and varied applications is the very positive 'support effect' for the mobility of senior citizens: this could mean making everyday journeys that bit easier, or, and this is particularly valuable, in improving their opportunities to enjoy their leisure. It is not only in my capacity as President of the Federal Council of Austria but also in my function as the regional head of the Styrian Senior Association and as the honorary Chairman of the Styria Social Aid Scheme that I am delighted to support this initiative. An important contribution was also made by the event held on the steps of the Austrian Parliament in Vienna.

GREGOR HAMMERL
PRESIDENT OF THE FEDERAL COUNCIL OF AUSTRIA

Personal transport is problem child number one for climate protection in Austria. Ever increasing fuel prices are however motivating many drivers to change. It's a fact: three quarters of all car journeys are shorter than seven kilometres. Electric bikes are the ideal alternative for shorter journeys, and to bring people to public transport. Because with a 'tailwind' you can get to work or run errands with minimal effort.

And in addition, cycling is fun and it keeps you fit. With our "Climate: active mobility" promotion scheme we are supporting the electric bike market and thereby also creating new green jobs.

With this in mind I welcome the publication of this pertinent, high quality and brand-independent handbook, because as before there is still a huge information gap both for end users and also for municipal decision-makers and tourism authorities, for example on the subjects of 'Quality differences in pedelecs' and 'Infrastructure'.

NIKI BERLAKOVICH
FEDERAL MINISTER FOR LAND AND FOREST ECONOMY, ENVIRONMENT AND WATER, AUSTRIA

The topographical layout of Stuttgart, with height differences of 300 metres within the city, is perhaps one of the reasons that the world's first car was invented in Stuttgart. When it comes to encouraging cycling, this same topology is a huge challenge. I love riding a pedelec, because the extra push from the electric motor makes cycling so much more pleasant. Pedelecs transform Stuttgart into a 'flat' city. There are already many pedelecs in Stuttgart - in private use, as official vehicles for the city authorities, or as part of the public bike hire system *Call a bike*.
The European project *Go Pedelec* is an ideal platform through which to share our experience with cities and partners across the whole of Europe. This new handbook will surely convince decision makers, dealers and individuals that you can get around town on a pedelec healthily, emissions-free and affordably. My sincere thanks go to the partner organisations from the Netherlands, Germany, Austria, Italy, Hungary and the Czech Republic. With your remarkable work you have once again demonstrated that collaboration in Europe can contribute hugely to our common goal: to improve the quality of life of our citizens.

WOLFGANG SCHUSTER
MAYOR, STUTTGART

Graz is set for electro-mobility! Not only are we continually extending our tram network, we are also the centre of the E-Mobility Model Region of Greater Graz. Here pedelecs are a significant component in the framework of our various activities. Information is all gathered in the newly constructed E-Mobility Centre in the city's central zone, where residents also have the opportunity to access comprehensive resources. Many products are available to borrow, and so also to test. It's what you might call a permanent incarnation of the *GoPedelec* test track. A test ride is an important step in the decision making research before a purchase, because quality really matters.

SIEGFRIED NAGL
MAYOR OF GRAZ

One of the central results of our *Go Pedelec* project is in your hands. You will find much information here which despite the pedelec boom in certain European countries you will find in no relevant magazine, nor online, nor anywhere else. Much is about visionary characters, sorely needed even in this highly dynamic sector. Visionaries, but supported by the experience of what is in my opinion Europe's leading pedelec association, *ExtraEnergy e. V.*, under the leadership of Europe's leading pedelec expert, Hannes Neupert, and by the contributions of project partners and third party experts. Please note that the *Go Pedelec* project also offers you many more valuable resources at *gopedelec.eu/downloads* - for example a document with information about pedelecs especially for municipal decision makers, a document on pedelecs and renewable energy, a huge freely editable poster collection about pedelecs for use in your school, town hall etc., a report on a pedelec survey across six countries, brochures und *Best Practice Guides* (case studies of positive activities with pedelecs in communities, regions and companies). In addition we hope to extend the core activites beyond the project end in all partner countries as far as our resources and those of interested third parties permit: workshops for municipal decision makers, expert training and of course roadshows. Cooperation partners are sought: see *gopedelec.eu/continuation* for more details. Last but not least: the EU framework promotion programme, *Intelligent Energy Europe (IEE)* also offers many infomation resources such as handbooks and tools around the cycling theme, especially for municipal decision makers, collated at *eltis.org*.

THOMAS LEWIS
GO PEDELEC PROJECT COORDINATOR

10 reasons why the pedelec will catch on as a form of transport

These reasons have been compiled together among the *Go Pedelec* consortium and are listed in order of importance from a municipal point of view. Within the *Go Pedelec* consortium the municipalities or organizations of the following cities are represented: Naples (IT), Graz (AT), Miskolc (HU), Stuttgart (DE) and Utrecht (NL).

Hannes Neupert, Antje Hopf

1

Space-efficient to park

Pedelecs need just as little parking space as any bike, but because of their ease of use they have the potential to convince 30 %[1] of car drivers to move to cycling. This creates space for more greenery and play areas in town centres.

2

More mobility in less space

Pedelecs offer much mobility but take little road space, because they allow people to keep up an even and matching pace largely irrespective of gradients or headwinds. They use the available road space more efficiently while still allowing riders to cover similar distances to typical car journeys in town and in rural local transport.

3

Comfortable, cheap and and definitely faster than a car around town

Compared to public transport or cars, pedelecs are in general considerably more affordable. Costs for a pedelec currently stand at just € 40 per month[2] or less, including depreciation of purchase cost, maintenance and wear.

SMART MHD[3]

TIME

JOURNEY TIME 20 MIN | WORK TIME 40 MIN — 60 MIN

MONEY

COSTS € 4.82*

*COSTS OF USE AND DEPRECIATION

PEDELEC[4]

TIME

JOURNEY TIME 33 MIN | WORK TIME 6 MIN — 39 MIN

MONEY

COSTS € 0.67*

+ health benefits: see point 7

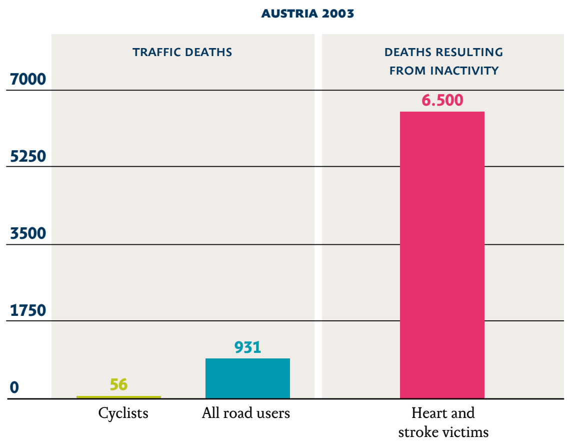
References Car costs from *Auto-Motor-und-Sport:* 1h ride in *Smart mhd* = 14,52 € costs[5]
Assumed net salary costs (6.99 € / h), working hours (39.12 hours per week) are average values for 2006 in the following set of countries: BE, BG, CZ, DK, DE, EE, IE, GR, ES, FR, IT, CY, LV, LI, LU, HU, MT, NL, AT, PL, RO, SL, SI, FI, SE, GB, NO und TR[6]
Average car speed in European cities : 30.13 km/h[7]

4

EMISSIONS SAVING

Pedelecs cause only minor CO_2 emissions, are silent and emit zero particulate matter.

5



SAFE

Pedelecs are safer in traffic because they are slower and lighter than cars. Statistics show that the probablility of early death due to lack of exercise is considerably higher than when you ride your bike to work every day and tackle the traffic without being in a 'sheet metal tank'.

Source: WHO Statistical Information System, 2003 & KfV, Accident Statistics 2003

6

MOBILITY ENHANCING

Pedelecs are at least as good as cars for satisfying most everyday mobility requirements, just cheaper, cleaner and more healthy.

7

HEALTH ENHANCING

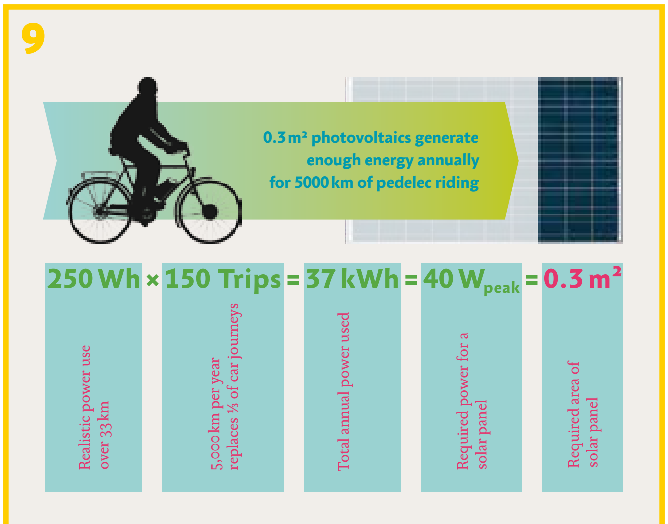
According to the *WHO (World Health Organization)*, 30 minutes of cycling every day can extend life by 8 healthy years.[7] This applies equally and more for pedelecs, because they can easily and beneficially be used by unfit people or people with health problems to get back into cycling. Furthermore, with suitable pedelecs you can find even more opportunities with which to combine exercise where previously a car was needed, for example transporting cargo or children.

8

ENERGY EFFICIENT

With 250 Wh you can travel 33 km, while the same amount of energy can hear just 10 litres of water from tap temperature to shower temperature. According to *Wikipedia* a shower takes around 60 litres of water, so in energy terms it's equivalent to 198 km of pedelec riding. See also the article on pages 60 – 63.

9



SUSTAINABLE

CO_2 emissions can be reduced even further with the use of electricity from renewable sources. 0.3 m² of solar panels installed on a central European house roof provides sufficient electricity with which to ride a pedelec 5000 km.

10

CLIMATE TARGETS

The more people ride pedelecs the easier it will be to achieve CO_2 reduction targets, especially because pedelecs increasingly replace car journeys. However also very significant for the CO_2 footprint of a pedelec is what you feed yourself! The pedelec is a hybrid vehicle combining electric motor and internal combustion engine (and in this case the rider is the IC engine, converting biomass - our food - internally into the form of work moving the pedals). Given this, just as with electrical energy, it is only via decentralised production and decentralised consumption of this food that the highest overall efficiency can be achieved.

1 *Umweltmaterialien* Nr. 173 Luft *"Elektro-Zweiräder Auswirkungen auf das Mobilitätsverhalten"* — Published by the Bundesamt für Umwelt, Wald und Landschaft BUWAL, Bern 2004 and *BP* page 56 'zum Landrad', which supports this result.
2 Calculations by *ExtraEnergy* based on market values from the previous year. As a basis for calculation the lifespan of a pedelecs including batteries was taken as 4 years or 19,200 km, alongside a kWh price of € 0.2, plus annual repair and spares cost of € 150. Alternatively the figure of € 40 per month for motivational leasing via an employer could be used, in which a pedelec to a value of € 1,800 would be leased over a period of three years for €38.01 per month. (Publication: *Leaserad* at *Go Pedelec MDM Workshop Stuttgart.* 14th June 2012, page 22)
3 Average speeds established via GPS data for cars in the following European countries: London (19 km/h), Berlin (24 km/h), Warsaw (26 km/h), Manchester (28 km/h), Edinburgh (30 km/h), Rome (30 km/h), Glasgow (30 km/h), Bristol (31 km/h), Paris (31 km/h), Belfast (32 km/h), Munich (32 km/h), Amsterdam (34 km/h), Dublin (35 km/h), Birmingham (35 km/h) and Barcelona (35 km/h) – *ITIS Holdings*, 2008 & *Forbes.*
4 18 km/h as average speed is an estimate by *ExtraEnergy* for a Pedelec 25 in urban traffic. It is a conservative value and only 3 km/h faster than a bicycle.
5 Source: *http://www.auto-motor-und-sport.de/news/betriebskosten-was-kostet-autofahren-wirklich-3477357.html*
6 Source: *http://epp.eurostat.ec.europa.eu*
7 WHO presentation: Prof. Dr. Günter Klein, WHO – ECEH Bonn, at the conference *Wirtschaft in Bewegung* 18th April 2005, Bonn.

The Potential of the Pedelec

For many, at first glance the pedelec is simply a bicycle with some extra electrics. But for me, the pedelec is much more than that. It is the only form of transport by which the current world population of just over seven billion people can sustainably address the urgent issues of overcrowding, and depletion of energy and raw material resources. The *World Population Foundation* expects the birth of the ten billionth person in 2050[1]. In that same year, I expect that around 250 million new pedelecs will be produced annually for use worldwide. Currently there are around 24 million, of which around 22 million are produced and sold in China.

Today, around 130 million bikes are produced per year, considerably more than cars, of which around 60 million were produced worldwide in 2011. But the pedelec has even more potential than the bike and car combined. The pedelec is space-saving, has low energy demands both for manufacture and in use, as well as extremely low running costs, and it is accessible to almost everyone. The advantages extend beyond the personal level too, and are relevant to wider society. According to the *World Health Organization*, 30 minutes of gentle physical exercise are sufficient to extend life by around 8 years[2]. Pedelec riding can supply this exercise easily. Thus the individual is spared illness, and society is spared costs, through reduced sickness days and increased productivity.

The designs and potential forms which the pedelec might take have been barely touched on to date. Futurists such as the Australian solar car pioneer Hans Tholstrup[3] predict: "The most important type will be the workbike pedelec". His reasoning is that the workbike pedelec can provide mobility in the fast-evolving cultures of developing countries, encouraging prosperity. With a workbike pedelec, tradesmen and craft workers have the capacity to take their goods and services in person to a wider customer catchment area.

The pedelec is for me the icon of modern and above all human mobility – a ray of hope which is, as yet, still little recognized.

In this booklet, made possible by the support of the *European Union* and the *International Energy Agency*, you will find plenty of ideas and details about the pedelec. But no amount of reading can substitute for a test ride on a pedelec if you wish to truly understand their potential.

With warm regards

HANNES NEUPERT — CHAIRMAN, EXTRAENERGY E.V.

1 UNFPA-World Population Report 2011, *World Population Foundation*

2 Source: Dr. Günter Klein, *WHO-EHEH* Bonn. *European Centre for the Environment and Health* of the *WHO*. Presentation: "Wirtschaftliche und menschliche Nutzung körperliche Aktivität im Alltag", 18. 04. 2005. Conference: *Wirtschaft in Bewegung*.

3 Hans Tholstrup is the creator of the world's first solar car. With his *Quiet Achiever* he drove in 1982 from Perth to Sydney and so proved that it is possible to travel on solar energy alone. In 2010 he spoke at *ExtraEnergy e.V.* in Tanna on the future of pedelecs.

Market sectors with potential

Many people think of the bicycle as rather limited in transport capacity. But unnoticed by most of the population of Europe and many other regions worldwide, a very interesting new category of bike has been evolving.

Hannes Neupert

The Bakfiets: As the name suggests this springs from the baker's delivery bike, and it has become a much-loved family vehicle in the Netherlands. With a pedelec drive it will also spread to hillier parts of the world.

Kindergarten pedelec: For those who need to carry even more children than will fit in a Bakfiets the solution is the *GoCab*. There's plenty of room in the *GoCab* for eight children to be safe and comfortable. It makes the kindergarten run child's play.

Ideally suited to the bicycle ›expressways‹ which are ever more widespread in the Netherlands (see page 59), the *Velomobil Versatile* is also available as a pedelec with the *Daum* crank motor, and this ensures that it'll make speedy progress not just on the flat but also uphill.

XXL load carrying: the *Vrachfiets* from the company of the same name, from Rotterdam in the Netherlands, is lent out by *IKEA* stores in Holland to customers so they can transport their new furniture home.

Fleet bikes: Worldwide, according to *ExtraEnergy* estimates, there are already over 100,000 pedelecs in daily use in bike fleets. As pictured here for pizza delivery in China, but also for postal deliveries, for couriers, as tradesman service vehicles etc…

Not all that new, but still with huge potential: hire pedelecs are increasingly available as personal public transport, for an extended range around stations. Especially in rural areas this can lead to better transport connections and acceptance of the personal public transport concept.

Trend product: the pedelec
Express who you are

Possessions are an expression of the status and lifestyle of their owner. Products such as clothing, accessories and vehicles are evidence of taste and personality. Modernity and musicality are shown with an *iPod* and its very visible white earphones. Environment and fashion sense are simultaneously put on show with a jute bag complete with trendy print, and sustainable thinking is now demonstrated by hybrid vehicles. Since 2009 the market for (light) electric vehicles has been booming, with growth among buyers in many target groups, but also as technological progress expands the spectrum of design options and specifications.

Nora Manthey

When it comes to the design of electric bikes two approaches can be distinguished: *"Hidden"* and *"Open Power"*. The *"Hidden Power"* type conceals the electrical components as far as possible. It's built like a conventional bike – but with a motor.

The *"Open Power"* faction in contrast has a strong conceptual idea of the pedelec, and places the emphasis unapologetically on the electrics. But both tendencies lean heavily on the existing "bicycle" gestalt. Even though particular ideas have (re)appeared to create bicycles to new original designs, a truly iconic form for this new energy – as for example the *iPod* was for MP3 players – has yet to emerge.

HIDDEN POWER

The task of a product designer for a product which already exists is to make them better – more functional, more beautiful, more practical. An electric bike is thus seen as a 'better' bicycle. It is faster and you can go much further with less effort. Most pedelecs follow this lead and appear very bicycle-like in tone, despite working with the new technology. Often care is taken to make the electrical components as visually unobtrusive as possible. So, for example, battery packs disguised as drinks bottles fall under *Hidden Power*.

These are aimed at sporty target groups. The emphasis is on 'style' as much as on the competitive advantage of unprecedented speed and sweat-free lack of effort.

For the cycle industry, the design opportunities are first limited by this reference to the fundamental 'bicycle' concept, and second by the technical options available for production, for example the range of drive systems available.

Selecting a drive system is in the end a question of cost with which every successful designer in the industry must engage. The more limited the range on offer, the higher the cost, and also the more tightly limited the design freedom. The layout and basic design of the electrical components of available systems is often pre-determined. A *Panasonic* battery pack will typically be placed behind the bike's seat tube, and the motor is in the bottom bracket. So the design decisions move to the areas surrounding the system, for example perhaps a widened frame and a sporty-macho look to the bike.

Firms such as *BionX*, *TranzX* and others, meanwhile, offer highly individualized modifications, for example battery housings made specially to fit, in various colours or mounting options, providing the manufacturer more control over the looks of their product. Newcomers such as the auto supplier *Bosch* and *Brose-SEW*, who are coming into the market for pedelec and e-bike systems, have a major opportunity to seize a high market share in a short period of time, particularly by offering high quality and the capability to supply in large quantities.

OPEN POWER

Following the uptake and acceptance of light electric vehicles in the form of pedelecs and e-bikes, bolder designs have appeared. They are starting to show off their distinct electric nature, and to target new audiences. At the same time, sporty bikes such as mountain bikes are benefiting from new opportunities in motorisation, and are being fitted predominately with new lightweight, more powerful and smaller lithium batteries and motors.

Some companies emphasise the design of the bike itself, while others place the drive and components at the centre of attention. For the first iterations, the electrical parts are often bought in from highly specialized companies and then customised. The design is then placed in vehicles which only at first glance resemble bicycles: they often turn out to be racing machines.

Other ambitious designs come from motor manufacturers who develop their own vehicles to serve mainly as a showcase for their own drive system.

Spezialized Turbo Pedelec 45. · The electrical components are integrated without being hidden.

Diamant Saphir Pedelec 25. · Very close to a conventional bike with added electrical components.

SMART Pedelec 25. · Integration of the electrical components and unification of the design.

Haibike EQ Xduro Pedelec 25. · Full suspension mountain bike, built around the pre-configured electrical components from *Bosch*.

Copenhagen Wheel · Pedelec 25 for retro-fitting. The drive is not the main focus, rather the gathering of sensor data on air quality and networking to data centres and other users.

Audi Wörthersee **(Study).** A pedelec which puts the fun-factor of riding as top priority, alongside interaction with the user via a smartphone.

Alongside these are in-house developments from manufacturers who base them around a holistic concept. Hybrid vehicles are seen here in concept and gestalt as their own category, but without losing touch with their roots as two-wheelers. Such vehicles are often a combination of different two-wheeler types such as BMX, motorbikes and city bikes.

Designs from younger designers often integrate the electrical components very elegantly, within the frame tubing for example. But the electronics are at the centre of attention in vehicle concepts which aim to create new mobility. Concept studies often go well beyond the vehicle itself into wider society. Often the bike is no longer the focus of the design study, but instead particular components such as the battery or motor and their electronic controls. The system is intended to function as the interface between the person and their environment, and for example it could collect data for and about the user, be networked and be fitted as a kit to almost any conceivable bike.

Standardisation for design freedom

In the general development of LEVs, and in particular when it comes to public infrastructure projects, there is a dark secret: lack of standardisation. The electrical components of light electric vehicles such as motor, battery, connectors, controller and display do not conform to any one standard. Instead, every company uses its own system, with matching connectors and protocols, so that when a manufacturer is looking for particular components they are 'tied in' to their chosen system and variants of it.

A binding standard for LEVs would make possible the combination of different systems, create opportunities for customisation, and open up new areas for design and functionality. The EnergyBus organisation has been working on this sort of standardisation since 2002, and in 2012 it unites over 60 industry parties. Among them are system suppliers such as *Panasonic*, *Bosch*, *SEW-Brose*, *BionX* and *Electragil*, cycle manufacturers such as *Winora*, *KTM* and *Gepida* and also various battery producers and infrastructure organisations such as *DB Rent*, *Movelo* and *WSM*. Standardised charging connectors were released in March 2012, after a pilot trial in 2011. The corresponding communication protocol is based on the widely used *CAN Open* industrial machine language, well proven since 1992.

Standardisation as a constraint

Finally, design of vehicles is also constrained by lawmakers. The German StVZO has, for example, strict specifications as to which parts are required for safety: design doesn't come into it. For the 'Pedelecs 45' class for example rear view mirrors are mandatory, and these significantly alter the "face" of any bike. The decision of the European Union to place particular vehicle types under the scope of type approval tests has meant further limitations, because then any modification of the vehicle, even for example a new saddle, requires a new approval.

Moderate regulation encourages innovation, and anyway market reality shows that conformity to regulations is not always the most important selection criterion for buyers. Deciding factors are the look, functionality and ride feel, because people today don't just want to get around (fast) but also to look good while doing so. What 'good' means, the zeitgeist will decide!

MARKET DEVELOPMENT OF PEDELECS AND E-BIKES IN EUROPE

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There's hardly any more controversial subject than sales figures for pedelecs. These numbers are from *Zweirad Industrieverband (ZIV)* in Germany. *ZIV* has given a total for 900,000 units for 2011. Other sources such as the *EBWR (Electric Bikes Worldwide Report)* by Frank Jamerson maintain that the 1 million mark was already reached for 2010, and gives 1.26 million units for 2011. Because pedelecs do not have to be registered and because they are also often imported into Europe under various different customs codes, nobody can say exactly what the true figures are. But it is still clear that it is already very many, and it is ever increasing.

Growth with a tailwind

Pedelecs expand in sales and turnover

In 2010 sales of pedelecs exceeded the one million mark in Europe. What had been promised by steadily increasing numbers since 2008 had become reality. The market for electric two-wheelers is in top gear with ever more countries joining the pedelec bandwagon. It's not just unit sales which are growing, but also the turnover per bicycle is also increasing thanks to increased quality expectations from customers.

Nora Manthey

Sales of electric bikes in Europe have now exceeded the one million units mark.

Pedelecs are enjoying rapid sales, especially in their largest European markets: Germany, the Netherlands and, since 2009, Austria. A market report in the trade magazine *Bike Europe* stated that for 2010, sales of electric bikes in Europe had exceeded the one million mark. For 2015, 3 million are expected. Among these sales of electric two-wheelers the majority are pedelecs.
The entry of new players with high production capacity into the pedelec market also promises well for further rise in sales. Companies from the auto supply sector such as *Bosch* (2010) and *Brose-SEW* (2011) have given as reasons for their actions the future potential of e-mobility.

With growing acceptance of pedelecs they are increasingly replacing bicycles.

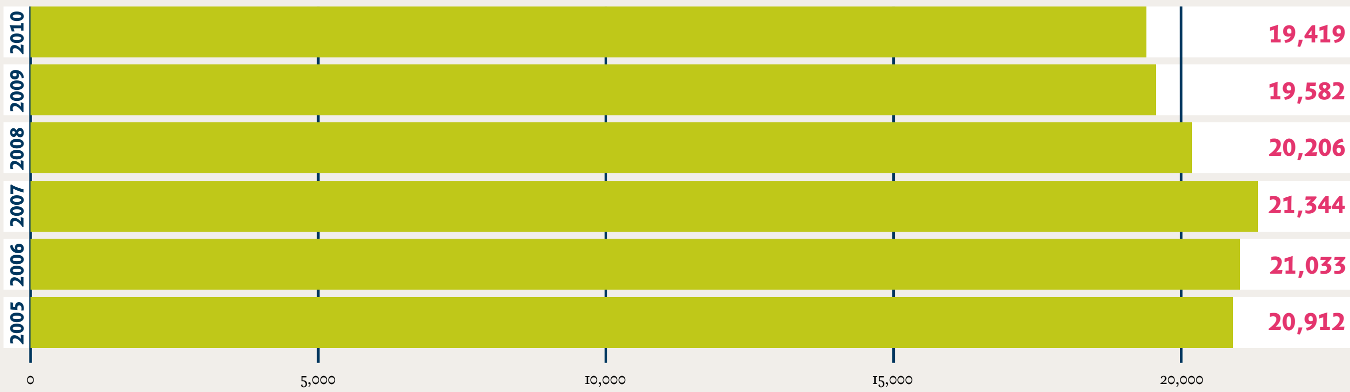
Other concerns such as *Siemens, Marquardt, Samsung, Höganas, Migros, Volkswagen* and not least car makers such as *BMW, Daimler, Audi, Opel, Toyota* and *Honda* are also following with products.

PEDELEC: BEST SELLER

Since 2008 the sales of pedelecs have been increasing rapidly, often by 50% or more year on year. The growth in unit sales in the Netherlands has been the most consistent, and this is at the same time the most mature market. Here it has been determined that as acceptance of pedelecs has increased they have displaced sales of conventional bikes. This increasing self-confidence for pedelecs is seen across Europe. While unit sales of bikes overall reduced slightly in 2009/10 because of the harsh winter and wet summer, pedelecs notched up another increase.

The figures illustrated in Figure 1 from the *Zweirad Industrie Verbandes (ZIV)* are a very conservative estimate. They do not reflect European import numbers, which implies considerably higher unit figures. China alone

CYCLE TURNOVER IN EUROPE (EU27)



QUANTITIES IN 1,000 UNITS — IN EACH CASE JANUARY TO DECEMBER

❷

exported 190,000 e-bikes to Europe in 2009 according to Bike Europe. When you add in the increasing production figures, experts from *ExtraEnergy* e. V. and the industry are united in the view that the data in the *Electric Bike World Report (EBWR)* is correct, and that in 2009 there were already 750,000 electric bikes on the road in Europe. *ExtraEnergy* e. V. believes that around 340,000 pedelecs were sold in Germany in 2011, and that it was already 250,000 in 2010. For 2012, sales of 450,000 are expected.

That makes Europe the largest market by unit sales for pedelecs and e-bikes, after China. According to the *National Statistics Office*, over 100 million e-bikes are on the road there. Annual production in Chinese factories rose from 58,000 (1998) to 33 million (2011).

Sales figures for the German *Derby Cycle AG* for the first half of 2011 paint a similar picture with 39,000 pedelecs sold. The previous year this was just 17,000, so an increase of 134 %.

Stefan Limbrunner, spokesman for *KTM*, has observed a true pedelec boom in his native market of Austria. Limbrunner reports sales of over 23,000 pedelecs in 2011. For 2010 it was 7,000, against just 700 in 2009. Sales were primarily of sporty models such as mountain bikes with electric drive, and among these the *KTM eRace* became the best-selling bike in the company's history.

The Dutch *Accell Group*, to which *Winora* belongs, stated in its 2011 company report that because of the wet summer and the wider economic situation that sales had remained below expectations, but they were still higher than 2010. CEO René Takens added that "Demand in Germany stayed very strong, particularly in pedelecs and innovative sports bikes."

PEDELEC: RECORD BREAKING PRICES

In developed markets especially, a change in consumer behaviour is noticeable. China too, just like the Netherlands and Germany, has seen a rise in the average price of a bicycle.

Turnovers continue to rise, sometimes by over 100 % in a single year.

