THE BIKE IS BACK WITH A BATTERY
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The attention the electric car receives as a promising means of sustainable transportation seems at times to overshadow the rise of that other electric vehicle: the pedelec or electric bicycle. For those who don't know yet: a pedelec is a bicycle assisted by an electric motor. That motor is powered by a rechargeable (lithium-ion) battery. The motor is intended to assist pedaling, not to replace it. It is the newest evolution of the bike. Its numbers are growing fast.

This paper assumes that the growing use of pedelecs requires a different approach from design research and policy making towards electric two wheelers. It will outline the major differences between regular bike use and pedelec use and addresses issues like city to city cycling, bicycle theft, parking and street charging.
THE BIKE'S MARKET SHARE

When it comes to sustainable mobility most of the transportation policies seem to focus on increasing the use of public transport, combined with land use policies such as transit-oriented development of transport development areas. {1} Much energy and resources are pumped in the construction and exploitation of bus, BRT and light rail systems to almost no avail. Currently only 3% of all kilometres travelled in The Netherlands are travelled using bus, tram or metro combined. Train users and cyclists make up for 8% of those distances each. And yes, car drivers and car passengers together make up for three quarters of the kilometre production, with respectively 51% and 24%. {2} Eight percent of the overall kilometre production is a significant market share, especially when we consider that the bike is mainly used for short distances. In mid-sized Dutch towns (matching the distances where bikes perform best) the share in the modal-split can be as high as one third of all trips.

<table>
<thead>
<tr>
<th>Modalities</th>
<th>Number of trips</th>
<th>Distance per person per day</th>
<th>Share in the modal-split</th>
</tr>
</thead>
<tbody>
<tr>
<td>All modalities</td>
<td>2,99</td>
<td>32,6</td>
<td>100%</td>
</tr>
<tr>
<td>Car, driver</td>
<td>0,99</td>
<td>16,5</td>
<td>51%</td>
</tr>
<tr>
<td>Car, passenger</td>
<td>0,46</td>
<td>7,9</td>
<td>24%</td>
</tr>
<tr>
<td>Train</td>
<td>0,06</td>
<td>2,7</td>
<td>8%</td>
</tr>
<tr>
<td>Bus/tram/metro</td>
<td>0,08</td>
<td>1,0</td>
<td>3%</td>
</tr>
<tr>
<td>Moped</td>
<td>0,02</td>
<td>0,2</td>
<td>0%</td>
</tr>
<tr>
<td>Bicycle</td>
<td>0,78</td>
<td>2,5</td>
<td>8%</td>
</tr>
<tr>
<td>Walking</td>
<td>0,58</td>
<td>0,7</td>
<td>2%</td>
</tr>
<tr>
<td>Other</td>
<td>0,05</td>
<td>1,2</td>
<td>4%</td>
</tr>
</tbody>
</table>

The average Dutch citizen cycles about 2 to 3 kilometres a day. That distance did fluctuate somewhat over the years but is considered to be stable. Seen from an European perspective Holland (and Denmark) are at the top with about 1000 kilometres travelled by bicycle per person per year. {3}

<table>
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<th>Yearly distance travelled by bicycle per person in the EU15, 1995 {3}</th>
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<tr>
<td></td>
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<tr>
<td>km</td>
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As a result both Holland and Denmark comprise a vast infrastructure and practice that supports cycling. Children learn to bike when they are young and know from early on how to behave in traffic. Other road users are well used and adjusted to
cyclists, sharing their road space. The geomorphology and climate (except for wind) are favourable as well. These factors combined may very well sustain the market share of the bike in the years to come. Still, it doesn't seem likely that bike use will increase spontaneously its share in the modal-split.

**TWO DIRECTIONS**

Lets assume for a moment that the bicycle with its human engine has reached its maximum market penetration with roughly 1000 kilometres per year, per person. At that point we should ask where we go from here. There are two interesting directions that could be taken: focus on other European markets or focus on the possibilities that a much improved bike can offer. We briefly explore both directions.

At an European scale we may want to take a hard look at the regional differences in bike use. The scale is substantial with a high of 1019 and a low of 24 kilometres per person per year. {3} This is a difference of a factor 40.

These differences can in part be explained by geomorphology or climate. The highs and the lows are so far apart that we may have to assume other factors are at work as well. In most countries an effective cycling infrastructure is lacking as a result of decades of car-oriented infrastructure policies. By means of travel demand management it should be possible to get the French, the British, the Portuguese, the Spaniards and the Greek to cycle. It may perhaps not be reasonable to expect them to travel 1000 kilometres per year by bike any time soon. But so far the French, the British, the Portuguese, the Spaniards and the Greek travel even less than 250 meters a day. There is room to grow here, at least in targeted communities, life style or age groups.

At the same time we may want to improve our understanding of what a new generation bicycles could mean for both the communities that are used to biking and those that are not. Please consider for a brief moment the phases the bike already went through.

The bike was invented as a 'walking machine' (Laufmachine), much as the vehicle small children use when they start to learn biking. Rotary cranks and pedals were introduced to the front-wheel hub. The pedals made it necessary to increase the front wheel that was turned by using muscle power.

