Nordic Council of Ministers

REDUCING CO_2 EMISSIONS FROM FREIGHT

Recent developments in freight transport in the Nordic countries and instruments for CO_2 reductions

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Content

Preface

Road transport contributes to a large part of the Nordic countries' CO_2-emissions. While a declining trend is reported for transport emissions in the EU as a whole, forecasts indicate that with current trends and adopted policies, EU-wide emissions from transport will only be 12% lower in 2030 than in 2005, compared to the 30% reduction target for the non-ETS sector. Moreover, forecasts indicate that freight transport will continue to increase in the Nordic countries, particularly due to increases in transport demand.

Where several reports from the Nordic Council of Ministers have focused on measures to reduced CO_2-emissions from passenger cars, the focus of this report is therefore on measures that can be used to reduce CO_2-emissions from freight transport. The report distinguishes between measures that impact emissions through five main channels: reducing transport demand, increasing transport mode efficiency, modal shifts, transferring to fuels with lower carbon content, and moving towards lower-carbon vehicle technologies. As it is difficult to achieve reductions in transport demand, the report concludes that it is important to use measures that support a technological change and an increased use of lower-carbon fuels. A greater harmonization of policies between the Nordic countries (and other countries) may also benefit the effectiveness of policies.

This report is financed by the Nordic Council of Ministers and written by Institute of Transport Economics (TØI), National Road and Transport Research Institute (VTI), Environmental Research Institute (IVL), and Tampere University of Technology (TUT) in cooperation with the Environment and Economy Group (MEG) and Climate and Air Pollution Group (KOL).

November 2018

Signe Krarup
Chairman of the Working Group on Environment and Economy under the Nordic Council of Ministers

Summary

Introduction

Both passenger cars and freight transport by road are significant causes of CO_2-emissions in the Nordic countries. While for passenger cars, policy measures aimed at reducing CO_2-emissions have started to sort effect, this is much less the case for freight transport. In addition, the demand for freight transport in the Nordic countries is expected to continue to increase in the future. As such, the Nordic Council of Ministers called for a study on the reduction of CO_2-emissions from freight transport, with a focus on road transport.

Following this call, the current report discusses the (inter)national climate framework and objectives of the different Nordic countries in light of freight transport developments in terms of CO_2-emissions and transport volumes. This leads to the observation that at the current rate, all Nordic countries face sizable emission reduction gaps compared to their 2030 climate commitments. In a discussion of several types of policy measures, we show what the different Nordic countries are currently doing to reduce CO_2-emissions from freight, and illustrate differences and similarities between the countries. Where possible, we also discuss the cost-effectiveness of different measures.

Climate objectives and targets

Norway, Sweden, Finland, Denmark and Iceland have all committed to the objectives in the Paris Climate Agreement. In addition, the Nordic countries are influenced by the climate framework established at the EU-level. The EU's goal is to reduce greenhouse gas emissions from the non-ETS[1] sector (which includes most transport) by 30 percent in 2030, compared to 2005. As part of an effort sharing mechanism, this objective has been translated into slightly different targets for EU-members Sweden, Finland and Denmark, while Norway and Iceland, as EEA-countries, intend to participate in a manner similar to regular EU countries.

Despite these objectives, neither the "Paris" or EU frameworks establish how emission reductions have to be achieved, meaning that national plans and reduction objectives are needed. During the last five years, all the Nordic countries have implemented Climate Acts outlining a set of climate objectives towards 2050. Common for these Acts is the objective to turn the countries into lower-emission societies by 2045 (Sweden) and beyond 2050.

[1] Emissions Trading System.

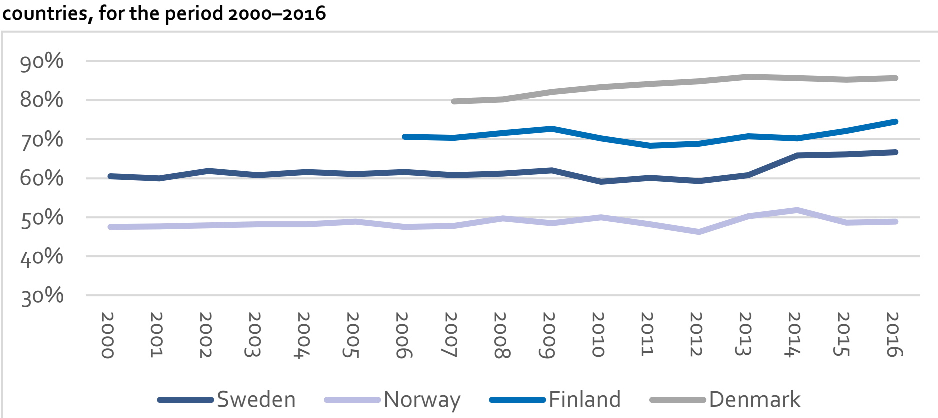
When it comes to specific objectives for emission reductions from the transport sector overall, there are some differences between the Nordic countries. Sweden and Finland have set ambitious objectives through official statements, aiming at 70% and 50% reductions in CO_2-emissions by 2030, compared to 2010 and 2005 respectively. Norway has stated that the transport sector is to contribute a "sufficient share" in light of the Paris Agreement and Norway's climate objective for 2030, and set ambitious objectives that by 2025 all new vans are to be zero-emission vehicles, and by 2030, all new heavy LGVs and 50% of new HGVs (heavy goods vehicles) are to be zero-emission vehicles. In addition, goods distribution in the largest city centres is to be virtually emission-free by 2030. This is in line with the ambitions from the EUs 2011 White Paper (European Commission, 2011). Finally, Denmark has not officially adopted emission reduction targets for the transport sector, but is expected to publish a Government Roadmap for achieving its non-ETS objectives for 2030 later this year.

Developments in freight transport

When it comes to CO_2-emissions from freight transport, developments over the last decade have differed between the Nordic countries. While Sweden and Denmark report drops in CO_2-emissions from freight transport (both around -19%, although the change for Sweden is somewhat uncertain), Norway and Finland have been at a relative standstill. Forecasts indicate that CO_2-emissions from freight transport in Norway will further increase towards 2030, while emissions in Denmark are expected to lie around the same level in 2030 as they do today. Sweden and Finland expect reductions, but like for Norway and Denmark, these are not sufficient if the non-ETS target for 2030 is applied directly to freight transport.

Because developments in CO_2-emissions are determined by underlying factors, we further looked at developments in freight transport. As such, it is important to notice that freight transport modal shares differ between the Nordic countries. This is illustrated in Figure 1.

Figure 1: Development in the modal share of road in domestic transport performance in the Nordic countries, for the period 2000–2016



The figure shows that in Denmark and Finland, freight transport by road is the dominating mode with over 85% and 70% of total domestic transport performance, respectively. The same goes for Sweden, where the share of domestic freight transport by road currently lies around 66%, while in Norway, road transport makes up nearly 50% of domestic transport performance. Interesting are also differences in the role of waterborne transport, which is most important in Norway (ca. 45% of domestic transport performance, excluded petroleum transport from the continental shelf to the mainland), followed by Finland (ca. 19%) and Sweden (ca. 11%). In Denmark, waterborne transport only plays a marginal role. Freight transport by rail, in turn, makes up a share of about 20% of domestic transport performance in Sweden and Finland, around 5% in Norway, and only a fraction in Denmark.

Means of reducing CO_2-emissions from freight transport

Reducing transport demand

When it comes to policy measures, the first and most obvious way to reduce CO_2-emissions from freight transport is to reduce the demand for this type of transport. Although this is no easy task in light of forecasted developments, main examples of policy measures in this regard are taxes and duties, registration fees, zoning regulation, and transport- and area planning. Table 1 summarizes the most important policy instruments in the different Nordic countries.

Table 1: Summary of main policy instrument used for reducing transport demand in the different Nordic countries

	Norway	Sweden	Finland	Denmark
Toll/road pricing	+	+	–	–
Euro vignette	–	+	–	+
Road use tax ("veibruksavgift") on fuel	+	–	–	–
CO_2-/NOx-tax on fuel	+	+	+	+
Energy tax on fuel	–	+	+	+
Emergency supply fee on fuel	–	–	+	–
Reduced tax on biofuels	+	+	+	+
One-off tax on HGVs	–	–	–	–
Environmental zones	–	+	–	+

The table illustrates that while Norway, and to some extent Sweden, employ toll/road pricing, this is not the case in Finland and Denmark. Sweden and Denmark further use the Euro vignette scheme for heavy HGVs as road infrastructure fee.

Fuel taxes, in turn, show both similarities and differences between the Nordic countries. The Norwegian fuel tax has two components, a road use charge, and a

CO_2-component. In Sweden and Denmark, in turn, fuel taxes consist of an energy component and a CO_2 component, and are about the same level. In Finland, the energy and CO_2 components are complemented by an emergency supply fee. All Nordic countries tax biofuels at a reduced rate compared to their fossil fuel counterparts.

Further, none of the Nordic countries charge purchasing taxes for HGVs, and any environmental differentiation through yearly fees (Norway: vektårsavgift; Sweden and Denmark: Euro vignette) does not yield materially different cost levels.

Finally, environmental zones are used in a number of cities in Sweden and Denmark, but these are aimed at reducing local pollution, not CO_2-emissions. Oslo and Bergen in Norway have quite recently introduced Euro class-differentiated toll-fees, which are also aimed at reducing local pollution.

Increasing transport mode efficiency

A second way to reduce emissions from freight transport is to improve the efficiency of transport modes (for example by increasing vehicle capacity), improving capacity utilization (e.g. use of consolidation centres), or better transport planning. The (increased) use of digitalization, automatization and platooning also falls in this category, but is harder for authorities to influence other than through facilitating infrastructure and legal changes.

The Nordic countries show a trend of relaxing restrictions on particularly weight and length of road vehicles. This is particularly the case for Sweden (64 tonnes, 25.25 metres) and Finland (60–76 tonnes and 22–25.25 metres, depending on the number of axles, expected to be extended further). While a few studies suggest that this yields efficiency improvements and cost reductions, the downside of such initiatives can be that they make road transport more attractive compared to other modes, which may counteract efforts to reduce transport demand or modal shift.

Modal shift

A third way to reduce CO_2-emissions from freight transport is to move transport towards modes with a higher energy efficiency per transported unit. Indeed, both the European Commission and the Nordic countries consider it desirable to shift (longer-distance) freight from road to rail and waterborne transport. Main policy instruments are taxation and subsidies, as well as facilitating infrastructural measures (terminals, sufficient infrastructural capacity, connection roads).

For Norway, the modal shift potential is estimated at 5–7 million tonnes transported, of which 2.4 million tonnes is considered feasible. This makes up about 7% of total domestic transport performance overall, or ca. 23% of domestic transport performance over distances >300 km, but requires strong measures that are not always socio-economically beneficial. Domestically, the maximum annual CO_2-reduction is limited, and estimated at 0.2 million tonnes, i.e. around 8% of total CO_2-emissions from HGVs. The main policy measures that are used to incentivize modal shift are a subsidy scheme for waterborne transport ("økobonus") and schemes to reduce delays and cancellations for rail.

In Sweden, one policy measure to induce modal shifts is an "eco-bonus" for rail, which was implemented in 2018. A similar "eco-bonus" for waterborne transport is currently being discussed. When it comes to the potential of modal shift in Sweden, a handful of studies has been carried out in somewhat more detail. Although there is a theoretical potential for modal shifts, there are also capacity barriers, as well as counteracting policies, such as the permission of heavier road vehicles.

In Finland, there are currently few policies in place to promote modal shift. Rather, the opposite seems to be true, as there are indications that the relaxing of physical restrictions for road transport has gone at the expense of the modal share of rail. Although the share of HGV transport on long-haul trips suggests that there should be potential for modal shift, the major commodities within Finnish longer-distance haulage are food products and grouped goods. As the delivery of these commodities may be time-sensitive, the potential for using rail transport may be limited. Another aspect that hampers modal shifts from road to rail is the limited rail capacity stemming from Finland's largely single-track network.

