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Electric vehicles are here to stay!

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Abstract

Electric vehicle (EV) motor has past of nearly 160 years. EVs were never matured when compared to internal combustion engines. EVs were always there but in their own limited capacity. Issues such as insufficient infrastructure and lack of support from auto industry delayed the EV penetration for too long. The present situation of congestion and emissions presses the need for clean vehicles and use of alternative energy sources. There are different competitors come along the way such as bio based fuels and hydrogen. Still EVs and plug-in hybrids are seen as promising solutions for near future.

This is the time to say that EVs are here to stay and this paper gives examples to illustrate the role of design to do so. The EVs have its own share of advantages and disadvantages. The aspects such as power and range of EVs are still in continuous development. In mean time it is a best solution for congested urban areas which is efficient in energy usage and local emission free. In comparison to state of the art systems of transportation, EVs can use their advantages to come up with new ownerships and advanced infrastructures. In these kinds of settings special purpose vehicles niche vehicles could play an important role to lead mobility into service based sustainable system. This paper tries to explore the ways in which design can play as an interface between consumer and technology. And also focuses on how different niche vehicles and portable solutions can play a role in stimulating the use of EVs.

1. Introduction

EV is an optimum vehicle for urban spaces. It is energy efficient, quiet and local emission free. Even with all these features it is a rare scene to see EVs at work in urban landscape. There are many reasons to explain why EVs don't get the same privileges as an ICE vehicle when it comes to the R&D expenditures and the concept vehicles development. The main being oil lobby and the availability of petroleum in abundance in the past and not to mention the short term advantages seen by the main stakeholders.

EVs are becoming a hype and the issue been discussed recently. It is not the first time though EVs are touted to replace the highly matured ICE vehicles. EVs are often remembered or revisited when ever sustainable solutions were pursued in order to curb emissions or ensure less dependence on conventional energy sources as well the dependence on the middle-east. There were instances when EVs tried to enter the market place in the last two decades, were halted by not fully developed hybrids and serious developments of efficient but expensive hydrogen based fuel cell vehicles (Campanari 2009, Jorgensen 2008).

In the year 2008 the surge is back with the EV projects like the 'Better Place' with support from different city authorities and automobile industry. There is certain amount of trust and build-up to believe that EVs are coming to stay this time around. This paper tries to discuss how design of EVs, and their interface with consumers and infrastructure development could play a role to bring EVs to the promise land.

2. EVs Advantages

2.1. Total/local emissions

Urban emissions are growing synonymously with the economic growth. These emissions are creating the alarming concern of health hazard of the local population. These are mainly created by the use of the internal combustion engine (ICE) vehicles, whose tank-to-wheel efficiencies are around 20%. The immediate concern of urban spaces is to eradicate emissions or least not to concentrate them at city centres. This is one of the reasons why some countries coming with congestion charging, relocating the speed ways and milieu zones (Munuzuri 2005). It is important to find out which energy source will emit fewer emissions through out its life cycle in comparison to the area where they are used. This comparison tells us that the most important aspect of emissions story is tail-pipe emissions.

EVs produce zero emissions at the point of use. Even when whole life cycle is compared an EV produces only 5% to 10% of the emissions of an ICE per km travelled. All of the EV's emissions occur at a power plant, which runs 400% to 500% more efficiently than an ICE.

2.2. Efficiency

Sustainability and similar development concepts are contextual and heavily influenced by the way traditionally urban systems are arranged. The one theory which could be applied to every urban context is pursuing the optimal solution for a certain need. It is difficult to say which solution best suits for a certain travel need when it is taken out of context. Using optimal solution in terms of energy use is the best point of departure.

An electro motor is 400% to 600% more efficient than an IC engine. The tank-to-wheel efficiency of an EV can go up to 90%. When run at lower speeds, i.e., at lower voltages, EVs function at its best.

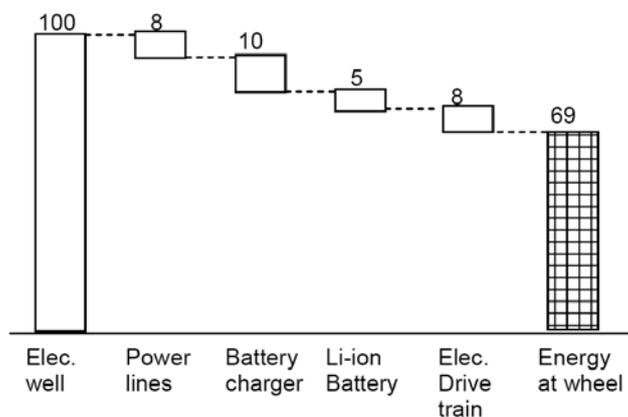


Fig 1: EV well to wheel efficiency

2.3. Sustainable energy resources

The main competition for EVs, in other words the technologies with the potential to compete with the ICE technology, is bio-fuels and fuel cells. Bio-fuels follow the suit of ICE architecture and fuel cells the EVs.

