Shift
Sustainable Horizons in Future Transport

Shift Policy Brief
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Examining the nature of technological change

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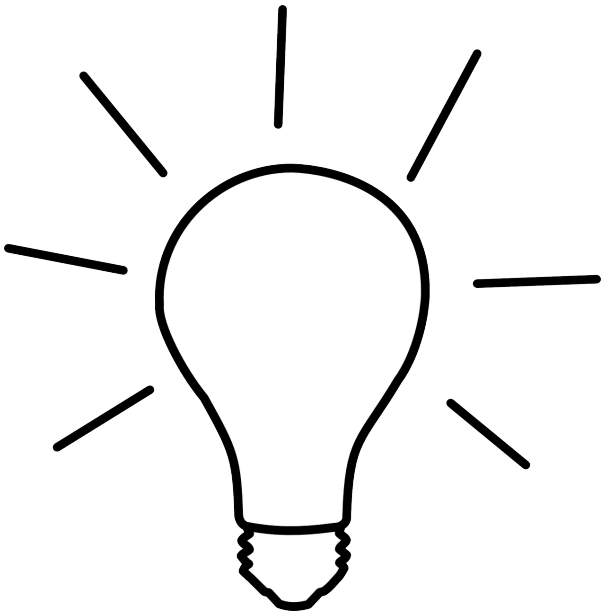
While greenhouse gas emissions from non-transport sectors fell 15 percent between 1990 and 2007, transport emissions increased by 33 percent over the same period and currently accounts for around 40 percent of CO_2 emissions from Nordic countries.

Several measures and initiatives to decarbonise transport have been introduced in Europe and in the Nordic countries over the years. This report focuses particularly on new vehicle and fuel technologies but it also deals with other transport innovations which can contribute to a shift to cleaner modes of transport, such as mobility as a service and autonomous vehicles.

The analysis considers how policy has mobilised key resources for low carbon transport innovations in the Nordic region and how the different technologies and fuels have developed. We look at six different innovations, technologies and services described with a TIS-approach - Technological Innovation System - which explains the nature and rate of technological change. It is an analytical framework for examining interlinking key functions for the development and diffusion of a new technology.



Key findings

- The development and potential market uptake of transport innovations relies heavily on the acceptance of new technologies.
- If the dynamics of an innovation systems doesn't work well, it can be due to problems with either the system elements or the system functions.
- Identification of systemic problems can be helpful for politicians to formulate strategies and to use tools to remedy malfunctions in innovation systems.

Nordic Energy Research

Background:
The systemic setting around new technlogies

The Technological Innovation System concept was developed to explain the nature and rate of technological change. A TIS analysis focuses on system elements and system functions.

There are four types of system elements:
Actors: individuals, organizations, networks, NGO's, companies, governments, research institutions.
Institutions: habits, rules, norms and strategies.
Interactions: networks and individual contacts.
Infrastructure: physical, knowledge and financial.

The functions in innovation systems refer to a set of activities that are key to the development and diffusion of a given technology. If the dynamics of an innovation systems doesn't work well, it can be due to problems with either the system elements or the system functions.

Thus, identification of systemic problems can be helpful for politicians to formulate strategies and to use tools to remedy malfunctions in innovation systems. The TIS-approach can also be used to analyze if and how technologies are related and interact - how synergies and conflicts can arise between technological systems.

The development of a new technology can be slow or fail because important actors are absent or due to lack of competence or, because specific institutions are not in place or not able to support the new technology. It can also be due to lack of interactive learning, trust etc, or to lack of resources.

Technologies may compete in markets and for resources, they may complement one another or be neutral to one another. A new technology may also benefit from the existence of an older technology, sometimes at the expense of the older technology. Finally a new technology can be locked out via the existence of an older technology.

Since the innovations studied in this analysis are in different development states - some are still in its testbeds while others are already on the market - not all functions are relevant to analyse for all technologies, fuels and services.

The analysis includes the following transport technologies and innovations:

- **Electric vehicles**
- **Electric road systems**
- **Hydrogen vehicles**
- **Biofuels**
- **Autonomous vehicles**
- **Mobility as a service**

The analysis of all functions in the innovation systems are carried out only for three of the transport innovations - electric vehicles, electric road systems and biofuels. These represent either partly developed technologies and/or they are already introduced on the market.

This is particularly so for electric vehicles and biofuel, whereas electric road systems are still in their infancy and subject to pilots and tests. For hydrogen vehicles, autonomous driving and Mobility as a service there are still not much sign of market formation or any substantial mobilization of resources.

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Findings and conclusions

Sufficient resources are necessary for transport innovations to develop and be commercialised. Most innovations are depending on support from public funding and efforts from relevant industries. All transport innovations and research projects mentioned in this study rely on public funding. The international car industry is also heavily involved in the development, particularly in the testing of autonomous driving.

The development of the technologies and fuels mentioned in this study are all influenced by national and international policy regulations. All Nordic countries have also established climate targets and introduced fiscal incentives which promote the electrification of cars or cars which use hydrogen or biofuel.

The development and potential market uptake of transport innovations relies heavily on the acceptance of new technologies. Electric vehicles seems to have climbed high on the legitimation ladder together with biofuel, although the last one still suffers from the food vs fuel controversy. Main technological barriers related to vehicle electrification is on-board energy storage, range, battery technology and charging infrastructure. Other barriers are related to price, energy sources and raw materials for batteries.

Both electric road systems and autonomous vehicles have still to prove its functionality and operability, whereas hydrogen must overcome technological barriers particularly related to the infrastructure.

Real market formation can so far only be traced for electric vehicles and biofuel. There is no commercial market for electric road systems or for hydrogen cars. Autonomous vehicles are in an early test stage and Mobility as a service are at the present being primarily ideas rather than realities, though interesting experimentation is taking place.

Autonomous vehicles and Mobility as a service are however regarded as innovations that will radically transform the transport system. The Swedish car industry currently carries out several pilots for the development of electric vehicles and electric road systems, in cooperation with Nordic research institutions. Likewise, pilots also take place for autonomous vehicles and mobility services where both private companies and public transport operators are involved.

Entrepreneurial experimentation takes place via tests and demonstration projects for all transport innovations. As of now, this study finds there are several possible pathways to a more sustainable transport system in the Nordics countries related to innovations in technologies and fuels and to new mobility services.

References

Decarbonising the Nordic transport system: A TIS analysis of transport innovations, TØI Report 1678/2019

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