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Nordic Knowledge Network for Electric Transport

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Abstract

Interested potential members are invited to help form a Nordic Knowledge Network for Electric Transport. A network that can deliver objective information about electric transport in connection with the electricity system to the benefit of both citizens and business communities. The Nordic countries Denmark, Finland, Norway and Sweden share the same electric grid and trade electric power at the Nordic power exchange Nord Pool. The electricity production is very different and diversified between the Nordic countries from hydropower dominated Norway over water and nuclear in Finland and Sweden to a mixture of coal, biomass and wind in Denmark. The high and increasing share of fluctuating wind energy especially in Denmark challenge the stability of the Nordic grid. Electric vehicles can become a very useful measure to the electric power system if interfaced and managed the right way - alternatively doing nothing will make electric vehicles a burden eventually.

With regard to research and development, the Nordic region will obtain a higher visibility and improve its ability to attract international cooperation if a knowledge network for electric transport is formed. The network shall: be targeted towards potential interested parties such as industrial companies, private and public institutions; deliver unbiased factual and impartial information; promote Nordic collaboration via invitations to joint Nordic development projects, sharing of knowledge and coordination; act as a focal point for transport technologies and new components; promote the use of electricity in the transport sector: optimize interaction between transport and the electricity supply systems; optimize electric transport with regard to reliability, energy, environment and economy; promote Nordic R&D in electric transport; assist Nordic organizations and industry in the area of electric transport.

Keywords: Energy, Promotion, Demonstration, Reliability

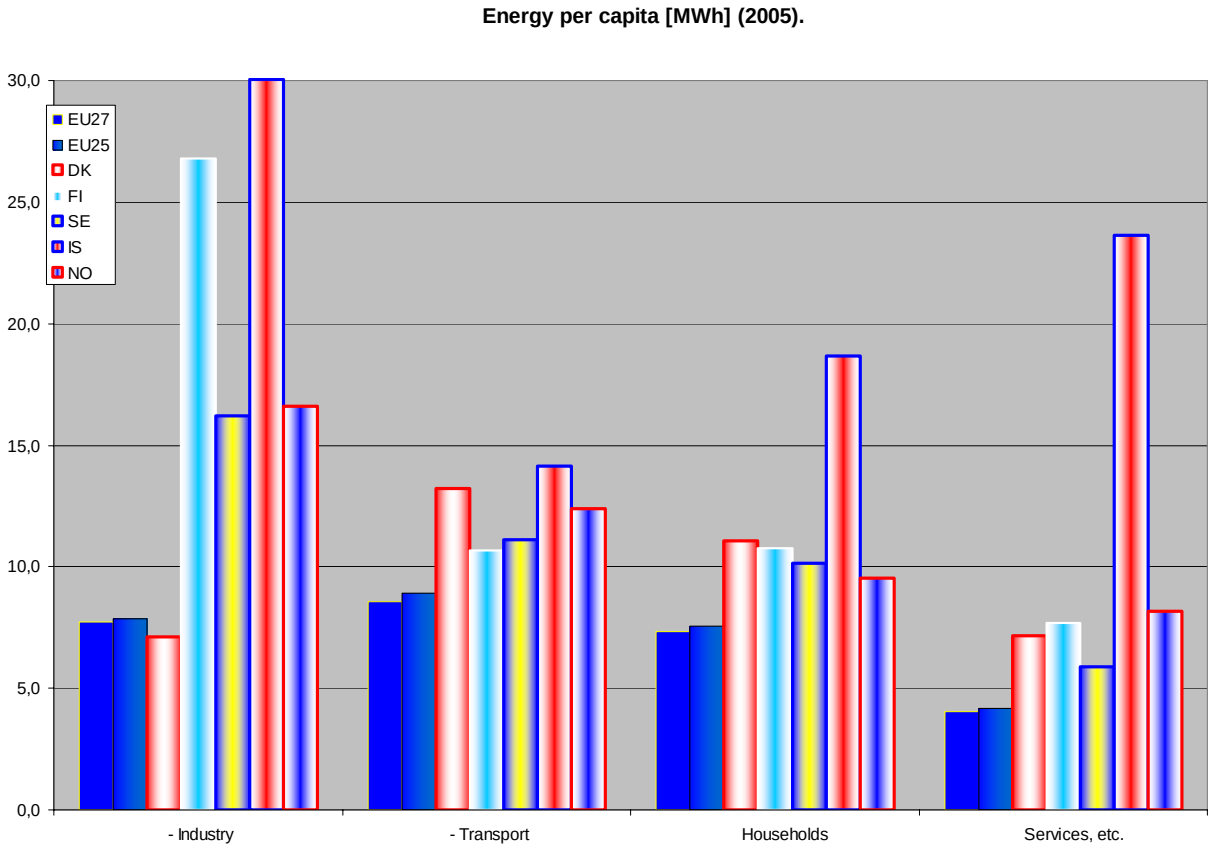

Figure 1: Energy consumption per capita in the Nordic countries compared to the EU average.

