

Poster Presentation: A Plus in Quality of Life

4a: Extended Personal Mobility by Electrically Powered Bicycles

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Introduction

The personal mobility in West Europe is on a very high level, possibly the highest in the world. As to a definition of personal mobility, that a person in using existing means of transportation and following common rules can move from one place to another! Basis for this is the dense net of roads, the well developed public traffic, the high frequency of trains and airplanes and last not least the existing vehicles for private use.

Why then thinking about extending private mobility?

The answer comes from different changes happening in recent time:

- The cultivation of health and physical strength during whole life up to an old age is getting more and more attention due to the progress modern medicine is making.
- The technical improvements of the electric bicycle (e-bike) which is basically well known for decades, open new possibilities for its use in daily life.
- Resulting from an increased ecological awareness people are looking more and more for alternatives to today's traveling concerning better protection of the environment.

For the evaluation of personal mobility could be used: the effective travel time, the dependence from external circumstances, the cost, the impact on the environment, and the effort of planning needed.

The following is to show that e-bikes are a serious extension or alternative to the personally used vehicles of today.

1. E-bike as additional or alternative vehicle for transportation of persons

Besides the public means for transportation today bikes, mopeds, scooters, motorcycles and cars are the usual vehicles for the daily way to work, to school, to shopping and to leisure activities. At least this holds for Europe. But the bike is the only privately used vehicle not contributing to the CO₂ emission directly. And it is also the only vehicle which contributes to improving health by regularly using it. Physical stress with sweating and fatigue, longer travel time, dependence from weather and limitation to suitable roads are seen as the major disadvantages of biking.

Especially in cities with high percentage of mopeds and motor scooters being equipped with two stroke motors the air pollution has reached a critical level. In some cities these types of two wheelers are forbidden already (China, Taiwan, Italy). To avoid this by using motorcycles or cars makes no sense during rush hours or is not possible because of higher cost.

When working and sitting in offices and in other modern working conditions the physical stress is reduced to a minimum by having no opportunity for any physical activities and by taking own or public vehicles and escalator or elevator for moving to other places. This makes many people to train their body and to strengthen their health by special activities in the evening or at the weekend. But for years now physicians agree on shorter but daily performed trainings to be better and more efficient.

E-bikes provide alternatives for the traditional vehicles as mentioned above. This applies especially to mopeds and scooters. Equipped with present-day technology as described later they can avoid the largest disadvantages but with a comparable transportation performance. It is left to the driver when and where the e-bike is used as a bike only and when and where as a motor driven vehicle with personal assistance. This is the main and important difference to mopeds and scooters on one side and to bikes on the other. And in most European countries the e-bike can be used on all roads and ways where standard bikes are allowed.

In Europe and especially in West Europe with its well known excellent infrastructure the need for another type of vehicle as well as the knowledge about its existence in form of the e-bike come into consciousness of larger parts of people step by step only. In contrary other countries experience today a vehement expansion. China, still being a developing country in this context some years ago now leads the world market based on sold e-bikes by far: from some thousands in 2001 to about 10 million per year in 2006! The 50,000 to 100,000 e-bikes sold in West Europe in 2006 not even reach 1% of the numbers in China. Even if the external conditions in China and Europe, the technical performances and the prices cannot be compared directly, this comparison shows the reality of the e-bike as an alternative to other personally used vehicles as well as the big potential in West Europe. Similar can be said for other countries.

For the first time all leading bike manufacturers showed own or licensed e-bikes in different designs, styling and application on the big European trade shows EUROBIKE, IFMA and EICMA in 2006. This indicates a change in the attitude towards e-bikes of significant parts of the customers.

2. E-bike as extension of the personal mobility

As result of a superficial estimation many people see the e-bike as a vehicle for elder people and people with a handicap only. In many cases this results from lack of knowledge or prejudice.

Often they overlook that with the electric drive switched off the operation as a bike is not changed at all. This holds at least for most e-bikes from European production. But also cheap copies with a design like a moped and with much plastic or the fear to be stigmatized prohibit them from buying an e-bike.

The desire for training physical strength and protection of the environment is not limited buy riding an e-bike. In contrary! Being switched on the electric drive system opens a new experience for drivers of any age, of any fitness and for any type of traveling or moving with a bike. At the same time most disadvantages of biking as mentioned above are avoided.

Faster, farther, higher are the attributes which must be dedicated to the bike with an electric drive system if the advantages shall be named shortly.

Commuters biking at suited whether to work or environment-conscious buyers leaving their car in the garage frequently, or sportsmen training regularly, they all can decide at any time whether to bike with their own force or whether they want to use the additional motor force too. Faster to be at the office and back home, farther to a special shop on shopping tour, or climbing up a steep long hill would be at decision just in the moment.

This freedom of decision counts even more in situations where external obstacles normally impede the use of a bike. Here the e-bike is the natural alternative to improve personal mobility. Having his house or his office in a town on a hill will go up the hill with the "hybrid system" human force + electric force and will go on biking on all other parts of his route – or will go on "hybrid"

Finally also those people shall be mentioned being up to now the most frequent buyers of e-bikes: With new technical solutions and improvements even more mobility, more range and more independence for elder people and people with a handicap.