For Denmark, the Danish Transport Authority estimated that the break-even distance between rail and road in terms of costs is quite large, even without taking into account the flexibility that road transport offers. Break-even distances are significantly shorter if a shift to/from HGV can be avoided at one or both ends of the trip. Given today's insignificant share of domestic freight transport on relevant routes, it is hardly realistic that modal shifts measures will be taken that can lead to significant reductions in CO_2-emissions from freight transport.

Transferring to fuels with lower carbon content

A fourth way to reduce emissions from freight transport is to reduce the carbon content of fuels. Driven by the EU, all Nordic countries are stepping up biofuel blending requirements in fossil fuels. Focus is also put on gradually increasing the share of advanced biofuels, which are more sustainable in production.

In Norway, the modification of vehicles, ships, and filling infrastructure with more environmentally friendly characteristics is (partially) subsidized through the ENOVA scheme. In Sweden, it is proposed to increase financial support to domestic biogas production, alongside some other programs improving the position of biofuels. In Finland and Denmark, measures are currently largely limited to the blend-in requirements. All Nordic countries employ lower fuel taxation for (pure) biofuels compared to their fossil counterparts.

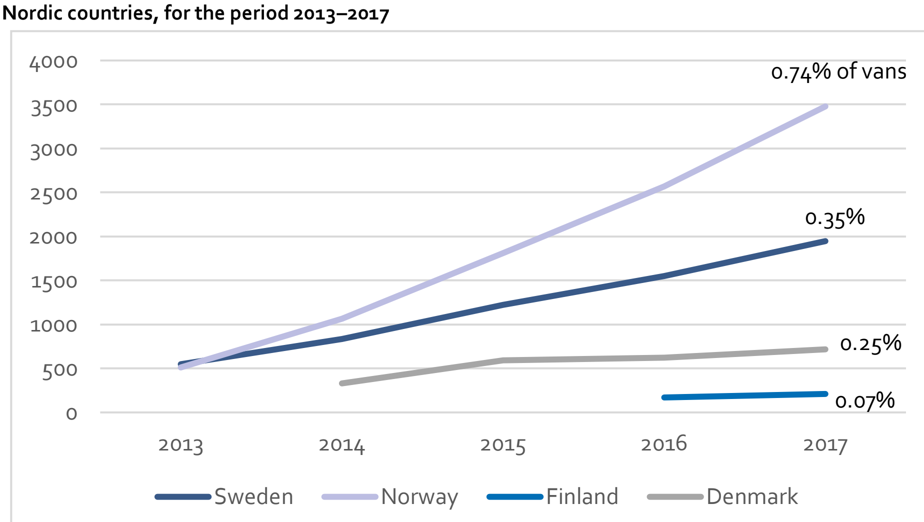
Moving towards lower-carbon vehicle technologies

A fifth way to reduce emissions from freight transport is through the adoption of lower-carbon vehicles. At the European level, overarching standards are set for fuel efficiency and CO_2-emissions of new passenger cars and LGVs. Earlier this year, the

European Commission further proposed an overall and legally binding 15% reduction target for CO_2-emissions in new HDVs (heavy-duty vehicles), by 2025, compared to 2019. For 2030, a preliminary target is set of 30% compared to the same base year.

As such, the European Union pushes towards more efficient conventional propulsion and the further development of alternative propulsion technologies. For the Nordic countries in general, a trend is visible of an increasing uptake of passenger cars with alternative propulsion technologies, with Norway in the lead. Meanwhile, electric LGVs still only make up a minor share of the LGV fleet in Nordic countries, varying from 0.07% in Finland to 0.74% in Norway. However, the absolute number of electric LGVs has increased rapidly over the last few years, particularly in Norway and Sweden (Figure 2).

Figure 2: Development in number of electric LGVs and their share in the total number of LGVs in the Nordic countries, for the period 2013–2017



At the same time, the uptake of alternative propulsion technologies for heavier goods vehicles is still very limited.

When it comes to freight vehicles, the most recent Norwegian National Transport Plan sets the following ambitions:

- By 2025, all new lighter LGVs are zero-emission vehicles.
- By 2030, all new heavier LGVs and 50% of new HGVs are zero-emission vehicles, and all urban distribution should also be virtually emission-free, emphasizing that the phasing in will come first in the cities.
-

Despite Norway's subsidy schemes for firms and other incentives like toll exemptions and access to public transport lanes, it seems unlikely that these ambitions will be achieved under business-as-usual, as general instruments aimed at the forced phase-in of low- and zero-emission vehicles, such as exemptions of purchase fees and VAT, are much weaker means for LGVs and HGVs, than for passenger cars.

Sweden, in turn, as its main measure employs a bonus-malus scheme incentivizing CO_2-efficient vehicles, but this only applies to passenger cars, light busses and goods vehicles up to 3.5 tonnes, and not HDVs.

In Finland there is a EUR 2,000 purchasing subsidy in place for electric passenger cars from 2018 to 2021, but there are no such incentives for LGVs or HGVs. A recent study moreover found that Finland has a very limited potential for using electric trucks compared to other countries, and that the Finnish electrification potential further varies considerably between commodities.

Other measures

In addition to the channels described above, authorities have the possibility to influence CO_2-emissions through requirements set in public tenders or through public procurement of goods and services. Other initiatives in multiple Nordic countries include demonstration projects (e.g. platooning and electric roads in Sweden) intended at reducing CO_2-emissions, and the establishment of knowledge and networking platforms. Finally, Norway is working on the introduction of a so-called CO_2-fund after the model of the successful NOx-fund.

Cost-effectiveness of policy measures

Where possible, the cost-effectiveness of different policy measures is addressed in the discussion of said measures.

For Norway, the National Transport Plan 2018–2029 is expected to reduce CO_2-emissions by around 57,000 tonnes annually (i.e. a reduction in CO_2-emissions of only 0.3% when looking at the transport sector as a whole). The Transport Plan further states that the largest emission reductions are expected to come from developments in technology and fuels (beyond the measures included in the plan) with a reduction of 9 million tonnes CO_2 or around 54% of total transport emissions.

Data from ENOVA further showed that the measures giving the largest CO_2-reduction per NOK in subsidies are energy management and biogas production, while support for electric busses and HGVs are the most expensive measures to support compared to the expected savings in CO_2. In comparison, it is cheaper to provide support to ships per reduced unit CO_2. This is largely due to the fact that projects and measures for ships are largely about rebuilding, whereas for vehicles, measures are largely about investment in new equipment. As there is currently still no serial production of low- or zero-emission HDVs, this new equipment still consists of vehicles that are rebuilt from internal combustion engines to electric powertrains.

For Sweden, specific information on cost-effectiveness is limited. Cost-benefit analyses for infrastructural measures in the Infrastructure Plan 2018–2029 indicate an overall negative socio-economic benefit, and CO_2-emissions from the overall transport sector are only expected to decrease by 1 percentage point, compared to if the Infrastructure Plan is not implemented.

For Finland, Liimatainen and Viri (2017) found that the 2030 emissions reduction target requires a reduction of emissions from overall transport of 3 million tonnes CO_2, compared to 2005, of which freight transport is to account for about 1.1 million tonnes. The authors estimate that this requires a reduction of 0.5 million tonnes CO_2 through the use of renewable diesel, 0.3 million tonnes CO_2 from improving the energy efficiency of freight transport by increasing average load and decreasing empty running, 0.15 million tonnes CO_2 from the use of LNG and electric HGVs, and 0.13 million tonnes CO_2 from reducing the energy consumption of HGVs. A cost-benefit analysis of improving the energy efficiency of HGVs and LGVs yielded a CO_2 abatement cost of 161 EUR/tonne CO_2, while with regard to the use of alternative energy for use in road and waterborne freight, CO_2 abatement costs were found to amount to 156 EUR/tonne CO_2 (Liimatainen *et al.*, 2015).

In Denmark, the Council on Climate Change's recommended cost-effective package of measures towards 2030 only includes one minor initiative regarding freight transport: the promotion of natural gas (CNG) in heavy road transport. Although the resulting reduction in CO_2-emissions is expected to be rather insignificant, the initiative is considered as preparatory step for a large-scale transition to biogas in the longer run – in 2050. The cost-effectiveness of Danish policy measures has further been assessed by a cross-ministerial working group. Here, it was found that only instruments regarding taxes on driving and fuel had an estimated CO_2-reduction potential of more than 2%, while the reduction potential for the majority of other instruments lies below 0.5%. In addition, almost all instruments for the transport sector have high costs compared to typical costs in other sectors. All in all, cost-effective achievement of the Danish non-ETS reduction target would include hardly any initiatives focusing on freight transport.

Finally, although they are driven by international developments, many of the policy measures discussed in this report are primarily directed at domestic markets in the respective Nordic countries. This means that a lack in harmonization or international coordination can lead to unintended policy outcomes or a sub-optimal effectiveness of policy measures due to leakages and spill-overs.

Conclusions and policy recommendations

In order for the Nordic countries to reach their CO_2-emission reduction targets in the years to come, a strong trend change is needed. This report pinpoints that it is obvious that changes must come within several areas. The policy review shows that it is difficult to achieve a greater reduction in transport demand. The same applies to the extent to which authorities can influence the utilization of vehicles, unless physical framework conditions such as vehicle length and maximum permissible total weight, are increased. The latter instrument will, however, improve the competitiveness of road compared to rail and waterborne transport, which in turn will lead to more goods being transferred from rail and sea, to road transport. Analyses for Norway and Sweden show that there is a limited feasible potential for modal shifts. In Norway, the maximum feasible annual reduction in CO_2-emissions is estimated at 0.2 million tonnes, or around 8% of total CO_2-emissions from heavy goods vehicles.

Therefore, in order to achieve agreed emission reduction targets, it is clear that a technological change is necessary. This change may in part come from increased use of lower-carbon fuels, such as biodiesel, biogas, and bio-ethanol, in conventional vehicles. However, although there is still a potential to expand the supply of such biofuels, their availability (and often price) is expected to be a bottleneck, as demand will likely materially outweigh supply, particularly for advanced biofuels. Remaining CO_2-reductions will therefore have to come from vehicles with low- or zero-emission propulsion technologies. Currently, such vehicles are expensive, and only available to a limited extent on the market. Particularly for heavier trucks, the few currently available trucks are rebuilt versions of internal combustion engine vehicles, to electric powertrains.

To achieve a change of trend, alternative solutions have to be attractive and cost-effective compared to today's transport solutions. Of the above-mentioned measures, it is primarily only increased vehicle dimensions that provide a cost-incentive in itself. For all other measures, incentives are needed, at least in an early phase. This applies both to freight transfers through modal shifts, but also to low-carbon fuels or alternative propulsion systems. For vehicles using either lower-carbon fuels or alternative propulsion systems, there is currently an additional cost element that is either distance-dependent (biofuels) and/or time-dependent, as investment costs for alternative propulsion vehicles are much higher than corresponding vehicles with internal combustion engines.

Norway, which has the highest number of battery-electric vehicles of the Nordic countries, also in terms of freight vehicles, has a rather expansive electric vehicle policy. As pointed out in the report, the most important instruments for the phasing-in of electric passenger vehicles, are not available for vans and trucks. In particular, this regards exemptions of purchase taxes and VAT, which are either small or do not apply in the case of vans and trucks, and therefore give much weaker incentives. It is therefore important that in an early phase, instruments such as public investment support towards additional costs, exemptions of toll charges and/or the allowance to use public transport lanes for this type of vehicles, are used to compensate for their additional costs. Further, environmental aspects should be receiving more weight vis-à-vis costs aspects in public procurement. This could contribute to increasing demand towards a critical mass, so that vehicle manufacturers will be able to start serial production, and later large-scale production. Over time, this will help reducing the cost difference between alternative propulsion freight vehicles, and conventional freight vehicles.