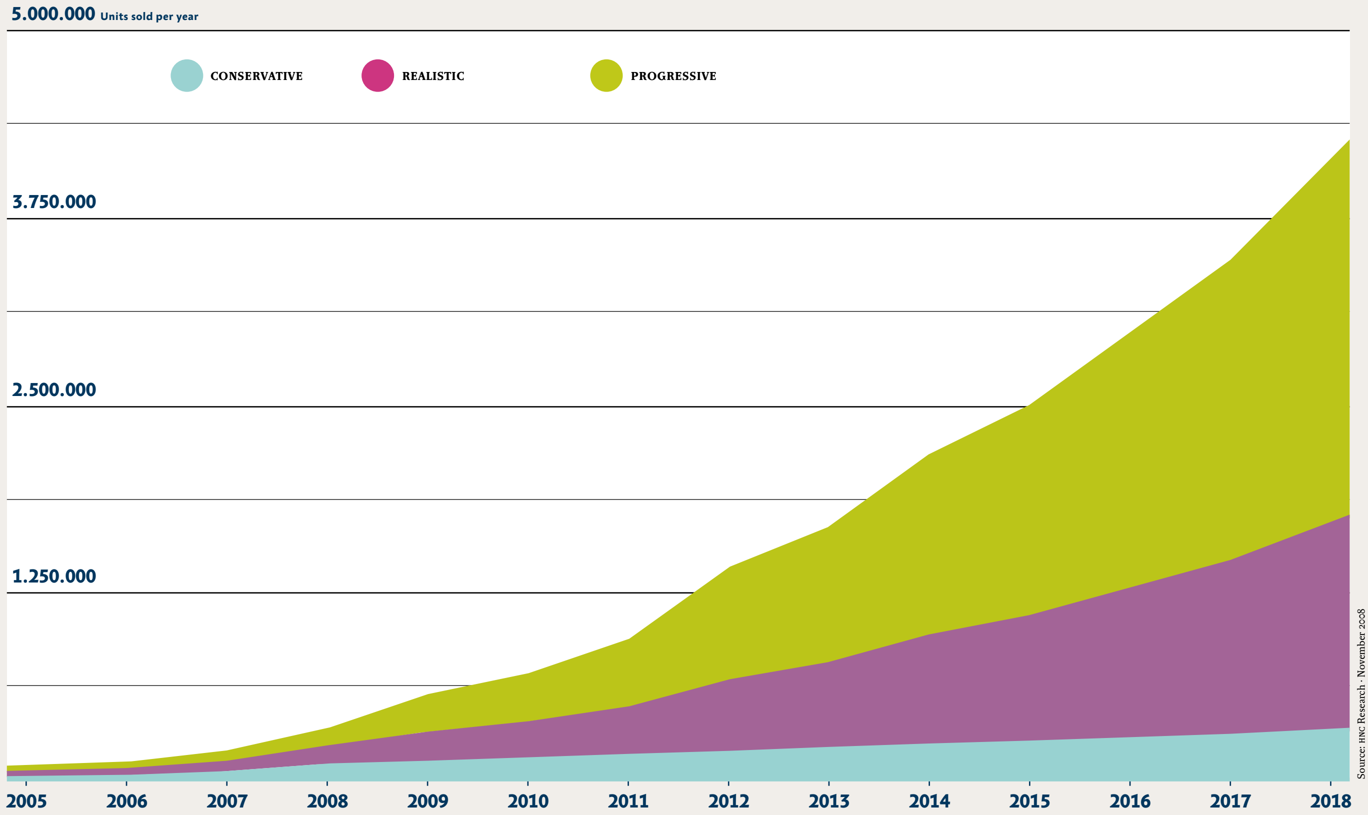
This can presumably be traced back to the trend towards pedelecs, even though these appear only in the latest statistics – and even then, they are often not detailed separately. A German consumer would pay € 490 for a bicycle in 2011 accoridng to *ZIV*, but in 2005 this was just € 345. In the Netherlands meanwhile one would pay on average € 916, a record price which the *RAI* industry association attributes specifically to electric bikes.

The *RAI* has also found that consumers now have more experience, place higher expectations on products and are ready to pay for this. So there are hardly any more 'cheap bikes' on the Dutch market, and an asking price of € 1500 for a pedelec is accepted by buyers. The development of new and quality-aware target groups is supported in this mature market by a wide spectrum of models available. So, according to *Bike Europe*, in the Netherlands there were 323 models from 28 different brands. Market leaders remain the established cycle makers such as *Gazelle*, the *Accell Group* and *Giant*, responsible for 55 % of sales between them.

Experienced consumers place higher expectations on their products and are prepared to pay for this.

China has also experienced a similar positive development in pricing. Here, the *National Statistics Bureau* credits the rising price and quality levels increasingly

EXPECTED GROWTH IN GERMANY TO 2018



❸

to new target groups such as students. These see looks, performance, quality and service as increasingly more important than price.

New models attract new customers and the tecnology is now just at the very start of the possibilities

Taiwan's exports to Europe also signal the change. The *Taiwan Bicycle Association* reported an overall decrease in exports, but at the same time an increase in the average unit price for exports of 32% to $372. This makes Taiwan no longer an "exporter of low and mid-end bikes, but instead at the high end", said chairman Tony Lo.

ELECTRIC BIKES: TRENDSETTERS

Industry insiders like Han Goes of *Q2 Consultants* forecast a renewed upswing in the trend. He considers that new models will bring new customers – in other words, that the new technology is at the start of its design and conceptual possibilities. The cycle industry needs to recognize this quickly, because otherwise they could be swiftly displaced by other market players such as the auto industry.

Increasing petrol and energy costs have changed thinking when it comes to mobility

Hannes Neupert of *ExtraEnergy e.V.* also holds that the growth potential of electric bikes is a long way from running out of steam. He believes that pedelecs will increasingly completely replace conventional bikes, and forecasts unit sales in a "realistic" scenario for 2018 of 1.6 million annually.

The LEV industry gives the credit for its success to a fundamental shift in image, alongside technical development and growing product diversity. What just a few years ago was laughed at as a "Granny-mobile", is today a trend vehicle. Since 2008 pedelecs have started to be sold in numbers which for retail, for industry and finally for households make them increasingly 'normal'. Rising petrol and energy costs, as well as the economic crisis, have changed thinking when it comes to mobility.

In the context of climate issues and the failure of global politics to address them, pedelecs are seen as an environmentally friendly, modern, urban mode of transport by municipal politicians. The airy motto "think global, act local" takes concrete form in events offering test rides, information, exhibits and pedelec hire systems.

The bike has been infected forever

Cycling enthusiasts have set themselves against it for many years, believing the bicycle to be one of the greatest engineering achievements of mankind, and immune to the electrification virus.

Hannes Neupert

When in the early '90s one of the first *ExtraEnergy Tests* was printed in *Radfahren*, then the membership magazine of the ADFC (*Allgemeiner Deutscher Fahrrad Club*), a tidal wave of letters flooded in from indignant readers, accusing the author (who is also the writer of this article), of sacrilege: how could he even think of writing about 'motor bikes', especially in a magazine which held as its holy grail the 'velocipede', propelled by muscle power alone?

For many cyclists, even the thought of motorized assistance on a bicycle was an affront. It was especially unimaginable for many politically engaged and organized cyclists even just to try a pedelec. It was all part of the self image and worldview to every day push a beloved bicycle uphill, or get up a good sweat, in a near-religious self-abasement – a sort of penance for a cleaner environment, to honour creation and following generations…

Yet any analysis of development trends over the last 100 years shows a strong and unmistakeable trend towards electrification, which in the last 30 years has transformed into the sharper form of electronification. The cycle industry has long seemed immune, but by 2010 at the latest one can say that the bicycle has, as one of the last mechanical objects in our lives, been infected with the virus of electronification, and it is now incurably infected. The purely mechanical bike will, believes *ExtraEnergy*, in future survive only in specialist niches, and otherwise it will be replaced by electrified bikes.

The process has already occurred similarly for other mechanical objects. Today, these have become fossilised as cult objects or decorative items. Examples of such near-extinct categories include the washing mangle, the mechanical typewriter, the mechanical telephone, the mechanical car, mechanical cameras or vinyl records.

I hear "That's a shame" in reaction, but do we really miss these objects in everyday life? Of course it's cool to put a vinyl LP on the record deck and listen to the analogue music with all of its hiss and crackles – but in reality, this product has been completely replaced by the 'bits and bytes' of an MP3 file. You only really listen to records in a fit of nostalgia while you digitise them.

Should you have attempted to explain to a record player dealer in the '80s of the last century how things would develop, he would have declared you completely mad and gone back to his vinyl. It's a similar story today for many cycle manufacturers and dealers, who still don't want to fully accept that the mechanical bike has no chance at all of recovery from the virus of electronification, and its only chance is via resurrection through reinvention. The mechanical bike is dead, long live the pedelec!

SYMPTOMS OF THE ELECTRONIFICATION VIRUS

A The virus is highly contagious, meaning there are many customers for the electronified product. The propagation rate of customers may suddenly increase during the course of the infection thanks to newly developed functionality and hence new applications. (Factor 3 to 30).

B Infected customers will happily pay to be supplied with the electronified version of the product. The many extra functions are the trigger. Prices rise by Factor 3 to 4.

C Products in a new category often have a radically reduced lifespan, which has negative ecological consequences. As new technological opportunities appear, the products age ever faster and customers get upgrade fever ever more frequently. The EnergyBus Standard could offer some relief here: for the health of customers and of the environment, even if many manufacturers would rather just supply everything new. See 'Best Practice', page 32.

This picture doesn't show tailgaters all driving too close, but a truck and three cars which are driving autonomously with just a 6 m gap between the vehicles, at a speed of 85 km/h, over 120 km in normal traffic in Spain on the 28th May 2012, guided behind the leading truck. This experiment was carried out under the framework of the EU-supported project SARTRE (*Safe Road Trains for the Environment*). The vehicles guided themselves within the 'car train' using off-the-shelf sensor systems (cameras, radar and lasers) and were networked together via radio. One example of what's possible with today's technology and some software. More at: *www.sartre-project.eu*

Information for mobility and safety

Availability of information and the possibility of accessing it almost anywhere via mobile data networks has already made its mark on our everyday mobility, and it will increasingly define and transform it.

Hannes Neupert

The simplest example is certainly a digital display panel which gives dynamic updates of when the next bus or tram is expected to arrive. This helps us reach decisions as to whether we should wait or choose another means of reaching our destination. Furthermore, navigation systems in cars have over the past decade meant that the upcoming generation just don't know where to start with a paper map.

The popularity of smartphones has ensured that navigation is now available any time and anywhere. So apps can tell is where, in an unfamiliar city, we can find an available hire bike, how to reach the nearest bus stop and that the next bus going in the direction we need leaves from there in 3 minutes.

Cars today, with their satellite navigation system and good digital maps, actually know where they are, and know very well what is happening around them thanks to countless inbuilt sensors (radar, laser, video image processing, rain sensors); they can make parking easier or recognise potential hazardous situations, and even apply braking assistance.

It would be very easy with new legislation to only certify new cars if the car itself could ensure that even with an inattentive driver the 30 km/h speed limit in residential areas could not be exceeded, similar to how modern goods vehicles simply cannot now be driven faster than their legally required speed limiter permits.

Car manufacturers have been working for some time on car to car communications to help prevent crashes: so cars send information continuously to following vehicles, for example, so that this could perhaps provide warnings about stationary traffic or a broken down vehicle just past a curve in the road.

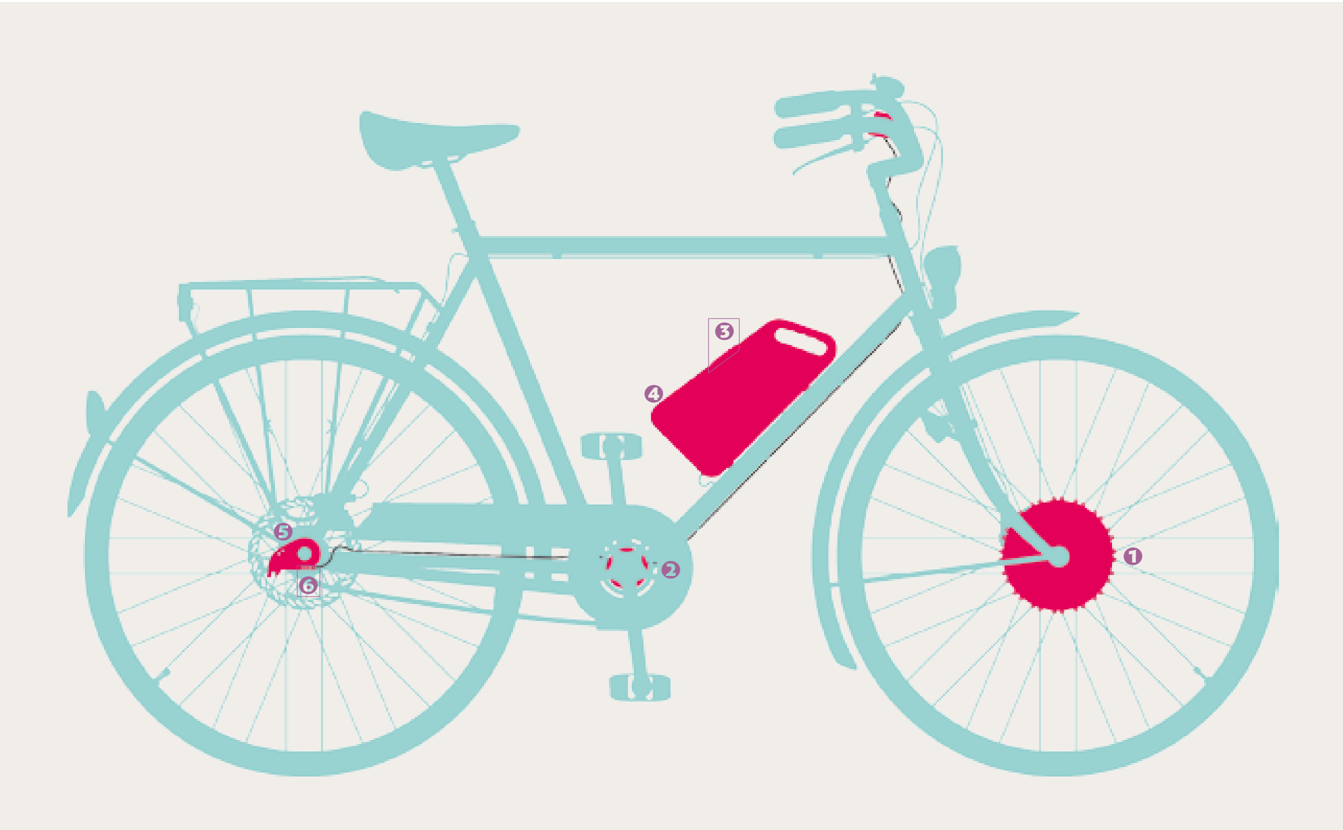
If pedestrians and cyclists could also communicate automatically with cars via their smartphones it's conceivable that digital pavements and digital cycleways might be created. When in residential areas, the more vulnerable road user would be automatically granted priority. A car would brake automatically when it sensed that the path of a pedestrian or cyclist was about to cross its own, and in addition pedestrians could be warned via an alarm and vibration from their smartphones to watch out for a potential collision. So with a suitable smartphone app the whole world could suddenly be equipped with digital bike lanes and walkways.

Today, this sounds futuristic – but technically it's just the combination of existing technology.

E-mobility for beginners
What's what?

E-mobility is a hot topic, and now there's a whole mass of jargon hitting the public realm. It's often not clear what it actually means. So here's a brief guide…

Nora Manthey



A pedelec 25 (Pedal Electric Cycle) is a bike with an electric motor ❶, which supplies power assist only when you pedal. A sensor ❷ measures whether you are pedaling, and passes this information to a controller ❸. This sensor is required by law for pedelecs and ensures that the motor only provides assistance when the rider is pedaling.

The motor cuts out automatically at 25 km/h, because this is the highest speed possible while still being regarded legally as a bicycle. So you can ride without helmet, driving license or insurance wherever cycling is permitted.

Power is delivered by a battery pack ❹, which can be re-charged via a suitable charger from any mains socket. Batteries are often mounted to the rear rack or onto the frame, and sometimes they are built into the frame.

The range of a battery depends on several factors including: rider weight, assistance level, bike and rider handling, route choice and weather. In optimal conditions and depending on manufacturer, the range of one battery can be up to 100 km. Most models available now have an average range of around 50 km, although this can be easily increased by using the power sparingly.

Pedelecs can have either rotation or torque sensors ❺. Rotation sensors simply determine whether the cranks are moving, and power assist is switched on once pedaling has started. Torque sensors instead measure the rider's pedaling effort. One design of torque sensor combines magnets and Hall Effect sensors ❻ to measure minute bending in a component (here a drop-out). This bending is caused by the transfer of muscle power, via the chain, to the rear hub. The intensity of the motor assistance provided is then controlled using this information.

Ah (short for Ampère hour) describes the charge available. The capacity of the battery is the maximum available amount of charge. But without also knowing the voltage ➢ V (Volts) this isn't an absolute quantity. The actual energy available is better expressed in ➢ Wh (Watt hours).

Battery Storage for electrical energy. Often used as synonymous with ➢ Battery pack. On ➢ Pedelecs the batteries are the single most expensive component. They differ in size, chemistry and weight.

Battery pack A complete unit for energy storage, consisting of many individual parts, assembled into a 'pack' and packaged in a housing together with the ➢ Power electronics.

BATSO stands for *Battery Safety Organization*. The *BATSO* safety standard has been developed since 2002 and includes testing for transport and use. This makes it the highest available standard. Since May 2012, on the way to becoming an *EN* standard. *www.batso.org*

BMS (*Battery Management System*) ➢ Power electronics which are built into the battery pack ensure that the cells are kept in the best possible condition so that the battery lasts as long as possible. In addition a *BMS* can provide information such as the number of charge cycles, current charge status, battery health status and expected remaining service life via an electronic communications protocol such as ➢ *EnergyBus*.

Cable loom Cable connections which join the various electrical components. Because there are not yet any cable looms optimised for ➢ LEVs, these usually look untidy and are often a point prone to failure.

Centre motor A motor built into the frame or attached to the bottom bracket (crank motor), which drives via the chain. Generally requires a specially designed frame.

Charge cycle Discharging and then charging a ➢ Battery (100 %), which could consist of several partial charges (e.g. 4 × 25 %) – what counts is the energy added. A specification of for example 500 charge cycles means that the battery can be 100 % recharged at least 500 times and will still retain the minimum remaining capacity as specified by the maufacturer (generally 85 % of the capacity when new).

Connectors These are releasable electrical connection elements and are used in the manufacfture of power and data cable connections. The most commonly used *connector plug* on LEVs is in general the charger plug. Often however the pins on identical-looking plugs are differently configured, which can inadvertently lead to incompatible batteries and chargers being connected together. This can result in an avoidable dangerous situation.

E-bike An (usually) two wheeled vehicle with an electric motor which can also function independently of pedalling (pure electric). Often incorrectly used as synonymous with ➢ Pedelec. E-bikes are treated in Germany as ➢ Small powered bikes for which insurance is mandatory. If assistance is limited to 20 km/h (E-bike 20), they can be ridden without a helmet.

Electric bike Often used umbrella term for ➢ Pedelecs 25, ➢ Pedelecs 45, E-bikes 20 und E-bikes 45.

E-mobility Short for *Electric Mobility.* General term for vehicles with electric motors. In practice ➢ Pedelecs and ➢ E-bikes dominate, so cycle-like vehicles with electric motors, as well as ➢ E-scooters.

Energy density is, for batteries, the amount of energy which can be stored and then made available per unit of volume or weight. There are batteries which are optimised for maximum capacity per unit volume or weight, others for maximum power delivery per unit volume or weight. Energy density also applies to drive systems, where it is the deliverable power of the drive per unit volume or weight.

EnergyBus Standard An open standard developed since 2002 by the membership organisation *EnergyBus e. V.* for the electrical components of ➢ LEVs. Consists of a connector family and a communication protocol based around the *CANopen* industrial machine language. Power transfer is coupled to the data communication. In March 2011 the protocol between battery and charger was released and in March 2012 the standardised connector. *www.energybus.org*

E-scooter A purely electric vehicle without pedals, similar to a roller. *E-scooters* are ➢ Small powered bikes and insurance is mandatory.

EPAC A term used in European legislation for Pedelec 25s, standing for *Electric Power Assisted Cycle*

Front hub motor Motor in the hub of the front wheel. Greatest advantage is the ease of fitting and compatability with any sort of gear hub or coaster brake.

GS The *GS Mark* stands for *Tested Safety* in German, and it is specially for Germany. More on pages 76 – 77.

Hybrid vehicle A vehicle driven by a mix of at least two types of drive. For a ➢ Pedelec these are human muscle power and an electric motor. For cars labelled "hybrid" it is usually the combination of electric and internal combustion motors.

Hub motor A motor which is fitted at the hub of either the front or rear wheel.

LEV (short for *Light Electric Vehicle*). Umbrella term for electrically driven lightweight vehicles such as ➢Pedelecs, but also e-wheelchairs, e-lawnmowers etc.

Li-Ion battery A battery with lithium chemistry. Lithium is currently used in almost all commercial systems, because lithium technology has advantages over other types, including holding more energy per unit weight and volume.

L1e EU vehicle class A two-wheeled powered vehicle (small powered bike) with speed limited by design to 45 km/h and capacity up to 50 cm³, or up to 4 kW for electric motors. Pedelecs 45, and all e-bikes, fall beneath this.

Memory effect An effect which occurs primarily in nickel-based batteries. It appears when the ➢ Battery is 'top up' charged, before it is empty. The battery 'remembers' the level from which it was charged and then 'expects' a recharge at that level, so it only provides energy out down to that level. This effect does not occur on batteries with lithium chemistry (➢ Li-Ion battery).

Motor controller Power electronics for controlling the motor power output.

Pedelec 25 (from *Pedal Electric Cycle*): by far the most widespread form of ➢ Electric bike. The motor only provides assistance while you are pedalling. If the motor assist is limited to 25 km/h and the ➢ Motor power rating is no higher than 250 W, then it is treated the same as a bicycle within the EU. You can ride it without a helmet or proof of insurance, and can ride on cycle paths. Was patented in 1982 by Egon Gelhard and first sold in 1992 by *Yamaha* in Japan.

Pedelec 45 A fast ➢ Pedelec, whose motor assists while pedalling over 25 km/h up to a maximum of 45 km/h. Needs type approval as a small powered bike and so also proof of insurance. Some *Pedelec 45s* have a control, e.g. a twistgrip throttle, with which they can be ridden purely electrically up to 20 km/h.

Power assist factor (or U-factor, from the German) describes the power which the drive system provides in addition to the rider's pedalling effort. In the *ExtraEnergy Test* this is not the basic electrical power (motor output), but the calculated value of the mechanical work, in other words the power which actually works to propel the rider. The pedal effort measured on a reference bike without motor is compared with that applied when on the ➢ Pedelec 25. The difference is the motor power.

Power electronics Nowadays the high currents in chargers and motor controllers are controlled as required by power electronics.

Push assist This is mostly activated via a button, more rarely via a twist grip. It propels the pedelec up to 6 km/h (a legal limit) without any need to be pedalling. It's handy on ramps or when walking uphill. In Germany riding vehicles with push assist requires either a driving license or a moped test certificate.

Range means the distance in km which can be covered with motor power. Often given by manufacturers as an absolute (estimated) number. The actual range is relative and depends on factors including terrain and riding style. It is more or less important for different applications. Range in the *ExtraEnergy Test* is calculated from measured values and published for differing types of route, as well as being weighted differently according to product category.

Rear drive Typically a hub motor in the rear wheel. Can be combined with a derailleur transmission or integrated with hub gears.

Regeneration Returning energy from braking to the ➢ Battery. Some drive systems switch the motor into a generator mode when braking. Currently this can extend range by around 10%.

Rotation sensor Used in pedelecs of simpler construction. Measures pedal motion at the bottom bracket and when the pedals are turning, enables the electric drive.

Small powered bike A motorised two-wheeler with a top speed limited by design to 45 km/h (since driving license reform 1998/99). Can carry two people when designed to do so.

Torque The force which a drive system exerts in a turning action (whether on pedals or wheel rotation). Given in Newton metres, and is an indication of the assistance force available.

Torque sensor Most pedelecs in the price range from € 1,500 upwards have a torque sensor which measures the applied muscle power very accurately, and so enables the motor controller to apply motor power in proportion to the pedalling effort applied.

Volts (abbreviation: V) Unit of electrical potential. For pedelecs, nominal voltages of 24, 26, 32, 36 and 48 V are typical.

Wh (short for Watt hours). The actual energy capacity of a battery. The product of charge (➢ Ah) and voltage (➢ Volts). A 36 V battery with 10 Ah capacity will deliver 360 Wh (36 V × 10 Ah) of energy.

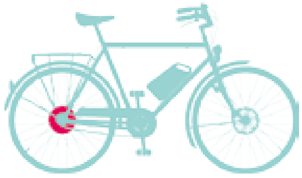
Drive positions
Front, centre, rear

There's no simple answer to the question of which is the best place for the motor - at the front, centre or rear of the bike. Just as with cars, where front, mid and rear engines all have their fans, pedelecs too have differing priorities according to their intended use, and these demand appropriate solutions. Here we present an overview of the advantages and disadvantages of the various possible drive positions.

Hannes Neupert

HUB MOTOR IN THE REAR WHEEL

+ Good traction (grip) with diamond frame geometry
+ Generally easily compatible with existing derailleur transmissions (some systems are also available with integrated hub gears e.g. *BionX*)
+ Generally easy to retro-fit as a kit.

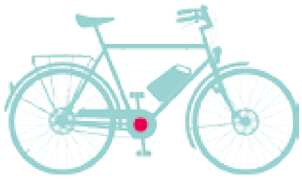


– Cables must be disconnected for wheel changes
– If combined with a rack-mounted battery, very rear heavy
– Extra unsuspended mass in the wheel
– In most cases no coaster brake is possible

Examples *8Fun, BionX, TranzX, Heinzmann, Panasonic, Sparta (Accell), Ultra Motor* and many more.

CENTRAL MOTOR

+ Good traction (grip) with diamond frame geometry
+ Weight of the drive is central, and for full suspension frames it is part of the suspended zone
+ No extra moving mass in the wheels
+ No disconnection of cables needed to fix a puncture – the wheels are just the same as on a classic bike
+ Little prone to damage with compact design & short cables
+ Fitting is simple when well integrated with the frame

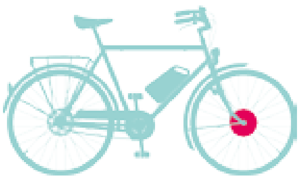


– Not or only with difficulty retro-fittable, because mid drive generally requires a special frame (an exception is *Sunstar*)
– Increased development effort needed in the cycle design
– Not always compatible with a coaster brake

Examples *Panasonic, Yamaha, Bosch, Brose, Electragil, Sunstar,* and many more.

HUB MOTOR IN FRONT WHEEL

+ Simple construction for the pedelec
+ Easily retro-fittable
+ Free choice of pedal power transmission
+ Coaster brake easily possible



– Slight traction problems when riding uphill and on slippery surfaces (the front wheel slips when there isn't enough weight on the front wheel and in the absence of traction control)
– Potential accident risk when retrofitting powerful motors to forks not dimensioned appropriately for this.
– Extra unsuspended mass in the wheel

Examples *8Fun, TranzX, Heinzmann, Chindalang, Libahuang, Tongchin,* and many, many more.
(circa 2000 – 3000 suppliers in China)

Drive systems

Many people assume that electric motors have already been so highly developed that not much further evolution or improvement is possible. But particularly when it comes to pedelec drive systems, which involve the synergy of muscle and electric power, there is still much scope for improvement.

Hannes Neupert

It started with roller drives, where the motor shaft, with a roughened surface, would drive directly onto the tyre.

Today, from a worldwide perspective the gearless hub motor dominates. It has proven itself by the million, especially in China on bikes with smaller wheels and generally moderate riding speeds.

In Europe, geared front hub motors are most heavily represented. These can be made considerably lighter and more compact than the gearless motors, which in Europe tend to be used mostly in rear wheel drive systems.

In Japan and Switzerland crank motors are common; in the Netherlands it is once again hub motors. The dominance of a particular type of drive system is historically based – and influenced by particular manufacturers.

Today, any such dominance is being diluted by the ever wider range of models coming onto the market.

Electrical drive systems are still mostly developed separately from muscle power transmissions. But the future surely lies in integration which permits maximum efficiency. Some manufacturers have already taken the first steps in this direction.

Electromagnets and permanent magnets, time-proven principles are applied in most LEV motors.

Friction roller drive on a solar bike from Russian solar bike pioneer Alexander Popolov, 1989.

Gearless hub motor from *BionX*, which, like all gearless hub motors makes regeneration – the recovery of electrical energy when braking – easy to implement.

The best selling pedelecs 25 drive system in Europe in 2011 – the geared hub motor from the *8Fun* company in China

The crank drive motor from *Bosch* follows its successful predecessors from Japan, from *Panasonic* and *Yamaha*.

A role model for the pedelec – the principle of combining electric motor and IC engine, as solved in the *Toyota Prius*. For pedelecs it would work similarly, with the combination of electric and muscle power, for example in the futuristic prototypes from the company *Nexxtdrive*.

The English company *Nexxtdrive* for example has combined two electric motors and a planetary gearbox into a single hub, which work in conjunction with the muscle-power drive. *Toyota* has used a similar solution on the drive of the *Prius*, in which two electrical motors are combined with an internal combustion engine via a planetary gearing system, so that a clutch and gearing system are not needed. The effect is of a stepless gearbox of very high efficiency, which allows the internal combustion engine to work at its optimal load and rpm range. For a pedelec, muscle power would take the place of the IC engine.

Even more radical is the proposal from Harald Kutzke and Andreas Fuchs, whose 'fully digital' drive combines three electrical machines: a muscle-powered generator, which converts effort into electrical current, and two hub motors, which transfer energy both from the battery and from the rider's efforts to the road.

Display and user controls
Human Machine Interface (HMI)

Human Machine Interface – or what is often also called the 'man-machine interface' by developers. This includes all of the elements which provide communication between person and pedelec.

Hannes Neupert

INPUT DEVICES

Starting up the system generally works without a key via a push-button or, even simpler, at the first turn of the pedals. Some systems start with a classic ward key or a radio key which as in the picture above must be held against the display.



Power assist levels or ride modes are as a rule set via buttons on the handlebars. It has proved worthwhile to equip these buttons with at least status LEDs or an LCD display which provides rider feedback on the bike's current status and on how much charge capacity is left in the battery. Such rather "basic" displays are especially suited for hire bikes and for users who "just" want to ride along more easily.



OUTPUT DEVICES

On larger displays mounted centrally on the handlebars there are generally also buttons or controls provided for selecting functions without lifting a hand from the handlebars. The software options are essentially limitless. In particular, the current trend toward linking up smartphones with complex apps will spark further developments.


ROTATION SENSORS

Simple pedelecs have a sort of on-off switch to activate the drive system when pedalling. They are essentially e-bikes which have been legalised as bicycles with one of these rotation sensors. *ExtraEnergy* argues that these vehicles should be recategorised as powered vehicles (see page 73).



TORQUE SENSORS

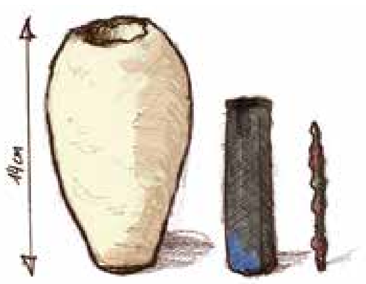
There are generally fitted to the crankset, in the bottom bracket, at the dropouts or on the rear axle. Forces are measured by minute deformations of the sensor. By measuring these deformations the motor controller can calculate precise information about the muscle power being applied by the rider through the pedals. Only by using a torque sensor of this type can a good pedelec be made to ride intuitively, uniting human and motor power harmoniously, and at the same time effectively handling transient peak loads through the motor.