Bio-fuels will still need a decade or so development for the second generation bio-fuel in order to substantially supply the demand. The first generation has its own share of problems as they use corn and other food resources to make volumes. Next to that this fuel can neither be stored for too long nor can be distributed with a pipeline. The second generation bio-fuel is promising as it uses algae and food waste for the oil production. It is still though at laboratory stage and needs completely different infrastructure to generate this in required large amounts.

In the early 2000's fuel cells are projected to solve the oil problem by around 15-20 years. The hydrogen supply is one of the main obstacles for this technology to prosper. The bigger dilemma is to carry hydrogen or generate electricity at a stationary fuel cell or plant. The main advantage is that fuel cells could be used as range extenders once EVs are developed fully. Fuel cell vehicles do have the future and potential to replace ICEs in long term, once the hydrogen is generated from sustainable energy sources like wind and sun.

Comparing with the competition, EVs can function with the sustainable energy sources in order to charge the batteries. Intelligent charging patterns and optimized vehicle design will enhance these advantages for 'value for energy' (Hatton 2009). The major infrastructure, like electric grid and different voltage lines, is already in place and with slight modifications in terms of charging/loading batteries EVs are best bet for the near future.

2.4. Simple and silent

EVs are simple, silent and easy to operate. EVs are much simple in construction when it comes to drive and driven parts of the vehicle. Much needed acceleration and deceleration in city spaces is easily handled by an EV and less energy wasted during deceleration as energy can be put back into battery by regenerative braking. The complete absence of mechanical couplings can make concepts like drive by wire and steer by asymmetric speed of wheels.

Sound pollution is one of the issues in the urban spaces next to emissions. Urban spaces are filled these days with sound barriers and absorbers in order to provide better liveable spaces. EVs are a promise in disguise! These are silent and contrary EVs are fitted with artificial sound for pedestrian and cyclist's safety.

3. Not the first time!

Definitely, it is not the first time there is visible surge for EVs. In early 90's the EVs were pursued in California in search of zero emission vehicles. It never took off and instead it gave a push for hybrid electric vehicles (HEV). EVs seem to have less or limited scope for market expansion in the United States, reasons could be either the long distances or the 'highway big-car' culture. Which is not the case with Europe and not till mid 2000's HEVs are becoming popular. HEVs, i.e., plug-in HEVs, are touted to be the next best thing as they take best out of the both worlds (Bradley 2009). It is quite a challenge for EV to sustain by itself in the near future. EVs can coexist with its surrogates and definitely have advantages. The following features and aspects could improve and accelerate the EV penetration this time around.

- PHEVs are important as a back-up as well can function as 100% EV

- FCEVs can function in the future as range extenders
- High energy density batteries could yield more range (Yang 2009)
- Fast charging algorithm can improve the range limit and immediate loading (Hatton 2009)

Today, the share of HEVs in car sales is small. It is below 1% in many European countries like Austria, Belgium, Denmark and the Netherlands, and it's about 1.2% in Sweden and 2.2% in the United States. The number of HEVs and their market share are going to increase substantially by the year 2015. The market share is tripled in Europe in amount of three years.

The market for EVs and heavy-duty EVs is small. However, the sale of pedelecs, e-bikes and e-scooters are surging and this trend will continue. Acceptance of EVs in the two-wheeler segment might prepare the market for advanced electric purpose designed vehicles such as the Venturi electric vehicle (www.venturi.fr) (see Fig 3) and the Th!nk (see section 4.1) (Weinert 2008).

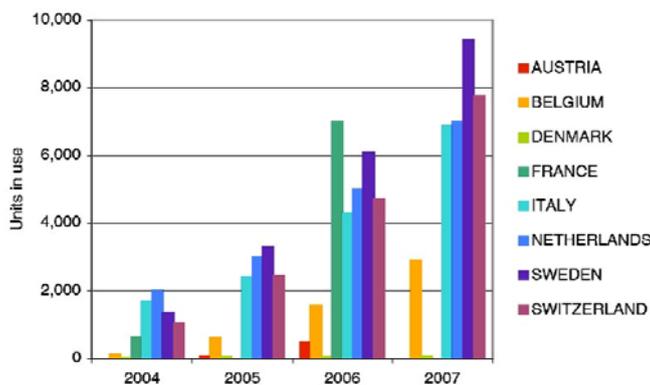


Fig 2: HEV fleet size in some European countries

4. Inspiring developments

EVs do have a certain number of wow products already in the market and in the pipeline of R&D. The technology has a story to tell and potential to replace ICEV and now it needs the inspiring design for a good interface. It is also the regulation and governmental bodies need to give enough support in terms of regulation as EV technology can do things better than the traditional technologies (Fontaine 2008). Following sub-sections examples are given for inspiration, design and interface.

