Stockholm Environment Institute

Decarbonizing road freight systems

Stakeholder-generated scenarios for deep emission reductions in Sweden

SEI policy brief
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Photo (above):
Overhead catenary electric road system being tested in Sandviken, Sweden © BJÖRN NYKVIST / SEI

Key messages:

- **Sweden's twin goals – to reduce carbon emissions by 70% in 2030 relative to 2010, and to completely decarbonize by 2045 – present a dilemma: Sweden's diesel truck transportation sector will likely have to choose between meeting near-term goals with biofuels, and pushing more heavily towards electrification options that are essential for long-term climate mitigation goals.**
- **Even though Swedish stakeholders believe that biofuels remain important for Sweden, a shift in sales from internal combustion engines to electrification of trucks will likely start in the coming decade. This means that an analysis of post-2030 biofuel use is needed – and sooner rather than later – to determine how to make this second shift that will unfold among the truck fleet.**
- **Both biofuels and electrification are important for Sweden's freight transport stakeholders; however, a push towards massive biofuel deployment over the coming decade for the 2030 goal would need to be accompanied by an in-depth discussion about how achieve the next needed transition towards electrification.**
- **These insights emerged from SEI analysis of discussions among key stakeholders, who provided up-to-date outlook on key technological measures essential to reduce diesel truck transportation emissions as part of the global effort to limit climate change.**

Introduction

Increasing transport activity goes hand in hand with economic growth (IEA, 2017), and shifting freight transport to alternatives, such as using sea or rail shipping options, has proved very difficult. Thus, a fundamental energy transformation away from fossil diesel fuel is required in any future scenario (except one of strong economic decline) that will aim to limit global warming to 1.5° Celsius above pre-industrial levels, as recommended by the Intergovernmental Panel on Climate Change (IPCC, 2018). This is the case even if exceedingly efficient transport systems are developed, with no or limited growth in freight transport (Regeringskansliet, 2013b; Trafikverket, 2016). The task of completely transitioning road freight transport to eliminate emissions poses phenomenal technological, societal, entrepreneurial, and governance challenges, focused on trucks and the energy they use, and on key stakeholders across public and private spheres.

We report here on results from a case study (Nykvist and Suljada, 2016) exploring what the future holds for the different technological measures that can contribute to reaching the Swedish CO_2 emissions goals of a 70% reduction in 2030 relative to 2010, and a complete decarbonization by 2045. The results are based on input from a broad range of Swedish stakeholders, including vehicle manufacturers, logistics companies, fuel suppliers, policy-makers and researchers. The main

research question, which was also posed to participants in our first stakeholder workshop, asked: *"What are the most important drivers influencing how we reach the 2030 and 2045 climate goals?"*

The research offers an up-to-date, forward-looking qualitative and quantitative analysis that highlights the strong underlying trends towards electrification. The analysis uses three scenarios to explore the roles of biofuels and three electrification options applicable to heavy vehicles: electric road systems, battery electric, and hydrogen fuel cells. At the same time, the results also clearly point out the growing dilemma between a) meeting near-term Swedish climate goals with biofuels, and b) pushing more heavily on the electrification options, where the latter is more critical for long-term climate mitigation goals. The trend towards electrification is viewed as central among stakeholders, and, according to our research, is likely the more affordable long-term strategy.

Results and policy recommendations

Swedish stakeholders in the transport industry now expect electrification to play a very large role in decarbonization of road freight over the long term. Scania recently released assessments showing that electrification is clearly the most cost-effective long-term strategy (Scania, 2018) During 2018, Volvo launched its first electric truck prototypes intended for series production in 2019. The use of pure battery trucks and electric road system technologies is expected to be cost competitive in niche applications by the mid-2020s. Notably, this follows the ongoing breakthrough for battery electric buses that are on the verge of being commercially competitive (IEA, 2018). A conservative estimate from our research shows that, compared to the current cost of diesel trucks, electrification can be cost competitive by 2030 for large segments of transport demand (Figure 1). Results for each technology are rather sensitive to various assumptions (such as future oil prices), but average costs to reach the climate goals in the three scenarios are remarkably similar.

