



New opportunities in Sweden within road transportation

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Introduction and background

This report is written within the continuation of the project Future Climate – Engineering Solutions. In the first phase of the project participating engineering associations developed national climate plans. These were presented before the United Nation's summit meeting COP 15 in Copenhagen in the end of 2009. The second phase started in 2010 and will be finalized with a conference in London the 22nd-23rd of September 2011.

In this second phase participating organizations are asked to elaborate on the aspects *new and promising technology*, *energy efficiency* and *renewable energy* concerning some of the areas *energy production*, *industry*, *transport*, *buildings/heating* and *agriculture/waste*. The effects on new (green) jobs and emissions are to be analysed.

This report is focusing on road transportation. This is an area where Swedish engineers are involved in great measure by development of carriers, the formation of infrastructure and system solutions and the integration of information- and communication technology.

The Swedish Association of Graduate Engineers believes that Sweden has promising circumstances to be one of the countries that develop transport solutions for a low carbon society. We have the industry for cars and heavy vehicles and many subcontractors delivering products to the automotive industry. One example is within safety where companies deliver to many of the manufacturers in the world. Sweden has a rather long tradition in the field of bio-fuels and the well established forest industry can develop towards using cellulose for producing these fuels. Our production of electricity is also almost totally without fossil sources, that is hydro, nuclear and biomass/waste. The electric grid can already manage a large number of electrified vehicles and 65 percent of the households have access to a parking place with a charging possibility. This in combination with industrial knowledge in transmission and storage of electric energy make us believe our circumstances are good.

In 2009 the transport sector used 93 TWh (335 PJ) of which 85 TWh was oil products, 4,6 TWh renewables and 2,9 TWh electricity. 93 percent of the energy used for domestic transportations 2010 was for road transport. The emissions from road transport is about 10 percent higher now than 20 years ago, in spite of much more energy efficient cars. The total amount of transport has however increased during this time. The transport sector stands for 1/4 of the final energy use and 1/3 of the emissions.

The Swedish parliament has a goal of a fossil-independent transportation sector in 2030. This cannot be done without economic incentives, tougher legislation in the EU, better availability for alternative fuels, increased tax on cars with high emissions and efforts for demonstration projects and research.

Measures in separate areas need to be taken. It is regarding human behavior, development of the technology in the vehicles, alternate fuels and better planning and logistics – not least for the

transportation of goods – and information- and communication technology.

Many countries are of course involved in the development of transport technology with less emissions. Some countries are at the forefront in some areas and other countries in other areas. It is difficult to speak about being in the top of the total field of road transportation, especially for a small country like Sweden. Nonetheless, as mentioned above, we believe that we have good possibilities to be one of the important players in the development of road transportation for a low carbon society.

Development of conventional technology

The cars used in Sweden are relatively large and energy-consuming compared to other European countries. However, from 2009 to 2010 the average consumption decreased from 6,7 l/100 km to 6,2 l/100 km. This reduction corresponds to 70.000 tons of CO₂.

By improving the cars performance when it comes to air and rolling resistance, engine control, power-steering, gearbox friction, changed transmission, automatic engine shut-off when standing still and battery charging when breaking, Volvo has managed to improve their conventional diesel private car quite substantially.

Sweden has good knowledge concerning internal combustion engines, even though only a small part of the development is taking place here. This engine can still be more energy efficient with less emissions of particles, nitrogen oxide and carbon dioxide. There might still be a potential of 50 percent savings for private cars and 20 percent for heavier vehicles. To some extent this means that in the near future, diesel cars can compete with hybrid and electric technology. However the advances in the further development of established technology can for even greater advantages be combined with hybrid technology.

There are no clear signs that less heavier materials, such as composite, are going to be used in the near future. This is an area where much development still remains to be done even though such materials have been used for aircrafts for some time.

Bio-fuels

The use of renewable motor fuels is constantly increasing. The increase between 2009 and 2010 corresponds to a decrease in emissions of fossil CO₂ by 100.000 tons. In 2009 the 4,6 TWh of biofuels was divided as 2,3 TWh ethanol, 0,4 TWh biogas and 1,9 TWh FAME. Ethanol is used for buses and E85 as well as for low-admixture in petrol. During the last two years it was sometimes more expensive to use E85 than petrol in flexi-fuel cars with the result that E85 was used in 60 percent of the occasions. Gas is used in small proportions but it is increasing every year and most of all for buses, where 1/5 of the registered buses in 2010 were gas buses. The gas consists of 60-65 percent biogas and the rest is natural gas. FAME in Sweden mostly consists of RME (raps-methyl-

ester). As for ethanol it is used both for admixture in various proportions in diesel and as a pure fuel. In addition it can be mentioned that the total use of petrol, diesel and ethanol has decreased somewhat the last year for personal transportation whereas the usage of gas has increased a lot. In the case of cargo transport petrol is decreasing but diesel and gas are increasing.