Finally, the report presents a number of examples where a lack in harmonization and/or coordination between countries has led to unintended policy outcomes. These examples illustrate that considering border-crossing effects and coordination to a larger extent is important when considering new policy instruments. A greater harmonization of policies between the Nordic countries (and other countries) may benefit the effectiveness of policies. In this regard, the importance of evaluating implemented policy measures should also be emphasized. To improve policy-making and learn from good/bad examples in other (Nordic) countries, a better understanding of the cost-effectiveness of measures is desirable.

1. Introduction

Both passenger cars and freight transport by road are significant causes of CO_2-emissions in the Nordic countries. Even though these countries take part in international obligations to significantly reduce emissions from the transport sector by 2030, it appears that both traffic volumes and CO_2-emissions have increased in recent years, and are expected to keep increasing significantly in coming years. This indicates that existing policy measures will not be sufficient to achieve climate objectives; on the contrary, at the current rate, considerable gaps remain between CO_2-emission levels in practice, and CO_2-emission objectives, for all the Nordic countries. This is particularly the case for emissions from heavy transport, for which existing policy measures have so far only had very modest effects on emission levels and growth rates.

Although the share of passenger cars in transport CO_2-emissions is higher than of road freight, and as such offers a larger potential for emission reductions, it is also for passenger cars that policy measures have recently started to influence both the levels and growth rates of CO_2-emissions. The main contributors to this development have been related to measures covering the purchase of vehicles, such as tax- and VAT-exemptions on electric vehicles, which have resulted in an increasing share of electric cars in new car sales (Jordal-Jørgensen *et al.*, 2017).

For freight transport by road however, the measures that are available for influencing CO_2-emissions are much weaker. Unlike for passenger cars, there are for example no purchase fees on HGVs[2], so that these cannot be waived.

In this project, financed by NORDEN (Nordic Council of Ministers), measures for reducing CO_2-emissions from freight transport in the Nordic region, with emphasis on road transport, are reviewed. The project covers the whole spectrum of existing policy measures for reducing CO_2-emissions from road transport. Attention is also given to measures directed at transferring goods from road to rail and waterborne transports. Existing measures are discussed in the context of objectives regarding CO_2-emissions in the different Nordic countries, including a discussion of costs and effectiveness, remaining CO_2-emission reduction gaps, and recommendations to fill these gaps. For the Nordic region, the elements are also brought together in a comparative analysis.

The project has been coordinated by TØI, which also has been responsible for the country analyses for Norway, Denmark and Iceland. Sweden and Finland are covered by participants from VTI[3], IVL[4], and TUT[5] respectively.

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[2] Heavy Goods Vehicle.

[3] National Road and Transport Research Institute, Sweden.

[4] Environmental Research Institute, Sweden.

[5] Tampere University of Technology, Finland.

The report is structured into seven chapters, including this introduction. We start by outlining our methodological approach. This is followed by a discussion of the international and national climate framework and objectives of the different Nordic countries, including the role of (freight) transport in Chapter 3. In Chapter 4, we discuss developments and forecasts for freight transport in terms of CO_2-emissions, transport volumes, modal share, and the adoption of alternative technologies. This chapter also addresses the emission reduction gaps compared to country objectives. In Chapter 5, we discuss existing and planned policy measures in the Nordic countries by the main channel through which they yield CO_2-reductions. Where information is available, the cost-effectiveness of these measures is also addressed. Finally, in Chapter 6 we present conclusions, while Chapter 7 discusses policy recommendations.

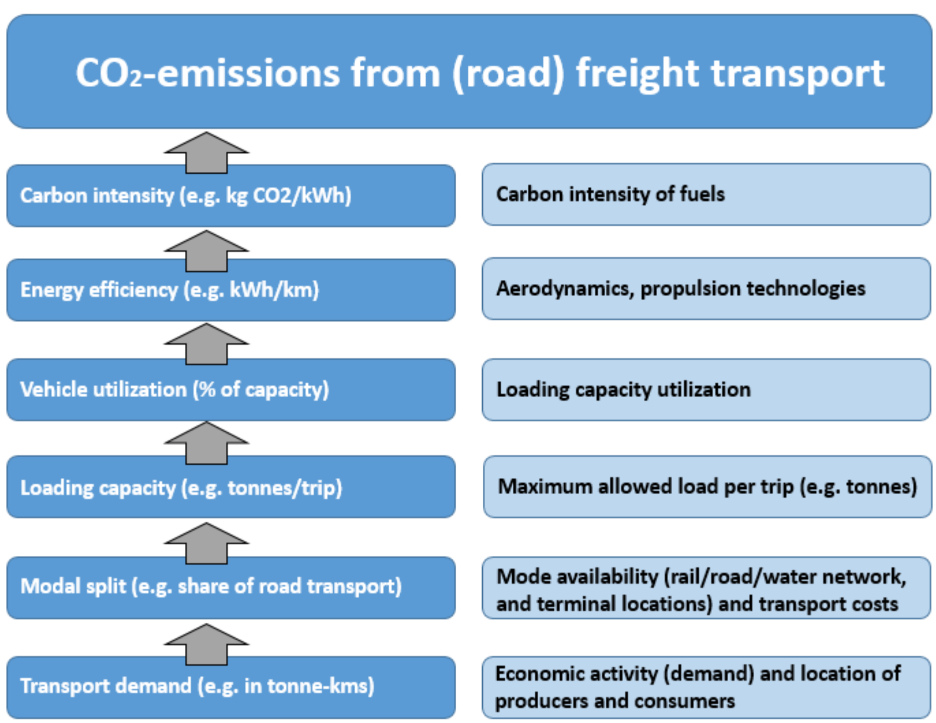
2. Methodology

2.1 Literature review

The backbone for the current project is formed by a literature and data review for the individual Nordic countries and relevant EU policy requirements. The starting point is a review of which international commitments the Nordic countries are bound to in the coming years with regard to reductions in CO_2-emissions. Sources for this review are primarily publicly available documents and reports prepared by the European Commission and public authorities in the Nordic countries. This is further supplemented by publicly available investigations and research reports analysing effects of different policy measures.

The report is structured so that it first addresses the most important drivers of transport performance and greenhouse gas emissions, followed by a discussion of which measures authorities can use to influence the total level of CO_2-emissions from freight transport. This causal context is illustrated in simplified form in Figure 3.

Figure 3: Simplified causal context for reducing CO_2-emissions from freight transport



As seen from the figure, the demand for goods is the primary driver of emissions from freight transport. The demand for transport is affected by both economic activity (level of demand for goods in tonnes) and where producers and consumers are located. Emissions from road transport further depend on the share of road transport in total transport performance, and on physical external conditions, such as the maximum allowed weight of a vehicle. Mode choice may be affected by accessibility to infrastructure (road and rail infrastructure, and waterways) and terminal locations, where the goods can be loaded onto different modes of transport. Mode choice can also be affected by the costs of using the different modes of transport, for example fees or taxes on fuels or usage of infrastructure. Further, total emissions are dependent on the energy efficiency of modes and the carbon intensity of fuels.

The Nordic countries have quite a variety of freight transport patterns, linked to their different business structures, geographic conditions, and infrastructure. For that reason, the impact of policy instruments can differ between the countries.

Emphasis is therefore placed on a comparative analysis of means that the Nordic countries use for reducing emissions from road transport, and for transferring freight from road to rail and sea (modal shift). The analysis covers the full range of instruments: economic (as fees), technical (as emission standards) and other means to stimulate technological development that reduces CO_2-emissions per tonne-km, as well as transport and land planning.

Based on the literature review, a comparable overview and analysis is given of:

1. Climate objectives and targets.
2. Developments in CO_2-emissions.
3. Developments in transport and traffic volumes.
4. Policy measures aimed at reducing CO_2-emissions from freight transport by road. This covers, amongst others:
   a. Reducing transport demand.
   b. Increasing transport mode efficiency.
   c. Moving towards modes with higher energy efficiency per unit transported (modal shift).
   d. Transferring to fuels with lower carbon content.
   e. Moving towards lower-carbon vehicle technologies.
   f. Other measures.

2.2 Data

The data used in the analysis is mainly based on official statistics from Statistics Norway, Statistics Sweden, Statistics Finland and Statistics Denmark. For Iceland there are only very limited statistics available, mainly limited to CO_2-emissions.

2.3 Definitions, boundaries and limitations

Developments in transport volumes are presented for national vehicles and vessels registered in each of the Nordic countries due to data accessibility. This can also be explained by the fact that it is primarily for these vehicles and vessels that the authorities have the greatest potential to exert influence. Transport volumes are also influenced by foreign-registered vehicles and vessels, but their market access is regulated by the EU through regulations on cabotage.

National data on CO_2-emissions is primarily based on fuel sales related to all road and rail transports, and seaborne transports between domestic ports in each country's territory is included. As such, climate targets for transport primarily refer to CO_2-emissions from transports *fuelled* in each country, and can be affected by vehicles or vessels that mainly operate at the domestic level, but sometimes refuel abroad.

LGVs[6] are used for passenger transport, freight transport, and other transport (handcraft, service, etc.), and typically in urban areas. For LGVs, there are uncertainties related to the share of driving within freight, service, and passenger transport. The report includes all driving with light goods vehicles, although some of it is related to passenger transport.

In the report we further distinguish between vans/light trucks (maximum 3.5 tonnes payload), hereby called light goods vehicles or LGVs, and heavy trucks (over 3.5 tonnes payload / 7.5 tonnes total weight). The latter are defined by inclusion criteria in annual HGV surveys, and hereby called heavy goods vehicles or HGVs.

Domestic aviation is not included in the report, since domestic aviation is part of the European Union Emissions Trading System, rather than emission reduction objectives for the non-ETS sector, to which most transport emissions belong.

Finally, Iceland is only discussed to a limited extent. The reason for this is that there are only very limited statistics available, mainly limited to CO_2-emissions. The main mode of domestic freight transportation is HGV transport, with in addition probably some coastal transport.

[6] Light Goods Vehicle.

3. Climate objectives and targets

This chapter describes objectives, regulations, targets and ambitions with regard to reductions in greenhouse gas emissions. Firstly, we discuss the international framework that influences and helps shape national policies and commitments. Consequently, we discuss the emissions reduction framework for each of the Nordic countries. In both steps, we first state overall climate objectives and then discuss what this implies, or may imply, for emissions from transport. As such, the chapter gives an overview of the (general and transport) emission reductions that the Nordic countries intend to achieve, and by when.

3.1 International and EU objectives

Norway, Sweden, Finland, Denmark, Iceland, and the EU as a whole have all signed and ratified the Paris Climate Agreement. This agreement entered into force in late 2016, and has as main objective to limit global temperature increase to well below 2 °C, while pursuing efforts to cap it at 1.5 °C.

The Paris Agreement, however, does not determine through which measures its objectives are to be achieved, and does not set objectives for individual sectors of the economy. Instead, all Parties to the Agreement will have to make national plans on how they will reduce greenhouse gas (GHG) emissions, including quantified reduction objectives. These plans – also known as Nationally Determined Contributions (NDCs) – are to be updated every five years starting in 2020, and ambition levels are meant to be increased with each update (European Commission, 2016a; NIER, 2017; UN Association of Norway, 2018). At an overarching level, the climate objective framework is thus set at the level of the United Nations, but the operationalization is left to the Parties themselves.