It is important to note that Sweden's success in reducing CO_2 emissions from road freight by around 25% from their 2010 levels is by and large due to biofuels, which today supply around 20% of the energy for trucks (Figure 2). Until 2030, stakeholders expect biofuels to remain the most important solution.

Figure 1. Cost relative to diesel cost in 2017 across the three scenarios. Red lines represent the average cost in each scenario for all transported goods in tonne-km (tkm)

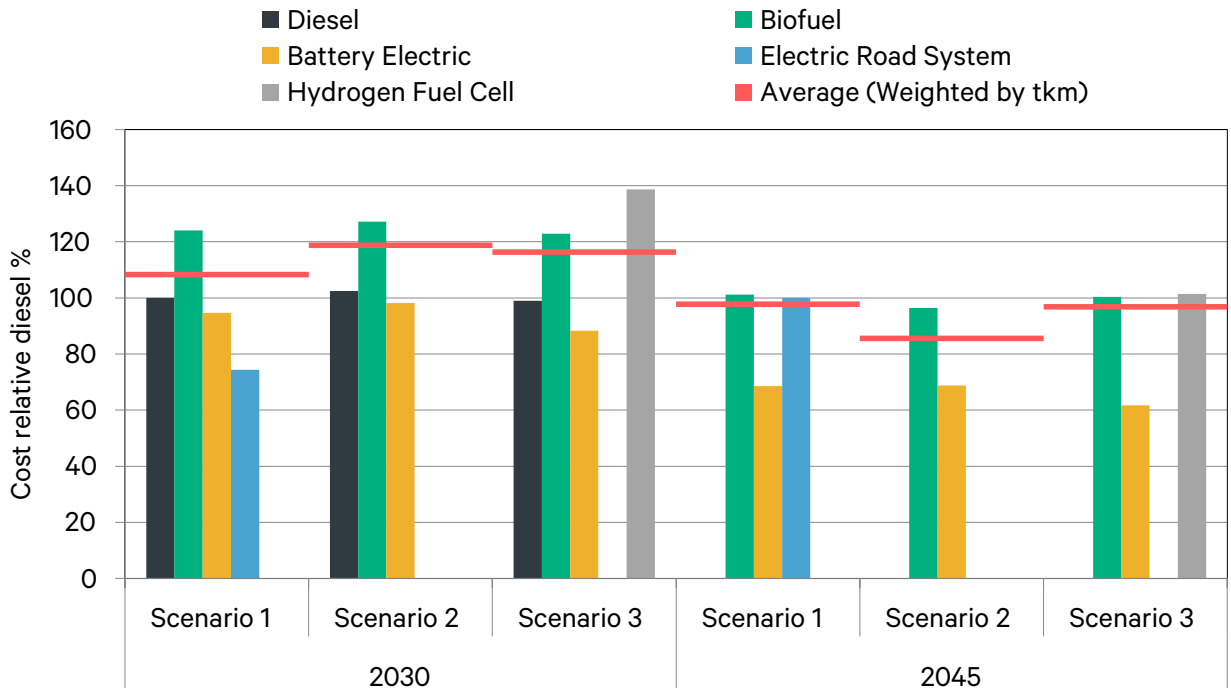
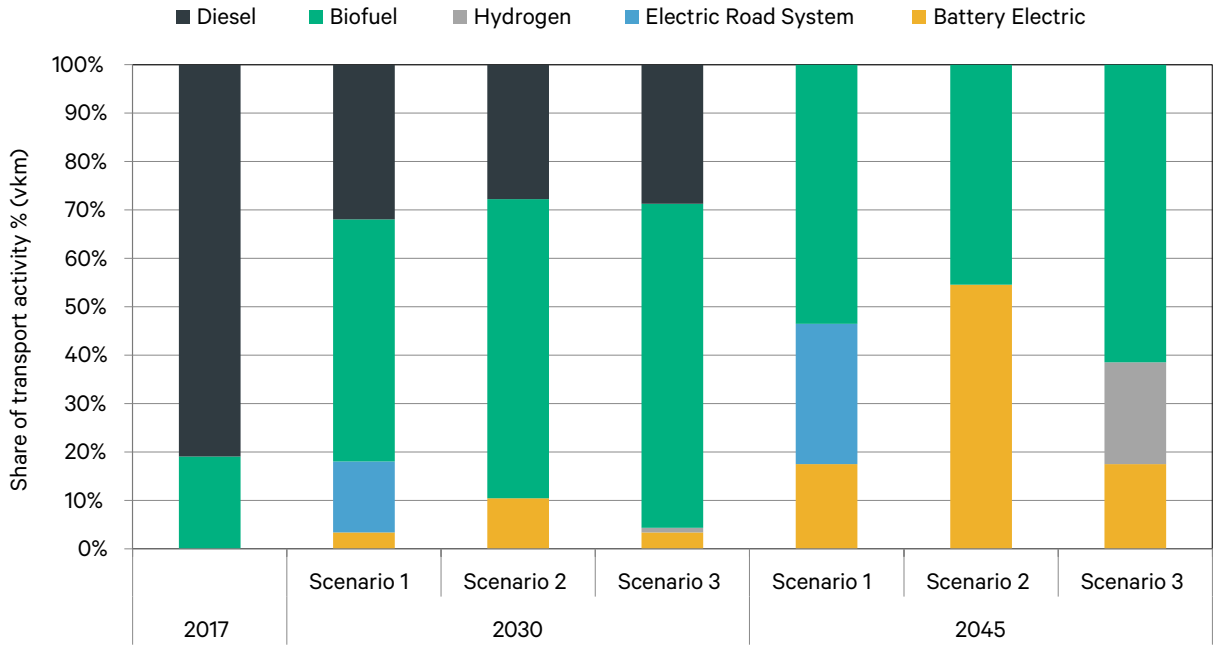