1 Introduction

The burning of fossil energy is a matter of increasing global concern because of its impact on the climate and because the depletion of our energy reserves – in particular oil – threatens the security of supply.

This seems as a very strong incentive for changes in the transport sector which is extremely dependent on oil and conducive to environmental problems. At present, huge amounts of money are allocated to the development of more efficient transport based on electric power which are considered one of the most attractive solutions to the above problems.

In the longer term, the energy supply systems will also be subjected to major changes as a result of requirements for increased integration of renewable energy, flexibility and reduced environmental impact. For the Nordic countries, the perspectives of this development are substantial.

The Nordic countries Denmark, Finland, Norway and Sweden share the same electric grid and trade electric power at the Nordic power exchange Nord Pool. The electricity production is very different and diversified between the Nordic countries from hydropower dominated Norway over water and nuclear in Finland and Sweden to a mixture of coal, biomass and wind in Denmark. The high and increasing share of fluctuating wind energy especially in Denmark challenge the stability of the Nordic grid. Electric vehicles can become a very useful measure to the electric power system if interfaced and managed the right way - alternatively doing nothing will make electric vehicles a burden eventually.

The Nordic countries' have a historic tradition of close collaboration in many fields and when joining forces few other regions in the world will be able to demonstrate similar knowledge about

- renewable energy sources and their integration in energy supply,
- production and the use of conventional and electric means of transport
- efficient energy utilization.

It is therefore proposed to establish a **Nordic Knowledge Centre for Electric Transport** which shall act as a focal point for new technology in transport, promote electricity in the transport sector, optimize the interaction between transport and electricity supply systems, support Nordic R&D in electric transport and not least assist the Nordic business community and public authorities in this field.

2 Background - a Global Status

Fossil energy is a limited global resource, and the use hereof contributes to global warming through the emission of greenhouse gasses. The dependence on oil suppliers is also increasing concurrently with oil wells being emptied at a global level. The transport sector is globally a very sensitive area with its large energy consumption, low efficiency and an almost 100 per cent dependency on oil. Despite increased environmental requirements for transportation means, the local environment is also burdened by and toxic fumes and particles.

These conditions are a powerful incentive for changes in the transport sector. The development of transport solutions based on electricity is viewed by many as the best alternative to solve the problems. It results in huge amounts of money being invested in the development of hybrid vehicles (HEV and PHEV) as a first stage towards electric vehicles without direct grid connection during operation. In limited parts of the transport sector, electric vehicles are already used extensively with the railroads as the most predominant example.

3 Electric Energy as Energy Carriers for Transport

In this document, electric transport is to be understood as all mobile transport platforms powered by electric energy. This may be in the form of battery/electric vehicles, hybrid vehicles (both plug-in and non-plug-in), with or without hydrogen/fuel cells, trains and busses powered by contact wire or running rail. It includes internal transportation of goods, off-road as well as road, hydroelectric and in principle also air transport. It includes individual technologies and partial systems, the means of transport as a system, and system and community frameworks, also including connection with the energy systems.

Electric energy in transport has a number of advantages in comparison with for example biofuels. These include great flexibility and the possibility of exploiting a wide range of renewable energy sources, including wind, solar, biomass, wave and hydroelectric energies. Furthermore, electricity can be distributed via the national grid and converted to means of transport with an extremely high efficiency without having to invest considerably in infrastructure.

Electric means of transport have profited substantially from the major steps of progress in control and conventional power technology during the last couple of decades. It has improved systems in the means of transport and resulted in a larger degree of freedom to select appropriate technologies, for example engines.

In particular autonomous electric means of transport (that is no direct grid connection during operation as for example cars and trucks) are, however, also facing various challenges. Meeting these challenges requires knowledge, technology and market development. In this context, the costs of key components for energy storage and energy conversion as for example battery, engine and engine control are central factors. To overcome this difficulty, development of technology and market has to proceed hand in hand to obtain an ongoing distribution of development costs.