In addition to "Paris", the Nordic countries are influenced by the climate framework established at the level of the European Union. The EU's stated objective is to achieve a reduction in GHG emissions of 40% in 2030, compared to 1990. By 2050, this reduction should have increased to 80–95% compared to 1990 levels. In order to achieve these objectives, efforts are subdivided into three pillars (NIER, 2017 and Norwegian Government, 2016a):

- The first, a quota system (Emission Trading System, ETS), primarily addresses emissions from point sources such as energy intensive industry and power plants, as well as international aviation.[7] Quota ceilings are lowered year-after-year, so as to reach the EU's objective: to reduce emissions from this ETS-sector by 43 percent in 2030, compared to 2005.
- The second, or non-ETS pillar, addresses emissions from more diffuse sources. Most transport is included in this pillar. Here, the EU's goal is to reduce GHG emissions from the non-ETS sector by 30 percent in 2030, compared to 2005. Individual Member States are attributed varying reduction objectives (from 0 to 40 percent) based on per capita BNP, as part of a so-called effort sharing mechanism to achieve the overall goal. As EEA-countries, Norway and Iceland are not automatically obliged to partake in the EU's non-ETS efforts, but have nevertheless expressed their intention to participate in a manner similar to regular EU countries.
- The third, and least relevant pillar when it comes to transport, focuses on emissions from Land Use, Land Use Change and Forestry (LULUCF).

For freight transport, the most relevant pillar is thus the non-ETS sector. However, the framework itself does not determine how emission reductions have to be achieved, nor how much has to be contributed by the transport sector, compared to other non-ETS sectors. Indeed, more detailed EU objectives and ambitions are outlined in other initiatives.

With regard to transport, a European Strategy for Low-Emission Mobility was published in 2016 (European Commission, 2016b,c). This strategy has as main ambition that by 2050, emissions from transport are at least 60 percent lower than in 1990, and firmly on the path towards zero. The reasoning behind this ambition is that transport makes up almost a quarter of Europe's GHG emissions and in addition causes major air pollution. Moreover, the potential of transport in emission reductions has increased. Because over 70 percent of GHG emissions from transport stems from road transport, the strategy puts particular emphasis on this area. In summary, the strategy sets out to increase the efficiency of the transport system, speed up the deployment of low-emission alternative energy for transport, and to move towards zero-emission vehicles.

More specifically for heavy vehicle road transport, the EU published a strategy for reducing fuel consumptions and CO_2-emissions in 2014 (European Commission, 2014a). Beyond identifying the need for measures and the challenge of a knowledge gap in measuring and monitoring fuel use and emissions, the strategy offered little concrete compared to similar strategies for cars and LGVs.

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[7] International aviation is covered by the ETS. For maritime transport, the International Maritime Organization (IMO, 2018) agreed on an "initial strategy on the reduction of greenhouse gas emissions from international shipping" in April 2018. Main features of this strategy are 1) to have GHG emissions from international shipping peak as soon as possible, and to have reduced them by at least 50% in 2050, compared to 2008, while pursuing efforts to achieve emission reductions consistent with the temperature goals from the Paris Agreement; 2) to reduce CO_2-emissions per unit of transport performance by at least 40% by 2030, compared to 2008, with an intended 70% reduction by 2050.

Other European-level initiatives contributing to shaping national policies on reducing transport emissions, are e.g. the Renewable Energy Directive, which sets targets for the overall use of renewable energy and its use in transport, and the Energy Efficiency Directive, which established binding measures for reaching the EU's 20% energy efficiency target in 2020 (for the energy system including transport) (European Commission, 2016b). The policy measures stemming from these initiatives will be discussed in more detail in Chapter 5.

3.2 Norway

As described above, Norway is a Party to the Paris Agreement. In addition, Norway has committed to the EU's objective of reducing total emissions by 40 percent by 2030, compared to 1990 levels, by incorporating this objective in its 2017 Climate Act. This Act also formalizes the objective to turn Norway into a low-emission society by 2050 and defines this as an emission reduction of 80–95% compared to 1990-levels.

Part of Norwegian emission reductions is to take place through Norway's participation in the European ETS-system[8], and nearly 50 percent of Norwegian GHG emissions come from ETS-sectors (particularly oil, gas, and industry).

With regard to non-ETS emissions, Norway intends to fully participate in the EU reduction effort for non-ETS sectors (for the period 2021–2030). At the moment, Norway and the EU are moving towards a finalization of a non-ETS reduction target of 40 percent in 2030, compared to 2005-levels. This implies that yearly emissions from the non-ETS sector have to be reduced by about 11 million tonnes by 2030 (Norwegian Parliament, 2016; Norwegian Government, 2016b, 2018a; Norwegian Environment Agency, 2017).

Within the non-ETS sector, transport[9] stands for about 60 percent of emissions[10], of which in turn the largest share is made up by road transport. For these reasons, the Norwegian Government (2016b) expects that large domestic emission reductions in the non-ETS sector will have to come from the transport sector, and also Cicero (2017) states that there virtually seems to be consensus that the transport sector is to contribute with the largest emission reductions.

[8] Through its EEA-membership.

[9] Including fishery and construction equipment.

[10] Which means roughly a third of Norwegian overall emissions.

In this regard, the Norwegian National Transport Plan sets more detailed objectives and ambitions, the most relevant of which are presented below (Norwegian Government, 2016b):

- The transport sector is to contribute a sufficient share in light of the Paris Agreement and Norway's climate objectives for 2030.
- By 2025, all new smaller LGVs are to be zero-emission vehicles.
- By 2030, all new larger LGVs and 50 percent of new HGVs[11] are to be zero-emission vehicles.
- By 2030, goods distribution in the largest city centres should be virtually emission-free.
- Facilitate modal shift from road to rail/water for longer-distance freight transport.
- Contribute to reductions in GHG emissions from freight transport by stimulating the adoption of environmentally-friendly technologies, alternative fuels, and improving efficiency within transport and logistics. Much emphasis is put on stimulating faster adoption of new technologies.

The transport plan is less concrete on how these ambitions are to be achieved or which instruments are to be employed. An extensive overview of existing and potential policy measures is therefore given in Chapter 5.

3.3 Sweden

In 2017, the Swedish Parliament decided to implement a climate policy framework with an overall objective to reduce net emissions of greenhouse gases to zero, by 2045. The framework consists of a Climate Act (Swedish Government, 2017) that entered into force on the 1st of January 2018, a set of climate objectives, and the establishment of a climate political board. Emission reduction objectives are also part of the Swedish national environmental objectives, particularly through the environmental quality objective "Reduced Climate Impact" (Miljömål, 2018).

With regard to non-ETS emission reductions in general, Sweden partakes in the EU's abovementioned effort to reduce non-ETS emissions by 30 percent in 2030, compared to 2005 levels. As part of the European effort sharing mechanism, Sweden has been attributed a larger-than-average objective of reducing its non-ETS emissions by 40 percent (European Commission, 2018a).

For the transport sector specifically – which stands for about half of Swedish non-ETS emissions – the current Swedish target is that by 2030, emissions from domestic transport (excl. aviation) have been reduced by at least 70 percent compared with 2010 (Swedish Ministry of the Environment and Energy, 2017; Swedish Environmental

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[11] Heavy Goods Vehicle.

Protection Agency, 2017). This target entails that emissions from transport may not exceed 5.9 million tonnes of CO_2-equivalents[12] by 2030 (National Institute of Economic Research, 2017) and implies that transport is expected to play a larger than proportional share compared to other non-ETS sectors.

3.4 Finland

In Finland, the 2015 Climate Act aims to reduce overall greenhouse gas emissions by 80 percent by 2050, compared with 1990-levels. Should other targets be set though binding international agreements or legislation at the EU-level, Finnish emission reduction targets will be adjusted accordingly.

In addition to ETS obligations, Finland's non-ETS contribution as part of the EU's effort sharing mechanism is set to a reduction of 39 percent compared to 2005 non-ETS emissions (European Commission, 2018a).

None of the abovementioned objectives include specific targets for the transport sector. However, there is a target for reducing emissions from the transport sector by 50 percent by 2030, compared to 2005 levels. This transport-specific objective was set in the Government Report on Medium-term Climate Change - Policy Plan for 2030 (Finnish Ministry of the Environment, 2017) and in the National Energy and Climate Strategy for 2030 (Finnish Ministry of Economic Affairs and Employment, 2017). Similar to Sweden, this implies that the transport sector is attributed a larger than proportional reduction task compared to other non-ETS sectors.

The Energy and Climate Strategy further states that the transport sector should have "very low emissions" in the long-term. In April 2018, the Finnish Ministry of Transport and Communications established a task force with the task of identifying and evaluating measures for making transport carbon-free by 2045.

When zooming in on freight transport, Finland does not have specific emission reduction targets. Consequently, there are practically no specific measures for reducing CO_2-emissions from road freight. To illustrate the potential role of freight transport, we therefore turn to estimations by Liimatainen *et al.* (2015) and Liimatainen and Viri (2017). These authors find that the emission reduction targets for the transport sector imply that CO_2-emissions must be reduced by ca. 3 million tonnes compared to baseline levels for the sector as a whole, of which freight transport should contribute about 1.1 million tonnes.

Similarly, cumulative emission reductions between 2015–2050 should amount to approximately 68 million tonnes CO_2, with freight transport accounting for about 21.5 million tonnes.

[12] Domestic transport emissions (excl. aviation) in 2010 equalled 19.5 million tonnes CO_2-eq.

3.5 Denmark

In June 2014, Denmark adopted a Climate Change Act (Danish Energy Agency, 2018a). The Act sets the goal that Denmark must transition to a low-carbon society by 2050 and become independent of fossil energy. This goal is in line with the EU's political objective to reduce CO_2-emissions by 80–95% by 2050, compared to 1990. For 2020, the Danish target is to achieve a 40% reduction in overall CO_2-emissions. This is estimated to be achieved without further initiatives (Danish Energy Agency, 2018b, p. 15).

So far, Denmark has not officially adopted emission reduction targets for the transport sector specifically. A Government Roadmap for achieving the non-ETS objectives for 2030 is expected to be published in autumn this year, and to also include transport-related initiatives.

For the time being, Denmark's short- and medium-term objectives and targets for CO_2 reductions from transport therefore largely follow the EU's country-specific 2030-targets for the non-ETS-sector. This non-ETS-sector includes national transport emissions, and Denmark's non-ETS-target is a 39 percent reduction in CO_2-emissions by 2030, compared to 2005-levels (European Commission, 2018a). This goal is operationalised as a linear reduction path from 2020 to 2030. In practice, the target functions as a ceiling for the total emissions during the ten-year period.

The only specific target for transport is a renewable energy share of 10% in 2020. However, this target is a point target, which entails that it could be achieved by a temporary increase of the blend-in of biofuels in petrol and diesel.

3.6 Iceland

In 2007, the Icelandic government adopted a climate change strategy which set forth a long-term vision for the reduction of net emissions of GHGs by 50–75% by the year 2050, compared to 1990 levels. In 2010, the climate strange strategy was followed by an Action Plan for climate change mitigation. This Action Plan built on an expert study on mitigation potential and costs from 2009, thereby taking account of the 2007 strategy and likely international commitments.

In November 2010, the Icelandic government adopted a Climate Change Action Plan in order to execute the strategy. In November 2017 a new government took office. In its governmental agreement there is a focus on climate issues, and the following statements are set forth:

- Iceland shall reduce greenhouse gas emission by 40% before 2030.
- Iceland is to be carbon neutral no later than 2040.
- A new action plan will be published with defined and financed projects.
- A climate committee will be established.
- All sectors of the society are to be included in the actions to be taken.
- Increased focus will be put on the effects of climate change on the oceans.

- New concessionary investment agreements are to be in accordance with climate strategy.
- The carbon tax will be revised.

In 2012, Iceland published its first yearly progress report in which GHG-emissions and removals were compared with the goals put forward in the Action Plan. In 2015, an agreement was concluded between the European Union (EU), its Member States, and Iceland, concerning Iceland´s participation in the joint fulfilment of commitments of the Union, the Member States, and Iceland, in the second commitment period of the Kyoto Protocol. Herein the Parties agree to fulfil their quantified emission limitation and reduction commitments for the second commitment period inscribed in the third column of Annex B to the Kyoto Protocol jointly.

