How can we decarbonize road freight transport by 2030? Stakeholder-driven scenarios for the future of heavy vehicles in Sweden

Road transport accounts for a growing share of global greenhouse gas (GHG) emissions, and the same is true in Sweden. In 2013 emissions from Sweden's road transport accounted for 33% of its total GHG emissions, compared with 28% in 1990, and road freight emissions accounted for 12% of the total in 2014, compared with 7% in 1990. While Sweden's GHG emissions have declined overall, road transport emissions have proved especially difficult to mitigate. The Government of Sweden has the goal of reducing GHG emissions to zero net emissions by 2045, and of achieving a fossil-fuel independent transport sector by 2030. There has been much debate on how to both interpret and reach these goals, but reductions of between 70% (SOU 2016:47) compared to 2010 are likely needed to reach long-term goal of zero net emisisons by 2045. The most recent trend since 2010 for road freight CO_2 emissions is positive (fig. 1). While increasing the use of biofuels, blending biofuels in diesel and petrol, and improving energy efficiency are all making contributions, the sector activity is tightly coupled to economic activity, and climate efficiency in terms of emissions linked to transported goods remains poor, and the challenges involved in reaching the 2030 and 2045 targets remain substantial.

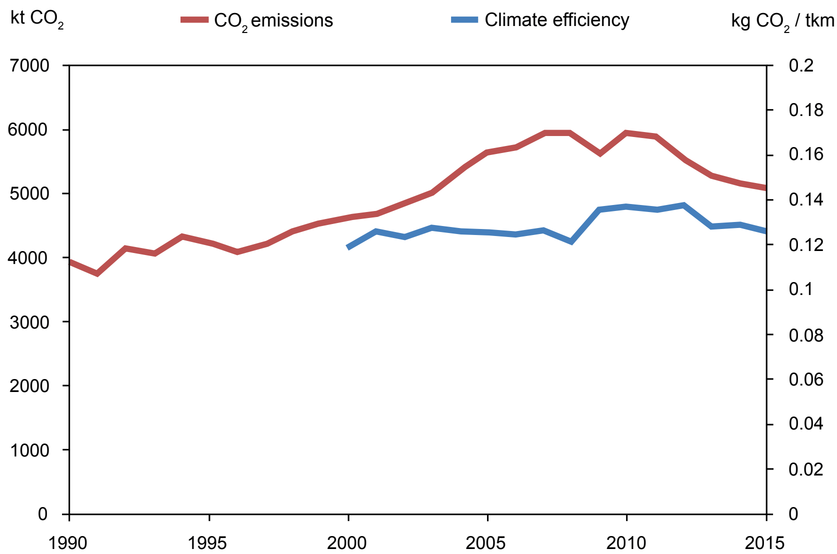

Figure 1: Carbon dioxide (CO_2) emissions from Swedish road freight in kilotons (1990 to 2015) and climate efficiency in terms of emissions per tonne-kilometre of freighted goods (2000 to 2015).

Source: Swedish Environmental Protection Agency and the Swedish Agency for Transport Analysis

Biofuels have long been seen as the most effective option for achieving Sweden's goals for road transport, but electrification is emerging as a key solution, and both sets of technologies are now considered important by Swedish policy-makers (SOU 2013:84). In the personal vehicle market, a faster-than-expected decline in the cost of batteries has made electrification increasingly feasible.[1] Both battery electric vehicles and plug-in hybrid electric vehicles are viable near-term options. Together with longer-term solutions such as hydrogen fuel cells there is a range of options for fuel switching and efficiency improvements in cars. However, a decarbonization pathway for heavy-duty vehicles and road freight is less clear. Freight vehicles demand much more energy than cars, and in general there is much less research on transitions to a more sustainable road freight transport system.[2]

This brief introduces an ongoing case study and participatory research process that explores scenarios with different combinations of technologies for lowering GHG emissions from road freight transport in Sweden. We are inviting interested parties to contribute to our analysis in upcoming workshops, which are part of a broader exploration of opportunities for global decarbonization pathways in the EU Horizon 2020 project TRANSrisk (Box 1). We aim to analyse the benefits, uncertainties and risks arising from deep structural changes required to mitigate emissions from road freight and explore what kind of governance measures can support successful future transition pathways. This brief provides a system-wide overview of our case, and is also an invitation to stakeholders across the sector to participate and offer their feedback and insights.