Another key problem is that the operational range of autonomous electric means of transport - which are operated by renewable

energy - still is somewhat smaller than those operated by fossil fuels. Although the operational range will actually be sufficient for a very large part of the actual applications, limitations will still be part of the evaluation which the potential buyer of an electric vehicle has to consider. However, this problem is rapidly reduced as battery capacity and charging time have recently been improved. In particular, nanotechnology improvements are expected to lead to continued development in the future, concurrently with the decrease in specific energy storage prices. Finally a third key factor is reliability and durability of central components such as energy reserves and energy converters (e.g. chargers, batteries and engine control). An important development objective should be that the price for and lifetime of these components will match the expectations of conventional means of transport.

In addition to the qualities attached to the general function as energy carrier in the transport sector, electric transport can attain great importance in the electricity supply system. A key energy planning problem is to achieve a high coverage of renewable energy and also to accumulate green energy at night when electricity consumption is generally low. In particular, fluctuating energy sources such as wind power and solar cells require a balance of energy when present, and without making the electricity system unstable. In this case, electric transport can be an important stabilization factor via storage of electric energy in batteries.

In summary, the perspectives of electric transport are:

- renewable energy in the transport sector instead of fossil energy;
- increased energy security via substitution of fossil energy;
- reduced emission of greenhouse gasses (CO_2) via substitution of fossil energy;
- possibility of minimizing local air and noise pollution;
- possibility of promoting energy-efficient utilization of energy;
- possibility of using the means of transport as flexible consumption of power and for peak-shaving facility of electricity system;
- promote the exploitation of fluctuating renewable energy sources such as wave, wind and solar sources in the electricity system;
- improved exploitation of geothermal and nuclear electricity production during low charge at night;
- exploit electric vehicles as energy storage which are able locally to return electric power to the national grid (Vehicle-to-Grid);
- (new development potential for the business community).

4 Electric Transport in a Nordic Perspective

Acting as one region, the five Nordic countries have an excellent opportunity to assume a prominent role both at European and global levels in developing and exploiting electric transport with all its advantages of security of supply, environment, employment and economy.

The Nordic countries have a diversity of electric systems with different strengths and weaknesses which are very complementary. Although they have their own national systems, they also have a historic tradition of close collaboration and are in practice thoroughly integrated (with the exception of Iceland). Via NORDPOOL - a Nordic power exchange for trading electric power - a successful common Nordic market for electric energy has been created, joining together the countries both with regard to electricity and price. They therefore have a mutual interest in exploiting electric energy in the best possible way as it results in the lowest prices and highest predictability.

Norway, Sweden and Iceland have a very high share of hydroelectric energy. Sweden - just

like Finland - has a high share of nuclear power. As the only country, Iceland has a significant geothermal electricity production. Denmark has a very high share of combined heat and power, and with regard fluctuating renewable energy Denmark is in the special situation that its share of wind power in the electricity system was the world's highest with 20 per cent already in 2005. Denmark has thus a long and unique experience in analysing problems of how to integrate fluctuating renewable energy in the electricity system and in trying to meet the various requirements of flexibility in the electricity system. As the Danish government expects 50 per cent of the Danish electricity supply to emanate from wind power in 2025, a variety of new effective means will be required to stabilize in particular energy storage, inter alia by integrating electric vehicles in the electricity system.

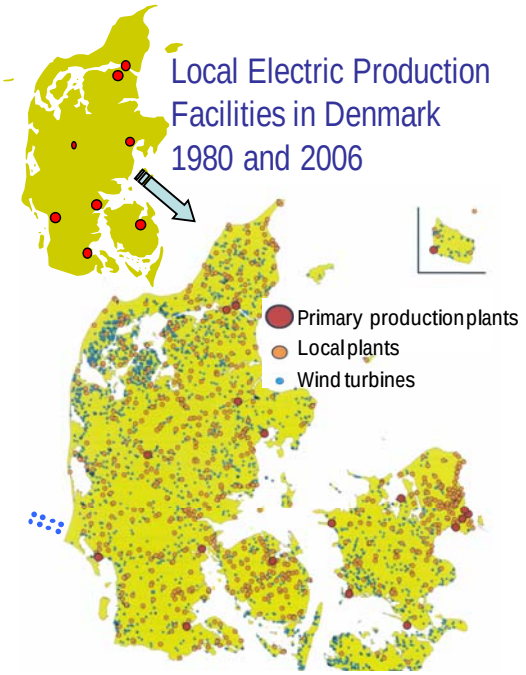

Figure2: In 25 years Denmark has transformed from central electric production to highly distributed electric generation with high share of wind energy. *Similar transition may be underway in other EU-countries* [1]

At international level - including the other European countries – energy from renewable energy is experiencing heavy growth, especially within solar cells and wind power, and many other countries are therefore approaching "Danish" conditions in different ways. Finally, Denmark has special challenges and opportunities in being the most important linkage between the NORDPOOL area and the electricity market of the European Continent.