3.7 Summary

All the Nordic countries have signed and ratified the Paris Climate Agreement and are therefore obliged to contribute to the main objective, which is to limit global temperature increase to well below 2 °C above pre-industrial levels, while pursuing efforts to cap it at 1.5 °C.

In addition, the Nordic Countries are influenced by the climate framework established at the level of the European Union. The EU's goal is to reduce greenhouse gas emissions from the non-ETS sector by 30 percent in 2030, compared to 2005. Most transport is included in this sector. As a part of a so-called effort sharing mechanism, individual Member States are attributed varying reduction objectives based on per capita BNP, resulting in slightly different targets for the Nordic countries: While Sweden is attributed a 40% reduction target, the target for Finland and Denmark is a 39% reduction. As EEA-countries, Norway and Iceland are not automatically obliged to partake in the EU's non-ETS efforts, but have nevertheless expressed their intention to participate in a manner similar to regular EU countries.

Neither the "Paris" or EU frameworks establish how emission reductions have to be achieved, and thus national plans and reduction objectives are needed. During the last five years, all the Nordic countries have implemented Climate Acts outlining a set of climate objectives towards 2050. Common for all the Nordic Climate Acts is the objective to turn the countries into low-emission societies by 2050.

When it comes to specific objectives for emission reductions from the transport sector overall, there are some differences between the Nordic countries that are worth noticing. Sweden and Finland have set ambitious objectives through official statements, aiming at 70% and 50% reductions in CO_2-emissions by 2030, compared to 2010 and 2005 respectively. Norway has stated that the transport sector is to contribute a "sufficient share" in light of the Paris Agreement and Norway's climate objective for 2030. At the moment, Norway and the EU are moving towards a finalization of a non-ETS reduction target of 40 percent in 2030, compared to 2005-levels. Denmark has not officially adopted emission reduction targets for the transport sector, but a

Government Roadmap for achieving the non-ETS objectives for 2030 is expected to be published in late 2018.

When looking at freight transport specifically, none of the Nordic countries have specific emission reduction targets. Nevertheless, it is worth noticing that Norway has set some ambitious objectives for the sector through its National Transport Plan, most notably that by 2025 all new lighter LGVs are to be zero-emission vehicles, and by 2030, all new heavy LGVs and 50% of new HGVs are to be zero-emission vehicles. In addition, goods distribution in the largest city centres is to be virtually emission-free by 2030.

4. Developments in freight transport

Now that we have discussed the EU and the Nordic countries' GHG-reduction targets for 2030, we turn to a discussion of developments in CO_2-emissions and the underlying freight transport.

4.1 CO_2-emissions

4.1.1 *European Union*

At the EU level, emissions from transport[13] make up around 23% of total CO_2-emissions.[14] Road transport makes up the lion's share, with over 70% of transport emissions (European Commission, 2016c).

While a declining trend is reported for transport emissions in the EU as a whole, forecasts indicate that with current trends and adopted policies, EU-wide emissions from transport will only be 12% lower in 2030 than in 2005, compared to the 30% reduction target for the non-ETS sector (European Commission, 2016b). Meanwhile, emissions from heavy-duty vehicles (including freight HGVs) are projected to keep increasing materially towards 2030 due to increases in transport demand (European Commission, 2018b). All in all, the European Commission therefore recognizes that a sizable reduction gap exists and that "current transport policies need to be reinforced to ensure the achievement of the EU's 2030 targets" (European Commission, 2016b, p.24).

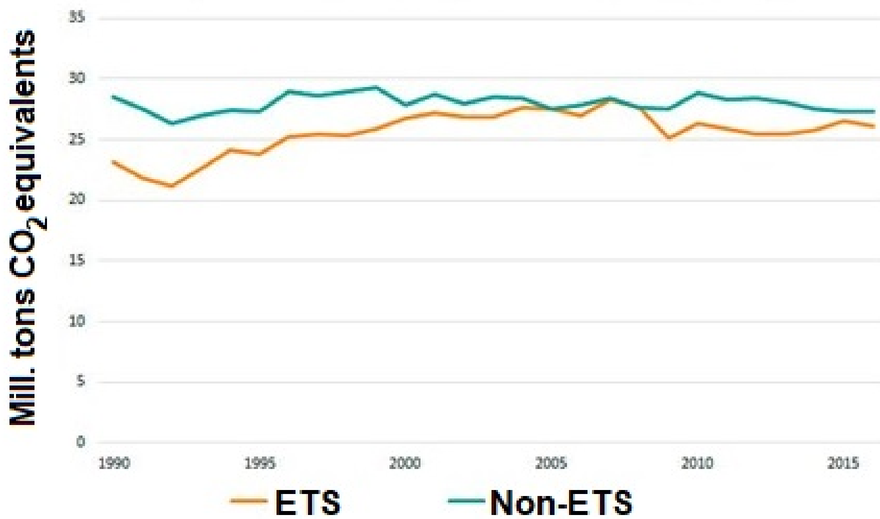
4.1.2 *Norway*

For Norway, we start by illustrating developments in CO_2-emissions in the ETS and non-ETS sector, for the period 1990–2016 (Figure 4).

[13] Excluding international maritime transport.

[14] I.e. emissions included in the ETS and emissions outside the ETS (where transport emissions make up roughly a third of emissions).

Figure 4: Development in Norwegian carbon emissions from the ETS and non-ETS sector for the period 1990–2016. In million tonnes CO_2-equivalents



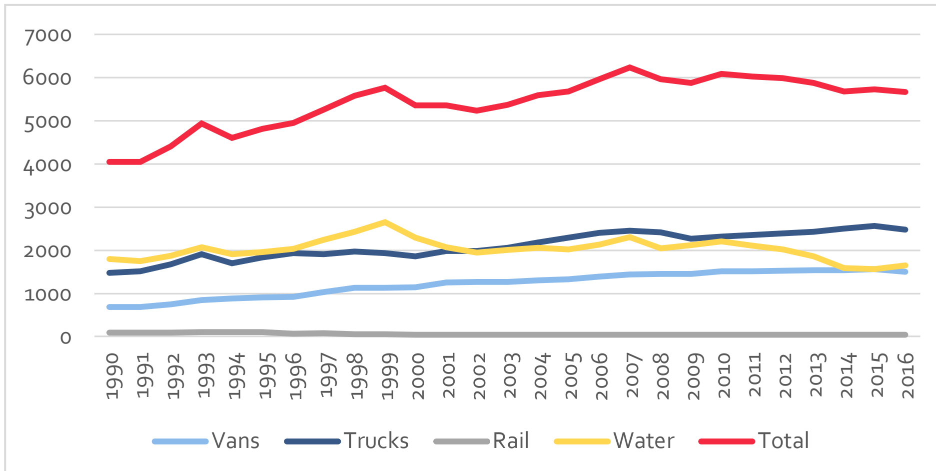
Source: Adapted from the Norwegian Environment Agency (2017).

It can be seen that non-ETS emissions make up just over half of total emissions and amounted to about 27.5 million tonnes in 2016. This constitutes a decrease of 0.7% compared to the 2005 baseline for Norway's non-ETS reduction target for 2030 (Norwegian Environment Agency, 2017).

As part of the non-ETS sector, statistics on CO_2-emissions from transport are collected from Statistics Norway (2017a)[15], with Figure 5 illustrating developments for different freight segments.

[15] A more detailed assignment to transport segments (e.g. heavy HGVs and busses) has been carried out by TOI, based on historical shares in vehicle-km's.

Figure 5: Development in Norwegian CO_2-emissions from different freight transport segments, for the period 1990–2016. In 1,000 tonnes



As can be seen from the figure, total emissions from freight transport have shown a modest decrease in recent years and reached ca. 5.7 million tonnes in 2016.[16] Although this is about the same level as the 2005 baseline, the role of different modes changed significantly over the last decade. CO_2-emissions from rail, for example, have been and remain only marginal. Emissions from waterborne transport, however, show a decrease from 2010, followed by a stabilization around the current level of 1.65 tonnes, i.e. a significant reduction since 2005.

Meanwhile, CO_2-emissions from road transport show a clear upward trend. In 2016, HGVs emitted nearly 2.5 million tonnes of CO_2, an increase of 68% compared to 1990, or 8% compared to the 2005 non-ETS baseline. LGVs, in turn, emitted almost 1.5 million tonnes of CO_2 in 2016, which constitutes an increase of 120% compared to 1990, or 13% compared to 2005. Of all mobile sources, road freight also stands for the largest absolute increases in CO_2-emissions (Norwegian Association of Heavy Equipment Contractors, 2016).

The above raises the question whether (freight) transport will be able to "contribute its sufficient share in light of the Paris Agreement and Norway's climate objectives for 2030". Applying the 40% non-ETS reduction target directly to freight transport implies that emissions should be below 3.40 million tonnes CO_2 in 2030, which would require a reduction of 2.3 million tonnes compared to 2016.

With regard to forecasts for CO_2-emissions, we chose to use several sources. For road transport, we use Fridstrøm and Østli (2016), whose report is based on National Transport Plan projections for transport performance and mileage (Hovi *et al.*, 2017),

[16] For perspective, this means that in 2016. freight transport stood for nearly 35% of emissions from transport overall (incl. fishery and construction equipment), i.e. about 20% of overall non-ETS emissions.

and models developments in CO_2-emissions for different scenarios.[17] Under the trend scenario (business-as-usual), CO_2-emissions from LGVs are expected to decrease to 1.2 million tonnes by 2030, while emissions from HGVs are projected to increase to nearly 2.9 million tonnes. For road freight, this gives an increase of over 13% compared to 2005 levels, rather than a decrease.

For waterborne transport, DNV-GL (2014) projects that CO_2-emissions will reach 4.0 million tonnes by 2030. This is an increase of 18% from their estimated level of 3.4 million tonnes in 2015. The emission level in 2030 is a reference level, where only the Energy Efficiency Design Index for new ships is taken into account. However, DNV-GL's estimates are much higher than Statistics Norway's estimates for 2015, which is due to different methods. Data from Statistics Norway is based on fuel sales, while DNV-GL bases its calculations on ship tracking information (AIS-data). These estimates include cargo vessels, passenger vessels, fishing boats and vessels related to the petroleum activity to/from and at the Continental Shelf, that are also included in Statistics Norway's numbers, except for fishing boats (which form a separate category). Another report by DNV-GL (2016) illustrates that the main emissions from waterborne transport are related to passenger vessels and petroleum-related activity. Only a minor share is related to domestic freight vessels.

For rail transport, CO_2-emissions are marginal, and forecasted to make up less than 50,000 tonnes CO_2 by 2030, i.e. only slightly over their 2005 level.

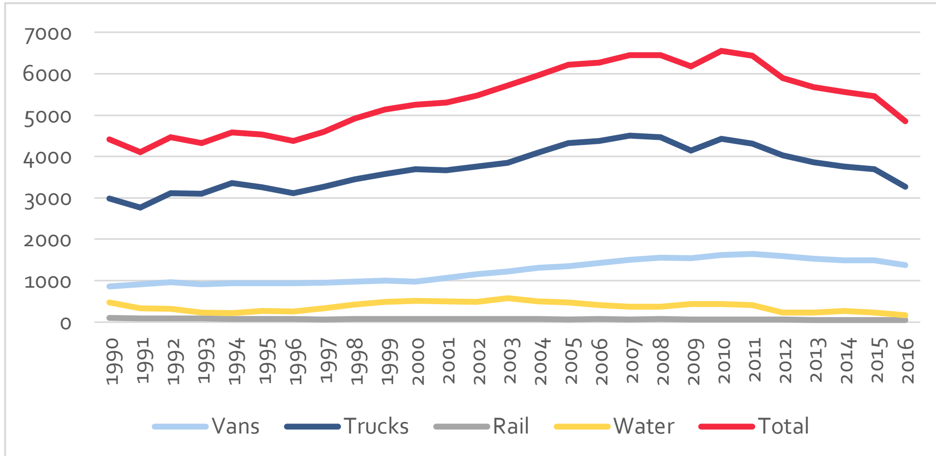
4.1.3 Sweden

For Sweden, statistics on CO_2-emissions are published by Statistics Sweden (2017a and 2017b), building on inputs from the Swedish Environmental Protection Agency.[18] Based on these statistics, Figure 6 illustrates how domestic CO_2-emissions from different freight segments have developed over time. It should be noted that especially the figures for vans/LGVs and water transport also comprise passenger transports.

