Shift
Sustainable Horizons in Future Transport

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Prospects for low-carbon options
for on-road freight transport in the Nordic countries

Authors: Mats-Ola Larsson, Julia Hansson,Kenneth Karlsson, Raffaele Salvucci and Martin Hagberg, WP1 and WP2 Shift

In studies funded by the Nordic Energy Research project Shift and the Swedish Transport Agency, researchers at IVL Swedish Environmental Institute and DTU, the Technical University of Denmark, have investigated low-carbon technology-based alternatives for on-road freight transport and the likelihood of these becoming reality in the Nordic region by 2030 and 2045/50, respectively.

The studies have evaluated different scenario settings and which solutions might be suitable for different types of freight distribution. The alternatives for on-road freight transport include hybrid and battery-powered electric vehicles, fuel cell vehicles, vehicles powered by biofuels or electrofuels as well as electric road systems.

Biofuel usage can be ramped up comparatively quickly, but the global resource base is limited. An electric vehicle breakthrough is imminent, although it is difficult to foresee which solutions will come to dominate the different transport segments. Hydrogen and electrofuels may represent alternatives in the longer term, but here the trend is more uncertain.

Key findings

- It is possible to drastically reduce Nordic transport GHG emissions to 2050 but strong and immediate actions are required.
- Biofuels are the easiest and fastest way to reduce the climate impact of on-road freight distribution. Globally, however, there is a considerable yet limited amount of sustainable biomass resources and demand for these is on the rise in other sectors.
- A large share of on-road freight transports will be electrified. So far, in particular battery electric vehicles for local distribution, are developed and implemented in the Nordic region. But also electric roads might become a large-scale option. In the longer term, fuel cell vehicles in certain regions and niches may also grow to great importance.
- Decarbonizing Nordic freight transport will require large amounts of low-carbon fuels and electricity. In the mid-term for on-road freight mainly in the form of biofuels while in the long-term also through electrified options and/or hydrogen. All these options need policy support.
- Actors involved in vehicle manufacture, fuels production, electricity distribution, service delivery and aftermarket platforms are interdependent. A host of new collaborations and standards are needed to support a transition to climate-neutral vehicles.
- Measures supporting technological transformation and fossil-free freight transport must be implemented across the Nordic region.
- A better understanding of stakeholder preferences may improve the design and implementation of policies.

Nordic Energy Research

Technology and politics determines the future

When it comes to goods transportation by road, there is a considerable discrepancy in all Nordic countries between carbon dioxide emissions and the commitments made to reduce them. Both technological innovation and low-emission fuels must be encouraged.

Which factors will be crucial when different climate-smart alternatives compete for market shares? This will be determined by the interaction between political decision making, technological development, availability, potential for scale-up and the strategies of vehicle and engine manufacturers and the fuel industry. Vehicle buyer's perception of the advantages and disadvantages of various options may also play a significant role. Our studies are based on a wide range of criteria and cost optimization and have analysed a wide selection of aspects and actors, which has enabled us to identify some of the most important factors.

Options and scenarios:
Low-carbon on-road freight transport

Climate neutral fuels

Biofuels are the easiest way of reducing the climate impact of road transport. Large-scale production of renewable fuels to replace fossil diesel in conventional and modified engines has already taken off and may increase comparatively quickly. In Europe the commercially important fuels are biodiesel (HVO and RME) and ethanol. In Sweden, biogas plays a role in certain niches. If usage is to increase, new instruments and expanded production capacity are needed. Some of today's biofuels are climate-efficient, others not. Stricter requirements must be imposed to improve climate performance.

But in a global perspective, bio raw materials cannot be sustainably harvested in sufficient quantities to satisfy all needs. The amount of bio-resources that can be used for fuel internationally is uncertain. Only a small portion of global fuel usage can be replaced by biofuel alternatives if these are to be produced sustainably. At national levels, however, there may be more resources available. Demand for biofuels may decrease as the combustion engine is challenged by electrical solutions. An increased demand for biomass is expected by the chemical, construction and energy sectors and as well as shipping and aviation.

Electrofuels are chemically identical to biofuels. They can be produced from renewable electricity and a climate-neutral carbon source, such as flue gases from bio power plants. Due to the current limited production, it is difficult to assess if electrofuels will be competitive for road transport. Also, the shipping sector is interested in electric solutions and electrofuels.

Battery-powered electric vehicles

Battery electric vehicles are few when it comes to heavy trucks, but the supply of models is growing. They have many advantages, such as lower noise level at moderate speeds, but primarily the potential to be cheaper than combustion engines due to high energy efficiency. The limitations are in the batteries: expensive (but prices are falling), with short range and long charging time (can be improved in the long run). The market for light distribution vehicles powered by electricity is developing rapidly. However, it is largely smaller vehicles for regional freight distribution that have reached a commercially viable level. But electric technology for heavier trucks and long haul is advancing rapidly, and battery prices are falling.

Electric vehicles can also be fitted with overhead lines or rails enabling them to run on electric roads, with fuel cells driven with liquid hydrogen, or in combination with an internal combustion engine. Battery powered electric vehicles in combination with range extenders are more expensive but much more flexible.

The development will benefit from the vehicle industry promoting new business models to finance the expansion of the charging infrastructure for trucks and also to press battery costs. Public actors may be needed to support expansion of the charging infrastructure. The manufacture and recycling of batteries will become increasingly important. Access to rare materials, inefficient battery production or poor recycling could slow development.