Policy and technology trends

Current rapid developments in battery technology are revolutionizing the way consumers and the auto industry think about personal transport. However, electrification of road transport of goods is more challenging. Heavy batteries and long charge times have led most analyses to conclude that electrification is not a realistic option. As with personal vehicles, a switch from liquid fuels to battery electric solutions would also involve a fundamental shift in behaviour and logistics. Still, there are options and factors that could

Box 1: TRANSrisk project

The EU Horizon 2020 project TRANSrisk studies low-carbon transition pathways, focusing on how transitions can be implemented in ways that are technically, economically and socially feasible and assessing the risks and uncertainties of each pathway. SEI is part of a consortium of 12 organizations participating in the three-year research effort, which will explore mitigation pathways in 15 case studies in a range of countries around the world. The project runs from September 2015 until August 2018. For more information, visit http://transrisk-project.eu/

1 Nykvist and Nilsson, 2015

2 Berggren et al., 2015

make electrification a concrete and feasible option in the near term. In this case study we are paying special attention to an old technological solution receiving new attention: to supply continuous electricity through overhead lines or rails in the road (fig. 3). Such electric road systems (ERS) are now considered as a serious option by a range of actors in Sweden and internationally. In this case study we will investigate how a diverse set of factors, such as changing transport demand, future progress on hybrid trucks, increased use of biofuels, technology development, cost reduction of battery and fuel cells, and the development of ERS systems could be combined to reach ambitious CO_2 reduction goals.

Figure 2: Overhead catenary lines in modern trolley busses in Boston, U.S. (upper) and Karlskrona, Sweden.

Proposals to limit or even ban sales of fossil fuel vehicles from 2030 are rising on the political agenda globally. Paris and Oslo are among the first cities to ban the local use of diesel cars in the wake of "dieselgate" in 2015, when Volkswagen was found to have manipulated emissions testing for its diesel vehicles, and more manufacturers are under scrutiny. A newly proposed European Commission policy plan would phase out first-generation biofuels by 2030, signaling a clear preference for member states to meet their renewable energy obligations in transport through newer approaches, including electrification and more advanced biofuels.[3] Unlike some other EU member states, Sweden has achieved high GHG emission reductions

Figure 3: In-road conductive demonstration track at Arlanda, Sweden (upper) and overhead catenary lines demonstration track outside Gävle, Sweden.

from first generation biofuels, for example, through wheat-based ethanol that also produces animal feed as a co-product. From Sweden's perspective, the EU developments are a challenge to meeting its climate targets, because blending of first generation biofuels has contributed substantially to lowering its CO_2 emissions in recent years. Hence, even if Sweden has a large potential for both first generation biofuels and more advanced biofuels from agricultural and forestry feedstocks,[4] it is more important than ever to gather forward looking analysis and knowledge from a range of experts and stakeholders to contribute to a better understanding the role of biofuels in Sweden's efforts to reduce road transport emissions.

While ERS is both an old technology and as yet untested in large-scale applications for heavy freight, it is increasingly considered as having potential and is being more thoroughly investigated. Several test tracks and pilot projects for electric trucks using electric road systems are already under way in Sweden. For example:

3 European Commission, 2016

4 Börjesson et al., 2014

- Elways[5] is testing hybrid and/or battery electric cars and trucks with an in-road conductive solution using electric tracks built into the road (see fig. 3).

- Region Gävleborg (Gävleborg County Council), Scania and Siemens, is testing a solution with overhead catenary lines (overhead cables), very similar to those used for electric trains.[6] (see fig. 3).

- Volvo and Alstom in the EU project FABRIC[7] are testing in-road conductive technology.

- Lund University is also testing in-road conductive technology in the research project Elonroad.[8]

The systems developed by Scania and Siemens in particular are more advanced, with system prototypes demonstrated on public roads in 2016 and 2017, not only in Sweden, but also in Germany and the U.S.[9] Swedish agencies and industry partners are financing these pilot projects and supporting research jointly, and the Swedish Government has initiated international collaboration on electric road systems at the highest political level.[10] Industrial actors and universities are innovating at a rapid pace.

Finally, new factors such as rapid advances in autonomous vehicle technology complicate forward looking analysis of road freight transport. The uncertainties in both technological development as well as global and European political and regulatory developments call for a broad analysis of factors that support or hinder the deployment of each combination of technologies. And a combination of technologies is most likely to lead to a sustainable solution, so TRANSrisk will take an inclusive perspective, which will include scenarios where biofuels dominate, scenarios where biofuels continue to be an important fuel alongside electrification in hybrid applications, and full-scale transitions to electrification using batteries or electric road systems, or hydrogen fuel-cell solutions. A main task of our case study is to include electric road systems in the mix of options we consider, but forward-looking analysis of the range of different solutions to decarbonize road freight is more relevant than ever.

Developing scenarios for decarbonization of heavy vehicles

Decarbonizing road freight transport poses a huge technological, societal, entrepreneurial and governance challenge involving stakeholders from the public and private sectors. In particular, there is a need to consider the impacts and risks associated with technology choices, such as new resource dependencies (for example, lithium and cobalt for batteries) and for analysis of what developments are needed in institutions and governance to influence actors' priorities and perceptions. Hence, the project adopts a socio-technical approach to explore the necessary shifts in technology, policy, markets and society.

5 http://elways.se/

6 http://www.regiongavleborg.se/regional-utveckling/Infrastruktur/elvag/

7 http://www.fabric-project.eu

8 http://elonroad.com/

9 Tongur and Sundelin, 2016; https://www.wired.com/2017/03/running-delivery-trucks-trolley-wires-isnt-crazy-sounds

10 http://www.regeringen.se/pressmeddelanden/2017/01/sverige-och-tyskland-i-unikt-innovationspartnerskap/

Box 2: Participatory scenario development

Over the course of this project SEI will run workshops that bring together stakeholders from policy, industry and academia at the same table to help develop and refine the research and contribute to new analysis of the road freight sector.