Concluding one can say: Whether in town or on tour, whether well trained or untrained, whether old or young – with an e-bike all can renew their experience in biking to a new extend.

3. Features and technical equipment of progressive e-bikes

At today's e-bikes two types of drive systems are applied: The drive system with wheel hub motor which can be mounted into the front or into the rear wheel and the drive system with a motor driving the pedals and via the chain always the rear wheel. Main advantage of the motor at the pedals is the use of the gear system also for the electric drive.

Compared to this the wheel hub motor has some significant advantages- especially when spoked into the front wheel:

- Higher reliability and longer lifetime of parts in the drive system of the bike
- With the wheel hub motor mounted in the front wheel both power sources "driver" and "motor" work separately: the driver actuates the rear wheel via the chain whereas the motor actuates the front wheel. With this "parallel hybrid" system both forces can be applied completely independently.
- At any electric drive acting on the pedals the total driving force must be transmitted via the rear wheel to the road. As a result higher wear of chain, chain wheels, bearings, gear system and tires have shorter operation time resulting in increasing failures and breakdowns.
- Best utilization of the energy stored in the battery
- There is no shorter way for the transformation of electrical energy to force on the road than with a hub motor!
- No losses of energy in an additional mechanical power transmission!
- Pleasant riding characteristic, support for pushing and operation with trailer
- The "all wheel drive" yields a pleasant feeling when riding the bike. Especially with heavy load and deep ground the motor powered front wheel drags the whole bike forward and stabilizes the whole vehicle.
- On very steep parts of the road, on ramps or on a winding path the bike must be pushed forward the engagement of the front wheel with control by the twist grip makes these difficult situations very easy.
- And the front wheel drive has proven its superior operation in many applications with heavily loaded trailers.
- Easy maintenance and repair
- Disassembling and assembling of the front wheel with the motor is a matter of minutes. With just 3 screws the wheel is fastened in the fork and only one connector just beside the motor makes the electric coupling.
- Higher economic efficiency
- In case of a failure or breakdown of the system the modular design makes possible to exchange just the defective part only. This saves time and money.
- The longer life time as mentioned above improves the economic efficiency too regarding the life cycle cost.
- Better appearance
- With a wheel hub motor all parts and especially the frame remain as on a normal bike except the hub in one wheel. This makes this drive system being optimal for the retrofitting of existing bikes without changing the specific design of the bike

range with pedaling up to 100



additional weight by drive system: 9 kg



easy to use: no warranty,
recharge battery only

support up to 35 kph



clean operation: no oil, no petrol

Figure 1 shows some values which can be expected from an e-bike manufactured in Europe



Figure 2: Retrofit kit for the conversion of a bike to an e-bike

Figure 2 shows the components of such a retrofit kit. By choosing the suited motor, the matching control unit and the cables fitting the frame the kit can be applied to bikes from 12 inch to 28 inch. With the control unit the carrier not only covers the “brain” of the whole system but also with the batteries the “heart” which delivers the energy for the support during riding.

With this system of HEINZMANN a twist grip is used for the control of the motor power. So the driver can activate the accurate motor support at any time and in any situation as needed. And at the twist grip also the ON / OFF – switch and the display of the battery condition are placed.

In West Europe e-bikes are bought as so called “pedelec” mainly. This artificial word (pedal + electric) means that the electric support can only be activated when the driver is pedaling too. This and the limitation of the continuous motor power to 250 Watt and of the maximum supported speed to 24 kph are the condition in many European countries for rating the e-bike still as a bike. This allows e-bikes to be used on all ways where bikes are allowed and the driver is neither obliged to wear a helmet nor to have a license nor to carry insurance.

So the personal mobility with an e-bike is not restricted by any legislation compared to using a normal bike.

At an e-bike of the type electric moped (called e-bike too) the motor power is controlled by a twist grip too. But the drive system can be operated without pedaling. So riding without pedaling is possible as with a moped. In Germany and in some other countries the continuous motor power is limited to 500W and the supported speed to 20 kph to avoid the obligation for wearing a full helmet. In most of these countries the e-bikes must carry insurance too.

Some manufacturers offer e-bikes with electrical support up to 37 kph. These bikes need an insurance in most countries and the driver a license. But experience with these e-bikes is overwhelming!

Regarding the question to best battery technology one could say: "Since electric vehicles with batteries are known the trouble with the battery is known too". During last decades many weak points have been improved but nevertheless nobody is really happy with what has been reached. Especially capacity (and that means range of the vehicle), life time, robustness and size and prices do not fulfill the expectations of the user. Today in West Europe predominantly batteries with NiCd-, NiMH- and Li-Ion-cells are used. Lead batteries for e-bikes are out nearly. The main features of the batteries at same capacity are:

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|-----------------------------|--|
| Nickel-Cadmium (NiCd) | very robust, highest weight, largest dimensions, more than 500 charging cycles, very toxic |
| Nickel-Metal-hydride (NiMH) | middle weight, middle dimensions, extensive monitoring, typical 500 charging cycles |
| Lithium-Ion (Li-Ion) | lowest weight, lowest dimensions, very extensive monitoring, more than 700 charging cycles, dangerous good |

4. Samples of existing e-bikes and electric vehicles

The following figures give an impression how different e-bikes can be and which other vehicles can be powered electrically for getting higher personal mobility.



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