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Reflections on Synergies between the Introduction of BEV's in Denmark and the Danish Energy System

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Abstract

The Danish government's new energy policy is aiming at a 50 % wind electricity by 2025 which is a major challenge for the Danish TSO[1]. The power system will have to change in many areas. System balance, market services and operational security will be challenged, and new system solutions and technologies will be needed. One of the future key measures is electric vehicles and therefore electric vehicles have an extra dimension of importance i Denmark compared to many other markets. This require a certain level of interface with the electric power control architecture. Producers of electric vehicles are advised to test their vehicles in a real 'future' environment before scaling up the production.

The Danish tax system makes it possible to sell the expensive battery electric vehicles at a fully commercial and competitive basis compared to conventional combustion engine vehicles.

To make people buy electric vehicles the ownership of BEV's can obviously be made more attractive if BEV's are allowed to park for free, will be allowed to use taxi/bus lanes, will be exempted from possible future road pricing, etc. The common understanding in Denmark is that the BEV has a great potential. This paper will give the reader some reflections on synergies between the introduction of BEV's in Denmark and the Danish energy system together with a general update on the most important activities that support the role out of EV's in Denmark.

Keywords: Fast charge, wind energy, Large scale demonstration, incentive, Denmark

[1] The Transmission System Operator is responsible for the high power transmission system energy and power balancing

1 Introduction

Electric cars will be a very important measure for the Danish Energy Systems in the transition from fossil oil dependency to a sustainable Danish energy supply.

The following statements from a couple of key stake holders in Denmark indicate the support and ambitions when it comes to the role out of electrical vehicles in Denmark:

The Danish Minister for Climate and Energy, Connie Hedegaard:

" An electrical driven car removes at least 3 times the amount of CO2 than if fuelled with renewable fuel in the fuel tank compared to the used amount of energy, thus it is proposed to implement in Denmark a factor of 3 for BEV's, HEV's, P-HEV's and electrified railways compared to renewable fuels."

Chief Consultant from Danish Energy Association:

"In 2020 we expect 20% of all cars in Denmark to run on electricity."

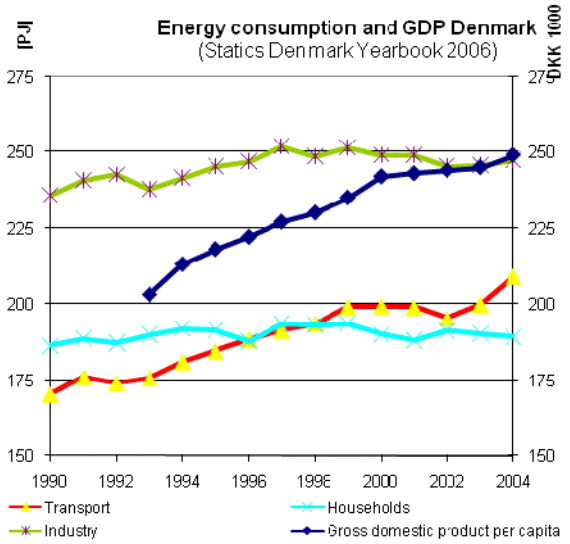
2 Renewable Energy Production in Denmark

Denmark has a lot of wind energy already and intends to get even more. The Danish government has set the target that wind energy should cover 50% of Denmark's electricity production by 2025. This paper reflects on synergies between the introduction of Plug-In Hybrid Electric Cars (PHEV)[2] and Battery Electric Vehicles (BEV) in Denmark and the Danish energy system which has to prepare for an ambitious increased use of renewable fluctuating energy.

[2] BEV is used throughout this paper as a common descriptor of both Plug-In Hybrid Electric Cars (PHEV) and Battery Electric Vehicles (BEV) since the energy storage is the central functionality requested.

3 Energy Demand in the Danish Transport Sector

The energy consumed by transportation is growing compared to other sectors in Denmark

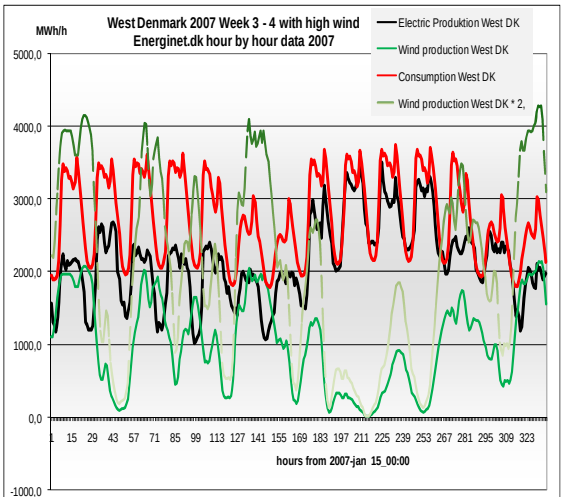


Denmark has managed to keep energy consumption stable during a long economic growth period except for the transport sector.