Bio-fuels are under debate. Since production in many parts of the world is increasing dramatically, a number of threats appear that needs to be handled: landuse in competition with food-production, illegal cutting of forests, diminishing rainforests, pesticides, eutrophication, unsustainable wateruse or high use of fossil energy to produce the bio-fuel. Therefore it is positive that the EU now is developing a certification system for the production of biofuels.

Sweden possesses long since great know-how in bio-energy. As more than half of our area is forest-covered and we have a long tradition in pulp and paper production it is natural to extract fuels from biomass. Nevertheless the competition for biomass is hard since it is demanded from the forest industry for wood products, for pulp and paper, by the energy sector for electricity and heating and as raw material for fuels. Bio-energy alone cannot replace fossil fuels for transportation, it has to go hand-in-hand with a more significant use of electricity and increased energy efficiency.

The development however shows that the production of bio-fuels can be an integral part of the "bio-refinery". In Örnsköldsvik in mid-Sweden there is a pilot-facility to produce ethanol from woodproducts. In this R&D-plant they are developing processes to produce ethanol from cellulose. This region has a tradition in chemical processes and the aim is to provide knowledge and equipment when building similar plants in other places inside and outside of Sweden.

Another development going on in Sweden is to use black liquor to produce various types of fuels through a gasification process. Black liquor is a residual product from pulp production which is normally burned at the plant thus producing electricity or heat. It is however a qualitative residual that contains much energy and can be better used recycling chemicals and producing fuels for transportation. Its energy content is 14 MJ/kg which can be compared to 42 MJ/kg for oil. The total amount of black liquor produced in our pulp and paper plants corresponds to 40 TWh annually.

A pilot facility is situated in Piteå in northern Sweden at Europes largest pulp mill, Smurfit Kappa Kraftliner. Here the company Chemrec produces different products from the black liquor. The project has been financed by the energy agency, an environmental foundation and the industry. Other participating partners are research institutes and technical universities.

Since the infrastructure for producing pulp and paper is already at hand the process of producing biofuels from black liquor has good opportunities to compete with oil at large scale without depending on subsidies. The mills must however compensate for the energy that the combustion of the black liquor is producing today. This can be done by using logging residues.

The gas produced consists of carbon monoxide and hydrogen gas. These can be reprocessed to biomethanol, BioDME, synthetic diesel or pure hydrogen gas. Lifecycle analysis indicates that the reduction in climate gas emissions can be as high as 95 percent compared to fossil fuels. In the autumn of 2010 the first heavy trucks started filling up BioDME from this facility.

Hybrid and electric vehicles

Volvo had some early experiences with hybrid technology but then a long time passed before they tested the technology again. Together with the energy producer Vattenfall they have formed a company that has made a hybrid car that can be driven on diesel, electricity or using both. The front wheels are driven by diesel and the back wheels by electric motors. If the distance is planned to extend 50 km the car chooses disposal of the systems.

Volvo has a hybrid truck where the main power source is a diesel engine that works on either conventional or bio-diesel. It is supplemented with an electric motor that mainly is used when starting off, during acceleration and idling. When the diesel engine operates it recharges the batteries. This is also the case when the vehicle is retarding.

Pure electric cars will in the near future be limited to distances below 100 km before charging is necessary. This is however fully enough for most daily commuting. It can be a good alternative as a second car for many families. Apart from the distance the performance of the hybrid or electric car is just about similar to one with combustion engine only. Volvo has a pure electric car on the market and SAAB has in co-operation with a specialized company developed an electric car that has not reached the market.

Battery technology

The cost and performance of the batteries continues to be the main obstacle. Other problems that need to be handled are that performance must not be too much worsened by repeated charging and the batteries capacity in cold climates. Most of the effort today is directed towards lithium-ion batteries. EU expects them to be the main alternative for the coming 4-5 years.

The American company Boston Powers is built on the work of, and managed by, a Swedish researcher. Their technology for lithium-ion batteries are basically the same as other manufacturers' but the batteries are performing very well. This has been possible through a systematic technical thinking and deep chemical knowledge.

One obstacle for the development of batteries for vehicles is the absence of the overall picture. Vehicle manufacturers have not paid so much attention on electric propulsion systems and battery manufacturers have on many occasions been focusing on other applications, such as computers or mobile phones. This is an area where small innovative companies get the opportunity to work with large established companies. However there can also be problems

as the large company already have a functioning technology and wants to go forward slowly, while the small company is in greater haste.

A new technology not yet on the market is induction which makes it possible with wireless charging. This can be placed at the garage floor for optimal convenience for the driver. There is no development going on in Sweden but work is proceeding to identify promising technology that can be brought to the market.

Electrified roads

Basically this is based on traditional trolley-bus technology. The idea is simply that since the main obstacle with electric cars has to do with batteries, why carry the electricity with you in the first place? This opens up possibilities to decrease emissions from heavy trucks by making the dependence on diesel less significant. This is an alternative to trying to move goods from road to rail, since the roads after all make transportation flexible.