Energy storage

Electricity is generally something which you need to use just as soon as it's generated – so something that is very transient. But the existence of batteries is fortunate indeed, because without them a pedelecs would be impossible.

Hannes Neupert

Because it's hard for people to visualize electrical current, and because the processes within a battery are very hard indeed for most people to picture, batteries have always been a little mysterious. Yet according to several historians, there were electrical energy storage devices even in Mesopotamia at the time of the Parthian culture. In 1936, researcher Wilhelm König unearthed a container near Baghdad which by all appearances seemed to be for storing electrical energy.

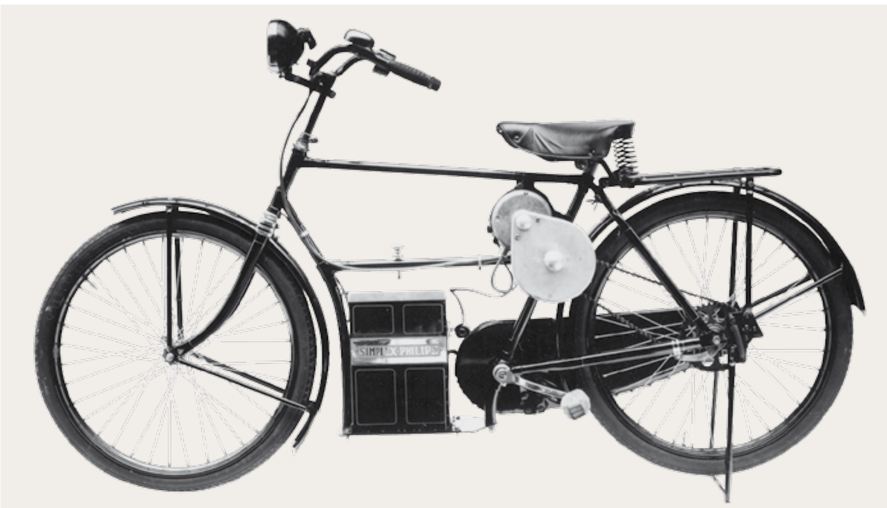


This means that batteries have been used by humans for well over 2000 years, although they were rediscovered for the modern age only in 1790 by the Italian doctor Luigi Galvani. A fully functional battery from this more recent past was first built in 1800 by Alessandro Volta. The first electric vehicles all used lead-acid batteries, which were impossible to seal completely. If an accident happened to the vehicle, this could lead to the battery acid escaping, as happened for example with the first commercial electric bike from Philips in 1932.

In the '80s of last century nickel chemistry emerged, which enabled the production of rolled round cells based on Nickel-Cadmium. These proved to be very robust and long-lived. So for the first time electric bikes practical for everyday use could be manufactured – even though the range with a battery weighing around 4 kg was seldom more than 20 km. Today it is possible, since the introduction to pedelecs in 2002 of lithium battery technology, to create batteries of the same basic weight and volume which deliver six to eight times the amount of energy. And development is ongoing – it could well be the case that in the next ten years a further improvement by the same factor will be achieved.

There are always promoters of bikes or batteries who make sky-high claims of their battery technology. They claim, for example, that their batteries will last for eight years. Such claims should in general not be given much credence, in so far as they are not matched by corresponding terms in the warranty. It is also often stated that one or other chemistry is exceptionally safe. But ten years of battery testing at *BATSO* have determined that there is no direct connection between battery safety and cell chemistry. Rather, the following factors play a role at the whole system level: cell chemistry, plus mechanical, thermal and electrical construction of the battery pack.

Currently, most battery packs are removable. But especially in the Netherlands there are a good number of pedelecs with a battery permanently mounted inside the frame. It could well be that this solution will catch on in the longer term, as long as the infrastructure is there to support it (for example via the possible future availability of a lockable charging cable infrastructure – see page 29).



FIRST LIFE

2 to 4 years of use as LEV drive battery. User pays a fee based on time in use or based on another specific accounting model.

SECOND LIFE

Used as a buffer together with many other batteries in a battery bank for temporary storage of solar energy, for example in the cellar of a residence for the energy supplied by solar cells on the roof. Service period: 8 to 20 years.

THIRD LIFE

Recycling with separation into the constituent parts and recycling of the valuable raw materials into the production process. So ideally new batteries will be made out of old batteries.

Banning to encourage sustainability

Second life as distributed energy storage

Why would *ExtraEnergy* encourage a ban on the sale of batteries as a way of encouraging sustainability in energy storage? The reason is that energy storage devices use resources optimally when they are in use for a long time: by serving as stationary energy stores after their mobile application, and finally by being so thoroughly recycled that the raw materials can be reused for new batteries.

Angela Budde & Hannes Neupert

For used batteries, there is a legal obligation for users to return them, and a legal obligation for retailers, public waste disposal facilities, manufacturers and importers to take batteries back. Once they are returned, Li-ion batteries can be disposed of via a mechanical or thermal recycling process. Up to 95% of the material they contain can be recycled in existing facilities. Worldwide, however, there are currently only a few facilities for battery recycling, but because of low return quotas these are still not yet running at full capacity.

RAW MATERIAL SHORTAGES RAISE PRICES

Extraction of lithium is still cheaper than recycling, so users such as manufacturers are given no incentive to direct their lithium batteries to a high-percentage recycling process.

Although sustainability is technically possible here, it is not being achieved, because without recycling there is no 'closed loop' and without a closed loop, there is no sustainability. But depletion of the raw material will in the longer term lead to higher extraction costs and so to higher prices.

HIRING IS CHEAPER THAN BUYING

Today, the shop price for a 300 Wh lithium battery is around €600, with, as a rule, a warranty period of just two years.

It's a profitable business, because sales depend on consumption. This market mechanism incentivises the suppliers to optimise their batteries for a service life as short as possible while still being acceptable to consumers. A ban on battery sales within Europe would halt this trend and make batteries with a long service life more profitable for suppliers – so forcing sustainability into the battery market.

Since early 2012, the company *Biketec* has been supplying pedelecs without batteries. The batteries can be hired for around € 15 per month.

Set against the purchase of a battery for €600 with just two years warranty (€25 per month), users would save €10 per month. *ExtraEnergy* estimates that at the current state of the technology a warranty period of at least four years is possible, and that in the longer term hire prices will settle to around 12 € per month.

SECOND LIFE AS DECENTRALISED ENERGY BUFFER

Avoidance of waste has by law absolute priority (Guideline 2008/98/EG and Closed Loop Economy Law (KrWG)). A particularly important aspect is extending service life (§3(20)KrWG).

LEV batteries which have passed their warranty period still have sufficient remaining capacity to work for several further years alongside many other packs in a battery bank, for example in the cellar of an apartment block, functioning as decentralised energy storage.

This is essential for energy reform, to reduce the loads on the network and to ensure security of supply. LEV batteries will play a decisive role for this function in the future.

Energy storage: real world experience

We carry batteries around constantly in our everyday lives: we walk around with them in our trouser pockets, put them on our bedside tables and even into childrens' cots. Batteries are in childs' dolls, mobile phones, alarm clocks, laptop computers, remote controls, postcards, bicycles, lawnmowers, cars and much more – they have spread their influence almost everywhere in our daily existence.

Hannes Neupert

So we implicitly trust that these batteries will only discharge their stored electrical energy how we wish – in the form of music from an MP3 player, in the form of transmitted speech on our mobile phones, and more recently in the form of a tailwind for our bikes. But unfortunately it is occurring ever more frequently that batteries release their stored electrical energy, and their chemical energy which is even greater than the electrical, in an uncontrolled manner and without warning, often in the form of a fire or even an explosion. This danger has been known about in technical circles since 2003, when the first major fires caused by pedelecs batteries occurred. Back then, the size of the world market for high energy lithium batteries was still very manageable.

Now, according to *ExtraEnergy* estimates, the market in 2011 was much larger, with around 2 million lithium batteries sold in the light electric vehicle sector. And there are currently developments in China which suggest that by 2015, annual sales in China alone of lithium batteries for the LEV sector will reach over 10 million, representing around three times the overall market in China for 2011. Lithium batteries over 100 Wh capacity are because of the many incidents classified by the *United Nations* as Hazardous Goods Class 9.

In 2011, two transport planes crashed, probably because lithium batteries in the hold had exploded. In China, also in 2011, there was the first fatal incident involving a lithium battery in an electric bike; a resident of the house tried to escape the blaze and died in a fall from a window. In Europe, over 30 fires as a result of lithium batteries have been reported in the press, with the frequency increasing in the last three years, in line with market growth within Europe. The number of unreported cases is probably large, too, because pedelecs batteries are not widely recognised as a cause of fires.

A small selection of press cuttings reporting fires. Unfortunately the list of fires has now become a very long one. Thankfully, very few of these cases have been fatal. To raise awareness with a graphic image *ExtraEnergy* has created a fictional newspaper article with the headline "Pedelec explodes: 13 OAPs die in their sleep". This case is fictional, and will hopefully never happen. But on the 30th September 2010 such an incident did very nearly occur, although fortunately the fire service in Aurich und Walle was on the scene quickly enough to rescue the inhabitants of a retirement home. This incident is documented in pictures 1, 2 & 3.

Image: Freiwillige Feuerwehr Aurich, DE

Image: Feuerwehr Zug, CH

Image: Freiwillige Feuerwehr Aurich, DE

Bild: Feuerwehr Zug, CH

Fire for a customer in Paris

Battery danger
The reality

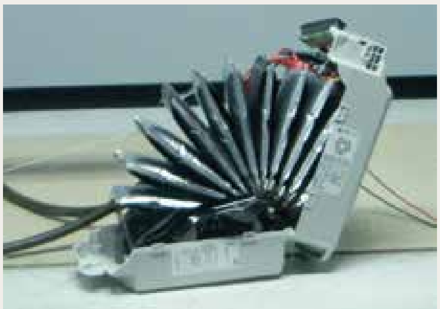
By analysing battery fires it has been established that the cause of the fire has always, to date, been a weak point in the design of the battery pack, such that it could not compensate with an extra helping of built in safety for foreseeable misuse by the customer. Batteries designed with state of the art technology withstand all three of the most serious forms of customer misuse.

Hannes Neupert

DANGER № 1 — OVERCHARGING

The moment when the battery overflows with energy. Occurs when the battery is fully charged but the charger carries on pumping more energy into the battery pack.

UNSAFE Eruptive conflagration shortly after exceeding the final charge voltage



SAFE Cells are bulging due to overcharging and have broken their housing as a result, but have not ignited. Gases or fluids have not leaked.

DANGER № 2 — SHORT CIRCUIT

The full energy of the battery discharges so quickly that the battery overheats or can explode. Fire can also be caused by overheating cables which ignite insulation or other nearby plastics.

UNSAFE Eruptive conflagration shortly after a short circuit

SAFE The BMS *(Battery Management System)* switches off quickly. In the second phase the electronics are bypassed. So the battery heats internally to over 100° C, but then cools again. Some fluid electrolyte has appeared, but no gases or other fluids.

DANGER № 3 — PHYSICAL DAMAGE

Mechanical damage to the battery packo, in a crash or by dropping it, can easily cause an internal short circuit which can provoke an even more dramatic reaction than an external short circuit.

UNSAFE Eruptive conflagration shortly after a crash.

SAFE Mechanical destruction of the battery housing, squashing the cells but no heating, no leakage of gases or fluids.

Battery Safety
The BATSO organisation

BATSO is the result of a long development process by expert teams at *ExtraEnergy*, *ITRI Institut, TÜV Rheinland* and *Underwriter Laboratories*. This group picture was taken on the occasion of the publication of the first *Test Manual* Version 01 at the *BATSO* Workshop as part of the *LEV Conference* in Taiwan on the 18th March 2008.

When in 2003 *ExtraEnergy* was confronted with the first major fire started by a lithium bicycle battery, this led to discussions with contractual partners *Deutsche Post AG* (the German post office) and to the consideration of a series of tests with the various batteries then in trial service on postal workbikes. Consequently *Deutsche Post AG* commissioned *ExtraEnergy* to carry out a test which would investigate the safety of pedelecs batteries in use.

ExtraEnergy cooperated in this with the leading institutions and individuals with experience in the field of lithium battery safety at the time: Dr. Mo-Hua Yang from the *ITRI Institute* in Taiwan (today *HTEnergy*), Prof. Dr. Martin Winter from the *University of Graz* (now at *Uni Münster*) and with the *Centre for Solar and Hydrogen Technology* in Ulm.

The test criteria from 2003 and 2004 were the following year evaluated in Germany and Taiwan for numerous battery packs in two test chambers built by *ExtraEnergy*, and in collaboration involving many meetings with two international testing and certification bodies, *UL Underwriter Laboratories* and *TÜV Rheinland*, the results were brought together in a well structured *Test Manual*, and presented as part of the *LEV Conference* in Hsinchu in 2008, on the 18th March.

Since then the *Test Manual* has continued to evolve its technical requirements, including those changes needed to satisfy the requirements of the Hazardous Goods regulations of the *United Nations* (UN 38.3), for which the awarding of a *BATSO* seal of approval is confirmation of compliance.

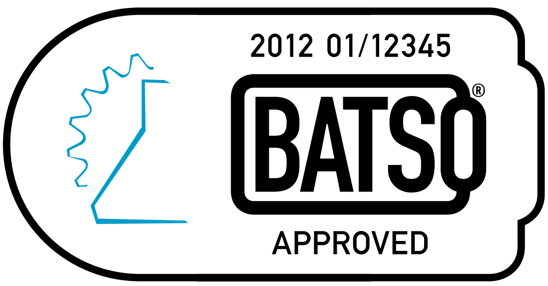
Since 2010 the first battery packs to comply with the *BATSO* 01 industry standard were tested at a battery laboratory in Shenzen (China) and consequently certified.

On the *BATSO*.org website there is a listing of all *BATSO* certified batteries.

Because the technical development of batteries is very fast moving, repeated tests are carried out by the issuing certification authority to ensure batch consistency, and inspectors check whether criteria are complied with in production operations, to ensure products continue to match the tested level of quality.

From the 7th April 2011 the separate *BATSO* became *BATSO* e. V. based in Berlin. This foundation welcomes new members who wish to promote battery safety in transport and use, by collaboration in committee and through communication work. Since the 31st May 2012, *BATSO* is on course for an EN Standard, as a precursor to it becoming longer term an IEC Standard worldwide.

www.batso.org



From 2013, test labs worldwide who are *BATSO* members and who meet the relevant requirements can not only carry out *BATSO* testing but also issue *BATSO* certificates. Quality and consistency of testing will be assured through a process such as the well proven so-called CB process. From 2013 central listing of *BATSO* certificates will also take place on *www.batso.org*.

Pictured here is a test mark as introduced at the member meeting in March 2012. To the left is the logo of the issuing test institute, in this case the Italian laboratory *TEC Eurolabs*, and to the top right the year of issue with the *BATSO* version code, as well as an incrementing number, and the *BATSO* logo.

Practical tips
How to handle batteries safely

GENERAL TIPS FOR MANUFACTURERS, DEALERS AND PEDELEC RIDERS

- Never charge non *BATSO* approved batteries overnight or unattended.
- Only use chargers which have an unambiguous connector, either one which is internationally standardised *(EnergyBus)* or which is exclusive to one company and which is available on the market with only a single charger specification.
- Only use chargers which are also unambiguously labelled and so can be easily matched to the relevant battery.
- For suppliers who maintain that their batteries are safer than *BATSO*, insist anyway that they produce a *BATSO* certificate.
- Inform your fire insurers that Hazardous Goods Class 9 in the form of lithium batteries (containing NO metallic lithium) will be charged and stored in the house, so that in case of a fire your insurance protection is valid.
- Store batteries separate from the bike, ideally in a cool but frost-free location which in the case of fire is as isolated as possible so that it remains a localised fire.
- For longer term storage remove the batteries from the bike if possible and every 2 – 3 months charge them for around two hours, then disconnect from the mains.
- Actively support the recycling of used batteries and thereby help fulfil the legal minimum requirements of the European Recycling Directive.
- Supply empty battery housings for current battery models to dealers for shopfitting purposes and especially for window displays.

FOR THE CYCLE TRADE

- Immediately cease selling and stop buying in any more batteries for which the supplier cannot supply a valid UN-T certificate from a recognised laboratory. Check whether the battery described in the test report matches the ones delivered (the simplest way is to check the picture and the weight).
- Do not display batteries in a window where direct sunlight may fall. Instead, ask your supplier for empty battery casings for display purposes.
- Carry out training in the correct procedures for receiving and sending Class 9 Hazardous Goods - the so-called "hazardous goods certificate".
- Continue to train staff about current pedelec drive systems
- Consider installation of a sprinkler system in the battery store and charge locations.
- Raise customer awareness on battery safety.
- Ensure that batteries which are sold are registered on the *BattG* list with the relevant authority in the land of sale or risk fines up to € 50,000. This is easily done online at: *www.umweltbundesamt.de* (for Germany, similar rules apply in other EU countries)
- Ensure that properly tested and certified hazardous goods packaging is available for the correct shipment of batteries

FOR MANUFACTURERS

- Inform suppliers in the supply contract that this is only valid for *BATSO* certified batteries. So there would be no obligation to purchase if when on checking a delivery batch it was discovered that the batteries supplied are not as safe as specified.
- Store and charge lithium batteries in a separate store which as a minimum is separated by a fire wall from the rest of the building. If possible discuss the risks with the local fire service and take suitable measures to minimise the potential danger. Measures might for example include a fire alarm and a sprinkler system for the battery storage and charging rooms.
- Qualification of staff to handle Class 9 Hazardous Goods, among which are rechargeable lithium batteries.
- Only use chargers which are unambiguously labelled and so can be easily matched to the relevant battery.
- Ensure that batteries which are sold are registered on the recycling list with the national environment agency or with the relevant authority in the land of sale.
- Ensure that properly tested hazardous goods packaging is used for the correct shipment of batteries.

FOR PEDELEC RIDERS

- If you already own a pedelec with a non *BATSO* tested battery, then only charge it when you are awake and present. If a fire should occur, react very quickly. It is best to go yourself to a place of safety and call the fire brigade. It can put your life at risk to approach the battery or to touch it.
- If you haven't yet bought a pedelec but intend to, choose one with a *BATSO* certified battery. This should have been implemented by all reputable manufacturers for the 2013 season at the latest.
- Only charge batteries using the charger intended for that pack. Caution: even when the plug fitted to another charger fits, the charger itself may not be compatible with the battery.
- Never carry batteries by aeroplane. When transporting on a car roof or tailgate carrier rack always remove the batteries and transport them inside the car.
- Regard claims and reassurances provided by manufacturers and dealers critically. Experience has shown that correct information about the dangers is often not provided.

The ChargeLockCable
Lock and load at the same time

The *ChargeLockCable* combines charging for light electric vehicles (LEVs) with theft protection and security, turning it into a cycle lock at the same time.

LEV theft protection, fast charging and charging either outdoors or under a roof - the technical committee of the *EnergyBus Consortium* has deliberated at length about all of these issues. As a result they have developed the ChargeLockCable. The so-called Charge-Lock EnergyBus System makes the charger cable into a bike lock.

Industry standards and a functional charging infrastructure are the most important issues for the future of the LEV industry (pedelecs, e-bikes, e-scooters etc.). Only thus can the product benefits of LEVs be convincing long term, and electric-propelled two-wheelers build their significance in mobility behaviour worldwide.

STANDARDISED SAFETY

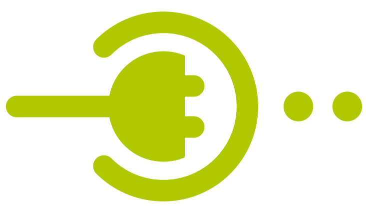
The matter of safety is an important consideration. Almost all currently commercially available chargers for pedelecs are only approved for use in dry conditions. So they are not suitable for charging in the open or even under a roof.

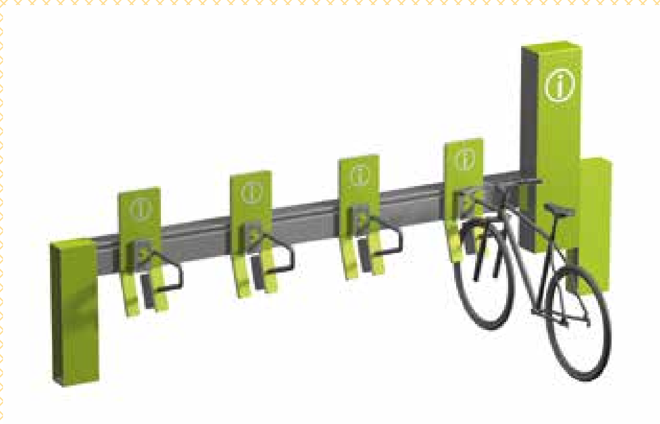
In principle, all power sockets which are located outside are also unusable for charging pedelecs because they are:

- not legal to use (unless you have a charger approved for outside use)
- impractical (no theft protection available)
- time intensive (charge time)

With the aim of establishing a system which will work for the whole industry, the *ChargeLockCable* is now being implemented as part of the *EnergyBus* Charging Infrastructure pilot project.

www.charging-infrastructure.org





DO IT YOURSELF

- ✓ Visit the pilot regions of Tegernsee, Schliersee and Achensee. These offer leisure cyclists numerous pedelec hire and battery charging stations all to the *EnergyBus* Standard. From 2013, introduction of the *EnergyBus ChargeLockCable* will begin.
- ✓ Consider compatibility now. When procuring bike stands be sure to equip them with electrical power. You can find possible suppliers at: *www.charging-infrastructure.org*
- ✓ Invite an MDM (Municipal Decision Maker) Workshop to your city. These workshops offer municipal decision makers information about the development of an LEV infrastructure for their region (see page 56).
- ✓ In the short term, don't invest in charging infrastructure, but instead in general cycle friendliness.

Range
What really takes you further?

Almost everyone coming round to the idea of an electric bike will at some point ask the question "How far will it go?" The question sounds reasonable, but it's not well thought through. Pedelecs are hybrid vehicles, propelled by a mixture of muscle and motor power. So long as the pedelec isn't excessively heavy or with excess drag, and so long as the rider isn't dependent on the electric power alone, you can always go a bit further on your own power, even if it is slower and more tiring. Nonetheless, demands for a suitable charging infrastructure, guaranteeing charging points any time and anywhere, are increasing.

Hannes Neupert

Yet even without any specific infrastructure, the pedelec has established itself in increasing numbers on the market in Europe, Japan and particularly in China. Pedelec buyers use the existing network of normal mains sockets, which exist in even the furthest-flung areas. If you don't charge at home, you can take a battery charger with you and recharge in typically 3-4 hours – or carry a second battery with you. This makes day touring of 100 km or more practicable; a distance which is hardly required in everyday urban use. So no specific infrastructure is really necessary for pedelecs.

It's different for other LEVs such as electric scooters, because their batteries are so heavy and cumbersome that they are not easy to carry to the nearest power socket. Electric cars have the same problem. They need an infrastructure which sadly is not yet in prospect.

RANGE IS A TERM TO CONJURE WITH

While with cars filling up the tank is self-explanatory, charging pedelecs batteries can often seem problematic for new users.

Also there's often anxiety about the range – unnecessarily, as most electric bikes will now easily cover around 40 km. Journeys around town are seldom longer than 20 km.

There are those who use the bike's motor to cover longer journeys so that they can leave the car behind: but for example in the Netherlands the average distance covered is still just 15 km.

Nonetheless, there is still a demand for more range, and for pedelecs there are three options:

INCREASED BATTERY CAPACITY

Increased battery capacity means that for long journeys you remain independent of any infrastructure. The higher range also makes sales pitches easier, because customers always want to go further. The disadvantage is that a larger batter is heavier and, all things being equal, larger, and this will negatively affect the bike's handling.

This disadvantage could soon be a thing of the past, though, because the battery industry expects that the energy density of commercial batteries will increase dramatically in coming years. So, when today you might get around 40 km range with a battery weighing around 1 kg, in 5 to 8 years time it might take you 200 km with the same motor assistance.

FAST CHARGING

Batteries which can be charged quickly anywhere are a tempting idea. If you assume you could charge in 5 minutes for a 10 km range, it follows that you could ride for 30 km then recharge from this in just 15 minutes. With just short pauses you would have a limitless range. With a widespread network of fast charge stations, batteries could be cheaper, smaller and lighter. They could be concealed even better within the frame or integrated with the bike design. Pedelecs would retain more 'bicycle' character, and stay under the 20 kg mark.

BATTERY EXCHANGE

Battery exchange assumes either a standard battery or a fleet of identical vehicles. The idea has already been successfully implemented in several tourist areas for hire bikes, and you can exchange batteries in hotels, guest houses and tourist centres. As an 'island' solution for a particular region it works wonderfully.

Today's reality, however, is that there is a new pedelec battery launched almost every day on average, and that shows that in the short term the idea isn't possible to implement widely. Perhaps there will be a new opportunity in 10 years' time, when batteries have become so small that they are no longer relevant as design elements.

One plug for all
Widespread infrastructure demands standardisation

"City buys pedelec fleet", "Tourism Authority wants to extend electric bike offering", "New e-mobility pilot project" – we read such headlines almost daily. Yet all of those who need or want a good user environment for vehicles partly or completely propelled by electric power come up against the same problem: there is no standard connector which would make a widespread charging infrastructure possible.

Dr. Andreas Fuchs

Electricity suppliers, transport companies and tourism organisations all want to be 'green', to save money or to retain customers, and ever more frequently pedelecs are used for hiring, leasing or just for trying. But public authorities in particular, and companies in receipt of government funds, must behave in a vendor-neutral fashion, so they cannot decide on a charger and charger cable from company XY without angering that company's competitors.

Also, public charging infrastructure is an investment which in the end should be of benefit to all citizens. To expect such a system to be tied to a single vehicle or supplier contradicts both social and liberal political ideals. The European Union has forbidden the financing with public money of systems which favour or advantage particular companies.

A PLETHORA OF PLUGS AND A TANGLE OF CABLES

On cost grounds alone it is unthinkable to create a charging infrastructure which is compatible with all of the various charger cables for every company's vehicles. One count in 2011 gave 73 different charger plugs from 99 brands. A wall covered in connectors would not in any case be aesthetically acceptable everywhere, leaving aside the matter of cable tangle and the difficulty of protecting such an array of cables from the weather.

So without a standardised connector, cities, institutions and companies seem to have only one option: the 230 V Schuco mains plug or the CEE industrial mains plug. Not a bad choice for an electric car: it can easily carry along its own charger, protected from the weather in some corner of the bodywork.

For two-wheelers such as pedelecs, e-bikes or e-scooters taking along the charger isn't quite so simple. Firstly, by doing so a significant portion of the available carrying capacity is 'thrown away'. Also, if the battery cannot be removed from the vehicle, as on some e-scooters and even some pedelecs, the charger might end up out in the rain. Given that most chargers are not designed or approved for use outdoors, this would result in non-standards compliant operation. If material or personal damage occurred, there would be no insurance cover.

As a partial solution to the problem of weather protection of chargers, lockers with 230V mains sockets inside them could be provided. These lockers would have to be heated in winter, because most lithium batteries cannot be charged below 8°C without being damaged. The disadvantage that the charger must be carried around with the vehicle remains unaddressed. So what is really missing for charging infrastructure is the implementation of a standard connector.

HARMONISATION

A standardised connector does what a USB plug does for computers and connected equipment, or the standardised fuel tank openings for cars. It opens up the possibility of offering a public charging infrastructure which fits every vehicle. These connectors will need to be weather shielded, and protected against overcharging or incorrect insertion via electronic handshaking and standardised plug appearance. Details of the standard charging connector are at *www.energybus.org*

Harmonisation
The EnergyBus Standard

EnergyBus (EB) is the first and thus far only standard worldwide which has been developed from the start for Light Electric Vehicles (LEVs). In 2002 design work commenced, aiming to provide a solution for theinfrastructure and safety problems of the future. The first users of the EB Standard are involved in product development. The organization is made up from companies and institutions such as *Bosch*, *Panasonic*, *Deutsche Bahn*, *Philips*, *Rosenberger*, *Winora*, *ExtraEnergy*, the *ITRI Institute*, the *Fraunhofer Institute* and many more, including individuals.

The electrical, data protocol mechanical definitions were published as pary of the *LEV Conference* in March 2011, and are now available to members worldwide. Membership is open to all.

The consortium that makes up the *EnergyBus* organisation has attempted to invent as little as possible new, and wherever possible to employ the tried and tested. For information transfer between charger and vehicle *CANBus* was chosen, and as data protocol *CAN Open* is used. *CAN Open* is a machine language comparable to open source software systems.

In collaboration with *CAN in Automation* (*CiA*), also a membership organization, *Application Profile* CiA 454 has been developed. Using this, all information which is typically used in LEVs can be transmitted.

Thus the charger can query the charge status of the battery (or batteries), or the bike's display can request the charger status and display it. Safety critical information can also be swiftly processed, for example details of whether a new component is compatible, so as to decide whether to allow the system to be switched on or not.

A Technical Committee of the *EnergyBus Consortium* is also working on a system which would combine lighweight electric vehicle charging with theft protection and locking. The so-called *ChargeLockCable* would turn the charger cable into a bicycle lock (see page 31).

If you want safety and freedom of choice, there is no way around the need for a standard charging connector. *EnergyBus* is the first to offer this and new members who want to use and further develop *EnergyBus* are very welcome to join.

www.energybus.org

DO IT YOURSELF

✓ Public infrastructure through which any vehicle can connect to any charger point, needs a standardised connector. This must offer protection against the weather, incorrect insertion and overcharging via "electronic handshaking".

✓ A standard for LEVs consists of connector(s) and a communications protocol which controls the status and language between electrical components. Certain data, for example all safety critical items, are prioritized. At the same time, component and vehicle manufacturers can transmit their own data.

✓ A BUS system distributes information and electrical energy via parallel cables, as in a bus network. The components are the 'bus stops' at which data packages get on and off, carrying their messages in machine code.

✗ The European Union forbids the financing with public money of systems which favour or advantage particular companies. So a standard must be open to all, as membership of the *EnergyBus organisation* is.