Figure 2. Share of transport activity in vehicle kilometres (vkm) across technologies in the three scenarios.



To look forward quantitatively, we developed scenarios (see boxes 1, 2 and 3) based on the qualitative narratives created by the participants in our stakeholder workshops. The core assumption for each scenario is that the level of penetration depends on which technology is feasible for a given segment in terms of both technology and cost. For example, hydrogen trucks make more sense for long distances and the heaviest segment of freight. Electric road systems are the most cost efficient for long-distance trips using the major motorways with dense traffic. But given the cost reductions in battery technology (Nykvist and Nilsson, 2015), our cost modelling finds that neither electric road systems nor hydrogen fuel cell trucks can today be expected to compete with battery trucks for short distances. However, there are actors arguing that hydrogen technology has the potential for large cost reductions, following from production volumes and growing experience as seen in recent years for Li-ion batteries, and should not be ruled out (Krogsgaard, 2018).

Combining analysis of statistics of truck usage with stakeholder input, we find that the long-term outlook (through 2045) for freight transport using electric technologies can be on the order of 40% to 50% of vehicle kilometres (Figure 2). This is about twice the long-term potential compared to the latest in-depth public inquiry on the subject five years ago (Regeringskansliet, 2013a). It should be noted that the quantifications are highly uncertain, and to some extent arbitrary, but the long-term trend is clear: expectations among stakeholders on electrification are growing.

It is, however, also clear that Swedish stakeholders generally expect biofuels to continue to play a very large role in 2045. If truck manufacturers, policy-makers, and society, jointly and at large, put in consistent and coherent efforts towards one or several of the three electrification options, high-volume sales of electric trucks can be expected by 2030. Electrification of urban delivery trucks is expected across all three scenarios, mirroring recent developments in 2017 and 2018 when manufacturers announced that new electric models were in development. Nevertheless, additional time will be needed to replace fleets, and, thus, to contribute to emissions reductions. These challenges are similar across the three scenarios. Even if the transport system is at the cusp of competitive electrified trucks in the coming five to 10 years, reaching the 2030 goal with anything but biofuels will remain very challenging. Consequently, the mid-term solution expected by stakeholders is biofuels (Figure 2).