Electric vehicles with fuel cells

A fuel cell vehicle converts a fuel (usually liquid hydrogen) into electricity. The tank requires a similar refuelling time as a diesel engine vehicle and delivers approximately the same distance range. The fuel cell may also function as a range extender, complementing a battery. Fuel cells have better energy efficiency than combustion engines, but not as good as batteries and electric roads.

The best outlook for commercial breakthrough is probably to be found in local and regional freight distribution. Hydrogen distribution can be developed in the market without requiring large-scale expansion.

Although fuel cell technology is advancing rapidly, it has not yet got a commercial breakthrough. It is not clear what role it will play in the future. Fuel cells driven with hydrogen can in the long run become an increasingly realistic complement or alternative to batteries.

Many interdependent actors need to scale up to a commercially viable level at roughly the same rate. The interaction includes producers and distributors of hydrogen, fuel cell and vehicle manufacturers, and not least users.

Electric road systems

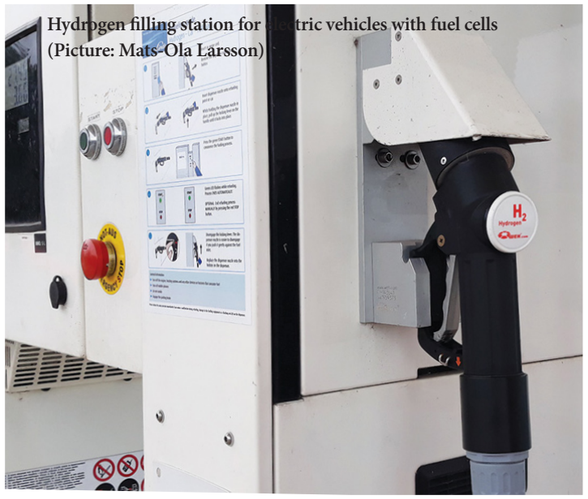
Electric roads supply electric power to vehicles. It can either be via overhead lines (as railroads), in-road conduction from rails or wireless electromagnetical induction embedded under the road surface.

All electrical road technologies have great potential as they reduce the need to store electricity on board. There are no commercial electric roads today, but some countries are preparing on a pilot scale. The specific technical solutions are uncertain, but electric roads will probably be of importance within a decade as yet another way of mitigating climate impact, provided that electricity and raw materials are sourced in a climate-neutral way.

The biggest challenge is funding. The build-up phase is costly, while a large number of users are needed to provide profitability at later stages. Decisions to expand the first networks with electric road systems need to be made before investors are able to assess the interest of the automotive industry and buyers.

It is likely that public actors will need to co-finance or procure the infrastructure. New business models may also be required for purchasing and owning vehicles, and for paying for electricity and infrastructural costs.

Truck from Volvo driven by liquified biogas. (Picture: Volvo)



Hydrogen filling station for tric vehicles with fuel cells (Picture: Mats-Ola Larsson)

Electric road with overhead lines. Scania's and Siemens' project outside Gävle, Sweden. (Picture: Scania)

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Possible scenario for on-road freight transport technologies 2030 and 2045/2050.
Prerequisites: National and international policies make an effort to change road transports to achieve fossil freedom as quickly as technology shifts allow, and all concerned parties act accordingly.

Freight	Market in 2030			Market in 2045/2050		
	Local	Regional	Long-distance	Local	Regional	Long-distance
Electric road systems			?			
Biofuels						
Battery vehicles						
Fuel cells	?	?		?	?	??

Up to 10 per cent of transports may come to utilize this technology
At least 10-20 percent of transports may come to utilize this technology
? Very uncertain prognosis
?? Extremely uncertain assessment

Nordic scenarios

The Nordic TIMES model, developed in the Shift project, covers all sectors of the national energy systems in Denmark, Norway and Sweden, including power and heat, industry, service, residential and transport as well as relevant connections and interactions. Scenarios to year 2050 is studied with a cost-optimization approach. Onroad freight transport is described by the selection of fuel and vehicle technology options described above, e.g. including biofuels, electricity and hydrogen as well as electric vehicles, hybrids and fuels cell vehicles.The possibility of modal shift is also included.

In scenarios with stringent CO_2 emission reductions reaching net zero emissions on the Nordic level by 2050, biofuels (mainly biodiesel) are the preferred low-carbon choice in the mid-term while electrified options and/or hydrogen increase considerably in the long-term. The development in other parts of the energy system influences the on-road freight sector. Key factors include biofuel import possibilities, availability of low-carbon electricity generation, and carbon capture and storage, which support the use of liquified natural gas (LNG).

For scenario results see https://shift.tokni.com/

Policy recommendations

- Switching goods distribution and long-haul transports to fossil-free fuels requires the adoption of many international courses of action. But individual nations, actors and companies also exert great influence on local markets.

Examples of such measures are that political actors demand that a gradually increasing proportion of new sales within the EU is made up of rechargeable or biofuel vehicles. Taxes on vehicles and fuels can steer more clearly towards climate-neutral solutions, also for the shipping sector. Quota or reduction systems can be used to leverage a gradually increasing proportion of renewable components in fuels. Standards and support can be designed to accelerate new technologies. Electric road systems, charging stations and other infrastructure may need to be procured or partially financed publicly.

- Transport buyers can demand a climate-smart approach to transport. Public actors can impose procurement requirements on new technologies. Vehicle manufacturers, fuel manufacturers, electricity distributors and financiers need to develop new products, develop new business arrangements and collaborate with new players.

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Contact

Julia Hansson
IVL Swedish Environmental Research Institute
e-mail: julia.hansson@ivl.se
phone: +46 –10 788 66 51