✗ Instead of creating many competing standards, it would be best to unite around one. This brings long term advantages to all participants.

Pro.bici pedelec loans
Pedelecs for academics

DO IT YOURSELF

- ✓ Work together with institutions and universities in your town
- ✓ Ask dealers whether they are interested in co-operation with institutions or universities
- ✓ Give people the opportunity to try pedelecs in your town and so to spread the word

The *Mobility Management Office at the University of Catania (MOMACT)* has loaned out pedelecs since April 2010. The *Pro.bici* service is aimed at university staff, researchers and professors who can make their way to work by pedelec without needing to use a fleet motor vehicle or their own car. Its objective is to bring sustainable mobility closer to users, and to let them experience for themselves the benefits of pedelecs around town.

IMPLEMENTATION

In total three pedelecs are available at *Pro.bici* for lending out, and *MOMACT* bought these with its own funds. Maintenance is carried out by a nearby cycle dealer. Pedelec loans are free of charge and are possible from Monday to Friday, 8AM to 1 PM. To book a pedelec all that's needed is a phone call or email, and filling out a simple form.

MOMACT has also promoted *Pro.bici* actively:

➤ In October 2010 an internal informational meeting was held: staff were invited to a small drinks party at which there was a talk about sustainable mobility and where pedelec test rides were offered.

➤ In November 2010 *MOMACT* organized an event as part of the ESD (Education for Sustainable Development) Decade from *UNESCO*, which in 2010 was dedicated to sustainable mobility. Alongside numerous other activites (conferences, statistics sessions, personal travel plans), *MOMACT* made its pedelecs available to the public for test rides. The test ride, which over 200 people took part in, led participants out from the historic center of Catania along normal trafficked roads.

RESULTS

The *Pro.bici* initiative has been used from the start by professors and numerous university staff. Many wanted to use nothing but the pedelecs, and were irritated when all of the pedelecs were out on loan. *MOMACT* internal statistics show that the number of pedelec bookings has increased in recent months. So an experiment has turned into a real successful pedelec loan service.

www.anea.eu

Marketing for makers & what customers want
Evolution and Revolution

The pedelec is a new product and one which is still fast-developing in its properties. That applies for manufacturers too, irrespective of which sector they come from: motorbikes, cars or the cycle industry. Similarly, for most customers it's a new product.

Hannes Neupert

Manufacturers, like customers, have a hard time defining which selection criteria are really relevant.
It's all comparable perhaps with the situation back when mobile phones were a completely new product. Here too it took some time before the industry and consumers came to terms with each other through evolution of the market and technology.

Today with the pedelec we are at the market status of the "*Motorola brick*" mobile phone: the first phone which it was really practical to carry with you.
But when compared with the size and performance of today's mobile phones it's now hard to believe that the "*Motorola brick*" was ever acceptable.

FROM IDEA TO INTEGRATED AND NETWORKED PRODUCT IN 8 STAGES

❶ The idea
❷ The first commercial product, it fulfils the basic function but still has many flaws
❸ The improved commercial product, differing from 2 by robust functionality and affordable price
❹ A technical innovation classified by many as not significant permits evolution to restart. For the telephone this was the replacement of the cord connection with a radio connection. For the electric bike this was the step from throttle control to the control of the electric motor in response to pedalling effort.
❺ The technology becomes more compact, lighter and thus more practical to use
❻ The design becomes acceptable for broad segments of the population and the product becomes attractive, but for many it is still not at a price point at which will give it dominant spread
❼ The technology becomes a true mass market item, even more compact, even more practical. Standards are implemented and enable an increase in quality together with simultaneous cost reduction in production. New sales models come into being (for the phone this was the contract mobile, given away for a token amount, and financed over a period through the monthly payments and call charges). For pedelecs this process lies ahead in the next five years
❽ The merging of the mobile phone with the functionality of a computer, digital camera etc. and being constantly online making for seamless networking, has revolutionized the mobile phone once again and has made it an indispensable personal accessory for the upcoming generation.
Similar networking of pedelecs and integration of them into our everyday lives will be experienced within the next 10 years. This will also mean the global demand for pedelecs rising dramatically.

Pedelec product categories
Which pedelec suits you?

The sheer number of electric bikes on the market make the hunt for the best pedelec ever more difficult. The criteria are various, the bikes on offer varied. And what is 'the best' for one person may be quite unsuitable for another. The new opportunities which electric bikes open up also demand clarity when it comes to your own preferences.

Nora Manthey

The *ExtraEnergy* team have been testing electric bikes since 1993. The objective was not to find a 'test winner' but instead to establish which vehicle would best fulfil particular requirements – so which is the best for a particular application. Since then, *ExtraEnergy* has classified pedelecs into eleven product categories. So there are *Easy Pedelecs* for urban e-mobility, fast pedelecs for business types or leisure, and fun pedelecs in the Sport category. For extra clarity, the particular types are divided into four overall groups: *Urban*, *Comfort*, *Leisure* and *Transport*.

Customer requirements of pedelecs and e-bikes are always the same, for example for more assist power, more range and lower price. But these are not all of equal importance. It's important for a well-paid commuter to get to the office whatever the price, while a parent purchaser would likely place less emphasis on speed and more on reliability or load capacity.

TEST FOR YOURSELF

Only you can answer the question of which pedelec will be the best for you. Ask yourself what sort of distances you would usually ride on your pedelec, and whether this is around town and/or with steep climbs involved? Which pedelec features are essential for you? Does your display need to give high tech info or is it enough for you to know how long the battery will last? Answer five basic questions and you will see which product type will suit you.

To help guide your decision, refer to the pictograms next to each product category. If at least three of the criteria match, your dream pedelec could be in that product category. Enjoy!

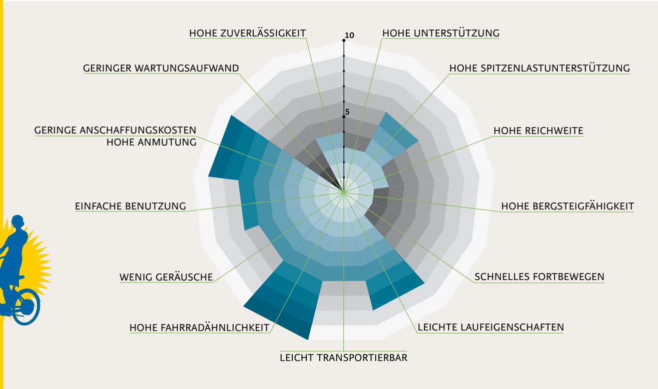
Are you clear about your requirements? Then search out a matching product category referring to the icons on the pages which follow.

THE EXTRAENERGY PEDELEC & E-BIKE TESTS

- *ExtraEnergy e.V.* has been testing pedelecs and e-bikes since 1993 as an independent organization.
- Up to 40 vehicles take part in each of the 2 tests each year
- The test consists of riding tests, everyday use tests (ergonomics) and optional safety tests
- They are ridden over a standard test circuit in Thüringen, Germany with three sections: touring, hills and urban.
- Custom measurement technology reads out speed, position, pedal effort, and motor output
- Afterwards range, power assist factor and average speeds are calculated
- To the measured values are added notes from the ergonomics tests, data such as price and weight, and any criteria for exclusion
- Taken together these values determine the ranking within each product category and the test results
- Pedelecs within each group are compared with each other and where appropriate awarded the test stamp of approval
- The results are online at *www.extraenergy.org*, in the *ExtraEnergy* magazine and in *E-Bike* magazine

URBAN • EASY

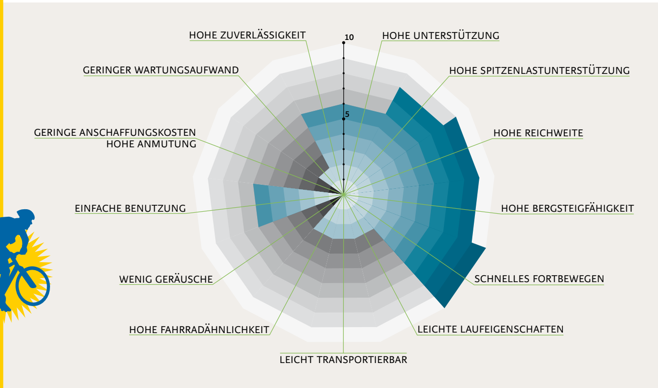
SIMPLE, BASIC RIDE



With an *Easy Pedelec* you can get around town stress and sweat free. The electric bikes in this category are recognizable though their strong resemblance to classic bikes. *Easy Pedelecs* are also relatively light, easy-rolling and user-friendly. Rides from A to B or shorter outings are made noticeably more pleasant thanks to the electric drive. The electric assist – concealed to a lesser or greater extent – of the *Easy Pedelec* is especially noticeable uphill and when setting off. A range of 20 km or more should be possible. Power users will see the usually low step-though frame as a distinct plus point. If you value a moderate purchase price and uncomplicated mobility more than striking design or technical sophistication, the *Easy Pedelec* is the right choice for you.

URBAN • BUSINESS

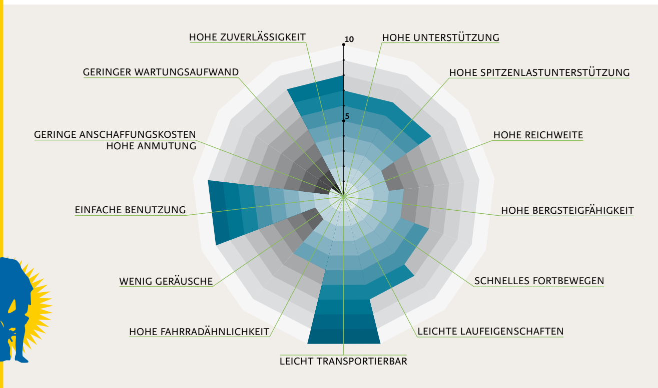
RIDE IN BUSINESS CLASS



If you commute regularly into town and back or maybe you even run a professional courier service? Then a *Business Pedelec* is made just for you. The key factors here are a range of at least 30 km and the speed. For pedelecs of the *Business* category *ExtraEnergy* sets a minimum average speed of 26 km/h over 5 km. As a general rule the only ones which achieve this are fast pedelecs, which in Germany require insurance. The advantage is that your steed is insured against theft. Sporty, high end and chic sum up the style qualities of the *Business Pedelec*. Naturally, price is not a (major) consideration here. More important to you as a *Business* e-biker is a good, city-capable specification (mudguards, lights, stand, luggage rack) and high levels of power assist, also at peak power, meaning that uphill the drive must at least double your pedal power. A multimedia display gives you full control of the vehicle and your performance. A *Business Class* pedelec.

URBAN • FOLDING

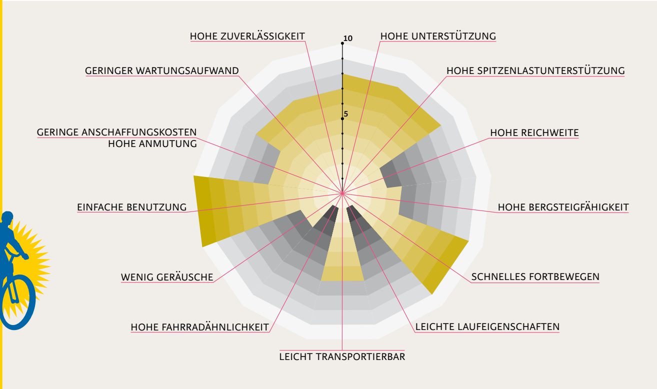
PRACTICAL AND FLEXIBLE



Small but perfectly formed – and super mobile! *Folding Pedelecs* (or '*Mix Mobility*') are ideal for you as a so-called "hybrid commuter", which means that you complete part of your journey by bus, metro, train or car. These electric bikes are designed to fit right into your patterns of life in the urban metropolis, and this pays off in flexibility and mobility. Because of the low weight you can take your pedelec with you at any time into a flat, hotels, office or restaurant, where it is safe from theft. Charging should be quick, and ideally without removing the battery. With a *Folding Pedelec* you can have a practical vehicle literally in your hand.

COMFORT • CITY-COMFORT

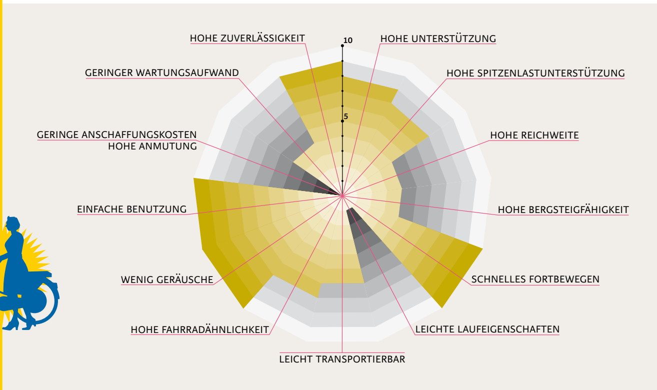
MODERN, BUT COMFORTABLE



The *City-Comfort Pedelec* is a vehicle for extra comfort in everyday use. It doesn't matter whether it's journeys to work, school or university, to go shopping, or for going out, anywhere around the city or suburbs: this pedelec will get you there comfortably. The comfortable saddle, a comfort specification and self-explanatory user contols mean a lot of riding fun completely free from traffic jams and parking problems. The minimum specification should include mudguards, lighting for safety in traffic, a stand and pannier rack, alongside a reliable drive system and ideally a removable battery pack. The overall appearance should be appealing and meet the design expectations of a modern urbanite. The *City-Comfort Pedelec* will have fulfilled its purpose if it gets you to the start of the working day relaxed; then in the evening it could perhaps whisk you away to other delights.

COMFORT • CLASSIC

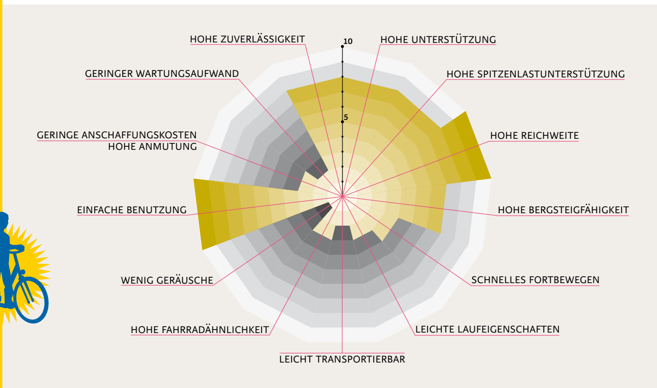
A TIMELESS SENSE OF QUALITY



If you prefer it classical, high quality and relaxed, the *Classic Pedelec* is ideal for you. You can enjoy the relaxed cruising style to the full with the upright and comfortable riding position. Visually it is very much derived from the bicycle; *Classic Pedelecs* are built to last indefinitely with robust quality components. A sealed chaincase to protect the chain is typical. Mudguards, good lights, a strong carrier rack and a solid stand are all on the minimum specification. High quality does come at a price, but with these bikes you are buying something for the long term. Together with the easy handling there should be a smoothly powerful assist system and a high range. Cruising through town and country could soon become an everyday activity with the *Classic Pedelec*.

COMFORT • REHA

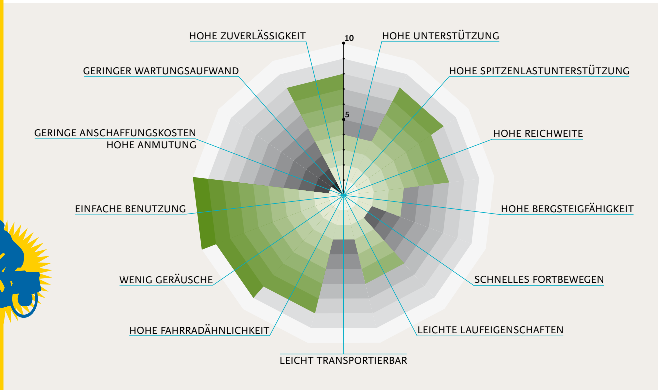
BACK IN MOTION



A *Reha Pedelec* (from 'rehabilitation') is both a means of transport and a training aid which is specially designed for rehabilitation purposes. So it needs a good, smooth assist system, which won't leave you in the lurch when it comes to the hills. A *Reha Pedelec* must be extremely reliable and easy to use. These vehicles usually have a low step through frame, or they are designed in special configurations so that you can apply just those limbs which have available movement, or which need training. A *Reha Pedelec* might for example be a tricycle with the steering linked to the backrest, for a rider who cannot use his or her arms well. Tricycles with hand cranks to replace the foot pedals are also possible. Depending on its specification and on your needs, such a vehicle can restore valuable mobility.

LEISURE • TOUR

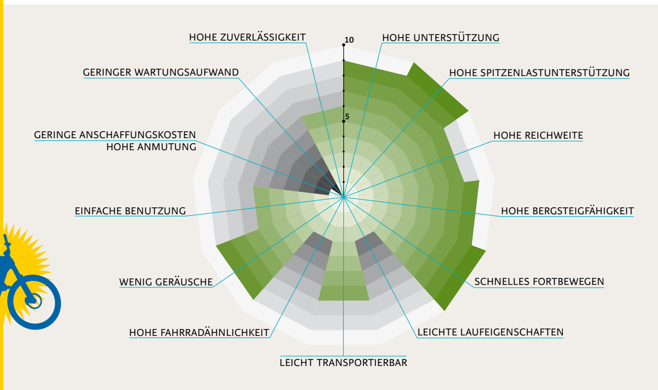
RELAXED TRAVEL



You love cycle touring and just want to go that bit further – and a *Tour Pedelec* will help you do just that, making it the ideal electric bike for leisure and tourism. These pedelecs can be ridden over long distances easily and efficiently. Climbing hills is child's play, and a comfortable riding position and comfort specification are all advantages of the *Tour Pedelec*. It should be technically high quality and have a good lighting system, an accurate battery charge level display and battery (or batteries) giving at least 40 km range. With suitable fittings and with a total weight limit of at least 110 kg you can load up your *Tour Pedelec* with everything you need, such as panniers, drinks bottles, spare batteries and GPS navigation system. Optional rain, wind and spray protection is also possible for this category. So saddle up your electric steed and ride out into the whole wide world.

LEISURE • SPORT

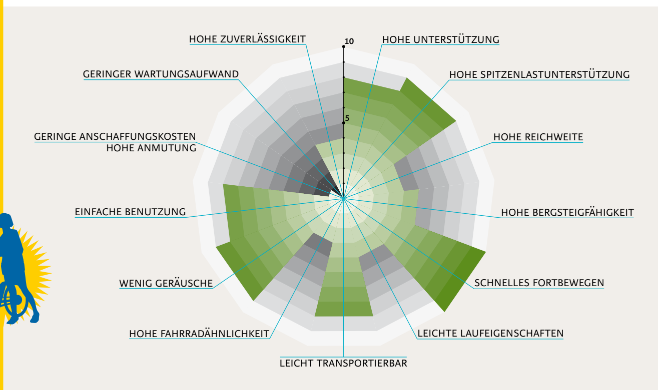
COMPETITIVE, DYNAMIC AND FUN



It's obvious to you: sports and pedelecs are by no means mutually exclusive – is just makes both more fun! Just as in 'real sports' this category is about performance, speed, sporting chic and all-terrain ability. Young people, sporting types and trendsetters will find in the *Sport Pedelec* a new leisure and training device which can also be useful in everyday life. For you, power and a spirited ride in any terrain counts. A powerful drive system combined with individual and dynamic style deliver image, fun and fitness. You'll doubtless have some appropriate sportswear in your cupboard. Put it on – get your pedelec – and go!

LEISURE • WELLNESS

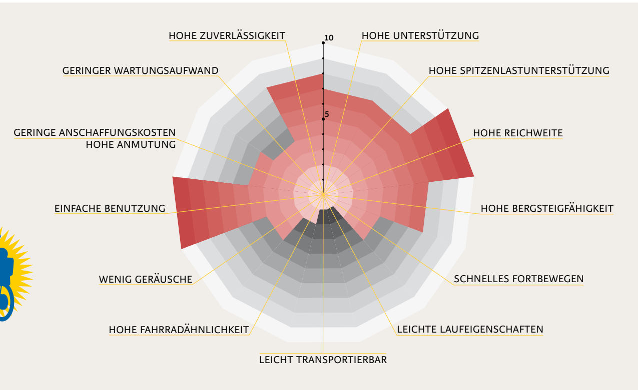
PEDELECS WITH THE FEEL GOOD FACTOR



The most frequently asked question is about this category: so what is a *Wellness Pedelec*? A *Wellness Pedelec* is designed for sporty leisure use, but with the emphasis more on relaxation and fun than on sporting prowess. The image is analogous to that of a yoghurt with aloe vera – an everyday product with an extra feel-good factor. Alongside the image, *ExtraEnergy* has of course set additional criteria: without good pedal assist, particularly on the hills and starting off, a quiet motor and good handling no pedelec will gain entry to this group. It's suited to anyone interested in electric bikes of all age groups, and who love to be on the move in the open air and so to gently nurture their health and fitness. Alongside these benefits, lively handling and an appealing design means plenty of riding pleasure.

TRANSPORT • FAMILY

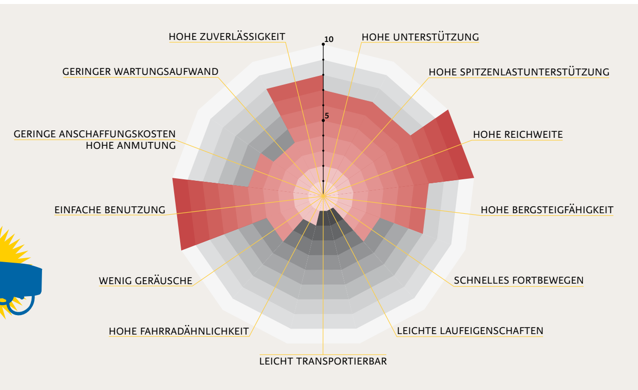
WITH CHILDREN AND THEIR GEAR



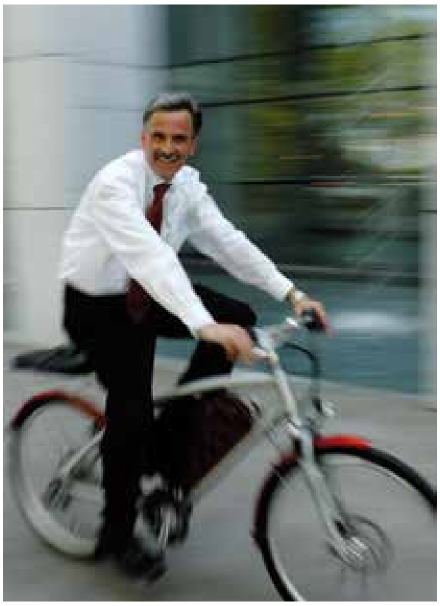
If you, as an environmentally aware family with children and shopping to transport here and there, don't need a motor, who does? *Family Pedelecs* are just as suitable for family outings as they are for transporting children and their gear around town. As an everyday vehicle for you and your children it must be especially safe and reliable. A powerful drive system is a must, because it needs to compensate for the weight of extra (small) passengers, equipment such as childseats and all of your various extra luggage. The payload limit should be no less than 115 kg. Minimum range of 30 km will cope with stop-and-go riding in town, and shorter excursions. A dependable battery status display, full traffic-safe specification, mudguards and an easy to use user interface all help make life easier.

TRANSPORT • CARGO

MOVE MORE



You are probably in the transport business, or just don't want to use your car for big shopping trips. The *Cargo Pedelec* is a multifunctional vehicle for the transport of loads and people. 135 kg payload capacity is the minimum, and it also needs special stopping and parking equipment. *Cargo Pedelecs* are very powerful so that even steep sections can be covered without difficulty even when heavily loaded. With their strong drive assist, these vehicles are faster and safer than conventional transporter bikes or rickshaws. As an experienced *Cargo Pedelec* rider you will learn to value the low maintenance requirements and the excellent price-performance ratio which these vehicles offer. Hills need no longer stand in the way of your transport tasks.



Tests and how to do them
The ExtraEnergy Test and its value

With the increasing popularity of pedelecs and an ever greater variety on offer, customers need ever more guidance. A test ride is certainly one of the best ways, but it is also normally the final deciding factor and it is well worth being well informed beforehand. Ever more publications include reviews of pedelecs, but it is not always clear how they were tested or which evaluation methods were employed. So the results can be all too arbitrary, especially when key figures such as range or assist power are not underpinned with well documented data. As an independent organisation *ExtraEnergy* has tested pedelecs since 1993, and over the years has developed and published a stringent methodology and measurement techniques all targeting what users really want from their pedelecs.

Nora Manthey & Andreas Törpsch

PRODUCT CATEGORIES

Most of the *ExtraEnergy* product categories appear familiar at first glance, drawing on 'classic' categories for bikes such as city or touring, as you'll find in other publications. What is different compared to most other tests is that categorisation is not decided by the manufacturer (City-Bike xy) themselves. Instead, at the foundation of the *ExtraEnergy* categories are 14 customer requirements together with their importance weightings. The categories, into which around 20 years of experience has gone, are made public and are regularly reviewed by an independent circle of experts to adapt to the latest developments.

In essence, these requirements are the same for every customer and every product. Everyone wants more powerful assist, better reliability and more range. But not everything is equally important to every user, so not every pedelec needs to fulfil each criterion equally well. What matters when making a decision is who will ride the pedelec and where, and what the products needs for this.

Because the user and the intended use are closely interrelated, a little lateral thinking is sometimes required. For a *Tour Pedelec* it is not, as you might at first think, the range which is the most important aspect, but the ease of use. Because you have luggage with you on tour anyway, carrying a second battery as well is relatively easy. Also, most batteries are now sufficient for typical daily distances, which is recognized in the 40 km minimum range for a *Tour Pedelec*. Ease of use however is essential, because one of the main areas of application for a *Tour Pedelec* is cycle tourism. Inexperienced users need a hire bike which they can handle easily, and on which they can if necessary fix a small breakdown themselves.

REQUIREMENT WEIGHTING

The differing requirements for the various different pedelec types are expressed through varying weightings of these requirements for each product category. To distinguish the 14 requirements clearly and to avoid arbitrary judgements, *ExtraEnergy* employed the 'pair comparison' method. So each customer requirement was compared with another, for each category. So for example we asked whether range for a touring bike was more significant than high assist power, and the responses were give values of 2 (more important), 1 (equal) or 0 (less important). Going through each requirement gave them all points, and these were summed to give the weighting, and hence the profile for that category.

The measured values and characteristics from the pedelecs on test are set against each requirement which they fulfil. In addition there are exclusion criteria and minimum requirements, for example the range of 40 km for a touring bike.

Leading up to the final test verdict, all values are entered into a spreadsheet, via which the bikes are automatically sorted into product groups, bearing in mind the exclusion criteria and minimum requirements. The weighted requirements, together with the measured values, give points for each bicycle. These are normalised from 1 to 10. This normalization also simultaneously sets the ranking, expressed as a K factor , for customer (*Kunde* in German) requirement fulfilment. The best bike in every group is declared the test winner and receives the top K factor of 10. All of the other pedelecs in the category are measured against this, and are awarded the seal of approval which matched their C factor.

CRITERIA CLARITY

One decisive factor when it comes to deciding how relevant a test is, is the clarity of the criteria used. In just about every review figures are given for range, average speed, and sometimes power assist level. Unfortunately how these figures were reached is often not clear or insufficiently documented. If they are then displayed as absolute figures, and so not put into (clear) context against typical results or against other bikes (within a product category) then they lack in explanatory force. They will then need looking at very carefully indeed.

ExtraEnergy records data on the bike using special measurement equipment. Measured qualities are the speed, pedal force, pedal cadence, electrical motor power and the route profile. From this, the range, average speed and power assist factor can be calculated.

The test circuit is fixed and consists of three sections: tour, hill and city. In this way the performance of pedelecs can be determined on the flat and on various road surfaces, on climbs, and while starting and stopping. Values for each section are later given separately. If you live in the mountains, for example, pedelecs with high values for the hill section are recommended.

Normally the course is ridden in the highest power assist mode. This setting is significant, because it is easy to extend the range with more sparing use of the motor.

Range in the *ExtraEnergy test* is determined according to the measured use of energy. Other range figures, which depend on, for example, riding until the battery is empty, are too inaccurate, especially when data on the route height profile and power assist mode used are missing.

Particularly high average speed figures should be seen in relation to other values such as the energy use, battery weight or the charge time.

*ExtraEnergy test*s have shown that different pedelecs often have their own characteristic average speed. This often depends on the type, so a *Cargo Pedelec* is generally ridden slower than a sporty model.

Which contributes how much power, man or motor, is expressed in the power assist factor. This so-called U factor (for the German '*Unterstützung*', meaning assistance) is a measured value introduced by *ExtraEnergy*. Assist power is often specified in other tests or in manufacturer claims. Sometimes figures of 200% or more are quoted, but where these figures come from is seldom clear.

The U factor in the *ExtraEnergy test* describes the amount of power which riders gain through the drive to supplement their own pedalling. In this case the motor power given is not the electrical output, but instead the power which actually reaches the road, or which in other words is contributing to forwards motion.

To determine this, rides are first carried out on a reference bike without a motor. In this way we can see how much power the rider would need on a conventional bike, and how much will later be needed on the pedelec to reach the same speed.

A U factor of 1 means that the drive system is doubling the pedal effort of the pedelec rider, who would have to put in twice the pedal effort on the reference bike to achieve the same speed.

Other details which you will find in a test report include bike data. The specification, for example which suspension seatpost or brakes are used, is straightforward. The weight is more interesting. In *ExtraEnergy test*ing all the bikes are weighed, as are the batteries, because manufacturer figures are often somewhat 'best case'. In the *ExtraEnergy test* the weight is given under "Weight or carry-ability" and as a measured value for the evaluation. So it will be counted when it comes to the relationship between use and category of pedelec. It is particularly important when the pedelec needs to be carried, but if this is seldom or never the case then a good power assist can easily cope with an extra kilo or two.

CLEAR PRIORITIES

In general, customers only see the end results of testing and then have to find their way through the multitude of test bikes. So it helps not only to know how to evaluate the results, but also above all to be clear about your own priorities.

To help, *ExtraEnergy* poses five questions: Where will the pedelec be ridden? Does it have to be lifted up steps? Will it transport cargo? Does it need a high tech display? And do you ride fast?