A company has been established to develop technology for electrified roads. Partners in this project are companies, the transportation agency and a university. Initial funding comes from industry and the agencies for energy and transportation. The main idea is to enable for trucks, that usually works on diesel, to use electricity on certain electrified highways. To make this interesting it must be possible for the truck to just carry on while the shift from diesel to electric and vice versa is done automatically. The first step was then to develop a current collector that can manage a speed of 80 km/h. This has been completed and the next step is to build a testline. The cost for electrified roads has been estimated to 1 million Euro per km. To enable also for private cars to use electrified roads it is necessary to look into possibilities where electricity is transmitted from the road.

Challenges for the grid

The demand for power in the EU is estimated to rise by 50 percent until 2050. It is however not the increase in the use of electricity for transportation that is the main reason for this. Due to the electric engines' much greater efficiency, even a total electrification would only lead to a 10-15 percent higher demand. In Sweden it might be even easier to handle the shift since we are expected to have a surplus of electric energy in a few decades. This is of course a prediction that is dependent on political decisions. However, peak loads can be a problem.

The demands on the grid will be very different from today. Instead of having a small number of large power plants there will be a large number of plants including very small ones. The share of renewable energy will be much larger where one of the implications is a more variable feed into the grid as a result of changes in for instance the wind speed.

The smart grid cannot be described as a final state, but more like a continuing process. It is possible to see supply and demand which makes it easier to plan and give the right kind of incentives in terms of variable pricing.

At the same time as an increased number of electric vehicles provide challenges to the grid it also poses opportunities. Electric cars with batteries constitute a substantial capacity to store electric energy. This means that the car can be charged at times when the demand and price is low, but it can also supply electricity to the grid when demand is high and the car doesn't need the capacity.

ABB is deeply involved in developing technology for the smart grid, in terms of transmission, storage and automatic controlling of the power system. They have major projects in for instance Germany but are also, together with other partners, planning a completely new urban district in Stockholm, called Norra Djurgårdsstaden.

Politics, incentives and behaviour

There are a vast variety of possibilities to help and hasten the desirable development through regulation and taxes but also by stimulating research and development. As mentioned in the beginning the Swedish parliament has agreed on a goal of a fossil-independent vehicle sector in 2030. Based on this the energy agency has announced a new program for electric vehicles. The main purpose is to investigate barriers for a large scale introduction of electric vehicles on the market, including a wide distribution of charging poles. This program has mainly a user perspective and thus complements more traditional R&D-programs.

Financing programs of this kind is necessary to start the process of industrial development towards a low carbon society in larger scale. This is often done in the form of public-private partnerships. Public procurement in the form of innovation driven procurement is a good way for the public to have a role in the development of new technology as a demanding and long-term client. Innovation driven procurement is a natural tool in the area of green technology since it gives the public an opportunity to act as forerunner at the same time as stimulating sustainable solutions.

An example is the joint procurement between the City of Stockholm and an energy company with the goal to increase the number of electric or hybrid vehicles with 6.000. 300 companies and organizations are interested in participating. The procurement gives them an opportunity to buy environmental cars cheaper at the same time as technology is developed.

For individuals there is a bonus when buying an environmental friendly car. This is suggested to be raised to 4.000 Euros for cars with the least impact on the environment.

We will also see the development of "mobility services" in the meaning that you don't have to own a car but rather rent it when needed. As an alternative it will be possible to own the car but have the battery exchanged and charged by a service company.

Also information- and communication technology plays a fundamental role in the transition towards a more dematerialized and sustainable society. Technology to replace travelling and bridge distances is already at hand. The availability of public transport can increase with information technology. Cargo transport can become more effective with better logistics and co-ordination.

Conclusions

There is no question about the development going in the direction of more environmental-friendly vehicles with less impact on the climate. The only question is how fast things will change. In the shorter perspective we will see a broad development with more effective conventional vehicles, bio-fuels of various kinds, electrified vehicles and services providing transportation in a more resource-economic manner. Since the amount of traffic is growing, not only in the developing world but also in the EU, this will however only be enough to stabilize emissions on present-day level.

In a longer perspective fossil fuels will be shifted out, focus will be on those bio-fuels that can be produced in an effective way with low input of energy and limited influence on agriculture, electricity will take an increasing part of transportation in different ways and societies will be better planned to enable different kinds of energy efficient transportation.

It is also evident that the technical development that will enable this already is going on in many countries all over the world. We believe that Sweden has good possibilities to be one of the countries that leads the technical and infra-structural movement towards fossil-independent road transportation. We have the car and heavy vehicle industry as well as a large number of subcontractors, we have knowledge about bio-fuels and a long tradition in forest industry, our electric energy is produced with low climate impact and we are good at smart grid technology. Both politicians and people in general have reasonably good knowledge and a mind to contribute.

It is very difficult to try to foresee the number of new (green) jobs that can emerge from this evolution. Countries that are successful will create thousands of new jobs, although in some cases they can't solely be referred to the transportation sector. In Sweden there are also threats, mainly because of the uncertain future for SAAB Automobile. If things don't resolve a number of subcontractors will also have problems. If the competence in the transportation sector is handled well, our prospects however are very good.



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