4.1. Certification of new vehicles

EVs has long been seen as city vehicles. It is optimum to operate in city limits and when there is no need to get on to a highway. This is one reason why many vehicles come with a 60 kmph limit for maximum speed, and this also has other benefit to achieve the long range. Many see this also as a disadvantage as the cities in Europe are small and EV won't be able to connect the next near by city. This problem is Solved by Norway's Th!nk (see Fig 2), which can go up to 100kmph, secured recently a certification to allow it to sell its EV in all European countries. Netherlands-based testing and certification authority RDW issued the highway-safe passenger car, or M1, designation. The certification was the first for an EV under the new Pan European Type Approval, which is aiming to improve upon the previous country-by-country approval necessary for car makers.

Segway is another EV, which invented a new way to move forward (see Fig 2). Which also have the regulation issue that person using motorised vehicle need to

have a comfortable sitting posture. After long lobbying and demonstration of its self balancing technology Netherlands Govt approved Segway to be a new category vehicle. This category will be issued a license plate and insurance tied with a specific person and could function as a moped on bicycle lanes at 25kmph.



Fig 2: commercially available EVs Th!nk and Segway

The two are examples for EVs which with their design and features able to create a special notch in the market by revising the regulation.

4.2. New forms of mobility

The autonomous electric vehicle is one of its kind EV developed by Venturi (see Fig 3). It's an EV powered with solar panels on the roof and a wind mill to recharge its batteries. The wind mill is suggested to use when the vehicle is stationary or while parking. It could be seen as sustainable in all means and create a completely different category of EVs.

The portable vehicles could also play an important role in making the present



Fig 3: Venturi, self powered electric car

transportation systems more comfortable and sustainable. Modular and portable two-wheelers when connected with a car or public transport could make the door-to-door transport possible. These are advantageous when particular amount of distance travelled in particular niche circumstances, like commuting, work-work or distances in exhibition grounds (see Fig 4).

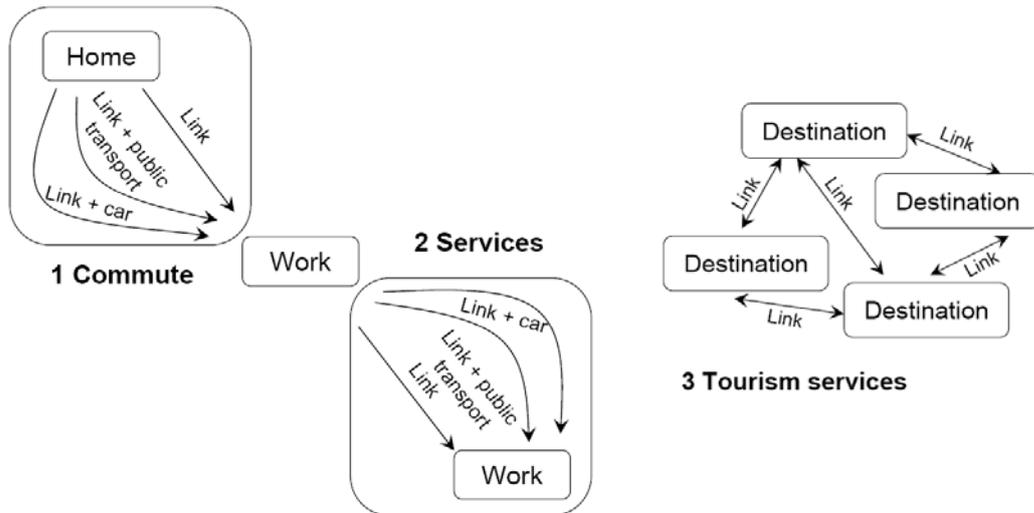


Fig 4: Different product market combinations for different niches

. The Link, personal mobility system (see Fig 5), has modular features. It's easy to store and carry able in to a train as it folds in to a compact size and weighs around 18kg. The Link is propelled by an electric hub back wheel motor and has a carrying