Increasing the front wheel reduced the effort that is necessary to start the bike, move it uphill or make it face headwind. It resulted into the iconic bike with its
large front wheel and small back wheel: the velocipede. Finally the use of chain wheels and a roller chain, transferring power from the pedals to the drive-wheel, improved the distribution of the muscle power drastically. It brought the bike roughly to the configuration as we know it today. At this moment we are witnessing the next evolution of the bike: the pedelec or electric bike. It coincides with an overall rise in interest into the possibilities electric mobility or e-mobility.

[Laufmachine]

REPLACING THE MOTOR OF A CAR

Say: e-mobility and most of us will think of electric cars. There is a strong case to invest in cleaner car technology cars. The sheer numbers as presented above (a share in the modal-split of three quarters) guarantees that the impact of introducing electric cars on our roads will be significant. It is nevertheless interesting to speculate what the conversion of internal combustion engine to an electric engine will mean for the way people use their car. It will certainly lead to better environment: less noise, less air pollution. But will the functionality of the car change much? Does the electric car drive faster? Does it drive further? Will it be easier to find a parking place? The answer is no. Driving speed is regulated by law and based mainly on safety, not on fuel efficiency and only sporadically on environmental impact. The capacity of the battery and the time that is necessary to fill up
an electric car may one day live up to a car with a combustion engine. It is not likely it will exceed it any time soon. Finding a parking space may be even more complicated because you may have to find a spot that can charge your car. Illegal parking will be a thing of the past. The environmental impact on the urban environment will be huge. But in terms of functionality it looks like that a car with an electric engine performs much like a car with an internal combustion engine.

INTRODUCING A MOTOR TO A BICYCLE

[Biketec Flyer T]

The attention the electric car receive as a promising means of sustainable transportation seem to overshadow the rise of the pedelec or electric bike. For those who don't know yet: a pedelec is a bicycle assisted by an electric motor. That motor is powered by a rechargeable (lithium-ion) battery. The motor is intended to (dynamically) assist pedaling, not to replace it. In legal terms a pedelec is in the EU a regular bicycle as long as the motor's power doesn't exceed 250W and as long the maximum speed is leveled off to 25 km/h. High speed pedelecs with a speed up to 35 km/h do exist. Switzerland for instance doesn't regulate the bike's maximum speed. In the EU such pedelecs are legally regarded as mopeds.

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In the year 2008 almost 140,000 pedelecs were sold in The Netherlands. This number grew from 22,000 in 2004, 34,000 in 2005, 44,000 in 2006 and 89,000 in 2007. {4}

<table>
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<tr>
<th>Year</th>
<th>Number of electric assisted bicycles sold in The Netherlands per year</th>
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<tr>
<td>2004</td>
<td>22,000</td>
</tr>
<tr>
<td>2005</td>
<td>34,000</td>
</tr>
<tr>
<td>2006</td>
<td>44,000</td>
</tr>
<tr>
<td>2007</td>
<td>89,000</td>
</tr>
<tr>
<td>2008</td>
<td>140,000</td>
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</tbody>
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Although pedelecs still represented in 2007 only 6% of the actual number of bikes being sold, due to their high price tag they already account for a third of the turnover in bicycles sales in the Netherlands. In 2008 this market share already grew to 10%. This makes it very lucrative to market them. In the early years sales were mainly targeted at the elderly population. Currently the pedelecs are discovered by commuters and other age groups. The introduction of city models and electrically assisted mountain bikes supports that development. One can safely say that a silent revolution is going on. It is a revolution that isn’t much debated by the research community, neither by policy makers.

MEET THE BIKE 2.0

The most interesting aspect about a pedelec is that it is a much improved bicycle. It is a bike 2.0. The motor multiplies someone’s muscle power. They assist. Some models already assist its owner dynamically. When this person faces increased resistance by wind or sloping terrain the motor will work harder to compensate for it. An electric bike is a bike that allow elderly to cycle until an older age. People living in cities or rural areas with steep height differences will benefit strongly from pedelecs. Riding up hill using a pedelec requires the same effort as riding a regular horizontal street. Pedelecs allow commuters to bridge longer distances. People using a pedelec do not sweat, which is a major issue with trips between home and the office. The Croydon (a London Borough) cycling campaign gives five reasons why they like pedelecs: {5}

SOCIAL NEED
There are many people who may want and need a bit of electric assistance, whether through inclination, age or physical frailty, or a need to ride quickly to work without needing to shower and change.
**ENVIRONMENTALLY RESPONSIBLE**
Pedelecs consume a tiny amount of energy compared to mopeds, motorcycles or cars; and the only consumables over-and-above a standard cycle are the batteries, which can normally be recycled when they have expired. Typical power consumption is 0.10 to 0.15 kW, compared with about 15.0 kW for a car.

**SOCially RESPONSIBLE**
Pedelecs, like pedal-only cycles, are relatively light and slow-moving vehicles that (unlike cars, motorcycles and lorries) pose little danger to pedestrians and other vulnerable road users. Under EU law, electric cycles cannot provide power over 25 km/h (or 16 mi/h).