A fundamental energy transformation away from fossil diesel fuel is required in any future scenario that will aim to limit global warming to 1.5° Celsius above pre-industrial levels.

Table 1. The 12 most important drivers for freight transportation strategies, and the levels of uncertainty accompanying them, as ranked by stakeholders.

Driver	Importance	Uncertainty
Political leadership	8	10
Policy coherence	3	11
Bioenergy policy	5	7
Local air emissions, particles, health, regulations	6	2
Driver	**Importance**	**Uncertainty**
Electrification of regional and urban distribution	5	0
Energy storage across range of applications	4	0
Renewable energy, global abundance, high access	4	0
Driver	**Importance**	**Uncertainty**
Innovativeness in industry and business models	7	6
Demand for environmental performance	5	6
Industrial transformation	5	5
Industrial opportunity	6	5
Driver	**Importance**	**Uncertainty**
Global de-facto standards	3	3

This table shows the results from an exercise ranking various categories and issues according to the level of importance, and the degree of uncertainty for future decarbonization scenarios. The numbers reflect the importance and uncertainty rankings as determined by a vote of key shareholders assembled by SEI.

Fundamentally different short- and long-term strategies

In our workshop, stakeholders contributed with around 100 individual interventions which were clustered to 25 different drivers. Stakeholders then scored the relative importance of these, leading to a set of 12 drivers with the overall highest importance (Table 1), judging political leadership, the Swedish and European Union (EU) policy on biofuels, and policy coherence as the most important but also most uncertain drivers. This creates an interesting feedback loop. One of the motivations behind research on explorative and stakeholder-driven scenarios is to develop robust policy recommendations in an uncertain future. But what if the largest uncertainty is policy itself?

Our case study finds significant tensions between biofuel-based strategies and the long-term potential of electrification. Furthermore, these tensions lead to a dilemma for Swedish climate change mitigation policy, between the goals for 2030 (70% reduction in transport CO_2 emissions) and 2045 (economy-wide, zero net emissions). To reach the 2030 goal, the robust strategy across the three scenarios would heavily incentivize biofuels to enable fossil fuel phaseout with existing fleets of road freight vehicles. But as electrification of road transport expands in the 2030s, biofuel demand is likely to rapidly stagnate and decrease; biofuel production systems will then have to pivot towards supplying new sectors, such as industry, ship transport and aviation.

Lorries parked in Operation Stack on a closed section of the M20 motorway, Ashford, UK © GAVIND / GETTY

While this development is easy to envision conceptually, it may be less feasible technically and economically. In 2018, Sweden is implementing a mandate initially requiring at least a 20% share of biofuel in diesel, with policy-makers striving to increase the share to 40% in 2030. It is by no means clear that the current development of Swedish and EU biofuels policies will enable enough biofuels by 2030. Sweden has a unique and, within the EU, heavily contested ambition level for biofuels (Kågeson, 2018). Even under an optimistic assumption on biofuel cost reductions, this technology will likely continue to be more expensive than fossil fuels through the 2030s (Figure 1). In addition, other external costs and impacts of diesel fuel, such as short-lived climate forces and local pollution, remain concerns with the use of biofuels.

Policy messages and concluding remarks

The main qualitative points in the three stakeholder-generated scenarios are presented in boxes 1, 2 and 3. Scenario 1 underscores that rather strong and concerted government intervention is needed to facilitate a rapid build-out of electric road system infrastructure.

BOX 1.
SCENARIO 1: TAKING THE GREEN ROAD.

Based on a shared socio-economic pathway with the following key global features:

- A more inclusive global economic development scenario unfolds, with a strong focus on reaching national and global environmental goals.
- Efficiency of resource use is high, and rapid adaptation responds to environmental challenges that unfold.

The qualitative narrative developed for Sweden resulted in a scenario in which:

- Local emissions and air pollution have strong implications for technology choices.
- Electric road-system technology is deployed early due to forceful government interventions.
- The lowest use of biofuel takes place, and a more rapid phaseout of the internal combustion engine results.