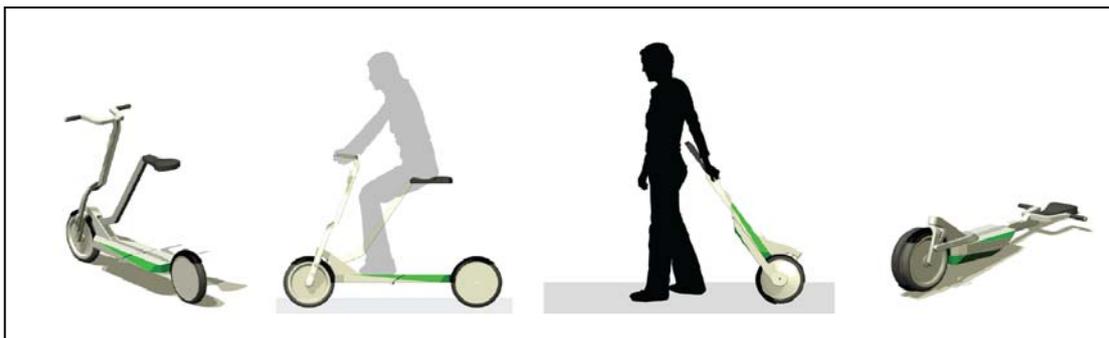


Fig 5: Link, personal mobility system with modular features

capacity of 100kg. It has two driving positions, one is standing and other is sitting. This vehicle does have the potential and features to extend persons mobility to any destination and combine with any other travel mode (Beella 2007).



Fig 6: Jack integrated with EV for the last mile

4.3. Mobility-on-demand systems

Mobility-on-demand systems provide stacks and racks of light EVs or bicycles at closely spaced intervals throughout a city. When one wants to go somewhere, need to simply walk to the nearest rack, swipe a card to pick up a vehicle, drive it to the rack nearest to your destination, and drop it off (Mitchell 2008).

Users of mobility-on-demand systems have the convenience and comfort of private automobiles without the associated high cost, insurance requirements, need to refuel, service and repair demands, or parking problems. Key factors in the success of mobility-on-demand systems are the costs to users and the system latencies – that is the times needed to walk from a trip origin to a nearby stack and pick up a vehicle, to travel to a stack near the desired destination, and to drop off a vehicle and walk to the actual destination.

Well-designed and well-managed mobility-on-demand systems should be able to provide more attractive combinations of costs and latencies than alternative systems such as private automobiles, taxis, and transit systems. Management is accomplished through an innovative combination of:

- Real time, fine-grained mobility demand sensing;
- Active real time management to balance vehicle (and parking space) supply and demand and meet latency targets at sustainable cost; and
- Sophisticated use of dynamic pricing for demand management. The mathematical model used for management represents the system as a network of stacks and links, with queues (maybe zero-length) of users waiting to access vehicles and of vehicles waiting to access parking spaces at stacks, and dynamically varying latencies and prices on stacks and links.

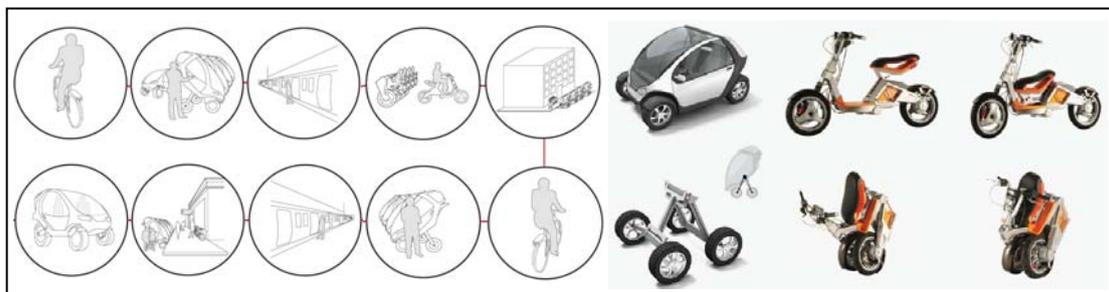


Fig 6: Mobility-on-demand system developed at MIT

5. Conclusion

HEVs and electric two-wheelers have gained a firm position in the road vehicle market and are expected to continue their market share in the vehicle fleet. The EVs position will depend up on the following factors

- Regulatory and other policy measures to overcome the barriers for large deployment of EVs
- The initial purchase price of EVs in comparison with the ICEVs and HEVs, the lesser the difference higher the penetration
- The quantity of EVs those manufacturers will be able to supply. It depends on two factors; the effect of financial crisis on proposed investments (which is the case of Th!nk) and present ICEV manufacturers financial stability

- Creation of a E-car category of itself with its advantages without the unnecessary comparison with ICEVs
- More special purpose vehicles based on EV technology
- Improvement in re-charging technologies such as ultra-fast charging in 10-15 minutes and optimal charging in 2hours of a 30kW EV
- High energy density batteries
- Development of a modular drive train for different EVs based on the requirement
- Developing the customer and travel need to suit the advantages of EVs but not the vice versa
- Creation of different typology and packaging of EV in order to facilitate new aesthetic and form appeal

We can conclude that the EVs probable arrival in large numbers and stay will depend upon largely above factors and inter relation among them.

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