**Effective**
Pedelecs tend to get used often, rather than left gathering cobwebs in the garage like many standard bicycles. Combined with a cycle trailer, they can easily help tow the weekly shop for a large family.

**True Cycles**
Pedelecs are true pedal cycles under the law, with all the everyday ease-of-use advantages this implies:
- right to ride, i.e. no tests, licensing, taxes or other hassles
- no need for helmets or special clothing
- train operators carry bicycles, enabling effective mixed mode travel
- right to use cycle and bus lanes

Pedelecs do not simply replace regular bicycles. They will change the way bicycles are used and have a significant impact in the way people move around on two wheels. Possibly it may allow the Dutch and Danish to bike even more. Probably it will allow the Portuguese and Greek for the first time in their lives enjoy a bike. Still their are hurdles to be overcome that aren't addressed yet in the design of bikes or in the infrastructure policies of local and regional authorities.

**City to City Cycling**
Most Dutch municipalities posses impressive bicycle networks. But that infrastructure falls short if you want to move between towns. The out-of-town infrastructure is often developed with recreational objectives in mind. They consist of scenic routes but do not necessary bring you straight from 'A' to 'B'. The out-of-town recreational routes posses another disadvantage. They aren't built with social safety in mind. Most recreational use takes place in the spring or summer sea-
son during daylight. In the winter time these routes are straight-out unfriendly to women, elderly and other vulnerable users with lacking illumination and the regular use of no-mans lands. If pedelecs are about to expand the reach of regular cyclists, than the overall networks need a serious second look to support that mobility. In densely populated regions regional authorities need to provide 'bicycles highways' that interconnect the urban networks.

BICYCLE THEFT

An electric bike is a great but expensive asset. Typically, the price of a pedelec will range between 1000 and 3000 euro. With their growing popularity they will become increasingly vulnerable to theft. Bicycle theft is a major issue in The Netherlands that hampers the further growth of bicycle use. On June 14th 2007, after 100 days in office, the Dutch government (Balkenende IV) pledged to halve the amount of bicycles stolen by reducing bicycle theft each year with 100,000 cases from the year 2006 level. In its statement the government claimed 750,000 bicycles were stolen in 2006. {6} But according to 'Statistics Netherlands' 909,000 persons (15 years or older) experienced bicycle theft in 2006. {7} Even the government seem to underestimate the severity of the issue. These numbers relate to regular bikes, bikes that fetch between 10 and 100 euros when they are sold after being stolen. Electric bikes are much more lucrative. Even the essential parts of a pedelec are at risk. A removable lithium-ion battery (currently standardised by the Energybus group {8}) will cost about 500 to 600 euros. The battery is relatively small, being somewhat larger than a milk pack and poorly locked on the vehicles.

PARKING

In the densely built areas most of the (pre-war) homes lack the ability to park a bike indoors. Because pedelecs tend to be much heavier that regular bikes (20-25 kilo), people will not want to carry them upstairs. They could opt for a bike with a removable battery and bring the battery in their home to charge it. In that case they have to lock up the bike outdoors and leave it their at nights and holidays. If they would think the removable battery too much of a risk because it detachable, they can always opt for a pedelec that integrates the battery in its frame. But than they face problems how to charge their vehicle. Remember it is too heavy to expect that people are willing to carry it upstairs. If local authorities want their citizens to cycle with assisted bikes they have to take a serious look at theft proof parking and charging. No effective solutions exist at this point yet.
STREET CHARGING

Solutions seem very well possible. Take a look at Velib, the Paris Self Service “bike hire” system that is available 24 hours a day, 7 days a week in the French city of light. It uses so-called stations that are equipped with roughly twenty bike stands consisting of a bike locking mechanism and a card reader. It securely stores and registers the position of the vehicle in the network to have it available at request. Because the bike makes physically contact with the stand it shouldn’t require rocket science to include a charging solution both in the parking facility and the vehicle itself to combine both parking and charging at the same time. It does require however that industry and local or regional governments meet and agree to develop jointly practical solutions and stimulate the roll out of such a system.

Then, having a high quality charging and parking solutions integrated in public places, may very well unlock the acceptance of similar solutions for other vehicles such as mopeds and cars.
CONCLUSION

The emergence of electric assisted bicycles (pedelecs or electric bikes) seem to signal the next evolution of the bicycle. It offers the prospect of a growing share for biking in the modal-split of those countries where the market seems to be saturated. It may very well offer an advanced path to introduce cycling in markets where the use of bicycles is traditionally weak, due to geomorphology, climate or culture. Local and regional authorities need to be aware that a changing use of bicycles over longer distances requires that the out-of-town recreational networks need to be adapted to work seamlessly with the urban networks. Local governments and industry should work jointly to effectively solve theft, parking and charging issues. That task is far from daunting. Components for the solutions are available. The bottom-up development of electric biking deserves nevertheless more attention it receives currently from design research and policy making. As a clean technology, a growing industry and a means to remain healthy, the electric bike deserves it rightful place between other modalities.

REFERENCES