When you have clear answers to these questions, you can determine according to your own priorities which product categories are in the running, and thus get a first overview.

But before a final purchase decision is made you should have a test ride, ideally of several models on your shortlist.

Test riding isn't just absolutely essential when it comes to seeing which pedelec really suits you; it can also be great fun!

The test as a reference
The digital test rider

Data assembled since 2009 on the *ExtraEnergy* test circuit, now covering over 100 bikes, was analysed in a joint project between the *University of Leipzig* and *ExtraEnergy e.V.* with the aim of creating a standard protocol for performance test stands. A test stand has the advantage in comparison to rides over real circuits in that the same conditions can be reproduced anywhere in the world.

Andreas Törpsch & Harry F. Neumann

To compare one pedelec with another, a standard ride cycle is needed. This riding cycle should as far as possible mirror usage in the real world, because it really makes no sense to perfect a product on the test stand, only to find that the methods used don't measure up to reality.

The critical input factor for pedelecs is the human, because pedelecs are muscle-hybrid vehicles. If the pedelec is working properly the motor assist produced should depend on pedalling effort.

This helps ensure that even despite powerful pedal assist and high speeds, the cycling character of the ride is retained.

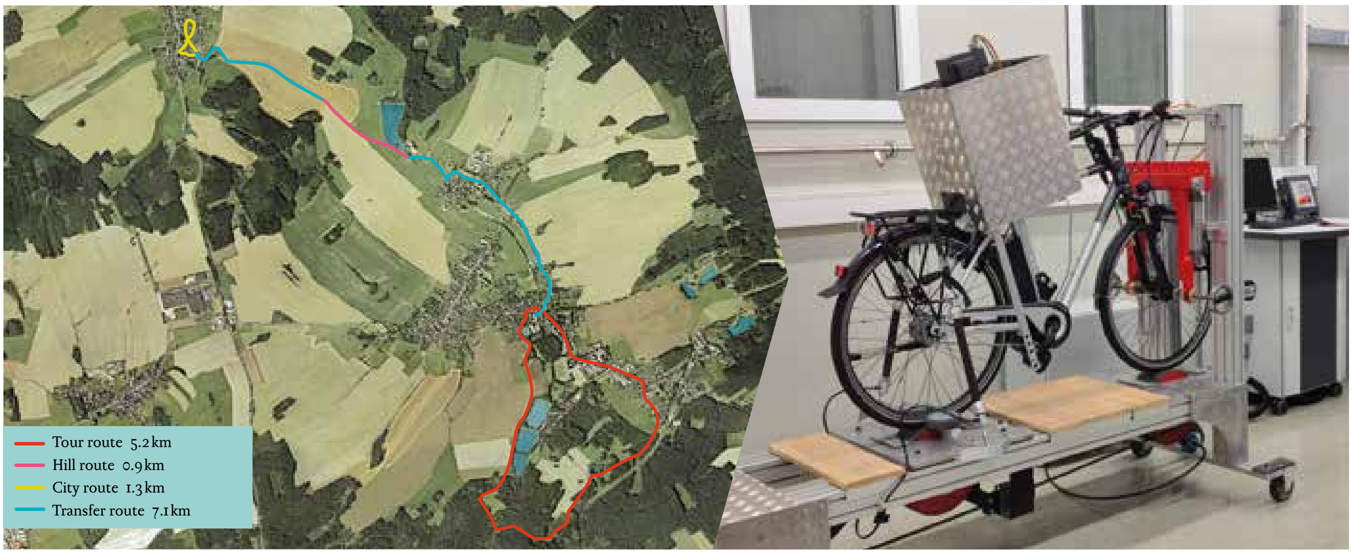
Alongside the pedal efforts of the rider, the progress of a pedelec is affected by the motor performance, the riding position, the weight, the rolling resistance characteristics of the bike and influences from the wider environment.

So the most important output value for a standardised ride cycle on a test stand is the rider's pedal effort.

This in turn depends on the force the rider puts on the pedals, and the pedalling speed, or cadence. The advantage of having this pedal effort as an output value of the test stand is that it is independent of the usage category of the pedelec: it stays identical whether it is for a *Cargo Pedelec* or a touring pedelec.

These variables are now brought together, embodied in a protocol which can be reproduced on a test stand, to represent the human element. All of the data (from around 700 rides) was combined to create a route model (with versions for pedelecs 45 and pedelecs 25 separately) with an accuracy of 5 cm, so that the model represents the average ride of all of the pedelecs tested to date. The data from the field testing, divided into the separate tour, hill and town sections, can now be applied as a standardised ride cycle for the test stand.

This is important both for users and for the industry, because figures in manufacturer specifications can finally be made comparable. Some legislative measures might be necessary here to compel the manufacturers and dealers to provide comparable figures for range – similar measures already exist for fuel consumption figures for cars, where it was only legislation which curbed the wild flights of fancy of the marketing men. *ExtraEnergy* makes this suggestion based on many years of experience. It is also worth mentioning at this point that measurements on the road will still be necessary in the future, as in cases of doubt they are even more accurate.



LEFT The three real world *ExtraEnergy test* routes: tour, hill and city. This is where since 2009 the test riders have been loaded with measurement sensors hand and foot – and the result is the digital test rider. **RIGHT** Here the digital test rider sits on the digital roadway which can precisely simulate the three test routes in Tanna: tour, hills and city. This lets anyone worldwide perform comparison test rides at any time and whatever the weather, and to compare the data with a vast archive of measured values.

The toughest test: everyday use
What really matters when buying

At first glance, buying a pedelec looks simple enough. You go to a shop, take a look around, sit on the bike, try one out if you like it, chat to the salesman a little, then glance down at the price… at which point you decide you need to think about it. But really, you should have sat down to think a bit earlier, because a pedelec really is more than just a bike with an electric motor.

Nora Manthey

In contrast to conventional bikes, electric bikes are complex products, whose performance cannot be summed up in single figure or component; instead they are a complex symbiosis of man and machine. The motor on a pedelec only assists when the rider is pedalling. So it is a hybrid vehicle combining muscle and motor power, and overall performance depends on other factors too. As a user you could (but you don't have to) get involved with details of the software set-up, the compatibility of the components and component selection. But what really matters in everyday use is ride quality and practical ease of use.

BIKE SHOP QUICK TEST

Of course, it's rare that you can borrow the pedelec from the dealer for an extended period, and several bikes? No chance. However there are a few simple tests which will quickly and easily simulate the most demanding situations of everyday riding. You don't have to actually take the pedelec to pieces in the bike shop, but you should ask for a brief introduction to the technology or for permission to fiddle a little. So you could for example check that removing the battery (if possible) is easy to do, and test the various mechanisms on other pedelecs and so learn more about your own preferences. With a new product like the pedelec, you need to get to know it a little before you can decide which is right for you.

It's easy to test how easy it is to carry, by lifting it. You should bear in mind that most pedelecs are heavier than conventional bikes because of the motor and battery. Rather than being scared off by the weight, it's worth first considering the actual requirements of your life circumstances. If your parking space is on ground level the vehicle doesn't necessarily need to be light to carry; but if you live on the third floor, weight could be critical.

TEST RIDING HELPS DECISION MAKING

What really matters in everyday use is ride quality and practical ease of use.

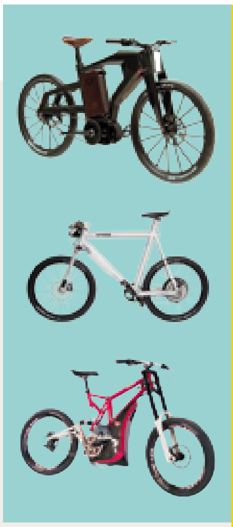
You can tell basically how easy the bike is to manhandle if you can push it out of the shop yourself for the test ride. You can also note how the seat height and handlebars adjust, and any motor settings; how easy it is to use.

A short ride on a flat road is only enough to get a first impression of the handling. You can only really find out whether you want a longer-term relationship with the bike if you can go up and down a bit. A hill or even just a ramp can give an impression of the power assist at peak loads. A couple of steps can be used for an extra carrying test. A good indicator of the rolling resistance of a bike is riding without the motor, because loss of power is always possible. Switching it off as you ride will also show you how easy the display is to reach and operate.

You should ask for a brief introduction to the technology or for permission to fiddle a little.

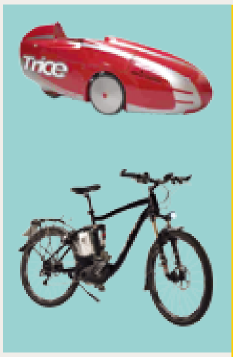
It's recommended that you try several bikes and various systems. You can do your own user testing using the questionnaire from the *ExtraEnergy* Pedelec & E-Bike Test. If you are lucky enough to find a wide range of pedelecs at your dealer, you can also record your impressions and evaluate them back at home before you decide on your electric bike.

It's recommended that you try several bikes and various different systems. You can do your own user testing.



€ 8,000 TO 60,000

It's amazing that there are pedelecs which cost almost € 60,000. This is an indication of how human-electric vehicles are well suited to the role of status symbols, to help the owner stand out from the crowd. Because of their intrinsic rarity, these vehicles are potentially value-retaining investments. Technically, all vehicles in this class to date have been nothing special, at least as far as the electronics go; instead they generate their value through high class materials, exclusive design and rarity. This will doubtless change in years to come, as ever more technology reaches the pedelec market.



€ 4,000 TO 8,000

This category is quite new, and owes its existence to the development of special LEVs which in general have little in common with conventional bikes. These are one-off, very exclusive products which as a rule are distinguished by special design or special technical functionality. Often they are products made in small numbers, which means either hand made or made to order. It's best to buy such vehicles direct from a specialist cycle dealer. With small production runs and small companies you should question whether the warranty and spare parts availability can be guaranteed under all circumstances.

⚠ You will have to judge whether the price-performance ratio is acceptable on a case by case basis.

€ 2,400 TO 4,000

Into this category fall many fast pedelecs, exclusively-specified regular pedelecs with assist up to 25 km/h, and cargo bikes. Customers are paying here for a good name which represents quality, style or prestige. Purchase through a specialist dealer is recommended here, so that technically expert maintenance and spares service can best be guaranteed.

⚠ There is some risk of purchasing an over-priced cheaper product if you buy beyond the specialist retailers.

€ 1,700 TO 2,400

In this price region you'll find most of the products worth recommending, from well known manufacturers. Here, in general the relationship between price and performance holds good. For expert maintenance, spares availability and professional advice buying from specialist dealers is recommended. While there you should definitely request a test ride, because even when products are similar in price there can be significant differences in ride quality and in the various types of drive system.

⚠ There continue to be some resourceful suppliers who will try to 'upsell' a lower value bike simply by putting a higher price tag on it.

€ 1,200 TO 1,700

Here there are a few products which are recommended and cheap. But in this price range there are also products which are technically no better than electric bikes from the discounters, but which when sold through the bike trade with a brand name attached are € 500 to 800 more expensive. It may well be that for the same price, you could buy a product whose batteries will be faulty after a year, or a product in which the batteries work reliably for five years. It's a similar situation with the availability of spare parts.

It's worth looking very closely at each individual case and making sure you are well informed.

€ 500 TO 1,200

For products in this price range you should only ever put your trust in the supermarkets when purchasing. Current offers from discounters like *Aldi* and *Tchibo* come in usually between € 599 and 799. These products are really cheap and come with a genuine warranty. Technically the bikes are however very basic, and can't be compared with a cycle dealer's bike for € 1700 to 2400. You should obtain further, independent information about any particular product.

On no account buy pedelecs in this price range over the internet.

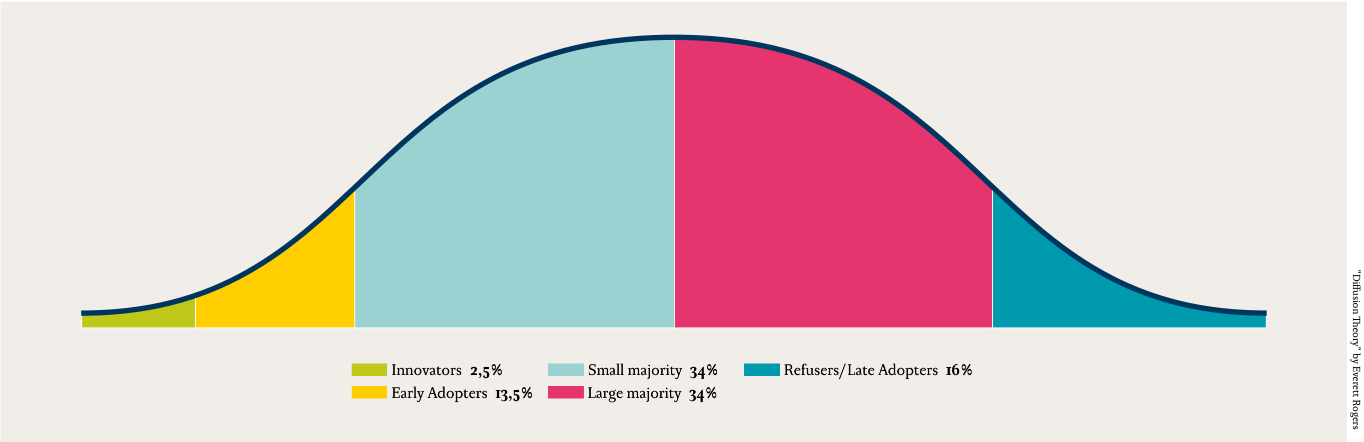
€ 80 TO 500

However alluring such a low price may look, buying new at this price is a waste of money: it means factory-fresh rubbish. You can find such offers often on *Ebay*, *Amazon* or other internet sources. The products mostly have cheap and heavy lead-acid batteries, and they are often not equipped to *StVZO* regulations, and do not meet current minimum standards. Vehicles on offer may often be sold as legal pedelecs, but they are often in fact e-bikes for which approval is required. Spare parts availability is seldom guaranteed.

Occasionally there may be cheap used vehicles here which are worth the price. New ones never are.

Note: This sorting into price categories is a generalization. Here, as ever in real life, "exceptions prove the rule". There are for example some small companies who have spare parts availability well covered, but experience has shown that this can change rapidly with a small company for all sorts of reasons. Even with larger, well-known companies there can be bottlenecks, but when a drive system has sold many 100,000 units, then it will always be profitable to remanufacture stocks of spare parts. It is to be expected that prices will tend to rise over time, simply because of depletion of raw materials such as copper and magnets and the welcome increase in wages for Chinese factory workers.

DIFFUSION OF INNOVATION



Pedelecs: a changing image

Before pedelecs came 'on trend' in Germany and the Netherlands in 2009, people had perhaps heard of electric bikes but they hadn't tried them out for themselves. Those who did know about them thought that they were only for the elderly or for rehabilitation purposes. This perception has now changed.

Nora Manthey

DESIGN

The first market-ready pedelecs looked very much like bicycles, and came to the shops with low step-through frames and coaster brakes. Clearly, the few manufacturers who were making them were directing their electric bikes at older people; the motor could help them gain a second wind. While the 60+ target group is still an important market sector in terms of sales numbers, new designs and more powerful motors are causing a turn in the trend.

Sporty electric vehicles such as e-mountain bikes for example are up and coming. They promise fun, sport and coolness, because suddenly going uphill is easy, and downhill even more exciting. Companies like *KTM* from Austria or *Winora* from Germany have notched up record sales figures with their e-MTB machines. E-mobility is also now taken seriously as a growth market which opens up new customer groups. This boom can be put down to the new lighter yet more powerful Li-Ion batteries, and to new suppliers, but it also reflects a changing attitude to healthy lifestyles and consumer behaviour.

ENVIRONMENTAL AWARENESS

Environmental awareness is growing within the EU and it is driving people to alter their consumption and transport habits. Behind this is improved access to ecological information, but also rising oil prices.

A 'Eurobarometer' from 2007 showed that 56% of Europeans are trying to save on petrol by walking or cycling. 20% of Dutch people could also envisage that they might soon buy a pedelec for environmental protection reasons.

From the manufacturers' perspective they are increasingly engaging with the green trend and are advertising with 'e' not just electrical but also environmental and modern mobility. Increasingly the 'LoHaS' group are being targetted.

LOHAS

LoHaS stands in English-language texts for 'Lifestyles of Health and Sustainability' and it denotes a group of consumers who are well educated and well paid and who aim to influence the world through their behaviour as consumers; i.e. to make it greener. They offer huge potential for pedelecs, because they live in urban spaces which are the ideal place to use electric bikes. Campaigns and designs will be increasingly tailored to this target audience.

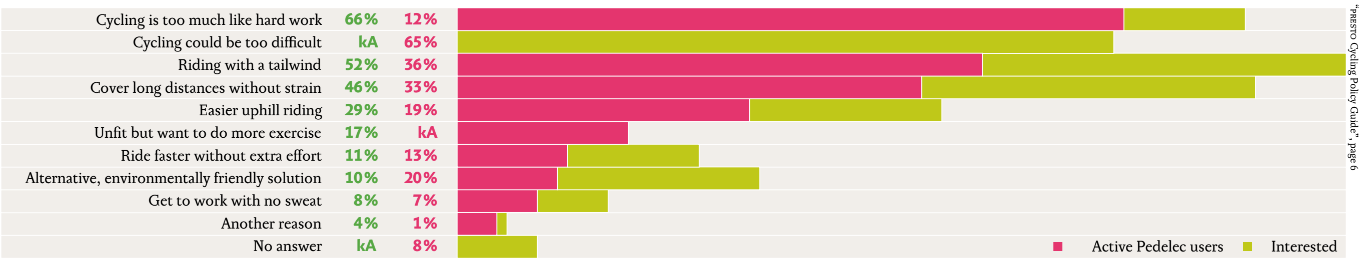
So advertising will feature family pedelecs, and commuters who live a modern and mobile life, and who are open to (clean) innovation, will be addressed directly.

Although no precise breakdown of target groups for pedelecs is available, the most recent figures show that the aveage age of pedelec riders is falling.

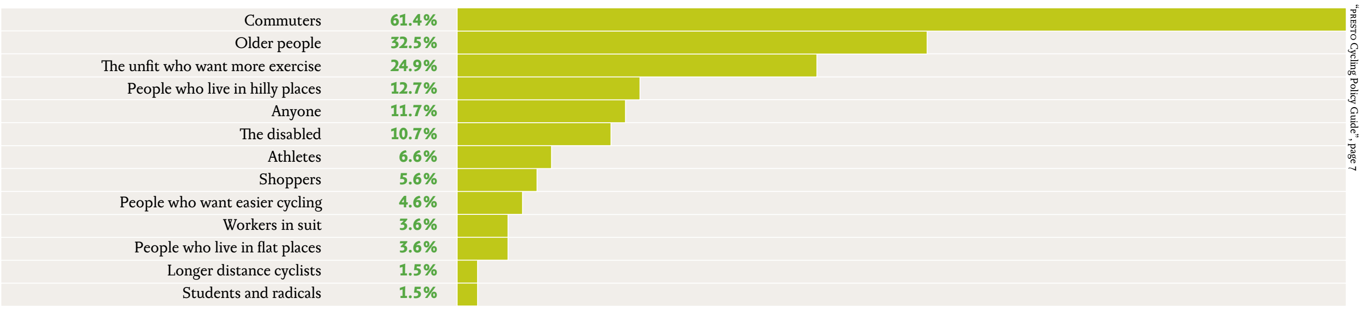
COMMUTERS

Commuters have the power to turn the trend. Instead of being seen as vehicles for the elderly, pedelecs can be positioned as modern everyday vehicles and a 'smart choice'.
A study from Belgium shows a dramatic change in the perception of pedelecs: 61.4% of those questioned gave commuting as a reason for using a pedelec. This still needs to be converted into reality, but the increasing variety of s-pedelecs (speed

REASONS TO USE A PEDELEC



WHO WOULD USE A PEDELEC MOST



pedelecs) points in the same direction. These assist the rider up to 45 km/h, and this makes them attractive for longer journeys or as car replacements around town.

DIFFUSION OF INNOVATION

Everett Rogers developed a theory that explored the acceptance of innovation over time in a social system. According to Rogers, innovations such as a new technology spread via two channels: mass media and opinion leaders.
One can see a huge and rising interest in e-mobility in the media since 2009, and in line with Rogers this can be traced back to an activity which has been applied to pedelecs, in particular by *ExtraEnergy* over many years: the test ride.

According to Rogers, the acceptance process runs in five stages: knowledge, persuasion, decision, implementation and confirmation. The individual will first become aware of the innovation, then actively seek out more information, then decide to take on or buy into the innovation, before starting to use it and to integrate it into his or her life. This process is the same for every individual, but Rogers assumes that there are some who are more open to innovations than others, the so-called opinion leaders. They are the first users (early adopters); a few go first, then the majority follow until the innovation has finally spread to every last one.

Pedelecs are today known to some and they are increasingly becoming a part of everyday life, particularly for those who have tried them. Alongside news coverage and marketing, for example with celebrities, test rides have proven themselves the most convincing argument. To accept and to use a new technology, you need to experience it.

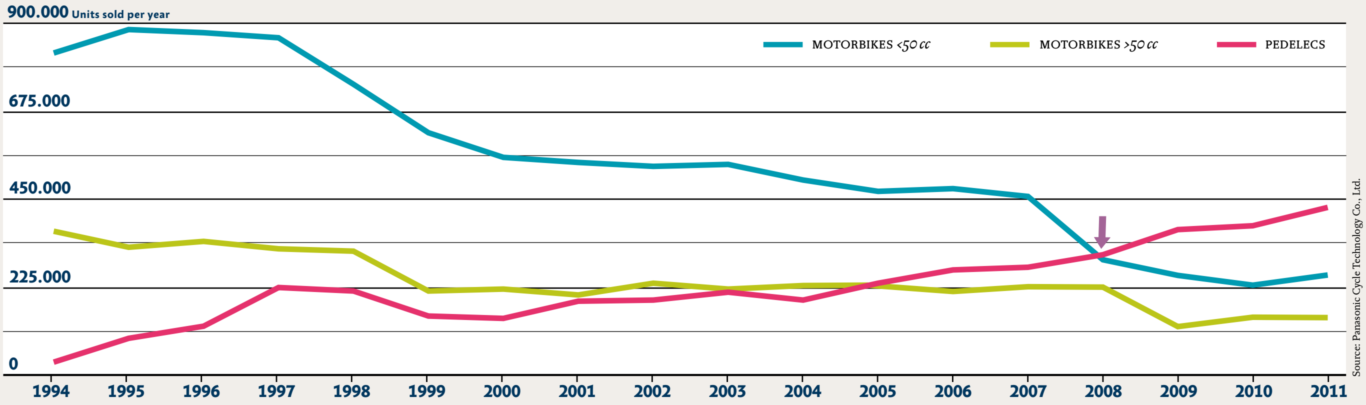
OPINION LEADERS

The term Opinion Leaders comes from Elihu Katz and Paul Lazarsfeld and their theory of two stage communication. Opinion leaders use the media more intensively and take up ideas more quickly than others, who in turn trust the leaders' opinions and then follow. Opinion leadership is usually limited to a single field in which the opinion leader is regarded as an expert.

LOHAS

LoHaS describes consumers who live a "Lifestyle of Health and Sustainability", which they confirm through their purchase decisions. The term was coined in 2000 by the American sociologist Paul Ray. Critics doubt the sustainability of consumerism and new terms such as *LoVoS* (Lifestyles of Voluntary Simplicity) are springing up to replace it. In Germany the related term "*ParKos*" means 'participative consumers', especially those using the internet.

DEMAND BY MODE OF TRANSPORT IN JAPAN



Pedelec riding is simply unimaginable!

You can grasp what a pedelec is intellectually but its essence can't be imagined – only experienced

Most people have learned to ride a bike, or at least, many of the currently around 7 billion have, because there are currently around 1 billion bikes worldwide. — Source: *www.worldodometers.info*

Hannes Neupert

Many people also have experience of motorbikes, but it's still hard to imagine what it feels like to ride a pedelec. Most people think it'll be a little like motorbike riding, but actually the magic is in the coupling of the motor power with muscle power. Car drivers could perhaps compare it with the feeling of power steering or using brakes with servo assist. You feel as if you're steering and braking all by yourself, but in fact most of the force is applied by the servo system. It's the same on a pedelec, so the satisfying feeling of having climbed a hill yourself remains, it's just easier.

The German inventor Egon Gelhard invented and patented the pedelec principle in 1982. Unfortunately he could not find a cycle manufacturer willing to implement his ideas in a product. To be fair, at that time this would have been extremely difficult, because digital motor control and sensor technology were still at early stages of development, and could not have been manufactured at an acceptable price. So it took another ten years until the Japanese motorbike maker *Yamaha* developed the first pedelec, and launched it onto the Japanese market in 1993. *Yamaha* understood that with the pedelec they were dealing with a new category of vehicle which only intuitively had anything in common with bikes and motorbikes.

Because it is hard to convince customers when you are the only supplier of something new, *Yamaha* also persuaded its competitors to enter the market, so that *Sanyo*, *Panasonic*, *Mitsubishi*, *Honda*, *Suzuki* and many others brought pedelecs to market in the following years. To convince cycle dealers of the benefits of pedelecs test tracks with a ramp section were built at bike shows. To convince end users, manufacturers of pedelecs went to all possible events and built a mobile hill circuit so that as many people as possible could take a test ride.

This was the only way in which the market could have developed continuously so that the pedelec is today made in numbers which exceed all other motorised two-wheelers. In 2011, 430,000 pedelecs were sold in Japan, against 257,000 motorbikes up to 50 cc and 148,000 motorbikes over 50 cc. Japan can be seen as a model for markets such as Europe, because, similarly, ongoing market development only occurs because of the product benefits, and from people experiencing these product benefits for themselves.

Test track at the *Tokyo Cycle Show* 1996, which inspired *ExtraEnergy* to being this method of convincing dealers and end users to Europe. As early as 1997 *ExtraEnergy* had installed a test track at the IFMA show in Cologne.

Test rides: be convinced by pedelecs and e-bikes
The GoPedelec Test IT Show

To be convincing, new technologies need to be experienced. For electric vehicles, experience has shown that the test ride is the argument with the greatest persuasive power. After just a few circuits of the test track, even skeptics become grinning electric bike riders. Furthermore, the new fans often include people who hadn't ridden a bicycle previously for many years.

Nora Manthey

The experiences of *ExtraEnergy*, garnered since 1997 on Test IT Tracks worldwide, coincide with the results of other studies. Han Goes from *Q Square Consultants* has confirmed its persuasive power in a survey which questioned test riders before and after their test rides. 50 % of all of those asked, after a test ride and a brief presentation, could envisage themselves buying a pedelec. Larry Pizzi, chief executive of *Currie Technologies* in the USA, has also confirmed this value from his sales figures. He says that the chance of a sale rises by 50 % if the customer has first had a go on the bike.

The report "*Electric two wheelers – effects on mobility behaviour*" from Switzerland opines that the potential of pedelecs as a new means of transport be achieved in a different way. The authors recommend that Light Electric Vehicle (LEV) promotion should focus on heavily motorised households, because LEVs are particularly good at replacing the (short) urban car journeys typical for this group. So it's no longer 'just' cyclists who should be addressed; the electric bike should also be portrayed as a car alternative.

ELECTRIC MOBILITY IS IN AND GREEN

The pedelec trend has already been bolstered by the increased costs of car driving and a growing environmental awareness, expressed in changing mobility habits. A Eurobarometer survey of European transport legislation from 2007 showed that 56 % of EU citizens are trying to save petrol by walking or cycling more. An increased shift from cars to pedelecs and e-bikes would significantly reduce transport-related CO_2 emissions, of which 50% in the EU are caused by personal car transport.

Pedelecs have especially promising potential to shift people from cars to bikes because they eliminate 'peaks' such as hills, headwinds or simply the effort of cycling. Car drivers also experience a hitherto-unknown sense of fun with this new way of getting around, if they are only given the opportunity.

THE TEST IT SHOW

Test IT Tracks are test tracks which are installed at trade shows and other events, and where pedelecs and e-bikes of all sorts can be test ridden. The construction includes curves, straights and an almost 20m long ramp with 10% gradient. So the benefits of the new vehicles, for example assistance on hills, can be experienced.

While previously these *Test IT Tracks* were implemented individually, in 2011 *ExtraEnergy* marshalled its forces and set up the *Test IT Show*. Now three mobile test tracks are travelling throughout Europe with strong partners on board: eight manufacturers are making their products available to the European public. The *Test IT Show* is part of the *GoPedelec* EU Project. Alongside the European events, the Test IT Show includes trade shows, festivals and more. This all reinforces a shift in focus for pedelecs and e-bikes from a purely cycling public audience towards the wider population, including those not interested in cycling.

So it's not just for cycling or tourism trade shows: cities, towns and regions, shopping centres, companies or even private individuals could all become Test IT Show venues. All you need is some space; the rest, including ramps, vehicles and advice is all brought along by *ExtraEnergy* and its partners.

You can find details of future events at *www.textitshow.org*

Pedelecs in practice
Tests rides lead to acceptance

The *GoPedelec*! project was set up in 2009 by four municipalities, three not for profit organisation and three companies. The joint aim of the ten partners from Austria, the Czech Republic, Germany, Hungary, Italy and the Netherlands is to raise awareness of pedelecs among both residents and local political decision makers.

GO PEDELEC! ROADSHOW

The highest profile part of the project is the road shows, which take place across five countries. They give residents the opportunity to try electric-assist vehicles on a custom built test circuit. This methodology comes from the *ExtraEnergy Association*, which has promoted pedelecs in this way since 1997. For the *GoPedelec*! project test courses with ramps are erected for a few days at the various venues. Residents can try out different pedelecs free of charge and can also find out more. In addition activities are run aimed at opinion leaders and particular target audiences:

- Consultation and knowledge transfer with local politicians
- Training and consultation for cycle dealers

MORE MEASURES

Local pilot projects on:

- Charge stations
- Parking facilities
- Hire and/or loan systems
- Cooperation with health organisations
- This very handbook and its translation
- Research and surveys of market participants, citizens and politicians
- Creation of an experience exhange network between municipalities.

Thomas Lewis · office@energieautark.at · www.gopedelec.eu

DO IT YOURSELF

✓ Trying is better than talking. Offer test rides. Even sceptics will get off a pedelec smiling.