At the same time the oil extraction in Denmark is topping and consequently starting to decrease. We have recently seen how growing demand rapidly pushes prizes on oil up. Normally, demand and supply finds a balance but with declining supply and increasing demand the world could face an uncontrollable situation unless alternatives are developed fast. The transport segment is consequently a key challenge to be handled as it is nearly 100% dependant on fossil oil and has major impact on our environment, our climate, our energy supply, our economy and not to forget our mobility. The main objectives at a national level are to mitigate consequent fossil oil dependencies by developing alternative energy supplies and making sure that the energy is used efficiently. There seems to be no single energy supply winner to take over from fossil oil but a variety of solutions must be activated including integration of renewable energy in all energy sectors including transport. Bio fuels may offer an interim help in the transition of the transport sector but there will be strong competition for the available biomass. The biomass has to be used where society gets the best overall energy efficiency.

Denmark has no natural water resources for electric power production and nuclear power has

been avoided for political reasons. Since World War 2 most of the Danish energy had to be imported. This has resulted in an economic focus on efficient use of the energy. The consequence is that Danish electric thermal power plants are among the most efficient in the world. The overall efficiency can even be more than 90% and the electric efficiency more than 50%. This has only been possible because of a political strategy to encourage district heating in urban areas. This means that the cooling heat from the thermal power plants can be used for the heating of buildings. The demand for heat is much lower during the summer period which means lower efficiency.



With 50% of electric power coming from wind there will be many periods where the consumption is smaller than the wind power production capacity. The energy that can not be sold internationally at reasonable prices should be stored or used meaningfully.

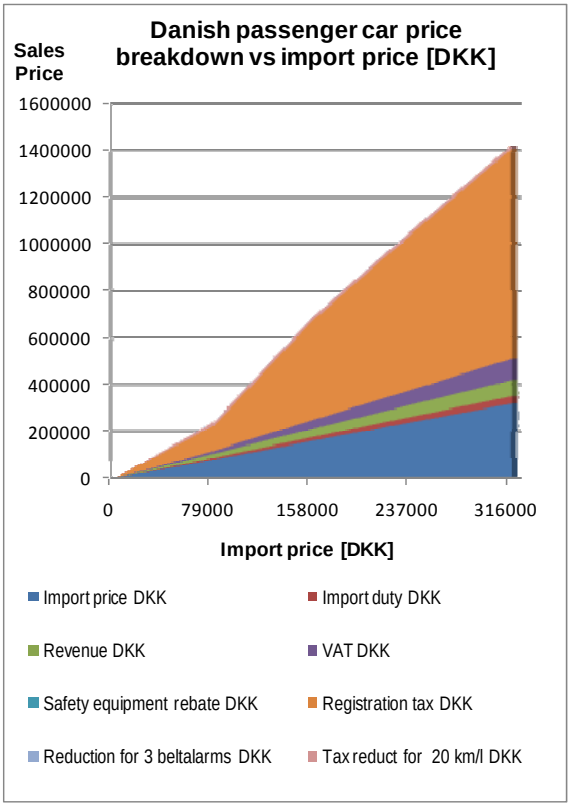
The power source for the electricity production is primary coal and natural gas but biomass and domestic waste are also very important contributors. Apart from a few central power plants located near the major cities a large number of combined heat and power plants are distributed throughout all of Denmark as is the wind energy.

Some might ask how the use of BEV's will influence our climate if the electricity should come from burning up coal as an alternative to burning gasoline and diesel. Actually, a BEV will be the more environmentally friendly alternative even if not charged with renewable energy such as wind power. The reason is that even the Danish coal fired power plants are more environmentally friendly than most other thermal power plants in Europe due to efficiency and filters. Another important aspect is that the use of fossil fuels are regulated via a European quota system which sets the limits for the emissions. This limit will not increase as a consequence of more BEV's. An increase caused by more BEV's will put pressure on the quota system which will affect the price of quota leading to an increased profitability for the use of renewable energy such as electricity from wind power mills.

4 BEV performance, availability, cost and the Danish tax policy

When fast charge intrinsically safe batteries become available with increased capacity at competitive prices the pure BEV can cover a wide range of the transport needs especially in urban areas and as such be a strong alternative to conventional transport powered by liquid fuels. One reason for this is the high efficiency combined with the obvious synergies with the electrical grid as a mean of energy storage. The ultimate battery is, however, still to be developed and international research communities should work together on this rather than compete. Research in energy storage should really have top priority in the international research programs since we have plenty of renewable energy around the world if only we could save it for later use. Energy storage is a far too important matter to be left for random investors to decide on. Regardless of the future development in the area of battery based energy storage it can be concluded that the current level of performance is now so good that the automotive industry has decided to include partly or fully electrical drivelines and traction batteries in many of their near future products. Electrical energy storage will be obligatory for future vehicles – the question is the level of hybridization and range on battery only.