Scenario 2 envisions that long-term domination of battery electric trucks can unfold without such government interventions, although the rapid expansion of battery production capacity in Europe will likely require public support.

BOX 2.
SCENARIO 2: MIDDLE OF THE ROAD

Based on a shared socio-economic pathway with the following key features:

- Development takes place without major social, economic, and technological changes. Sustainability is an ambition, but progress is uneven and faltering.
- Intermediate global challenges remain for reaching global mitigation goals, and for managing adaptation to climate change.

The qualitative narrative developed for Sweden resulted in a scenario in which:

- Global development of novel technologies is limited.
- Current policy direction and scenarios developed by authorities continue, with a high reliance on biofuels to 2030.
- Battery electric trucks later become widely used in 2045 due to the strong development trend for battery technologies.

Scenario 3 emphasizes that an even stronger, new industrial policy is needed to support hydrogen applications.

BOX 3.
SCENARIO 3: INEQUALITY – A ROAD DIVIDED

Based on a socio-economic pathway with the following key features:

- Increasing disparities emerge in economic opportunity and political power; unequal investments in human capital combine with increasing disparities in economic opportunity and political power.
- Inequalities and stratification increase both across and within countries.

The qualitative narrative developed for Sweden resulted in a scenario in which:

- Sweden pursues a strong national industrial policy with nuclear energy remaining in the energy mix, and with higher costs resulting from lower levels of cooperation and trade.
- National security of supply is important. The situation favours both biofuels and, later, hydrogen, as a new energy carrier in trucks.
- Domestically produced biofuels constitute a key energy source. With access to batteries limited, fewer electric trucks materialize.

Finally, the power grid needs to be expanded to supply roads with electricity across all the three scenarios. If any of these technologies – or a combination of them – is to contribute as portrayed in these scenarios, policy needs to foster public-private partnerships that foster rapid deployment of tests, and demonstrations and support for electrification infrastructure.

Our three scenarios require similar types of long-term policy strategies that support research, demonstration, and deployment of electrification technologies. All scenarios also require continued short-term biofuels support, but the contrast between the uncertainty ascribed to biofuels and the certainty placed on drivers behind electrification is notable. In essence, this means that in all three scenarios, the policy strategies required to fulfil 2030 and 2045 climate goals are very different, both in character and in the technologies supported. Whereas the 2030 goal requires a strong emphasis on biofuels, the 2045 goal is heavily reliant on electrification, and it is not obvious how these two align.

This mirrors an old but important debate of the illusive concept of technology-neutral policies (Azar and Sandén, 2011). We find that the 2030 goal forces policy-makers to refute the uncertainty around biofuels, and, thus, make a choice to promote this technology. In the long term, however, it is quite clear that this is the costlier pathway. Spending more resources on the fulfilment of the 2030 goal with biofuels may risk lowering the pace of development of long-term strategies. Moreover, these investments may increase both uncertainties and costs of achieving the 2045 goal. While both these targets are important, a strong push towards massive biofuel deployment over the coming decade would have to be accompanied by an in-depth and serious discussion on how the next needed transition can take place. Clear signals from stakeholders indicate that a shift from internal combustion engines to electrification will likely start in the 2030s. An analysis of which sectors and what type of support should focus on biofuels post-2030 is needed – and needed sooner rather than later – so as to ensure that the research and innovation put into all different options are relevant also for long-term climate goals.

Spending more resources on the fulfilment of the 2030 goal with biofuels may risk lowering the pace of development of long-term strategies. These investments may increase uncertainties and costs of achieving the 2045 goal.

This discussion brief is based on research conducted through the Transitions Pathways and Risk Analysis for Climate Change Mitigation and Adaptation Strategies (TRANSrisk) project. The brief draws on input from stakeholder workshops held in September 2017 and October 2018, and on bilateral feedback and dialogues with stakeholders over a two-year period. TRANSrisk is funded by the European Union's HORIZON 2020 Framework Programme for Research and Innovation, under grant agreement 642260 (website: transrisk-project.eu).

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