Key benefits for participants include:

- insights from a stakeholder-driven scenario analysis of the risks, uncertainty and potential associated with different CO_2 mitigation options for road freight
- opportunities to contribute to and shape policy relevant research and analysis
- access to analysis and modelling results of possible transition pathways, and
- learning about perspectives on the interaction between technological developments, policies and decision-making roles.

This socio-technical approach combines desk research with participatory stakeholder workshops that mobilize experts from industry, academia, and private and public agencies. We will develop a set of qualitative scenarios in partnership with stakeholders that will serve as the basis for our analysis of transition pathways, and gather quantitative data from stakeholders as input to our modelling efforts, which we will carry out together with Cambridge Econometrics using the E3ME model.[11] The first part of the scenario workshop will ask the following question:

"What are the key factors that determine the plausible options for mitigating CO_2 emissions from heavy road freight?" The first workshop will analyse a long list of factors and reduce them to a shortlist to inform solutions for reaching climate goals. Along with stakeholders we will then develop a set of scenarios that depict plausible futures for road transport in Sweden. These scenarios will focus on the conditions under which a transition could take place, describing different combinations of factors that shape the future of road transport. The scenario developoment will be linked to global scenarios used by the international climate change research community.[12] By doing this we enhance the comparability and relevance of our work with other studies, and make it more likely that we can scale up any lessons learned in Sweden to the European or global level. Another reason to do this is that, as a small export dependent country, Sweden is heavily influenced by global trends.

The second step in the study is to analyse in more detail the costs and requirements for technological development for each of the scenarios. This part of the work will again combine desk research with stakeholder engagement to validate different forward-looking assumptions and provide data for quantitative modelling and analysis by partners in TRANSrisk. The resulting quantitative transition pathways will be analysed in conjunction with the qualitative scenarios

11 https://www.camecon.com/how/e3me-model/

12 O'Neill et al., In press

Fig. 4: Sweden's first fully electric truck for electric highways has fulfilled road registration requirements.

developed in the earlier phase. This will allow us to identify barriers to be overcome and what governance interventions might be needed and when, in order to realize emission reductions consistent with the national goal for 2030.[13] The interaction between the scenarios and the pathways will allow for contextualized qualitative and quantitative analysis.

Reference list for further reading:

Berggren, C., Magnusson, T., Sushandoyo, D. (2015). Transition pathways revisited: Established firms as multi-level actors in the heavy vehicle industry. *Research Policy* 44, 1017–1028. doi:10.1016/j.respol.2014.11.009

Börjesson, M., Ahlgren, E.O., Lundmark, R., Athanassiadis, D. (2014). Biofuel futures in road transport – A modeling analysis for Sweden. *Transportation Research Part D: Transport and Environment*. 32, 239–252. doi:10.1016/j.trd.2014.08.002

European Commission (2016). Commission proposes new rules for consumer centred clean energy transition - Energy - European Commission [WWW Document]. Energy. /energy/en/news/commission-proposes-new-rules-consumer-centred-clean-energy-transition (accessed 12.9.16).

Nilsson, M., Nykvist, B. (2016). Governing the electric vehicle transition – Near term interventions to support a green energy economy. *Applied Energy*. 1360–1371. doi:10.1016/j.apenergy.2016.03.056

Nykvist, B., Nilsson, M. (2015). Rapidly falling costs of battery packs for electric vehicles. *Nature Climate Change*. 5. 329–332. doi:10.1038/nclimate2564

O'Neill, B.C., Kriegler, E., Ebi, K.L., Kemp-Benedict, E., Riahi, K., Rothman, D.S., van Ruijven, B.J., van Vuuren, D.P., Birkmann, J., Kok, K., Levy, M., Solecki, W. (In press). The roads ahead: Narratives for shared socioeconomic pathways describing world futures in the 21st century. *Global Environmental Change*. doi:10.1016/j.gloenvcha.2015.01.004

Tongur, S., Sundelin, H. (2016). The electric road system transition from a system to a system-of-systems. Asian Conference on Energy, Power and Transportation Electrification.

13 Nilsson and Nykvist, 2016

This project brief was written by Bjorn Nykvist, Timothy Suljada and Henrik Carlsen.

TRANSrisk
TRANSITION PATHWAYS AND RISK ANALYSIS FOR CLIMATE CHANGE POLICIES

Published by:
Stockholm Environment Institute
Linnégatan 87D, Box 24218
104 51 Stockholm
Sweden
Tel: +46 8 30 80 44

Author contacts:
Bjorn Nykvist
bjorn.nykvist@sei-international.org
Timothy Suljada
tim.suljada@sei-international.org

Media contact:
Tom Gill
tom.gill@sei-international.org

sei-international.org
2017

Twitter: @SEIresearch, @SEIclimate