[17] With a focus on developments in the total fleet following the replacement of conventional vehicles and the uptake of lower-emission vehicles.

[18] The most important (observation) variable for CO_2-emissions from domestic transport in Sweden is sold fuel volumes. Fuel data are taken from the surveys "Monthly fuel statistics" and "Deliveries of vehicle gas". The distribution of the delivered fuel volumes (for mobile combustion) between the different modes of transport and vehicle types is derived by using a number of models. The CO_2-emissions are calculated on the basis of distributed fuel volumes and national emissions factors. Emissions of methane and nitrous oxide are predominantly calculated by models, that comprise several other auxiliary and observation variables, e.g. emission factors, heat values (värmevärden), mileage and various variables describing combustion and purification technologies.

Figure 6: Development in Swedish CO_2-emissions from different freight transport segments, for the period 1990–2016. In 1,000 tonnes



It can be seen that total Swedish CO_2-emissions from these transports decreased significantly in recent years, falling below 5 million tonnes, after peaking at around 6.5 million tonnes in 2010. Trucks/heavy HGVs are responsible for the majority of these CO_2-emissions, while domestic waterborne and rail transport[19] stand for a minor part of emissions. The overall decrease in emissions can be largely attributed to emission reductions for trucks/heavy HGVs, which is caused by the relatively low increase in vehicle-kilometres and the high share of different types of biofuels. In 2017, for example, the biodiesel share was about 25% (interview with Håkan Johansson, Swedish Transport Administration).[20] Meanwhile, emissions from vans/LGVs and ships only decreased very modestly in recent years. Due to uncertain input data, specific figures need to be treated cautiously.

These developments beg the question whether Sweden is on the path to achieve its 2030 climate objective. For this, we look at the official CO_2-emissions forecast published by the Swedish Environmental Protection Agency (2017). This forecast assumes that the policy instruments that existed in 2016 exist until 2030, and that the official freight transport forecasts from the Swedish Transport Administration (2017a) are followed.[21] The forecast does not distinguish between passenger and freight transport, but looks at the 16.3 million tonnes CO_2 in the transport sector overall, in 2016 (while Figure 6 shows that around 30% of these emissions came from freight transports).

The (base) forecast predicts that in 2030, CO_2-emissions from domestic transport will still be around 13 million tonnes, where the objective is 5.9 million tonnes. Even when looking at the Environmental Agency's most positive scenarios for both decided and planned policies, a reduction gap of 1 to 3 million tonnes CO_2 remains. However,

[19] The rail network is nearly entirely electrified.

[20] On 13 June, 2018.

[21] See the discussion on developments in Swedish domestic transport performance in section 4.2.2.

given the lack of distinction between freight and passenger transport, no indication is given about how much of this gap should be attributed to freight transport.

The 2030-secretariat (2018) does make an attempt at estimating the gap for heavy HGVs and estimates that the reduction gap for 2030 is around 72%. However, due to uncertainties in the data, such as the level of fossil free fuel for freight and the distance driven by the vehicles[22], the gap estimation might be misleading.

4.1.4 Finland

For Finland, official figures on developments in CO_2-emissions are model-based. As such, both the developments and forecasts discussed in this section, use the same approach.

Emissions from road transport are based on the LIPASTO model for calculations of exhaust emissions and energy use in Finland (VTT, 2016a,b). The LIPASTO model bases its calculations on the official forecast for vehicle mileage (Finnish Transport Agency, 2014), which builds on expert views regarding GDP development, the transport intensity of various sectors of the economy, modal splits, and vehicle loading. As such, it forecasts a 17% increase in HGV mileage from 2012 to 2050. Hereby it takes into account the expected modal shift from rail to road and increases in average loads due to allowing 76t vehicles in 2013, but not any possible effects of allowing longer vehicles, which is planned in 2018, i.e. it is a "frozen policy" forecast.

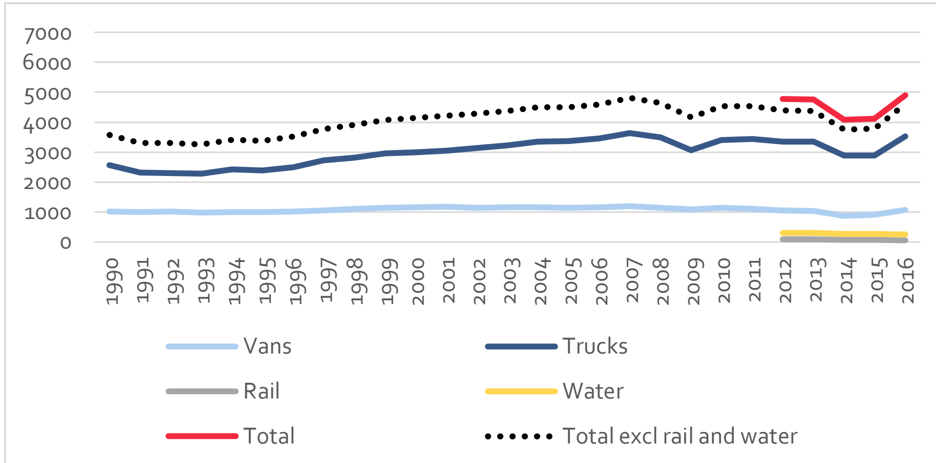
Similarly, the CO_2-emissions forecast is also a "frozen policy" forecast, as it takes into account the increasing biodiesel shares required by law until 2020, and then freezes the share at this level (13.5% of energy is biodiesel and has zero emissions for the period 2020–2050). Developments with regard to fuel consumption and the share of electric HGVs are "business as usual" forecasts based on expert views by VTT. Even by 2050, the share of electric HGVs is assumed to be very small (5,179 vehicles or 6%) in the underlying vehicle fleet forecast (VTT, 2016c).

The LIPASTO model also provides figures for emissions from rail and waterborne transport (VTT, 2012–2016-a and -b respectively). However, the share of freight transport has not been forecasted separately further back than 2012 (for rail) or at all (for waterborne transport). For waterborne transport, half of emissions is therefore assigned to freight, based on an estimation from the Finnish expert author.

Figure 7 shows the development in domestic CO_2-emissions from different freight segments for Finland.

[22] Assumption for fossil free fuel use for HGVs is based on the share of fossil free fuels in the whole road sector, which is probably an overestimation. There is also uncertainty in distance driven by HGVs. Current methods are also less accurate w.r.t. measuring distances driven by foreign HGVs on Swedish roads; see: http://2030.miljobarometern.se/nationella-indikatorer/index/fossil-energianLGVdning-i-nya-tunga-lastbilar-h3/info2/

Figure 7: Development in Finnish CO_2-emissions from different freight transport segments, for the period 1990–2016. In 1,000 tonnes



The figure clearly illustrates that road transport, and particularly HGVs, make up the lion's share of emissions from freight transport. In 2016, overall CO_2-emissions from freight amounted to nearly 5 million tonnes, of which over 3.5 million tonnes came from HGVs, and over 1 million tonnes from LGVs. While LGVs are showing a relatively stable or slightly decreasing trend, the picture is somewhat less clear for HGVs, where emissions peaked right before the economic crisis, but have shown some variation after that.

The above begs the question how Finland is doing with respect to its 2030 objectives. As mentioned, the official Finnish forecasts on CO_2-emissions use the same model as for the historical data discussed above. In this model, CO_2-emissions from HGVs are projected to remain at around the same level, all the way to 2050 (despite the abovementioned 17% expected increase in vehicle mileage). For LGVs, emissions are expected to decrease slowly but steadily, from around 1 million tonnes CO_2, to 0.7 million tonnes in 2050. Meanwhile, LGVs and HGVs together are projected to make up emissions of 3.6 million tonnes CO_2 in 2030, compared to 4.5 million tonnes in 2005, i.e. a reduction of just over 20 percent.

For waterborne and rail – both only making up a minor share of CO_2-emissions – forecasts do not allow us to distinguish between passenger and freight transport, which was possible for the historical figures.

The above suggests that a sizable reduction gap exists given Finland's objectives to reduce non-ETS emissions by 39% and emissions from the transport sector overall, by 50%, all for the period 2005–2030.

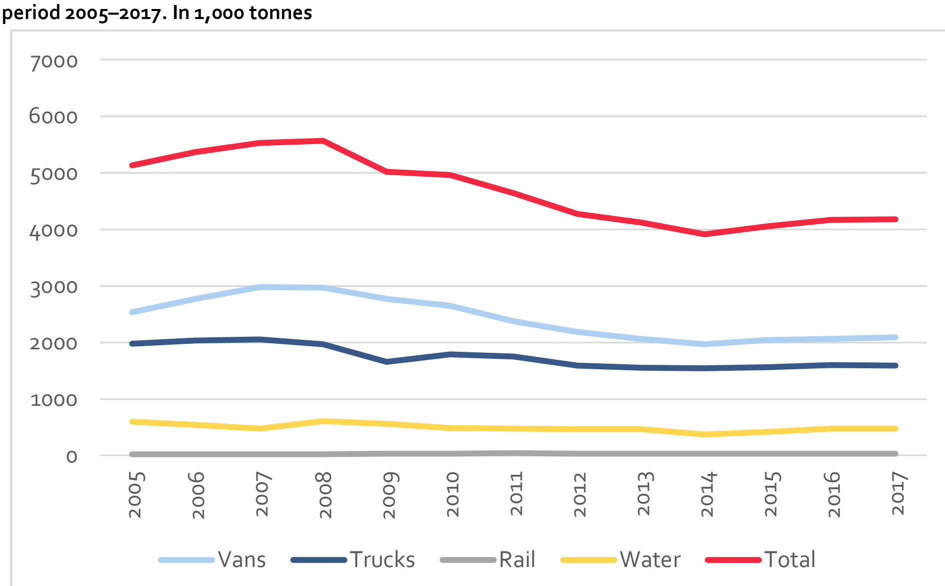
4.1.5 Denmark

For Denmark, official statistics on developments in CO_2-emissions from road come from detailed underlying data sets from the "Basisfremskrivning 2018" (Danish Energy Agency, 2018b and 2018c). As such, they are model-based.[23] Emissions from waterborne and rail transport build on own calculations based on energy consumption projections from the same "Basisfremskrivning".[24]

In 2017, transport accounted for about 28% of total national CO_2e-emissions. About a fourth of these transport emissions from national transport is caused by freight transport.

Figure 8 illustrates how Danish domestic CO_2-emissions from different freight segments developed over time.

Figure 8: Development in Danish CO_2-emissions from different freight transport segments, for the period 2005–2017. In 1,000 tonnes



The figure shows that in Denmark, overall CO_2-emissions from freight transport decreased markedly from the onset of the financial crisis, but started increasing again slightly from 2014. By 2017, Danish freight emissions amounted to 4.18 million tonnes CO_2, just under half of which stemming from LGVs. Emissions from HGVs follow at around 1.6 million tonnes, while waterborne and rail transport stand for considerably

[23] The fundamental principle behind these statistics is that they are consistent with the Danish Energy Agency's official data on Denmark's energy consumption and emissions as published in its yearly energy statistics. Hence, national figures for import and production of energy sources (coal, petrol, diesel, natural gas, wood etc.) for historical years are allocated to sectors and further split into sub-sectors, e.g. for transport road, railway, sea and aviation, and further ton passenger and freight vehicles. Model calculations are calibrated to fit with these figures for the latest available year. Most published data is aggregated for transport modes as a whole, while we use more detailed underlying data to distinguish between passenger and freight transport.