The cost of BEV's are still much higher than for conventional cars due to a low production volume and expensive battery packs - A catch-22 that inhibits the industrial scale-up to bring cost down. In Denmark a political decision has been taken to remove car registration taxes from Fuel Cell Hybrid Electric Vehicles and BEV's until the end of 2012. With a world record high car tax in Denmark this is a major incentive which in most cases fully compensate the additional cost of BEV's compared to conventional vehicles.



Denmark has a very high tax on cars but electric vehicles are exempted from the registration tax until the end of 2012.

The primary problem in Denmark is not the BEV price level but the lack of suitable BEV products. The first BEV expected to be available within 2010 will be well suited as car number 2. Most owners of 2 cars often also own a private garage. The infrastructure for night time charge, home in the garage is in general already in place. Charging posts at work and shopping centers will be established when needed.

The high Danish car registration tax spurs a lot of bizarre creativity to make attractive cars cheaper. Cars for goods transport have a lower tax than passenger cars. This Audi TT 3.2 V6 coupé was attempted converted into a pick-up truck to save 45% (=43.000€)

To speed up the launch of BEV's in Denmark a BEV demonstration program have been launched via the Danish Energy Agency where 35 million DKK can be won by fleet owners over the period from 2008-2012. The program will cover some of the additional costs implied by the use of BEV's such as battery lease, infrastructure, data logging etc. The consequence of these initiatives is that a wide range of demonstration projects are either launched or under preparation in Denmark.

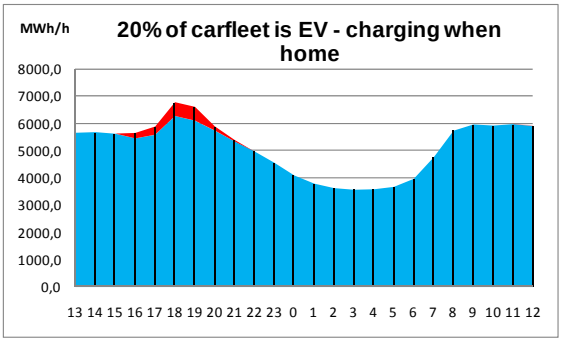
The tax exemption for the registration tax is a very strong incentive for passenger cars but more modest for professional vehicles because the registration tax is much lower for these. Vans may be competitive in short time. Anyway, the society will soon require also professional vehicles to be electric driven in urban areas to avoid pollution and dramatically reduce the traffic noise level.

5 Denmark as Test Site for BEV and Supporting Intelligent Infrastructure

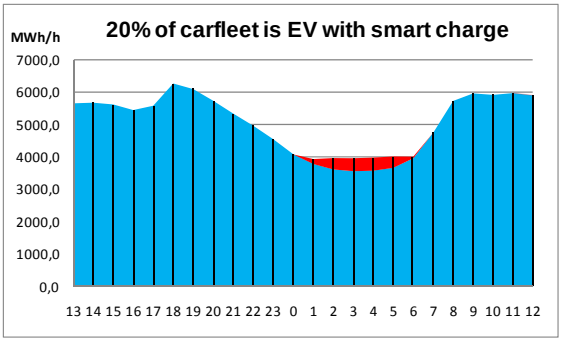
Over the last year a wide number of important actors have selected Denmark as test site for their activities within the field of BEV and infrastructure. Shai Agassi's Project Better Place has announced that its electric car scheme is set to roll out nationwide in Denmark in collaboration with the leading Danish energy company DONG Energy and with cars from Renault/Nissan. Swedish energy giant Vattenfall together with auto makers Saab and Volvo have announced their own plans to pitch into Denmark with their plug-in hybrid electric vehicles. Tesla Motors from the US have made a grand entrance in Denmark with its sleek lined, high performance Tesla Roadster all-electric vehicle and Chinese auto maker BYD (Build Your Dreams) have announced its intention to enter the Danish market with BEV and HEV models.