✓ Target invitations to informational events and ensure that you invite opinion leaders, potential opinion multipliers such as politicians, specialist dealers and other organisations.

✗ Make sure to demonstrate many vehicles from various suppliers. Pedelecs riders vary considerably when it comes to expectations, needs and tastes.

Pedelecs: a political view
Municipal decision-makers see pedelecs as an opportunity for cities

Politicians and transport planners have taken notice of the pedelec as a potential solution for congested European cities. It's true that politicians prefer to be pictured in or with electric cars, but alongside the yet to be resolved technical and wider problems of these it remains the case that electric cars do nothing to solve parking and congestion problems. A survey of European politicians as part of the *GoPedelec* projects has shown that two-wheeled light electric vehicles – available commercially for several years already as high quality, reliable products – are receiving increased recognition, but also that their full potential is not yet acknowledged.

Ton Daggers & Dr. Walter Vogt

For the *GoPedelec*! Project almost 150 politicians, planners and other decision makers in six European countries were questioned about their approach to pedelecs as a mode of transport within their cities. The results show that the pedelec is seen as having high potential to solve urban transport problems. Over 80 % of those asked in Germany, the Czech Republic and the Netherlands are convinced that (electric) cycling can contribute to reduction fo traffic jams in their cities. In Hungary two out of three politicians see this potential in pedelecs, and in Italy, somewhat over half hold this view.

Pedelecs: the image factor

Politicians and transport planners aren't only aware of the practical advantages of two-wheelers; they also see the image advantages which being a "cycle friendly" city entails. 80 % or those asked from Austria, Germany, the Netherlands and the Czech Republic agreed with the statement that encouraging cycling leads to an improved image for a city. Town planners increasingly realise that pedelecs can contribute to a positive external perception. At the same time the majority of those questioned believe that promotion of pedelecs will also have positive effects for conventional cycling. More bicycle and pedelec riders will in an ideal world lead to improved infrastructure for cycle traffic overall through cycle routes and parking facilities, which will in turn encourage more people to transfer to two wheels.

On the other hand, there is a loud demand from various parties to separate the pedelec from the bicycle. They quote the presumption of higher accident rates because of the higher average speed of electric bikes, although this is not as yet backed up by any robust figures. It will be necessary to watch developments carefully, especially in the context of the associated calls for universal mandatory helmet wearing and insurance.

Do decision makers really know what they are talking about?

The most often stated argument for supporting pedelecs in town traffic is that electric bikes help to make hilly areas accessible to cycling. Even in the Netherlands, famous for being flat, the greater comfort (making headway without sweating) is a decisive factor which many frequent electric bike users place as their top priority.

Another advantage, that with the battery's energy longer distances can be covered, is however not recognised by the majority of politicians and planners questioned. This is surprising in that the increased range is promoted as one of the strongest sales arguments by many pro-pedelec schemes.

The results of this study show that the politicians and decision makers questioned do basically recognise the potential of the pedelec for modern transport planning. The technical opportunities and more profound arguments are still however generally not well understood.

This can in part be put down to lack of experience, because an average of 35 % of those questioned had still never ridden a pedelec, although this varied from country to country. In Germany, the Netherlands and Austria over 80 % of those questioned had already tried an electric bike. In other countries it was on average 50 to 60 %, and in Hungary just 25 %. A similar difference exists in the numbers of pedelecs appearing on the streets.

Over 80 % of those questioned in Germany, the Czech Republic and the Netherlands are convinced that (electric) cycling can contribute to traffic jam reduction in their towns.

More cycle and pedelec riders will lead in an ideal world to improved infrastructure for cycle traffic.

The advantage of being able to cover greater distances with the help of the battery was not recognised by the majority of the politicians and town planners questioned.

To fill the knowledge gap and to bring the full potential of pedelecs into the consciousness of town planners and politicians, further facts and figures are needed for this audience, so that they can embed electric bikes in their planning.

Measures to promote more awareness must go hand in hand with more information.

DIFFERENCES: WESTERN AND EASTERN EUROPE

The *GoPedelec*! Survey shows considerable differences in the assessment of the potential for the use of pedelecs in western and eastern Europe. This can in part be explained by the different strengths of the prevailing cycling cultures. Thus the bicycle is more valued by society as a mode of transport in Germany or the Netherlands than in Italy. A further explanation comes from the relatively high price of pedelecs compared to the lower average income in the eastern European countries.
Despite regional differences all those questioned still anticipated a great future for the pedelec in Europe. Around two thirds expect a growing number of pedelecs in their town, and around 15 % a considerably growing number.

Despite regional differences all those questioned see a great future for the pedelec in Europe.

POTENTIAL PEDELEC TARGET GROUPS

From the perspective of municipal decision makers older people are the main target audience for pedelecs, because the motor will make cycling easier or even just possible again. The electric bike offers them the opportunity to stay mobile for longer, with associated positive effects for wider society in terms of social participation for this growing sector of the European population.

As a consequence of the under-appreciation by decision makers of the advantages of an increased range, they overlook the options of offering pedelecs to younger people. However those questioned were unanimous that pedelecs and bicycles could contribute to freeing up congested streets.

At the same time they concede no great potential for pedelecs in commuting traffic. This represents a missed opportunity to recognise and target communications at a significant target group. Equally underestimated is the significance of electric-assisted cargo bikes. Town planners and politicians still don't see these as an appropriate logistics alternative. Measures to promote more awareness must go hand in hand with more information.

Grass roots measures such as public hire and charging systems, theft and vandalism protected parking facilities and the "eco bonus" when using or buying a pedelec were positively rated by all those questioned.

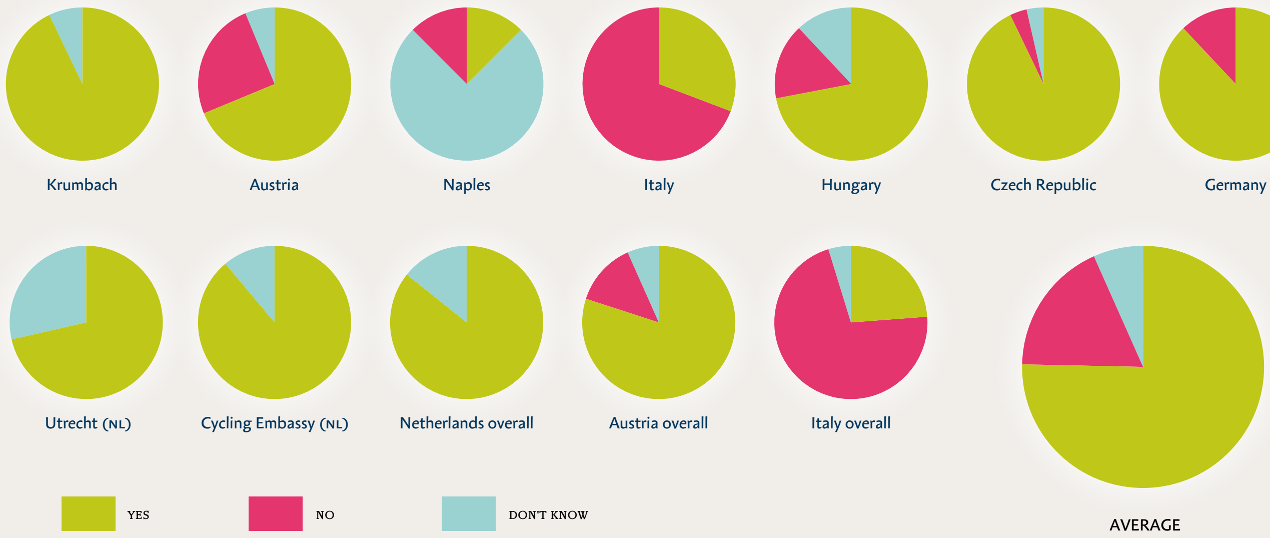
RESULTS IN SUMMARY

Communal decision makers see in pedelecs an instrument with which to reduce traffic jams. In many cases politicians and decision makers for transport in Europe are ready to engage in encouraging pedelecs, especially as the term "bicycle friendly" is basically seen as a positive image for a town, whether electric or not.

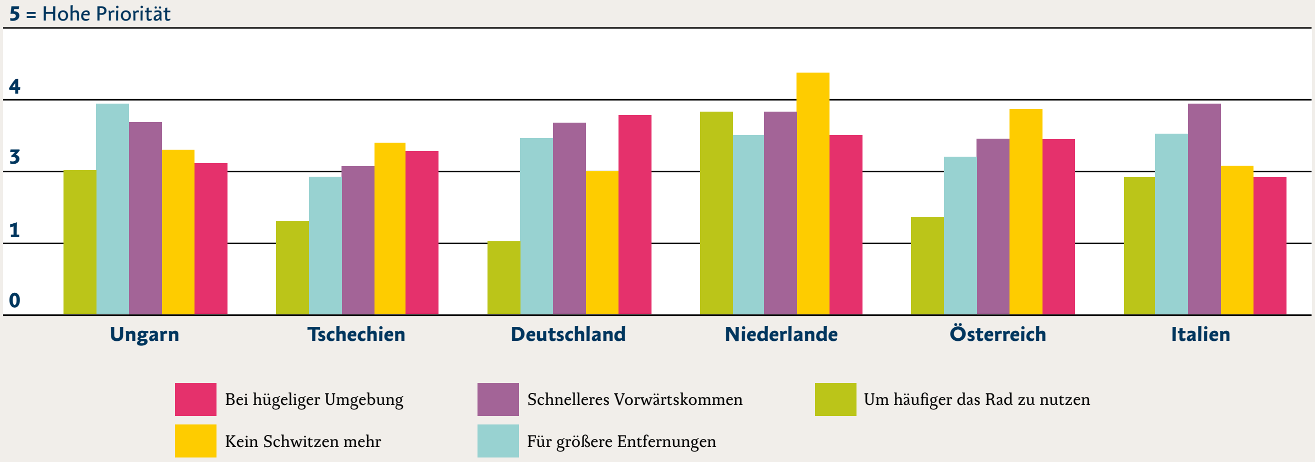
The 'elderly' target group is well known; the 'younger' target group and with them commuter traffic, are being overlooked, particularly because the point about higher range is (except in the Netherlands) underestimated in importance. In holidays and resort regions the significance of pedelecs is already apparent, although still with growth potential. Also underestimated is the potential of electric-assisted cargo bikes.

Although those questioned see a great potential for the pedelec as a mode of transport, they are not fully conscious of the regulatory consequences and the longer-term future prospects for pedelecs in transport politics. So there is a need for further targeted explanation and information to further improve the image of pedelecs and hence to promote them.

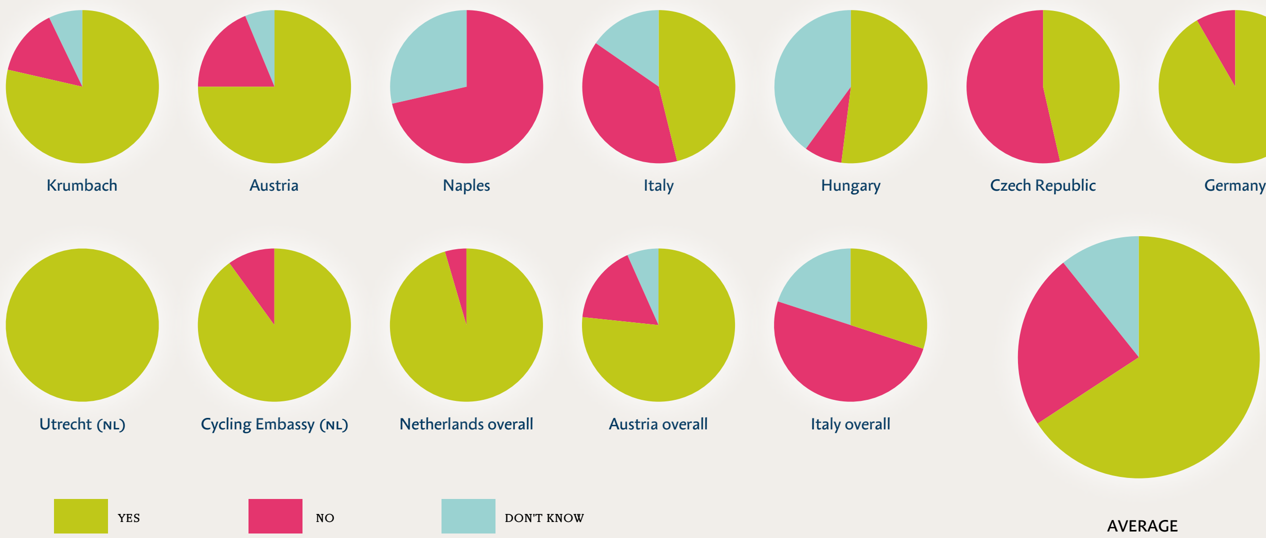
DOES PROMOTION OF PEDELECS ENHANCE A CITY'S MARKETING, OR IMPROVE ITS IMAGE?



IN WHICH WAYS CAN PEDELECS BE OF BENEFIT IN EVERYDAY TRANSPORT?



ARE THERE PEDELECS IN YOUR AREA?



GoPedelec dealer courses
Expert training and MDM workshops

EXPERT TRAINING
BECOME AN EXPERT ON PEDELECS AND E-BIKES

Dealers, members of the media and other interested parties are warmly invited to become Light Electric Vehicle (LEV) experts.

EXPERT COURSES ACTIVITIES

The courses run over two days. On the first day of the course brand-neutral information on the pedelec and e-bike market, technology, laws and trends will be taught.

On the course's second day drive manufacturers will be providing the information. This day will include both a theoretical and a practical part. In the theoretical section trainers from the drive and component sectors will present their technologies and services. In the practical part products and materials will be shown laid out on a tabletop, so that individual questions can be answered and practical tasks completed.

MDM WORKSHOPS
PEDELEC INFRASTRUCTURE FOR YOUR REGION

MDM (Municipal Decision Maker Workshops) inform responsible community postholders about the opportunities of implementing sustainable and climate-friendly mobility right on their doorstep.

Target audience is municipal decision makers who are seeking support in creating a future-proof and at the same time affordable pedelec infrastructure.

MDM WORKSHOPS ACTIVITIES

MDM workshops are one day events:

- Pedelec test riding
- Basic pedelec information
- Infrastructure: hire systems, charging stations
- Best practice from other regions
- Questions and answers

EUROPE WIDE AND MULTILINGUAL

On site professional translation service ensures that the training/workshops can be held in the appropriate national language.

CONTACT

Germany and Europe: *hannes.neupert@extraenergy.org*
Austria: *office@energieautark.at*

You can find further full details about MDM workshops and expert courses at the project website: *www.gopedelec.eu*

Stuttgart pedelecs
Pedelecs as municipal transport

The City of Stuttgart has for some time been engaged with pedelecs. Not just because *ExtraEnergy* e. V. has been active here for some time, but also because this hilly town seems made for pedelecs. Now the town council has set up *"Stuttgart Pedelec"* to increase awareness of pedelecs amongst the employees and residents of the city.

IMPLEMENTATION

For *Stuttgart Pedelec* the city of Stuttgart developed its own strategy to implement and popularise electric mobility in the town centre. In Stuttgart many are aware of the pedelec, thanks in part to the pedelec races organised in 2007 as the 'Pedelec World Cup' which attracted many well known participants, including the Mayor Martin Schairer. This positive feedback now needs to be reinforced for the longer term.

Since 2009, the city administration has leased 20 pedelecs, and bedecked them with the official colours and logo of the city. These electric bikes are kept ready for use in the town hall and other council buildings. Also in the fleet are 25 electric scooters, provided in co-operation with the Baden-Württemberg regional energy supplier *EnBW*.

OBJECTIVES

Stuttgart Pedelec is directed especially at those employees of the City of Stuttgart who are often on the road, for example caretakers who each evening need to lock up at four different schools, or technicians who are always out and about carrying out maintenance. It also aims to enthuse these people for "a new type of cycling without the sweat", which for this city with height differences of 300m is most important. To date, all of the test riders have been highly satisfied.

Patrick Daude · patrick.daude@stuttgart.de · www.stuttgart.de

DO IT YOURSELF

- ✓ Pedelecs which can be tried out in real world use have the best chance of catching on
- ✓ Shorter trips around town are especially easy to manage
- ✓ Offers an alternative to a service van
- ✓ Free loan system open to all staff enables even the lower paid to share in the benefits of pedelecs
- ✓ Don't be frightened off by hills, simply overcome such obstacles with electric assist

The "Landrad" pedelec project
The pedelec as car replacement

The *Landbike* (*Landrad* in German) pedelec project was initiated in June 2008 by *Kairos gGmbh* in the Austrian region of Vorarlberg, and it started one year later. It is the largest fleet trial in Austria, and for it 500 pedelecs from *Matra* were sold at a subsidised rate. In return, the buyers were asked to report about their riding behaviour on a regular basis. The objective of the study was to see to what extent the electric bike could replace the car, and to estimate the market potential. Additional partners were the *Vorarlberger Regional Government Office*, 25 cycle dealers from the region and the *Energie-Institut Vorarlberg*.

IMPLEMENTATION

Between May and July 2009, 500 pedelecs were sold. The price of this special edition of the *Matra iStep Cross* was € 1,250 for individuals and € 1,250 plus VAT for companies/organisations. To obtain these discounted rates the buyer of these so-called "*Landbikes*" had to declare that they were prepared to make data available about their use of the pedelecs.

Data collection was carried out via online forms which could be returned by e-mail. In addition, GPS trackers were placed in selected pedelecs to provide detailed information about riding habits, range and speed. The results will also be used in the development of future projects.

RESULTS

One of the most important questions was whether and to what extent the pedelec would replace car journeys. The survey of the test riders revealed that the pedelec didn't just replace car journeys but also journeys on conventional bicycles. 52 % of all of the journeys completed by pedelec in the project were covered by conventional bike before the study, and 35% by car. So an estimated 230,000 car kilometres per year could be saved with the *Landbike*. In addition, one in five of the *Landbike* users reported that their mobility behaviour had fundamentally altered, in that they used the *Landbike* significantly more frequently than the car. This shows that it is possible to motivate people with a pedelec to leave their car behind, while this has very seldom been achieved with a conventional bike in the past. The Swiss project "*E-TOUR*" delivered similar results in 2004: electric bikes replaced 30% each of car journeys, cycle journeys and journeys on public transport.

The most frequently mentioned reasons given for the persuasive power of pedelecs were also the main reasons for the purchase of a *Landbike*: "Cycling without sweating", "Being mobile without damaging the environment" and "Driving my car less".

This project, carried out in collaboration with commercial suppliers, has proven that after an initial boost often no further support is necessary: the technology convinces people all by itself.

www.landrad.at & www.kairos.or.at

DO IT YOURSELF

- ✓ The positive environmental effect and savings through reduction in car journeys are convincing arguments.
- ✓ Partnerships between private suppliers and the public sector can target quick results. One initiated, pedelecs spread by themselves.
- ✓ Support measures should concentrate on weak cycling regions and target a transfer from car to pedelec.
- ✗ There is no need for a charging infrastructure to start a pedelec project: pedelecs can be recharged at any power socket and range is usually high enough anyway.

Motorways for cyclists
Bicycle expressways for pedelecs

A network of new bicycle expressways is now being created in the Netherlands, aimed particularly at convincing commuters who travel less than 15 km to switch from the car to a bicycle or pedelec.

Bicycle expressways sound like a cyclist's dream: no junctions or traffic lights, smooth asphalt, 4 m wide lanes, plus wind barriers on bridges and even roofing on particularly exposed stretches. And the planned infrastructure for 'bicycle motorways' also foresees charging stations for electric bikes and mobile repair services.

The routes lead from suburbs to the town centres. In total 16 such highways are planned, with a budget of € 21,000,000, financed through the Netherlands Ministry for Infrastructure. A further € 60,000,000 will be contributed by the regions and communities involved.

KEY CRITERIA FOR BICYCLE EXPRESSWAYS

- Fast: zero or short waiting times at junctions or lights
- Comfortable: smooth asphalt and lighting
- Attractive: routes pass though the countryside
- Integrated: routes are linked into personal public transport systems

TARGET GROUPS

Fundamentally the bicycle highways are ratcheting up competition with the car. Target groups might be commuters with journeys of under 15 km, teachers and students, workers or simply cyclists.

Pedelec riders are the most obvious target audience, because they are often previously car drivers for whom only an electric bike, not a conventional one, is seen as worth considering. Furthermore, the bicycle expressways might have been purpose made for the higher average speed of pedelecs and fast pedelecs.

(SOCIAL) BENEFITS OF BICYCLE EXPRESSWAYS

A study by *Goudappel Coffeng* shows that bicycle expressways can benefit mobility, the economy, health and the climate.

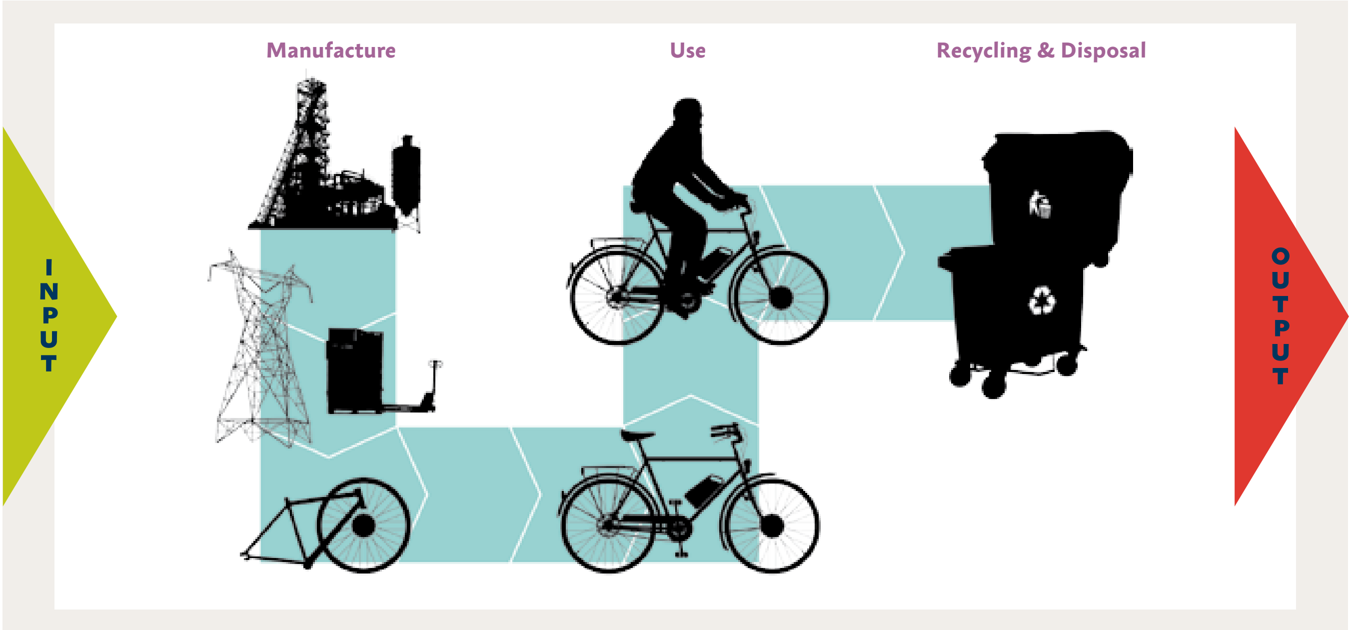
- Fast cycle routes lead to fewer car journeys and so can save up to 80,000,000 kg of CO_2 emissions
- Cycling is healthy. Bicycle expressways could save the health system € 100,000,000 in costs
- 15,000 hours of travel time per day could be saved by faster cycling, worth € 40,000,000 per year
- Car journeys could be reduced by 1% and cycling increased by 1.5 % with bicycle expressways

www.fietsfilevrij.nl

DO IT YOURSELF

- ✓ Improve existing cycle routes with asphalt
- ✓ Build new cycle routes while e.g. constructing or dismantling roads
- ✓ Widen existing paths
- ✓ Provide cyclists priority at junctions
- ✓ Provide junction designs safe for cyclists
- ✓ Provide safe and plentiful parking
- ✗ Do not invest in road building for cars: look to the future.

ACCOUNTING FOR INPUTS AND OUTPUTS OVER THE ENTIRE LIFE CYCLE OF A PEDELEC (CRADLE TO GRAVE)



The energy self sufficient pedelec
Or: what is really ecologically sustainable?

The term "sustainability" comes originally from the forestry sector, but its use has since snowballed, and it has also altered in many aspects of what it means. In contrast to the increasingly popular meaning of "sustainable", the concept of "energy self-sufficiency" has in recent years increased in appeal and acceptance. Pedelecs can be an important building block for mobility in individual or communal self-sufficiency concepts. But please note that sustainable energy is basically just renewable energy, and on this aspect too it's worth taking a closer look.

Thomas Lewis

Sustainable energy is fundamentally only renewable energy.

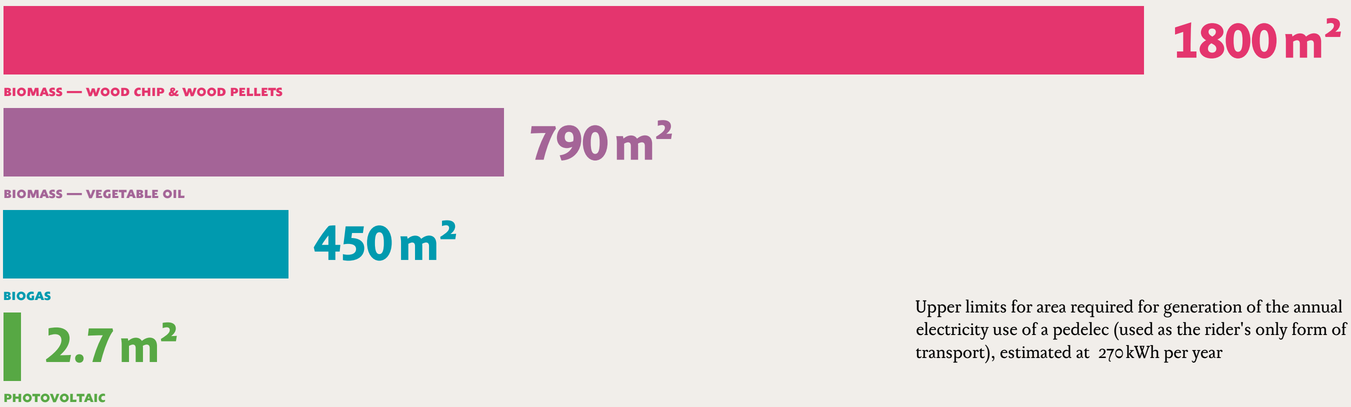
The 'creeping softening' of the term sustainability, which should in itself be easy to understand intuitively, was described wonderfully by the late leading German politician and energy expert Hermann Scheer. Wherever you see the words "sustainability" or "sustainable" bandied about in any "Sustainability Report" from a company or institution, you should consider very carefully what they are actually saying.

Is there a need for a scientific definition? Doesn't everyone have their own idea of what sustainable means anyway? Activities are sustainable when they can be carried out over (in human terms) very long timescales, without limiting resources for following generations. So in the energy sector 'sustainable' fundamentally means renewable energy, and then only in those forms where its production can actually be sustained over the long term. This is not the case, and has not been in the past, for many types of current biofuel production methods.

IS WIDER USE OF PEDELECS A CONTRIBUTION TO SUSTAINABILITY?

The question of sustainable energy production is neither unique to pedelecs nor to the transport sector: it is a fundamental problem. Hermann Scheer described the so-called "Energy transition", in other words the changeover to supply fully from renewable energy (100%), as potentially the greatest human cultural achievement since the industrial revolution. There are numerous technical options to make useful energy available from renewable sources, depending on local availability. With the exception of geothermal, all renewable energy can be traced directly or indirectly to the energy from the sun. So in future the problem of providing renewable energy is on one hand a technical problem (how efficient can solar energy, or its indirect forms such as wind, wave or biomass, become in providing useful energy with minimal losses) and on the other a question of area (how much area do we need to fulfil the necessary demand for energy via solar energy).

AREA REQUIRED FOR POWER GENERATION



Upper limits for area required for generation of the annual electricity use of a pedelec (used as the rider's only form of transport), estimated at 270 kWh per year

Whichever form of energy generation is chosen for renewable energy, it is clear that demand for energy must be dramatically reduced to make possible full supply from renewables.

It is just such a dramatic reduction in demand which pedelecs offer in comparison to internal combustion engines. If we examine a distance of 15,000 kilometres covered by one household by car per year, and further assume that 2,000 of them could be covered by a pedelec instead, this in approximate terms means a saving of at least 20 × 49 = 980 Kilowatt hours of end user energy per car per year.

The main reason for the positive outcome in favour of the pedelec, which also applies for a comparison of CO_2 emissions per kilometre against the car, is the trivial fact that the pedelec is essentially a bicycle which is only minimally motor assisted. Another contributory factor is that an electric motor has a considerably higher efficiency than an internal combustion engine.

EVEN MINIMAL ENERGY USE NEEDS A SUSTAINABLE SOURCE

A pedelec needs only minimal amounts of energy, but to be truly sustainable on the move it's necessary to ensure that this comes from sustainable, that is renewable, sources. The simplest way is to sign up with a supplier who provides exclusively electricity from renewable sources. But this only has the desired effect when the pedelec is only ever charged at locations where such an electricity supply contract applies, for example in a private house or at your employer's company premises.

Pedelecs could drive a drastic reduction in energy use, necessary for the transition to renewable energy

Care should also be taken to distinguish carefully between so-called "Eco electricity suppliers". Does the company really supply all of its customers with 100% 'eco' energy, or are distinctions made, for example between industrial customers who are shunted onto fossil fuel energy supplies, and private customers who are sold the renewable electricity?

One should select an electricity supplier who provides nothing but eco electricity and who sells this to all of their customers. In Austria there is a useful website from the national regulator at *www.e-control.at* which publishes the electricity mix of approved electricity suppliers in Austria. No such overview is known in Germany, but most supply companies do publish their mix on their websites, as publication is required according to an EU Directive[1].

The main reason for the positive environmental economics of pedelecs is the trivial fact that they are basically bicycles which are only minimally motor assisted.

HOW *ECO* IS ECO ELECTRICITY?