[24] Assuming 78.6 and 74.1 tonnes CO_2 per TJ for fuel oil and diesel, respectively (Danish Energy Agency, 2018d).

lower emissions. Remarkable compared to the other Nordic countries is the dominating of LGVs compared to HGVs.

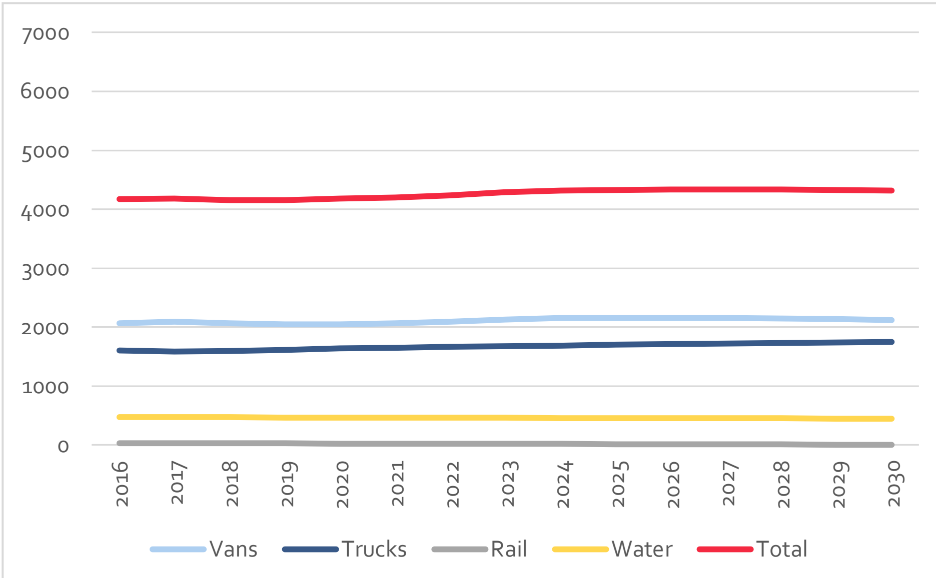
Official forecasts on CO_2-emissions, too, are based on data from the Danish Energy Agency (2018b), with "Basisfremskrivning 2018" being the most recent publication. The purpose of these annually updated forecasts is to form a basis for an assessment of whether Denmark's energy and climate targets will be reached within the framework of current regulation and without further initiatives ("frozen policy" assumption). It is assumed that no new energy policy measures are adopted and that all existing taxes will remain the same (except for measures already decided or measures that will expire implicitly). Biofuel shares at petrol and diesel pumps are fixed at current levels (i.e. E5 and B7).

However, "frozen policy" only applies to the field of (Danish) energy and climate policies. Hence, projections of transport volumes use assumptions on the most likely development of factors influencing transport demand: e.g. demographics, per capita GDP, world market energy prices and investments in transport infrastructure. In comparison, only infrastructure projects that have already been decided are taken into account in the basic projection used for transport appraisals. Traffic volumes are projected by using the national traffic model (LTM).[25]

Figure 9 illustrates the resulting forecast of CO_2-emissions towards 2030, taking into account the assumptions discussed above.

[25] For HGVs and LGVs, energy consumption and CO_2-emissions are calculated from traffic volumes based on the following:
- Today's traffic volumes are allocated to the 2018 vehicle fleet by vehicle type and age category.
- The age composition of the future vehicle fleet is determined using an age model with scrappage rates and the uptake of new vehicles matching each years' traffic volumes.
- The energy efficiency for new vehicles is expected to develop along the projections in Danish Energy Agency (2016).
- W.r.t. fuel use, it is assumed that in a frozen policy scenario, HGVs will still largely be using diesel in 2030. Electric and hydrogen HGVs are both expected to make up less than 1% of vehicle sales in 2030. The potential for gas (CNG and LNG) is expected to be significant. However, if no tax driven price differential relative to diesel (HGVs or fuels) is established, the operational costs for gas driven vehicles is expected to continue to remain slightly higher than is the case for diesel. Consequently, the share of gas is projected to be about 0.1% of total energy consumption by HGVs and LGVs in 2030.

Figure 9: Forecast for Danish CO_2-emissions from different freight transport segments, for the period 2016–2030. In 1,000 tonnes



The figure and underlying data show that emissions from freight transport are expected to remain rather stable towards 2030, as without additional policies, expected fuel efficiency improvements will approximately counterbalance increasing transport volumes.

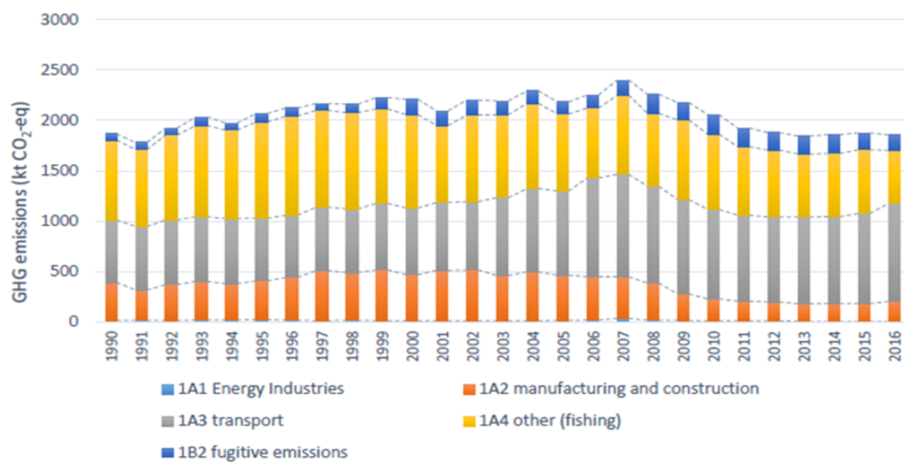
For the different modes, the already low emissions from rail are forecasted to move towards zero, while also waterborne transport is expected to reduce emissions, albeit only by a small amount. Meanwhile, emissions from LGVs and HGVs are expected to increase by ca. 2.5% and 9% respectively.

We saw in Chapter 3 that Denmark has not officially adopted reduction targets for the transport sector or freight specifically, but that a Government Roadmap including the transport sector is expected this autumn. Although emissions from freight transport decreased between 2005 and 2014, this decrease has recently turned into a slight increase. The discussed forecasts also point to a slight but further increase towards 2030. As such, freight transport is expected to contribute only a 16% reduction in CO_2-emissions by 2030 compared to 2005 levels. Without substantial additional political incentives, this implies a reduction gap of 23% or about 1.2 million tonnes CO_2 compared to non-ETS reduction objectives.

4.1.6 Iceland

In Iceland, emissions from fuel combustion in the energy sector accounted for 39.8% of the total GHG emissions in 2016 (Environment Agency of Iceland, 2018). Emissions from transport have significantly increased since 1990 (by 57%), whilst emissions from energy industries, fishing and manufacturing industries and construction have decreased (-84%, -47% and -33%, respectively). This is illustrated in Figure 10.

Figure 10: Development in total GHG-emissions from the Icelandic energy sector, for the period 1990–2016. In 1,000 tonnes CO_2e



Source: Adopted from the Environment Agency of Iceland (2018).

Emissions from the transport sector have increased by over half across the time series. The largest increase in emissions comes from road transport, which has increased by 75% since 1990, owing to an increase in the number of cars per capita, increased mileage, and, until 2007, an increase in larger vehicles. We have not found decomposed emission figures for passenger cars and goods vehicles. Since 1990, the vehicle fleet in Iceland has increased significantly. Also, the Icelandic population has grown by 30% from 1990 to 2016. Emissions from road vehicles peaked in 2007 and had decreased by 9.4% by 2015. Emissions rose again between 2015 and 2016 (+8.9%), limiting the emissions reduction since 2007 to only 1.4%. In recent years, however, more fuel-efficient vehicles have been imported – a change compared to the trend between 2002–2007, when larger vehicles were imported. Emissions from both domestic flights and navigation have declined since 1990. This decrease in navigation and aviation has compensated for rising emissions in the transport sector to some extent.

4.2 Transport volumes and modal shares

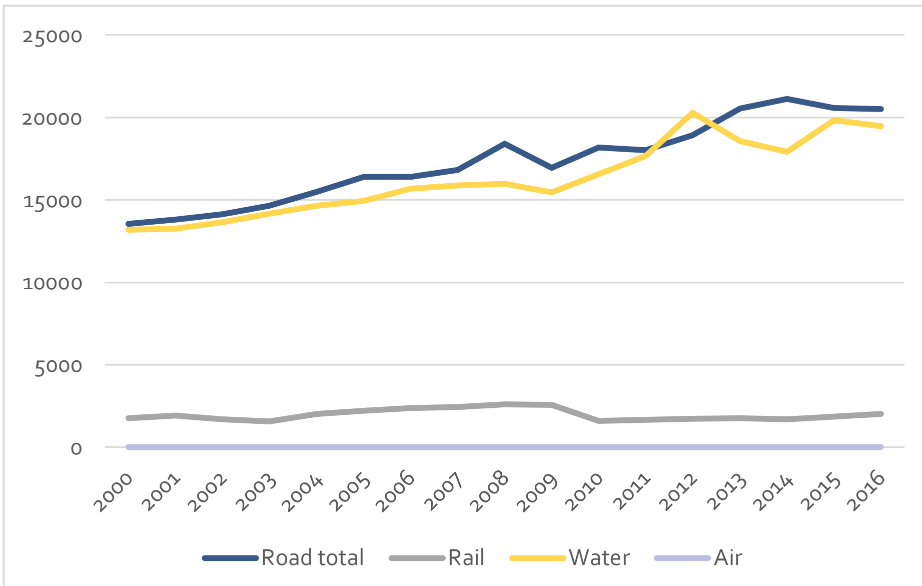
After looking at developments in, and forecasts for CO_2-emissions, we now turn to a discussion of underlying developments in freight transport, such as transport volumes and modal shares, in the Nordic Countries.

4.2.1 *Norway*

For Norway, data on transport performance for freight transport is collected from Farstad (2018) and supplemented with complementary data.

Figure 11 illustrates the development of domestic transport performance, for different modes, over the period 2000–2016. Data in this section exclude waterborne petroleum transport from the continental shelf to the Norwegian mainland.

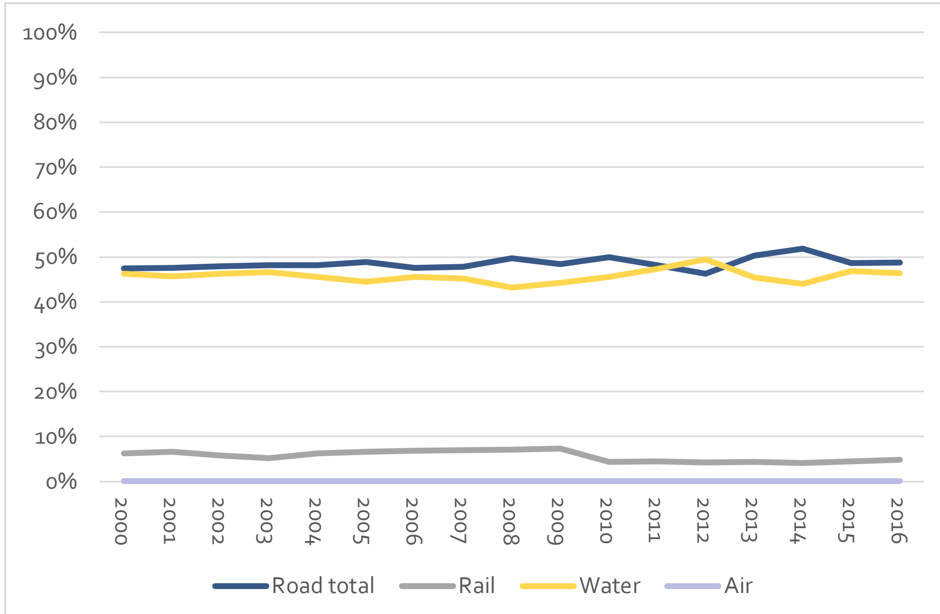
Figure 11: Development of domestic transport performance of different transport modes in Norway, for the period 2000–2016. In million tonne-km's



The figure shows that in terms of domestic transport performance, road and waterborne transports are dominant modes in Norway, while rail transport plays only a modest role. Transport by air takes a marginal place. Further, the figure shows that transport by road and water has been increasing significantly since the start of the century. Transport performance for rail, on the other hand, is currently only slightly higher than in 2000, with a fall around 2009/2010. Altogether, however, it is clear that total Norwegian domestic transport performance has increased materially.