With the prospect of a rapidly growing population of electric cars in Denmark clever minds have started thinking of electric cars not just as a non-polluting and sustainable form of transport, but also as a significant infrastructural component for energy storage and re-release that can be integrated with the electrical grid. German industrial giant Siemens has entered into a new research

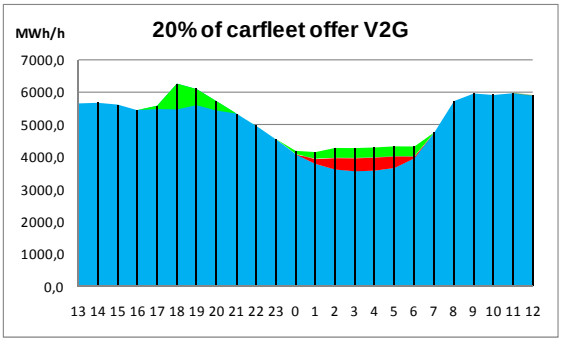
consortium, named Edison, with a number of Danish partners including DONG Energy, the Technical University of Denmark lead by Danish Energy Association. Many other projects focused on intelligent charging and vehicle to grid solutions are launched or under preparation.



If owners of EVs start charging as they return from work, it will peakload the electric system and increase emissions of CO2.



If owners of EVs use smart charging the batteries will automatically be charged at the best suitable time during the night where the load is low and prices lowest and probably also the highest share of CO2 free wind power.



Research is going on in the field of V2G Vehicle to Grid where energy can be taken from vehicle batteries and sold to the grid during peak load situations. The EV serves as a real electric storage measure.

Some projects will investigate the influence from cost of energy for the BEV and effects if it is lowered using the BEV battery as storage capacity in the Danish energy system. The BEV's are seen as an important measure both in the climate challenge and in reducing the dependency on fossil oil.

Denmark has nominated the island Bornholm as a test area for new measures needed to manage an electric power system with 50% energy from wind. Bornholm represents 1% of Denmark with respect to population, consumption and energy mixture. Electric vehicles are seen as an important measure for the electric system and as a measure that must react in a controllable and predictable way. It is therefore necessary to test and verify the performance of new electric vehicles to ensure that they can react to the control signals that are being implemented. All manufacturers of electric vehicles are invited to test their vehicles at Bornholm in an environment with a high degree of fluctuating renewable energy. The Danish population has generally a good acceptance for new environmentally friendly technology so the chance of proving a new product in a limited scale should be attractive to the car industry. Many other countries are moving towards more renewable energy and will face the same challenges in the electric system in a few years and therefore it is time to be prepared.

Additionally, the BEV is seen as a better car that runs emission free, is silent, accelerates faster, does not smell, does not spill oil and is very energy effective. On the long run it is difficult to find something that a conventional car can do that an BEV or HEV will not be able to do better. Until then the limitations on driving range will lead to the use of BEV's for short and medium driving distances such as from home to work, shopping, sports and other destinations where a driving range of >150-200 km will cover the need and where sufficient time is available to charge the batteries. To use BEV's for 8h shifts where the BEV is in frequent use will be difficult for some time to come due to lack of energy storage capacity and fast charging facilities and functionality. Replacing fossil fuel with electricity in our cars will nevertheless be a challenge where a variety of measures will have to be activated. First of all a range of sensible, safe and affordable BEV's must be available and the handling of national approvals and other measures must be included. National rescue teams must be informed and trained to handle the new technology including high voltage and high electrical energy capacity installations. And a full scale acceptance of BEV over

conventional cars will not happen until a 'Refueling' infrastructure is in place. To make BEV's attractive to the wide range of Danish citizens more transparency is needed. The change from conventional car to BEV is a large step especially if you are a non technical person with a normal or low income. Reliable information on technology, performance, safety and economy must be made available to all future potential BEV owners in addition to general information such as information about compatibility with infrastructure, charging station maps etc.

The ownership of BEV's can obviously be made more attractive if BEV's are allowed to park for free, will be allowed to use taxi/bus lanes, will be exempted from possible future road pricing, etc. The common understanding in Denmark is that the BEV has a great potential.

6 Main challenges

The main challenges for a successful changeover from conventional to electric powered vehicles in Denmark seem to be:

- Attractive prices on vehicles and energy that offset the operational short comings on range and transport capacity.
- A commercial market must exist to get commercial products available in a large scale. This market must be kick-started and maintained by tax incentives until prices are competitive.
- Temporary benefits must be implemented politically to make electric vehicles attractive. E.g. park for free, be allowed to use taxi/bus lanes, be exempted or favoured from possible future road pricing.
- Fast charging batteries and fast charge infrastructure must be developed in parallel with development of battery swap technology.
- Automatic charging interface, which will prevent the need for connecting/disconnecting charging cables twice every day.
- Smart and Reliable 'Tank-gauge' that will indicate safe range based on driving style and battery SOC+SOH analysis.
- Reliable information to customers on vehicle performance on battery operation.
- Large scale demonstration environment where new vehicles both test and verify compatibility with the future intelligent energy supply and energy management.

Don't Waste your Energy –

Have a look at Denmark.

References

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