Sweden has for years assumed the role of large-scale manufacturer of cars and trucks while the other Nordic countries have been heavily involved as sub-suppliers. Today, Norway is the leading Nordic country with regard to the integration of electric cars, and its production of new electric cars is progressing. Both Denmark and Sweden have also previously gained substantial experience with electric cars and other electric vehicles. In countries with on rail transport, this is to a large extent electric vehicles in both national and city transportation.

5 Nordic Knowledge Centre for Electric Transport

It is proposed to establish a **Nordic Knowledge Centre for Electric Transport**. The centre is expected to be able to deliver objective information about electric transport in connection with the electricity system to the benefit of both Nordic citizens and business communities. Electric transport has a new development potential for the Nordic business community with perspectives for employment, environment and economy. With regard to research and development, the Nordic region will obtain a higher visibility and improve its ability to attract international cooperation.

5.1 Objectives of the centre

The centre shall:

- be targeted towards potential interested parties such as industrial companies, private and public institutions;
- deliver factual and impartial information which is unbiased towards various technologies and decision-makers both with regard to the individual technologies and in a wider context;

- promote Nordic collaboration via invitations to joint Nordic development projects, sharing of knowledge and coordination;
- act as a focal point for transport technologies and new components;
- promote the use of electricity in the transport sector:
- optimize interaction between transport and the electricity supply systems;
- optimize electric transport with regard to reliability, energy, environment and economy;
- promote Nordic R&D in electric transport;
- assist Nordic organizations and industry in the area of electric transport.
- cooperation on standardization of control and power interfaces between the electric vehicles and the electric power grid.
- Help in building Nordic market structures for handling power interchange and auxiliary services between the electric vehicles and the electric power grid.

5.2 Focus Areas for the Activities of the Centre

Technological optimization of components to improve the energy economy is a central development issue for electric transport throughout the world. As Nordic resources are limited, taking part in the race on niche products has offered the best opportunity. For example, the Nordic region has significant competences in central areas such as power and control electronics, fuel cells, safety and environment.

The Nordic region can be among the market leaders in the area of technical optimization of electric transport systems in relation to the interaction with electricity supply and production as well as the practical handling of integrating electric transport in the market.

Another interesting possibility is to use vehicles actively as distributed electricity production plants (Vehicle-to-Grid). This would require the development of completely new control strategies and interface to grid and electricity market to in order to implement it on a large scale.

Finally, a new perspective could be to utilize the various countries' experience to analyse and test electric transport as an effective means to promote a sustainable energy and transport policy – that is to participate in national demonstration projects for electric transport.

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(In alphabetic order)

DONG Energy A/S, a state owned energy supply company producing and distributing energy in the form of oil, natural gas and electricity.

Department of Electrical Engineering at the Technical University of Denmark – DTU

The Systems Analysis Department and the Wind Energy Department at Risø DTU - the National Laboratory for Sustainable Energy at the Technical University of Denmark – DTU

Danish Technological Institute is an independent, not-for-profit institution approved by the Danish authorities to provide technological services to businesses and the community.

Dansk Elbil Komite is a committee to promote the use of electrical road vehicles.

Lithium Balance A/S, Battery Management Systems for electric transport.

ECO Consult, Specialist in assessment of environmental and energy relations.

VE-Net, a high technology network for renewable energy, managed jointly by the Danish Technological Institute and the Danish Energy Industries Federation, a part of the Confederation of Danish Industries.

Transportens Innovationsnetværk. A new Danish network focused on transport in broad terms. The network is initiated and supported by the Danish Ministry of Science, Technology and Innovation. The Danish Technological Institute is responsible for the technological coordination for land transport where Electric Transport will be one of the first themes.

References

[1] Source: The Danish Transmission System Operator (TSO) - Energinet.dk

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5 years experience with satellite electronics for battery management. 17 years with batteries, auxiliary power, and propulsion systems in trains at Bombardier Transportation. International R&D management in areas of energy storage, diesel propulsion, emission reduction and alternative fuels. Joined Danish Technological Institute in 2006 with a working focus on renewable energy and transport. Program Manager for Electric Transport since 2007.

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