But is 'eco electricity; always really electricity from renewable energy? Basically it cannot currently be guaranteed at every instant that the power you are using comes exclusively from renewable energy, given today's connection systems and current production and storage capacities. For pure 'eco electricity' it must be guaranteed and certified that the amount of electricity delivered over the course of a year as 'eco electrici-

If all electricty customers switched to eco electricity no more electricity derived from fossil fuels would be sold.

ty' must matched in quantity by the amount of energy generated by facilities which convert renewable energy to electricity. This requirement is strictly monitored at frequent intervals by approved certification companies such as TÜV, *Bureau Veritas* and others. This involves for example comparing the dealer's purchase contracts with sales contracts, and production facilities are also monitored.

In other words – if all electricity customers switched to eco electricity, no more electricity derived from fossil fuel sources would be sold.

ANNUAL ENERGY CONSUMPTION OF A PEDELEC

Real test rides, carried out annually by *ExtraEnergy*, have shown that an typical pedelec uses an average of 1 kWh per 100 km in electricity. To put that in context, in an electric kettle you need around one tenth of a kWh to bring one litre of water to the boil. Or a 100W light bulb left on for 10 hours would need 1 kWh of electricity.

On average a pedelec can ride 100 km on 1 kWh. An (economic) car needs 50 kWh for the same distance.

A car with internal combustion engine in contrast today requires around 5 l of fuel per 100 km, for a very economic model. 1 l of fuel contains around 10 kWh of energy, so it uses at least 50 kWh per 100 km.

DO PEDELECS REALLY LEAD TO FEWER CAR KILOMETRES?

On this question a number of field studies have already been conducted, for example in Switzerland[2] and in Austria[3]. Overall these studies have shown that between around 20% and 50% of all journeys conducted by pedelec were made instead of car journeys. In absolute numbers terms, in Switzerland and in the larger of the two Austrian studies it turned out to be around 800 km which was covered by the pedelec per year. It should be added that journeys carried out by conventional cycling and – to a lesser extent – journeys on public transport were also displaced by pedelec riding.

Having a pedelec in a household replaces 20 to 50% of journeys which were previously carried out by car.

So the potential savings from pedelecs are huge, not just because of their own low emissions, but because of their positive repercussions.

TO BE COMMENDED: EFFORTS TO LINK USE OF PEDELECS TO THE USE OF ELECTRICITY FROM RENEWABLE ENERGY

In Austria (as of 2011), a national subsidy for the purchase of company pedelecs was approved, so long as the company used only verifiably eco electricity.

In the Czech Republic, a collaboration between pedelec dealer *ekolo* and eco electricity dealer *Nano* operated until the end of 2011. When buying a pedelec from *ekolo* and an electricity supply contract from *Nano*, *Nano* provided the customer with a credit to the value of the cost (19.59€ or 500 CZK) of the average annual electricity use for a pedelec (over 10,000 km).

The Austrian retailer *Elektrobiker* declares on its website that only eco electricity is used.

How long someone who has been persuaded by a subsidy or a credit note to take eco electricity also stays with it is an open question. Electricity supply contracts can normally be changed after a year at most.

1 European Commission [2003]
2 BUWAL Bundesamt für Umwelt, Wald und Landschaft [2004]
3 Kairos [2010], Drage and Pressl

KEY PEDELEC DATA ON ENERGY AND SUSTAINABILITY

Max. continuous rating of the electric motor in Watts	250
Energy use in Watt hours per kilometre from *ExtraEnergy Test 2011*	10.31
Energy use in Kilowatt hours per 100 kilometres from *ExtraEnergy Test 2011*	1.03
Average battery pack capacity in Watt hours	332.29
Average range in kilometers per battery charge	36.30
CO_2 emissions in kilograms per Kilowatt hour Electricity from a hydro-power intensive country (Austria)	0.27
CO_2 emissions in kilograms per Kilowatt hour Electricity from a fossil fuel dominiated country (Greece)	0.84
CO_2 emissions in kilograms per Kilowatt hour Food for rider, average Austrian diet	1.01
Upper limits for area required in square metres to generate annual pedelec electricity use (as an only means of transport)	
Assumed electricity use in kWh/year	270
Photovoltaics	2.7
Biogas	450
Biomass (electricity from vegetable oil)	790
Biomass (electricity from woodchip)	1800

SOURCE Lewis et al. [2011].

SOURCES

- BUWAL **Bundesamt für Umwelt, Wald und Landschaft**. *Elektro-Zweiräder, Auswirkungen auf das Mobilitätsverhalten*, Umwelt-Materialien Nr. 173, Luft, 2004.
- **Thomas Drage & Robert Pressl**. *Pedelec-test (in Andritz) in the context of European Union project Active Access*. Downloadable at *www.active-access.eu*
- **European Commission.** Directive 2003/54/EG of the European Parliament and Council of 26. Juni 2003 concerning general provisions for the internal electricity market & for annullment of Directive 96/92/EG. 2003.
- **Kairos.** *Landrad, Neue Mobilität für den Alltagsverkehr in Vorarlberg (Endbericht)*. 2010, A report on a project in which 500 pedelecs were tested and users surveyed.
- **Thomas Lewis, Christiane Edegger & Ernst Schriefl**. *Pedelecs und Renewable Energy*, 2011. Downloadable at *www.gopedelec.eu*
- **Hermann Scheer**. *Energieautonomie – Eine neue Politik für-erneuerbare Energien.* Kunstmann, 2005.
- **Hermann Scheer & Carl Amery.** *Klimawechsel – Von der fossilen zur solaren Kultur*. Kunstmann, 2001.

Health – as a side-effect
The pedelec as an everyday fitness aid

Technological progress has in industrialised societies led to a decline in exercise. The consequences are muscular degeneration and an increase in 'civilisation diseases' such as cardiovascular diseases and diabetes. This goes alongside groundbreaking advances in medicine, but the best medicine is still prevention through exercise. But thankfully nobody can be compelled to exercise – or can they? Pedelecs offer a new, gentle way to keep healthy, one which is simple, fun, and which benefits the whole body.

Harry F. Neumann

Civilisation diseases result in considerable costs when it comes to public health. The challenge for prevention is to be effective before illnesses appear and lead on to numerous complications.

Forms of endurance exercise can have especially good and sustained effects. 30 to 45 minutes exercise three times a week shows fitness results which when complemented by exercises to strengthen the stomach, back and seat musculature represent the ideal programme for health protection. This means that a relatively modest outlay in time is sufficient to make life-changing improvements to your internal systems. Regularity is the key! Often, sadly, this is lacking.

Whether it is the inner slob, high barriers to entry such as poor fitness, the effort or a stressful life, there are plenty of excuses not to take exercise. For that reason preventative measures are needed which can be easily integrated with everyday life to guarantee high commitment levels. Further, they must make possible optimal control of the effort according to individual requirements. For this, pedelecs open up a whole new dimension.

EXERCISE EASILY EVERY DAY

With the pedelec, there are neither barriers to entry nor any problem with accessibility, because (almost) everyone can cycle, so pedelecs are no problem.

Electric bikes have all of the advantages of a bike and also open up additional superior opportunities for the integration of regular exercise into everyday life, and for motivation to take (more) exercise. Be it the ride to work, for shopping or for leisure – journeys which appear to be too long or too difficult by bike are achievable by pedelec.

With the motor assist helping, hills which would otherwise be an obstacle can be surmounted. The motor supports your own drive power and creates an easier and thus more pleasant experience, from which returnees to cycling, older riders and the overweight will profit in particular.

People with differing performance capacities can also ride together. Instead of spinning away alone in a studio you can glide together through the countryside. The experiential value of completing a ride, the opportunities for pauses and relaxation, all lead to better training effects and qualify pedelecs as aids to health. Pedelecs make it easier and more stimulating to stay fit – or to get fit.

INDIVIDUAL EXERTION CONTROL

While the majority of other measures in cardiovascular and metabolic prevention can only be applied and controlled in very limited circumstances, pedelecs enable adjustment across the whole spectrum of exertion from very low to very high power levels. To provide adequate regulation of the loading and for safety in training, the motor can simply add on appropriate power.

Contributing to this is the fact that on a pedelec all of the significant measures of power or work, and of exertion such as heart rate, blood pressure, energy use etc. can all be measured directly on the bike and rider.

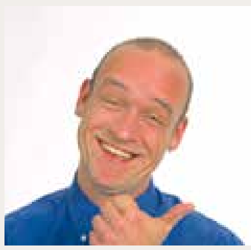
This good availability of measured values and the application of the motor permit precise control of exertion, as they might on an 'unplugged' stationary ergometer. The effects and the effectiveness can be preset before every ride, as if on a mobile ergometer.


Monday = bicycle

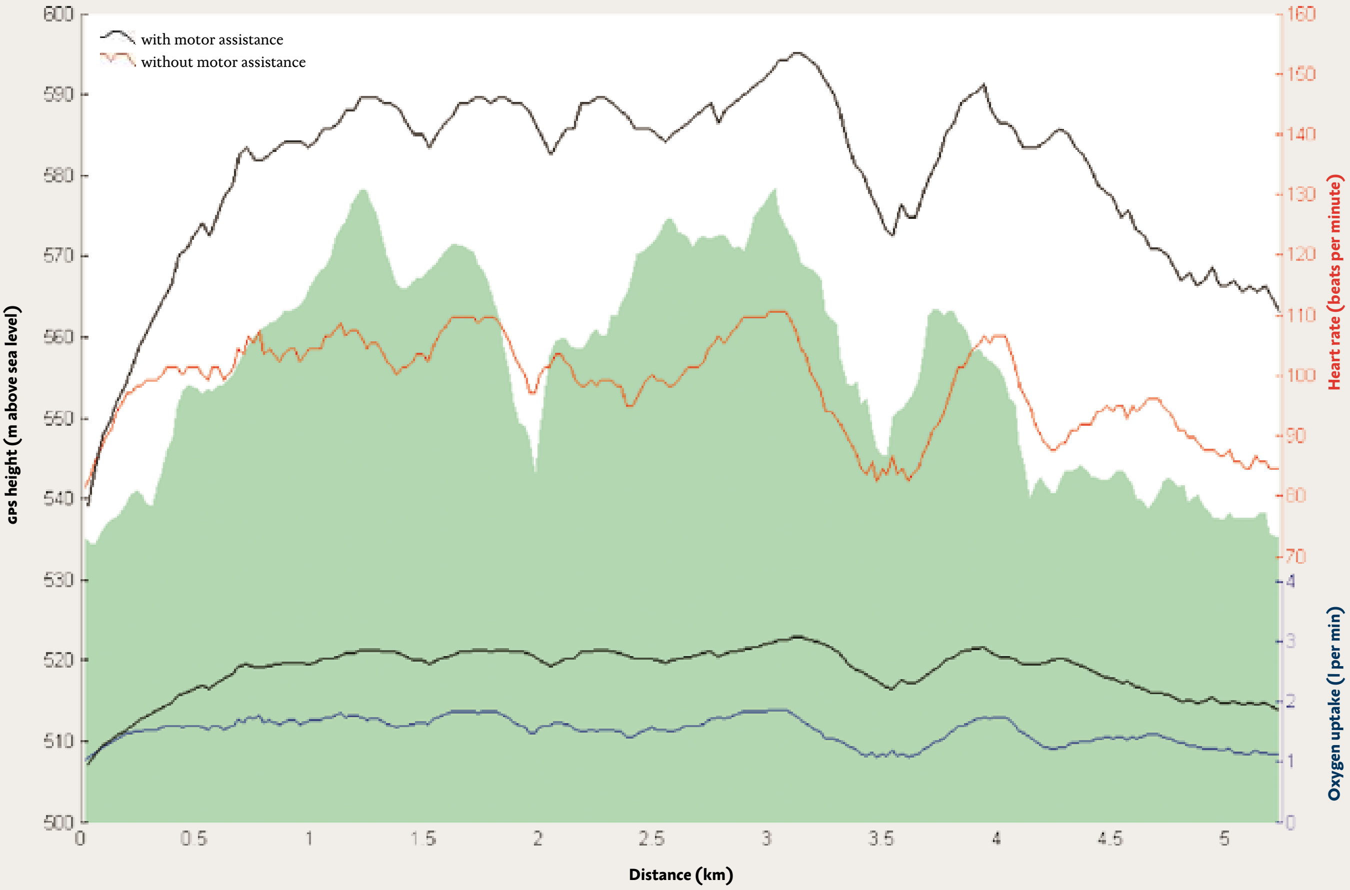

Tuesday = bicycle


Wednesday = bicycle


Thursday = bicycle


Friday = Pedelec

Sport on the way to work hasn't caught on: the pedelec offers the opportunity to integrate exercise into everyday life.



Pedelec riders with and without motor assist

Automatic adjustment to control exertion is to date still a futuristic concept, because it would require a motor controlled, for example, by heart rate. Signals from sensors on bike and rider would be processed together, and appropriate motor power directed to the drive system.

In comparison to a conventional bike, the mechanical performance of the rider can already be measured on a pedelec. This is important for objective evaluation, because the ride speed is just one element in ride performance or the energy use of the rider. Values for load and exertion could be used for purposeful control and regulation of loads.

Every rider could test their own fitness level for themselves, and adjust the load to dynamically reflect their personal requirements.

For those funding prevention and rehabilitation, pedelecs offer the opportunity to diagnose the regularity, effects and effectiveness of measures. This availability of data without further tests will lead to a new dimension in prevention and rehabilitation.

ADVANTAGES OF PEDELECS VS OTHER EXERCISE

- Accessibility
- No barriers to entry — instant mobility even for returnees to cycling, the old and the overweight
- Integration into everyday life — means to an end
- Increased riding range
- Simple pedalling exercise technique
- No high peak forces when setting off from a standstill or accelerating
- Superior individual control of exertion levels and so matching your physical system.
- Ride together despite different individual abilities
- Simple to document rides, and to do long term analysis
- Value of the outdoor experience
- Trend towards environmentally friendly transport

Let's go solar!
Young people discover the pedelec

Teenagers change their mobility habits rapidly as they grow up. At 16 they swap from the bicycle to the moped, and at 18 they get their driving license. The "*Let's go solar*" project at the Dornbirn Youth Centre in Vorarlberg (AT) brings young people into contact with alternative modes of transport in a practical way. The aim of this free of charge hire service is to make young people more aware and to attempt to direct their mobility habits towards more environmentally friendly modes.

IMPLEMENTATION

The project began in early 2009, and in June 2009 three pedelecs of the "*Landbike*" brand were purchased for € 1,500 each, because the '*Landbike*' has a good reputation. Additionally two cheap Chinese electric bikes branded *Swifi 140* were bought. These however quickly proved to be of low quality and in a short time they had broken down.

Initially the pedelecs were used by the Youth Centre staff in their visits to young people in the town. Over time the pedelecs were also tried out by the young people who were being visited by the Youth Centre. They now have the opportunity to borrow the bikes on a daily basis. Alongside the pedelecs, electric scooters and *Segways* are also loaned out.

The project has mainly been implemented within the Dornbirn Youth Centre, although it has also been regularly promoted at public events, so that additional young people can contact adults with similar interests.

COSTS

Costs for the project came to around € 7,000. Of this, € 4,500 was for the three pedelecs and the rest for staff salaries and public events. Costs were carried by the Youth Centre, which in turn is subsidised by the town, the province, the EU (Interreg IV), the Employment Service (AMS), the *Hit-Stiftung* and the *Rotary Club*. Ongoing costs, consisting of personnel and repair costs, are around € 800 per month.

RESULTS

The project is seen as very successful, because it has inspired the young people visited by the Dornbirn Youth Centre to rethink their attitudes to mobility in a practical and playful way. They are now more open to the idea of new e-mobile forms of transport, and in addition they now display more spirited and independent mobility habits day to day.
This change in attitude should be retained indefinitely by the young people and the project should in future also reach even more people.

The success of the project was to a considerable degree down to the choice of the "right language" to inspire and motivate the young people, so it is essential to bring on board suitably qualified staff.

Dr. Martin Hagen · martin.hagen@ojad.at

DO IT YOURSELF

- ✓ Before purchasing, carry out detailed research on the various products, as price and quality vary considerably.
- ✓ To motivate young people organise outings on pedelecs.
- ✓ Put the focus on the fun factor.
- ✓ Prevent the onset of boredom by offering a variety of electric vehicles.
- ✓ Organise races and obstacle courses.
- ✗ Cheap products aren't worth it longer term.
- ✗ Dry lectures don't convince; playful real world experience does.

LeaseRad

The company bike as motivation

LeaseRad GmbH was founded in 2008 by Ulrich Prediger in the *GreenCity* of Freiburg. This sustainable mobility service provider hires out bicycles, pedelecs and e-bikes. The focus is on service cycles for company and municipal mobility.

ENVIRONMENTAL ADVANTAGES

- Actively contributes to environmental protection and transport improvements
- Supports a positive, sustainable and innovative image for employers

HEALTH ADVANTAGES

- Actively contributes to employee health

ADVANTAGES FOR EMPLOYEES

- Get the latest pedelec every 2 to 3 years without any personal capital expenditure
- Pay for the lease installments out of gross salary
- Advantageous tax setup makes it much cheaper than buying

ADVANTAGES FOR EMPLOYERS

- High motivation factor with no additional costs.

www.leaserad.de

DO IT YOURSELF

- ✓ Organise company pedelec try-out events
- ✓ Within the company, inform staff about the benefits of pedelecs
- ✓ For employees: discuss motivational leasing with the HR Department
- ✓ For employers: make employees aware of the attractive pedelec motivational leasing scheme.

Savings with JobRad — LEASERAD

Selling Price E-Bike		1.799,00 €
distance to work		2
	without cash-remuneration	with cash-remuneratio
Gross Salary	3.000,00 €	3.000,00 €
leasing rate as cash-remuneration conversion (36 m., 10% resid. val., 0% down-payment)		-46,73 €
E-Bike insurance-rate as cash-remuneration conversion		-9,90 €
Employers contribution at leasing rate		0,00 €
added non-cash benefit for taxes		18,02 €
Basis for calculation for taxes and social security contribution	3.000,00 €	2.981,39 €
Taxes	470,75 €	460,25 €
Social security contribution	614,25 €	606,34 €
Net pay	1.915,00 €	1.876,78 €
Net pay für employee		38,22 €
Compared to Purchase		
Buying price / down-payment	1.799,00 €	179,90 €
Total cost incl. Insurance for 36 months	2.579,00 €	1.555,82 €
Savings compared to purchase		40%
Total savings for employer and employee in %		47%

Income tax 2012. No responsibility is taken for the correctness of this information. © LeaseRad GmbH 2012

Transportation safety
through legally required battery testing to UN38.3

Battery safety is usually taken as a given. But because practical experience has proven otherwise, the *United Nations* have dealt with the issue appropriately, and set out mandatory rules for their area of responsibility, which is transportation. These rules are the legally required minimum standards required of batteries for safety in transport.

Hannes Neupert

The test procedure for verification of transportation safety according to *UN 38.3* describes the tests which must be successfully passed by battery packs before they can be supplied by the battery pack manufacturer. However compliance with this requirement is in reality not monitored, which means that many manufacturers do not carry out these tests or they supply test reports which originate from similar battery packs. So it is to be recommended that only test reports which contain a detailed description of the battery type be accepted. To unambiguously identify the battery pack, the test report should as a minimum include the following details: type designation, dimensions, weight, photos from each side, illustration of the specification plate.

It is also wise to check carefully what is in the test report – batteries have been supplied with a negative test report, without anyone spotting it. Naturally only batteries which have fulfilled all of the criteria can be sold. In many cases too pre-production samples were used, which may well have changed before full production.
It can also be the case that while some batteries were tested with positive results, the batteries which are actually delivered do not meet the *United Nations* requirements. Furthermore, battery risks which occur in use are not covered by the *UN-T 38.3* test. So it is quite possible that a battery which tested successfully to *UN 38.3* bursts into flames when charged or in a crash! A voluntary test to address this is the *BATSO* Test, which over and above *UN 38.3* also tests for safety in use and under foreseeable misuse.

The *BATSO* Test includes testing all usage and misuse situations foreseeable in actual operation, for example charging and discharging under vibration, mechanical damage to the housing, external short circuit, overcharging etc. The complete test manual is available as a free download at *www.batso.org*. The *BATSO* test mark offers users the highest possible confidence that the battery pack has first been tested to the minimum legal requirements (*UN 38.3*) and second that it represents state of the art technology when it comes to safety in use.

The *BATSO* test mark indicates to end users, dealers and service personnel that the battery safety has been tested by an authorized laboratory according to *BATSO* 01, and that the production process is monitored. The ID number on the *BATSO* test mark makes it possible to check the validity of the certificate online, and to display pictures and technical data for the battery pack tested for comparison with the battery pack you actually have. A *BATSO* test with certification by an independent testing organization is no one-off affair. Rather, it includes regular inspection of the production facility, and randomised separate *BATSO* tests are repeated on production packs to check batch consistency.

Longer term it could well be that *BATSO* will also help ensure compliance in the dispatch process. Today, when sending for example a Nickel Metal Hydride (Ni-Mh) battery, there is no legislation which applies – even though the safest lithium batteries are safer than the most dangerous Ni-Mh battery packs. The aim of *BATSO* is for verifiable safety to lead to easier transportation, until the mandatory classification as Hazardous Goods Class 9 is no longer necessary.

Only in this way can the current discriminatory situation when compared to Ni-Mh be resolved.

There is a UN code on every approved transportation container for hazardous goods: decoding these is one of the things you learn in mandatory Hazardous Goods training. Here is the decoding for the data on the box pictured: UN 4G / Y20 / S / 08 / CN / 320204.

UN = United Nations; 4 = Box, or the type of packaging; G= Cardboard, so the packaging material; Y= Packaging Group II for hazardous goods; 20= proof pressure in Kilopascals; S= Solid, applies to the properties of the goods to be transported – in this case solids; 08= year of manufacture; CN=Country code, in this case China; 320204 = code for the approval authority and approval certificate number; PI:012= manufacturer code.

Good legislation is the basis *for the success of the pedelec!*

Whether legislation can have a decisive effect on the success, or lack of success, of new developments, is often questioned. But from examples in Japan, Germany, China and Europe it is clear to see just how critical legislation can be for market development and for the implementation of any technology.

Hannes Neupert

JAPAN

In 1992 *Yamaha* persuaded the Japanese government that a bike with an electric assist system working in proportion to muscle power could retain its status as a bicycle. Since then there have been over 4.3 million pedelecs sold in Japan, and in 2012 alone 430,000 units. To date Japan has held fast to the rule that motor power must be applied only in proportion to muscle power. That means that pedelecs must be equipped with a precise torque sensor to measure pedalling effort.

The *Sanyo* electric bike, launched in 1989 in Japan. Because it was legally a motorbike despite its bicycle character, the user had to ride on the road and wear a motorbike helmet. These serious disadvantages were not acceptable to customers, and so there were very few buyers for this vehicle.

The *Yamaha PAS* pedelec, first sold in 1993 in Japan, was the first vehicle which, although it had a motorised assistance system, was legally classed as a bicycle because motor power was controlled so as to be proportional to muscle power.

EUROPE

At the end of the '80s there were rules in Austria which meant that an electric bike, like a horse and cart, could only be ridden with a suitable 10 km/h number plate. From 1990 the national German legislature enacted the 'light moped' legislation as a trial, by which an electric moped limited to 20 km/h could be ridden without a helmet. In 1995 the Japanese regulations were taken into German law, so that pedelecs were treated as bicycles so long as a power assist factor of 1 to 1 for human power and electric power was adhered to. Then as part of European harmonization at the start of the 2000s the EPAC (the European term for *Electric Power Assisted Cycle*) regulations were created with the aim of bringing regulatory clarity across Europe. As part of this, the Japanese rules were taken out of application.

So it is now only mandated by the regulations that the electric assist may only work while the rider is pedalling – but it doesn't say how hard. This has resulted in electric scooters being sold as pedelecs with tiny stumpy pedals which you just have to move every so often to prevent the electric motor cutting out.

Normal for China: electric bikes which are really more like electric scooters. Unfortunately a trend seen also in Europe, especially southern Italy - this trend can only be stopped if for pedelecs 25 the electric power is permitted only to be exerted in proportion to muscle power, as is legally required in Japan.

CHINA

In China electric two wheelers have become a dominant mode of transport in many metropolitan areas as well as in the countryside. In 2011, 33 million electric two wheelers were sold in China. These were almost entirely electric scooters, which are treated legally as electric bikes thanks to the presence of pedals when tested. Experts estimate that there are 200 million electric two-wheelers on the road in China. Around the end of the '90s the government enforced this huge success in electric mobility through financial incentives: internal combustion engined two wheelers were suddenly hit with high taxes, with the result that these two-wheelers had disappeared from the streets of most cities within three years.

Many species in a forest of rules
What applies to which vehicle?

New vehicles throw up new questions. Who, where and with what one can ride is, with the proliferation of Light Electric Vehicles (LEVs) such as pedelecs 25 / 45 and e-bikes 20 / 25 / 45, ever harder to determine. Sometimes people think that pedelec 45s are illegal, that pedelecs 25s with push assist are banned from cycle paths, or that all cyclists must wear helmets. And it's not just in Germany that a tangle of national rules, requirements of the *Kraftfahrt-Bundesämter* (Federal Bureau of Motor Vehicles and Drivers), claims from interested parties and (supposedly) EU rules exist.

Nora Manthey

The 'electric bike' category is still at the start of its development, and yet to see the full unleashing of its potential. Ever improving battery technology and the growing number of suppliers on the market are leading to more, more powerful and faster electric two-wheelers. E-bikes, which today often still have pedals in addition to a throttle control, have developed further in the scooter direction. At the same time pedelecs, where the motor only operates when you pedal, will become ever more significant.

The categorization of new developments into the existing terminology of vehicle classification and road traffic regulations is not always obvious, because new paths in design, target groups and technology are being traveled. So clear distinctions for customers, industry and legislators are ever more important, but also ever more problematic.

CLASS AND SOCIETY

A decisive factor in which laws apply is the categorisation of the vehicles into one of the existing vehicles classes..

Pedelecs 25 are classed as bicycles within the EU. So, in Germany and in most EU countries, you must ride on signed cycle ways, may ride without a helmet, and share all of the other privileges of your unmotorised peers.

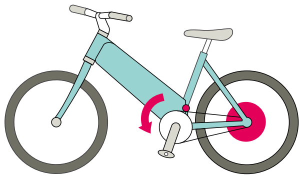
E-bikes 25/45 and pedelecs 45 are in a different category. They are treated as "Powered Vehicles of various types". E-bikes 25/45, among which e-scooters are also counted, can be ridden on electric motor power alone. The distinctions to be made between these so-called "self-driving" vehicles are made according to the speed which the motor alone can attain. If the motor supplies pure electric power up to 45 km/h, then all of the rules which are valid for small powered bikes (formerly mopeds) apply. In Germany, for e-bikes 25 you need a helmet, but no Class M driving license, which faster riders do need. Should the motor be limited to 20 km/h, then in Germany no helmet need be worn. The speed limits at which a helmet is needed, and what type of helmet must be worn, are not harmonised across the EU. Helmet laws also vary widely between countries. Child trailers may not be towed by any of these 'self driving' vehicles.

SELF DRIVING IS NOT SELF EXPLANATORY

Push assist on some pedelecs is a safety measure. At the push of a button the motor assists pushing the bike at up to 6 km/h. When walking uphill, or negotiating stairs or ramps in garages, push assist can help provide safe handling of the bike. But in Germany an argument has broken out about this push assist, showing that for these new vehicles the new regulations are still not clear. Push assist on pedelecs 25 would at first glance seem to make these into powered vehicles. A question to the *German Federal Ministry for Transport, Building and Urban Development* (BMVBS) clarified however that special regulations apply for mopeds and bicycles with assist motors up to 25 km/h, and that these "are treated as bicycles if they can be propelled exclusively by pedalling without any motor assist (§ 2 Abs. 4 Satz 5 StVO)". Furthermore, vehicles with push assist up to 6 km/h are also explicitly categorised as powered vehicles according to EU law. This was assumed into German legislation in 2011.

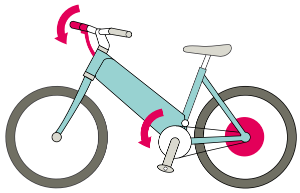
In simple terms: pedelecs with push assist are classed as pedelecs 25, and are thus bicycles in law. You must however keep moving the pedals when on a bike path instead of riding on the push assist alone (purely motorised) and dawdling along at 6 km/h. The regulations also add that pedelecs 45 may be ridden on bike paths if the motor is switched off; although outside built up areas this no longer applies.

PEDELEC 25
THROTTLE WITH THE LEGS



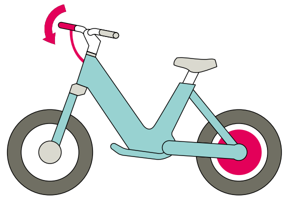
For pedelecs (*Pedal Electric Cycles*) the motor assist only engages when you are pedalling.
If the motor cuts out at 25 km/h and motor nominal power rating is limited to 250 W, then the same rules apply to these vehicles as to a bicycle.

PEDELEC 45
THROTTLE WITH HAND AND LEGS



The pedelec 45 is a mix of e-bike and pedelec. It can usually provide pure electric power up to 20 km/h. If you then pedal as well, the motor doesn't cut out at 25 km/h, but rather at 45 km/h. These are small powered vehicles for which you need proof of insurance and at least a moped driving license.

E-BIKE 20, 25 & 45
THROTTLE WITH THE HAND



The motor on an e-bike functions without pedalling, even if some models do still have pedals. The motor is usually controlled by a twistgrip. E-bikes are small powered vehicles, and their power is predominately limited to 20 km/h so that they can be ridden without a helmet (as applies in Germany). Helmets are compulsory for versions which go to 25 / 45 km/h.

	Pedelec 25	**Pedelec 45 / Small power bike / E-Bike 45**	**Small power bike / E-Bike / E-Scooter**
Designation	EPAC *(Electric Power Assist Cycle)* or Pedelec 25, legally a bicycle	Small powered bike L1e with low power, or high speed limited by design to 20 km/h	Small powered bike L1e
Power assist	When pedalling	When pedalling to 45 km/h & purely electric to 20 km/h	Purely electric to 20 km/h, or 25 or to 45 km/h
Motor nom. rating	250 W	1 kW	4 kW
Motor cut out	25 km/h	20 km/h (electric), 45 km/h with pedalling	to 45 km/h
Driving licence	no	Moped license (if born after 1. 4. 1965)	At least class M
Type approval	no	yes	yes
Registration	no	no	no
CE-marking	yes	no (yes for the charger if separate)	no (yes for the charger if separate)
Insurance req'd?	no	yes	yes
Number plate	no	Insurance indication	Insurance indication
Insurance	Household or third party*	via insurance indication	via insurance indication
***StVZO*-conformity**	yes	no, but requirements apply from the KBA *(Kraftfahrt BundesAmt)*	no, but KBA requirements apply
Cycle paths	Cycle paths	Road & cycle path without motor and outside built up areas**	Road & cycle paths outside built up areas
Helmet required?	no	yes (Germany & Switzerland)	yes
Trailers	yes	no	no
Lighting	as bicycles (*StVZO*)	as bicycles (*StVZO*)	as a small powered bike
Rear view mirror	no	yes	yes
Drink drive limit	1.5	1.1 if ridden with motor	1.1 if ridden with motor

Source: *ExtraEnergy.org*

* Check for pedelecs with push assist because some insurers expressly forbid self-propelled vehicles.
** Pedelecs with push assist must ride on cycle paths but without using the push assist function.

Overview
EU standards for pedelecs

For the last 30 years or so we in Europe have been on a long road from national autonomy to a single unified governance – although it would really be much better to strive towards worldwide unification at the same time. But when one observes how long the central European unification process is taking, it is clear to see that at a global level it would hardly go any easier or faster. But in general terms, people and their mobility needs are very similar, so it should be possible in the longer term to establish at least in basic terms very similar rules. Some ideas on this can be found on page 73.

Just like the transition which other sectors of industry have already gone through, the cycle industry currently finds itself amid the change from a purely mechanical industry to a complex one in which technical competence in software, power electronics, electro-mechanics and electrochemistry are all required. So this means that companies must address new challenges, for example electromagnetic compatibility. It can be assumed that this transition will require another 10 years. If any manufacturer does not embrace this change promptly they will as a result disappear from the market, or lose their market position.

DIRECTIVE 2002/24/EC - ART. 1(H)
Defines which vehicles are exempt from mandatory type approval.

This directive will be renegotiated in 2012. Imminent changes are thus to be expected.

PEDELECS 25 – Bicycles with electric motor assist. They have a maximum nominal continuous motor rating of 250 W (given on the motor specification plate). Drive power must reduce continuously up to 25 km/h and must cut off completely by 25 km/h at the latest. If the rider stops pedalling the drive must cut out immediately.

PEDELECS 25 and **E-BIKES 20/25** with motor power above 250 W up to at most 1000 W and maximum drive assisted speed of 25 km/h.

PEDELECS 25 and **E-BIKES 20/25** with motor power above 250 W are categorised as small powered bikes. They need type approval. They are however exempted from some requirements according to Annex I.

Legally **PEDELECS 25** are treated the same as bicycles, and need no type approval.

Pedelecs and their electrical components must comply with the requirements of *EN 15194*.

Pedelecs and their mechanical components must comply with *EN 14764*.

Not yet all of the EU-member states have yet made *European Standard* EN 15194 legally mandatory (to date it is only the UK and France who have applied this into national law). This means that in most countries the manufacturers themselves can state that their products comply with EN 15194. They can prove this through tests carried out at their own facilities, without employing the services of an independent testing institution.

CE mark

Most requirements of the *Machinery Directive* and the *Electromagnetic Compatibility Directive* are described in the standard for pedelecs *EN 15194*. But this extension has not yet been confirmed and published by the *CEN* (*European Committee for Standardization*). Meanwhile the *2006/42/EC* and *2004/108/EC* regulations should be followed.

The *Machinery Directive 2006/42/EC* classifies pedelecs as machines in the sense of the *Machinery Directive* and describes the requirements for health and safety in use of machines.

The *Electromagnetic Compatibility Directive 2004/108/EC* describes the requirements for the immission and emission properties of pedelecs. The main principle is that the safety of pedelecs must not be influenced by external electromagnetic fields, nor should other equipment be threatened in its safety by electromagnetic fields emitted by the pedelec.

Dream legislation

Because most laws evolve from history, and so won't be suitable for new things like pedelecs, we're taking the opportunity to write down what we would like. Any proactive legislator is very welcome to make these ideas his or her own!

Hannes Neupert

❶ A flat rate speed limit of 30 km/h in built up areas for all road users including cyclists. This would significantly reduce the potential dangers between road users because overtaking would make much less sense.

❷ The right to use cycle ways but no obligation.

❸ Status of pedelecs to be the same as bicycles, so no compulsory insurance or helmets, no driving license and no minimum or maximum ages.

❹ No compulsory dynamos, but a free choice of energy supply. In return compulsory daytime running lights front and rear.

❺ No power limit in Watts for lighting, but instead a minimum light output power of 80 Lux at the front, and permission to integrate indicators.

❻ No limitations by numbers of wheels or axles, nor by the number of people per vehicle.

❼ No drive system power limits. However limitation of the maximum power assisted speed in proportion to the pedal power applied. This means a ban on pedelecs with only rotation sensors, guaranteeing the cycling nature of the vehicle. This is the suggested relationship between human power input and power assistance cut-out speed:

Muscle power less than 50 Watt
= max assisted speed 15 km/h

Muscle power less than 100 Watt
= max assisted speed 20 km/h

Muscle power less than 150 Watt
= max assisted speed 25 km/h

Muscle power over 150 Watt
= max assisted speed 32 km/h

This rule would reflect the situation that applies on a bicycle: the top speed is linked to your muscle power. Nevertheless it would still allow even not so powerful riders to get up any hill, even loaded up, going at least at 15 km/h, thanks to the no longer limited electrical power.

❽ A ban on battery sales, to move manufacturers to sustainable leasing solutions instead (see also page 26).

Protective clothing such as helmets can make a lot of sense, but a compulsory helmet law, as is suggested from various quarters, would to say the least not be a productive idea under current circumstances.

It would dampen acceptance of cycle transport and so potentially lead to more deaths, because significantly more people in Europe die from lack of exercise than they do in traffic. Instead of a helmet a protective vest might be possible which in the case of a fall would inflate like an airbag, making the wearer into a sort of '*Michelin* man'. That would be much more suitable than a helmet which, while it protects the head, also increases the chances of a serious neck injury.

Furthermore, ever more active safety technology is to be expected and this could alter the whole situation very rapidly (see page 17).

A scarf which changes into a helmet in a crash. From *www.hovding.com*

The CE mark
Compulsory yet voluntary

The *CE mark*, which implies an *EC Declaration of Conformity* by the manufacturer, is all around us in Europe. It is on electric toothbrushes, mobile phone chargers and on almost every instruction manual for the most varied of devices. But on an electric bike? Here the "market conformity mark" can be hard to find, but in the *European Union* it is nonetheless compulsory for pedelecs.

Nora Manthey & Annick Roetynck

SAFETY BY SIGNATURE

The *CE mark* should guarantee that goods offered for sale in the EU fulfil particular safety requirements. But before anyone glues a little sticker with these two letters onto their product, or prints CE in the user manual, an *EC Declaration of Conformity* must be submitted.

In this, the "entity responsible for bringing the product to market" declares that their product complies with all relevant directives. This can in the first instance just be handwritten and signed, so it's entirely their responsibility. Once signed, this declaration is something like an insurance certificate, and with it the manufacturer or importer is responsible, not the owner. So manufacturers are not obliged to have the compliance of their products with the regulations tested in a test laboratory: they can simply guarantee it independently with their signature. So conformity can be declared without any compulsory testing.

Now, who would bet their life on an untested product? Unfortunately, far too many do just that, sometimes deliberately, and sometimes because they're unaware of the situation.

To properly evaluate an *EC Declaration of Conformity* isn't simple. Errors on the form such as a missing signature or incorrect details are the least of it.

National institutions such as Chambers of Commerce can help, but the real difficulty lies in the question of which directives and standards apply to the product in question. This lack of clarity makes it even harder to find 'errors' such as incorrect test procedures or standards missing from the listing in the *EC Declaration of Conformity*.

And often test labs are said by manufacturers to have performed tests, but not which tests exactly.

CE COMFORMANCE FOR PEDELECS

So to which regulations must pedelecs conform to be able to correctly carry the *CE mark*? Pedelecs 25 are classified as bicycles within the EU, and in legislation they are called EPACs. They are also "machinery" and fall under several directives.

The *Machinery Directive* 2006 / 42 / EG, the *EMC Directive* 2004 / 108 / EG and for chargers the *Low Voltage Directive* 2006 / 95 / EG all apply (see also the overview on page 72).

The *Machinery Directive* contains a list of essential health and safety requirements which affect the design and construction of the machine. Most of these requirements are already contained in EN 15194, which was specially developed for pedelecs and should bring together all of the relevant standards from the *Machinery Directive*. However, this has yet to be checked by the *European Committee for Standardization*, the *CEN*. When this occurs, EN 15194 will be published in the official journal and will then become a harmonised standard for the EU.

So a pedelec which complies with EN 15194, will automatically also comply with the requirements set out in the *Machinery Directive* 2006 / 42 / EG. A similar harmonised standard will also apply in the case of pedelecs for the *EMC Directive* 2004 / 108 / EG. Manufacturers must be able to produce documentation on demand showing that their product is 'electromagnetically compatible'.

This can be checked properly only by laboratory tests. The *EMC Directive* requires that the pedelec can be unambiguously identified with type, batch or serial number. In addition the manufacturer or person responsible for importing to the EU must be recorded with name and address. Finally, the manufacturer must then apply the *CE mark* to the pedelec.

SCOPE OF EN 15194

Pedelecs are classified in the EU as bicycles, and so they are exempt from type approval (2002 / 24 / EG). For them, EN 15194 applies and it should be available in the various national languages.

Most EU member states have not yet adopted EN 15194 into their national legislation as compulsory, with the exceptions being France and the UK. So most EU countries permit "self certification".

That means that if a manufacturer has their own test facilities or just believes that their pedelec complies with all standards, they can simply apply a *CE mark* and release it to the shops. Nonetheless many manufacturers today do have their products tested independently. Anyone wanting to err on the side of caution should ask for the test reports to be made available.

EMC INTERFERENCE

The *European Union* has correctly recognised that pedelecs are often on the road or close to other traffic. For this reason they require the same EMC tests as those which cars must undergo.

EMC means *Electro Magnetic Compatibility* and it denotes a desirable state of affairs in which technical devices do not affect each other negatively through undesired electrical or electromagnetic effects. Most people know the pulsating beeps you get when a mobile phone interferes with radio reception, but here we are concerned with much more powerful interference emissions: ten times higher than in household devices and more dangerous. Tests at the German *SLG* laboratories with improperly shielded vehicles threw up situations where the motor would start as if by itself when someone nearby broke off a radio phone call.

The EMC tests specified in EN 15194 can only be carried out on special, interference-shielded test stands. Only a few laboratories have this capacity and so 'false' tests easily find their way into *EC Declarations of Conformity*. EMC compliance is made even more problematic because it is a cost-intensive test, and only makes sense for a product ready for full production. Yet any tiny change on the whole pedelec system, like a different light bulb, could have an effect on the EMC test. For the cycle trade, with its typically short development cycle in small teams under tight competitive pressure, such extensive testing is burdensome.

COMPETING WITH CE

Legally it's a clear 'yes' to the *CE mark*. Pedelecs without it simply cannot be sold within the EU. For customers, the mark offers safety, and it makes whoever brings it to market responsible in product liability cases.

In practice, however, there are difficulties. Ignorance and lack of clarity about the correct test procedures and requirements lead to false certification or insufficient testing. In extreme cases a manufacturer could be held liable even though relying on false tests, if they have signed an *EC Declaration of Conformity*. If not, although their products would be on sale illegally without it, they would not be liable for damages.

Producers within the EU also complain about fake versions of the *CE mark*. These look confusingly similar to the *CE mark*, but small print explains that it stands for China Export.

Increasingly, it seems this is being seen as more relevant and worth taking seriously by the industry. After all, CE means more safety for producers and consumers. With it, manufacturers can sell legally in the EU knowing that their product fulfils all of the basic requirements.

Because the *CE mark* is valid across the whole EU, it represents a huge economic area with high export potential, within which there is no need to deal with individual national regulations. Quality is also a protection against cheap and unsafe imports – provided that it is effectively communicated and implemented.

The *CE mark* is an essential prerequisite for the production, import and sale of certifiable products within the EU. Fundamentally, with this mark, manufacturers declares themselves to the public authorities that their products comply with the relevant directives. These define the requirements for health and safety in the *European Community* (*EC*).

Making safety visible
The GS mark for pedelecs 25

With extra power of up to 250W at speeds of up to 25 km/h, riding is fun even uphill: and this applies even for retired people, environmentally aware housewives and indeed for anyone who wants some sporty exercise and to get around quickly. To ride such a pedelecs 25 there is no need for a driver's licence and there's no compulsory insurance: as the name suggests, the electric assist cuts out above 25 km/h. The fun factor is obvious, but when it comes to safety, matters are less clear.

TÜV Rheinland

With pedelecs it's quick and easy to reach high speeds, but this also involves risks. The bike must withstand the extra stresses and be of high quality. "Pedelecs place particular demands on components such as frame, fork and handlebars, as well as on the brakes. Safe enjoyable cycling is only possible when all of these are designed to withstand the expected loads," explains Wilhelm Sonntag, pedelec 25 expert at *TÜV Rheinland*.

SPOILT FOR CHOICE

The market for pedelec 25s keeps on growing. As ever more bikes come onto the market it becomes ever harder for a potential buyer to choose the right bike. So it is important to get comprehensive advice before purchase, and at least to take a test ride to check the ergonomics, and the handling under riding and braking. But it's not so easy to check the safety. Here's where recommendations such as the test stamps from *ExtraEnergy* or the *GS mark* have a role to play.

"A buyer can't really tell whether a pedelec 25 is safe over the course of a test ride. This is where the *GS mark* can help. GS stands for *Geprüfte Sicherheit* in German ('Tested Safety') and it shows the buyer that the bike has been put thoroughly put through its paces by an independent testing institute", explains Sonntag. The *GS mark* isn't a mark which gives the end user any information about the user performance of a pedelec 25, and so it gives no verdict on the range, purchase price or maintenance. The *GS mark* does however confirm that the product has been checked for safety by an independent third party.

In Germany, the *Geräte- und Produktsicherheitsgesetz* (GPSG - 'Equipment and Product Safety Law') applies to pedelec 25s. According to this, only products which do not risk the safety and health of the end user may be used in traffic. In addition, pedelec 25s fall under the *Machinery Directive*, on which basis pedelec 25s must be provided with the *CE mark*, although this is a self-certification by the manufacturer. So the *CE mark* does not indicate that the product has been independently tested for safety.

TORTURE TESTS FOR PEDELECS 25S

Alongside the requirements of road traffic regulations regarding lights and brakes, the European standard for pedelecs 25, *EN 15194:2009* describes precisely which tests a pedelec 25 must withstand in order to receive a *GS mark*. High average speeds, harder and more frequent braking, extra torque loads applied by the motor or steep uphill riding all add up to extra stresses. "To be confident that a pedelec 25 will withstand these loads, it has to undergo a tough testing regime. Alongside mechanical safety, electrical and chemical safety are also checked," says Sonntag.

For checking mechanical safety the bike must, amongst other tests, withstand numerous loading cycles on a roller test stand without damage. During the test it is loaded with 120 kg total mass and it is pedalled. Frame and brakes also undergo further tests.

THE GS MARK

The *GS mark* has a legislative basis in § 20/21 of the German Product Safety Law (*ProdSG*). A precondition for its use is that a GS institution has awarded the *GS mark* to a manufacturer or to their accredited agent. The *GS mark* shows that in normal legal use or in the foreseeable application of the marked product the health of the user will not be put at risk. The *GS mark* is a voluntary mark, meaning that the manufacturer or their accredited agent can decide whether to apply for a *GS mark* to be awarded.

Scope of application: According to § 20/21 *ProdSG*, awarding of a *GS mark* is possible so long as the legal provisions in § 8 *ProdSG* do not state otherwise.

Test stand for pedelecs at *TÜV Rheinland*

Alongside mechanical and electrical safety, the chemical aspects, materials and connections and their safety all pay a significant role. "We find ever more frequently that there are plasticisers dangerous to health such as polycyclic aromatic hydrocarbons in handlebar grips or gear shifters. Also, in leather items, for example saddles, we have found dangerous contaminants such as dimethyl fumarate or Chromium-6. To ensure that the end user does not come into contact with these contaminants these materials are not permitted in any components which the user touches directly. Only if this requirement is also met can the bike receive our *GS mark*", explains Wilhelm Sonntag.

As well as the laboratory testing, a compulsory requirement for GS certification is inspection of the manufacturer's production facility. "The manufacturer must be capable of producing pedelecs in production runs of consistent quality. To test this, we go to where the production takes place. Social aspects such as worker safety and the ban on child labour also play an important role here," says Sonntag.

While the *GS Mark* remains valid, ongoing checking of the production facility takes place at predefined intervals. If there are changes to the product, then the manufacturer or the person bringing the product to market must inform the testing institute without delay. If this change is deemed to be safety relevant it can be added to the certification after further tests, which naturally have to be passed successfully. If these changes prove not to be *GS mark* compliant, then the *GS certificate* is withdrawn.

"Only if a pedelec 25 withstands absolutely all of the tests and the manufacturer has manufacturing quality firmly under control do we award the *GS Mark*", insists Wilhelm Sonntag.

THE PEDELEC STANDARD: EN 15194:2009

This is actually called *EN 15194:2009, Cycles - Electrically power assisted cycles - EPAC Bicycles*.

It applies to all pedelec 25s.

It principally regulates the electrical issues on pedelec 25s, as also set out in the *Machinery Directive* 2006/42/EG and the *EMC Directive* 2004/108/EG. It refers for the mechanical tests to *EN 15194: 2005, City and trekking bikes – technical safety requirements and test procedures*. In the *National Appendix* (NA, informatively) of the German edition it is however recommended, deviating from EN 15194, that forks and frame be tested with higher test forces.

It is a standard, not a law. The EN 15194 standard is not yet in the list of harmonised standards of the *Machinery Directive*. This means that conforming to the standard does not confer any assumption of conformity for the directive.

Pedelecs – public charging infrastructure
Doing the right thing

Almost the whole world is well provided with private charging infrastructure, because just about every mains power socket is suitable for recharging pedelec batteries via the mains chargers which are usually supplied along with the bikes.

Hannes Neupert

With this in mind one could say that there is no need at all for a public charging infrastructure. And this conclusion is apparently justified, because the pedelec has caught on swiftly over recent years - without any such infrastructure. But you can also look at it another way: the pedelec might have caught on even faster if there had been a suitable public infrastructure. Be that as it may, the fact is that in recent years large amounts of money have been invested in public charging infrastructure.

Electricity company bosses, mayors and tourism heads love to smile at journalists' cameras in front of a public charging station for pedelecs. But practical experience has shown that such offerings are generally barely used. Moreover, using them can, depending on their construction, actually be dangerous for the user. So it is worth avoiding expensive, sometimes dangerous or illegal infrastructure. So here is a brief guide which should help with any decision making about infrastructure:

❶ Don't invest in any infrastructure which is tied in to chargers or pedelecs from any one manufacturer.

❷ Caution is especially advised for automated pedelec hire systems because currently these are only available as proprietary systems which tie up high levels of investment and can then very quickly lose their attractiveness and value.

❸ Organise touristic hire in partnership with tourism stakeholders such as hotels, museums, restaurants, swimming pools etc. - with partners who see it as extending their own offerings and who are happy to take on the extra business.

❹ Invest in cycleways, signage, GPS maps and extra information. Ensure that hotels and restaurants are provided with cycle-friendly infrastructure such as safe parking facilities, drying rooms, washing facilities, puncture repair and shopping opportunities.

EXAMPLES

Public AC mains voltage sockets (110 – 240 V) in the open air, into which the pedelec rider should plug his or her own charger so as to re-charge the batteries. This solution is dangerous, because the supplied mains chargers are generally only designed and approved for use in dry conditions indoors. So they could become a danger to the users if there is a rain shower, and they could also fail.

VERDICT Not legal to be used and dangerous!

Charging at AC mains sockets in waterproof lockers which fulfil the requirements of "dry indoors". Here the user can plug in the charger and battery, and then, once partially or fully charged, remove them.

This solution is legally fine, but of questionable practicality. First the bulky charger has to be carried along with the rider, and secondly, most of the chargers supplied with bikes only charge very slowly. So such stations make little sense for users who want to quickly top up.

If the lockers are located outside it is also worth remembering that most batteries should not be charged below 8 degrees Celsius so as to avoid damaging the cells.

VERDICT Legally acceptable, but of questionable practicality.

Battery exchange in a closed hire system (pedelecs, batteries and chargers all belong to a single owner). The user can exchange batteries as they wish at any hire point, and this service is paid for by the flat rate hire fee.

VERDICT The simplest method that has proven itself to date and has been implemented countless times. However it only ever works as an 'island solution' and it permits no mixing of drive systems.

Inductive stand charge systems, offered to date by only one supplier, offer a very user-friendly charging experience from the moment when the stand is placed on the inductive base plate. So far only possible for particular models. The disadvantage is that yet another electronic converter needs to be built into the bike, which can convert the energy received through inductance to a form which can be used to charge the batteries. When the pedelec is moved off the inductive base plate, charging stops. If ice or snow covers the induction base plate then the charging will be very slow if it works at all.

VERDICT An interesting technology for the future. This solution might be particularly suitable for companies with their own parking where locking of bikes is less important, but where speed of parking is more of a priority.

Available from 2014, the *ChargeLockCable* standard, based on the *EnergyBus* connector and its communications protocol, combined with a lock. This makes it possible to secure the pedelec with the locking cable to the charging stand and almost as a side effect to charge the pedelec.

If the pedelec batteries are suitable for fast charging they could be charged at up to 50 A and 48 V nominal voltage. Charge speeds for 10 km range extension in 5 minutes are already achievable with today's battery technology. If in addition cell heating elements are built into the battery pack it will also be possible to charge pedelec batteries in the open air in winter (see also page 31).

VERDICT A solution accessible to everyone, but only available from 2014. But you can still lay the ground today: when carrying out building works which are happening anyway, lay empty conduit to locations where a suitable cycle stand may be located.

FREQUENTLY ASKED QUESTIONS ABOUT PEDELEC CHARGING INFRASTRUCTURE

WHAT DOES FILLING UP A PEDELEC COST? Generally between 8 and 15 Euro cents.

HOW DO I PAY FOR RECHARGING? Paying for the electricity is uneconomic because the transaction costs would be higher than the price of the electricity used. And if the current has to be metered, then the costs of the infrastructure rise considerably as a suitable meter would be needed. So only business models in which the electricity is not charged for are likely to catch on, and the provider of the infrastructure will profit only indirectly if, for example, more people visit their shop. The electricity and safe parking facilities are also 'customer retention' measures, as is for example a children's play corner in a restaurant; they all ensure that the customers return.

You can find more detailed information about pedelec infrastructure at: *www.opi2020.com*.

Requests
to local politics, tourism authorities and funding bodies

Requests to local politicians, authorities, companies, parents, school governors and teachers, tourism authorities, town planners, industry groups, manufacturers, dealers, standards setters, mobility consultants and energy consultants.

Hannes Neupert

Build cycle infrastructure between regions (cross-country transport). Specify these cycle ways for heavier loads and wider vehicles such as for example *Cargo Pedelecs* or child transporters. It should also be possible to overtake without danger. The Bicycle Expressways in the Netherlands set a good example here (see page 57).

Integrate pedelecs into company mobility management policies. Make pedelecs available to staff members with the aim of replacing as many car journeys as possible with pedelec journeys.

Bear in mind the opportunity that the pedelec represents with its 'hill-busting' function, especially in hilly areas. Thanks to the pedelec, every region is now good for cycling.

Take bicycles and pedelecs seriously as means of transport, and not as fun and leisure items. Consider that with modern technology such as studded tyres, rainwear and weather protection it is no problem to use bikes or pedelecs all year round. This also means that cycle ways become useless if they are not also kept clear of snow and ice through the winter. It is still unfortunately common practice in many areas for the road clearing service to see cycle ways as snow storage areas onto which snow from car lanes can be dumped.

Make provision for pedelecs in planning rules for cities and municipalities, in the list of requirements for new builds in both residential and industrial accommodation, as well as for shopping centres and business parks. Today a minimum number of car parking places is often required; a suitably specified pedelec parking place should be seen as equivalent to a car parking space in such calculations. If despite this car parking spaces continue to be built by developers, at least the same number of pedelec parking spaces should also be provided.

As politicians, parents, humans: set a good example and take children to kindergarten and school by bicycle or pedelec. Make travel to school by pedelec attractive for those aged 12 and over and so prevent the switch-over to mopeds at 15 or 16, at which point pedelecs 45 can instead provide the daily dose of sporting thrill.

Sincerely and seriously engage for all parties involved in safety and quality, and thus for sustainable development of the market.

Standardise data given for range (see also page 42), standardise minimum warranties and possible exclusion criteria, and standardise definitions of minimum warranties for batteries and for vehicle electrical systems.

Requests
to national and global politicians

Pro-active legislation would help support the popularisation of pedelecs as a means of eco-mobile transport both in rural and urban areas (see page 73 for further inspiration).

Hannes Neupert

Tax equality between cars and bicycles. This would mean that it would be just as easy for a company to make works pedelecs available for its staff as today it is for them to provide a works van. Further, claimable distance allowances should be set up as transport mode neutral.

A pedelec should be fully depreciated after four years for tax purposes.

Investment in cycle path building and in pedelec parking facilities with provision for fast charging (see page 29). In almost all countries worldwide there is a huge investment backlog here, because systematic investment in cycle infrastructure has not been made over decades. If a goal of national and municipal politics was for example to achieve a 25% journey share for pedelecs and bicycles, then a sustained investment of 25% the funds available for transport infrastructure should be invested in this area.

Enforce the introduction of active safety methods.

Stringent checks on regulatory comformity by manufacturers, for importers and retailers. Unfortunately, every one of the pedelecs tested by *ExtraEnergy* in the last three years was not legal. So it can be assumed that there is not a single one in the EU which completely satisfies all of the applicable standards and laws. So on one hand the laws should adjust somewhat to the reality, and on the other they should be actually implemented in practice. Otherwise the only companies to be penalised are those who attempt to comply with the applicable rules. Examples include: *CE marking*, *EMC Directive*, *Machinery Directive*, *BattG*, *UN-T 83.3*, to name just a few (see page 74 – 79).

Ban the sale of batteries so as to shift suppliers to only bringing battery systems to market which are optimised for a long service life and which are also intended for a second use (see page 68). Implement the laws which apply to batteries and regulate recycling, such as *BattG*. Currently it is not required by legislation that batteries are safe in use. Only for their transportation are there legally mandated minimum requirements (*UN-T 38.3*). The only standard which covers safety in transportation and use is the *BATSO* standard, which is currently forming the basis for a new CENELEC standard. This also brings with it the prospect, initially at least in Europe, that a mandatory minimum set of requirements could be imposed on the market by legislation.

Reform the health insurance system into a bonus system, which would support those maintaining a healthy lifestyle with financial incentives. Insurers should be allowed to provide pedelecs for their members and if these are proven to be used regularly, this should have a positive effect on the contributory payment calculations. The *WHO* predicts that 30 minutes of gentle physical exercise daily leads to 8 extra years of healthy life (see also pages 62-63).

Require that in new builds or redevelopments of transport buildings such as harbours, stations or airports, a number of bicycle or pedelec parking spaces appropriate to the expected traffic volume must also be built.

Support the quiet revolution in local transport with pedelecs by ensuring that these are integral to electric mobility promotion programmes. They should not be seen as a token added extra, but taken seriously as a mode of transport which can in many circumstances replace the car, whether the car is powered by an IC engine or an electric motor.

There is still much basic research to be done in the field of human-electric hybrid vehicles.

Support free competition between suppliers by standardising the interfaces between electrical components based around *EnergyBus* standards. Utility for customers will then rise while costs remain static (see pages 30 – 32).

Standardise service interfaces for LEVs, so that all dealers can read error codes barrier-free and so can offer at least a basic service without being a contracted dealer of the component supplier in question.

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Norbert Haller: Page 38–41 (pictograms), 71
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Wikipedia: Page 25

GoPedelec! – a collaborative project supported by the EU as part of *Intelligent Energy Europe* with the aim of promoting the use of pedelecs. The *GoPedelec* Project has three central target audiences: users and potential users of pedelecs, cycle dealers, and municipal decision makers.

The collaboration partners are highly varied as to their backgrounds and roles within the market, but what unites all of the partners is the desire to accelerate the triumphal progress of the pedelec. The partners have been able to learn much from each other, and in particular the differing developments when it comes to bicycle and pedelec use across the partner countries has provided a positive stimulus to development. The most important results were: working groups for experience sharing among municipal decision makers, dealer courses and test tracks in Italy, Austria, Hungary, Czech Republic, Germany and the Netherlands. Find more details at the website: *www.gopedelec.eu*.

The Project Consortium would also like to thank the EACI and the *Executive Agency for Competitiveness and Innovation* for their support of the *GoPedelec*! project and is confident that this work will result in long term benefits.

Members of the Hybrid & Electric Vehicle Implementing Agreement of the International Energy Agency

As part of the *Hybrid & Electric Vehicle Implementing Agreement* of the IEA (*International Energy Agency*) under the chairmanship of Prof. Urs Muntwylers from Switzerland, *Working Group II* "Electric two wheelers" operated from 2006 to 2011. It was coordinated by AVERE, *The European Association for Battery, Hybrid and Fuel Cell Electric Vehicles* based in Brussels. IEA/AVERE are supporting the production of this handbook und the IEA has undertaken the financing of the translation of the Handbook into additional languages (French, Spanish and Chinese). The handbook will also be sent to important decision makers within Europe and beyond. Finally, Robert Stussi from Portugal/Switzerland and Hannes Neupert from Germany have directed the project. The work of this Working Group was also financed from the USA and Switzerland. More details of the Implementing Agreement are at *www.ieahev.org*.

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