Figure 12 shows the same developments, but now in percentage of total transport performance, i.e. it gives a clear view of developments in modal shares performance.

Figure 12: Development in modal shares of different transport modes in domestic transport performance in Norway, for the period 2000–2016



From this figure, it can be seen that the division across modes remains relatively stable over time. With between 45–50%, road and water make up roughly equal shares, and together stand for the lion's share in total domestic transport performance. Rail transport, averaging a share of roughly 6–7% in the years 2000, in recent year makes up a share of around 4–5%.

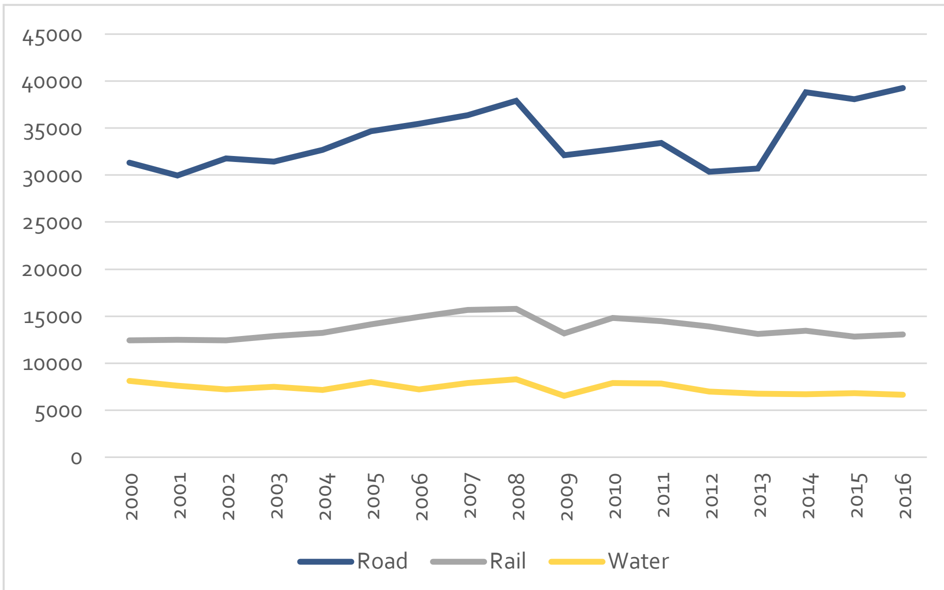
Forecasts by Hovi *et al.* (2017, p.24) indicate that Norwegian domestic transport performance will increase by on average 1.5% per year over the period 2016–2050. Road stands for the strongest increase (2% yearly), followed by rail (1.8%), while the increase for waterborne transport is expected to be more modest (0.9% yearly). The forecasts consider already decided infrastructural measures and effects of existing and planned measures.

4.2.2 Sweden

In Sweden, statistics on domestic transport performance of different modes are available through Transport Analysis (2017a).

Figure 13 illustrates the development of domestic transport performance for different modes, over the period 2000–2016.

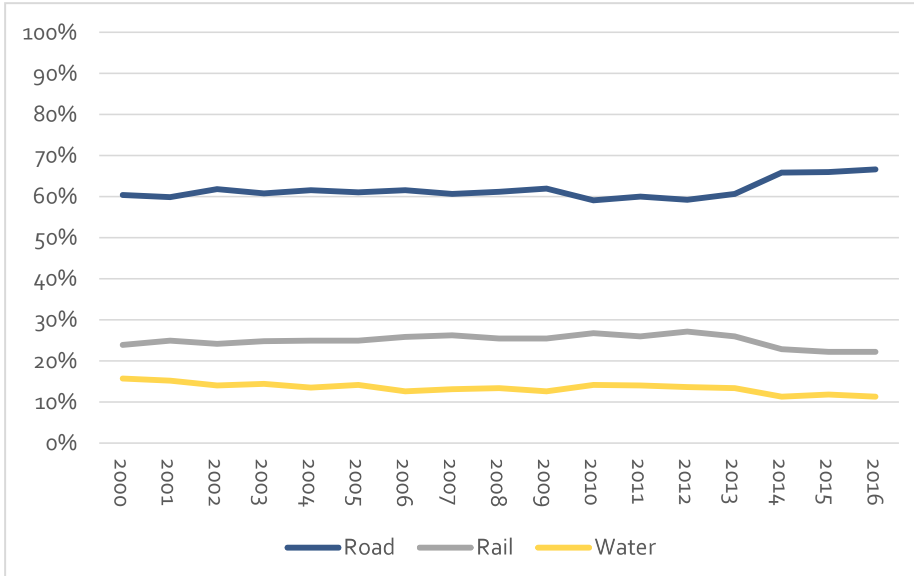
Figure 13: Development of domestic transport performance of different transport modes in Sweden, for the period 2000–2016. In million tonne-km's



This figure shows that transport performance increased between the start of the century, and until the onset of the financial crisis. This increase was strongest for road transport, followed by rail transport. Between 2008 and 2009, however, all modes experienced a marked fall. For road, a recovery seems to have started in 2013, but might partially have been caused by an adjustment of statistics. For rail and waterborne transport, in turn, a slight recovery between 2009–2010 was followed by a slow downward trend towards 2016.

Figure 14 shows the same developments, but now in percentage of total transport performance, i.e. it gives a clear view of developments in modal shares performance.

Figure 14: Development in modal shares of different transport modes in domestic transport performance in Sweden, for the period 2000–2016



This figure shows that despite variations in absolute transport performance, modal shares in Swedish freight transport were rather stable between 2000–2013, after which road transport increased somewhat at the expense of rail and waterborne transport. Currently, road stands for around 66% of total domestic transport performance. With well over 20% over time, the Swedish rail share is considerably higher than in Norway, while the Swedish share for waterborne transport (currently 11–12%) is considerably lower.

Forecasts by the Swedish Transport Administration (2017a) predict that Swedish transport performance will increase by on average 1.8% per year between 2012 and 2040, with the following expected annual increases per mode: heavy HGVs (1.8%), waterborne transport (1.9%), rail (1.5%).[26] This forecast assumes that the transport infrastructure is developed in line with the draft of the Swedish Infrastructure plan 2018–2019 and excludes investments after that period. Further assumptions relevant to freight are: a) increased fuel taxes for road transport from 2016, b) higher costs for sea transport due to more stringent sulphur requirements, and c) year-by-year increasing rail track charges until 2020.

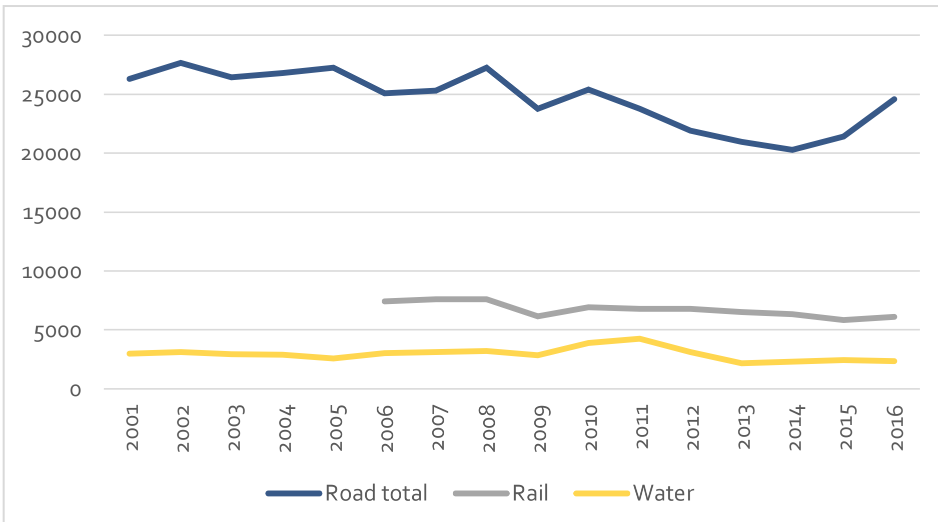
4.2.3 Finland

For Finland, we gathered data on transport performance for road from Statistics Finland (2018), and for rail and waterborne freight transport, from the Finnish Transport Agency (2017 and 2018a).

[26] It should be noted that this regard both international and domestic transports, and that the rates of increase are higher for the former.

Figure 15 illustrates the development of domestic transport performance in Finland, for different modes. Unlike for Norway and Sweden, time series for rail only start in 2006, while air transport, which also in Finland only plays a marginal role, is not included in the figure.

Figure 15: Development of domestic transport performance of different transport modes in Finland, for the period 2001–2016. In million tonne-km's

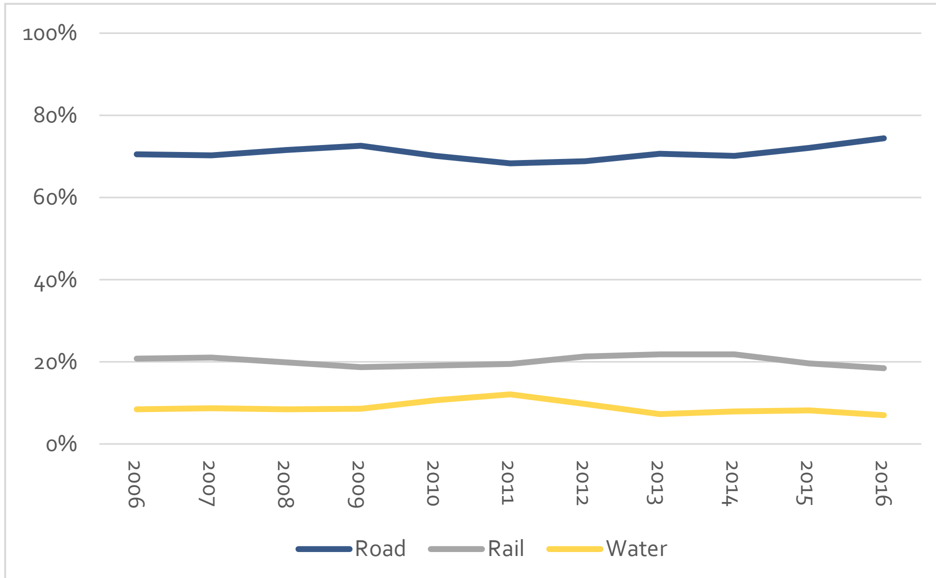


The figure shows that in Finland, road transport stands for the lion's share of domestic transport performance, but shows remarkable year-to-year variations. As for Norway and Sweden, a particular decrease is visible around the onset of the financial crisis. This is followed by a modest recovery in 2010, a gradual but significant decrease until 2014, and a material recovery over the past few years.

Transport performance for rail, in turn, also decreased around the onset of the crisis, but to a lesser extent. After a minor recovery in 2010, transport performance fell gradually back to 2009-levels.

Figure 16 shows how the above translates into modal shares.

Figure 16: Development in modal shares of different transport modes in domestic transport performance in Finland, for the period 2006–2016



The figure shows that in Finland, road transport makes up the largest share, at around 74% in recent years. The share of rail has remained relatively stable between around 19–21%, while waterborne transport makes up just under 10 percent of total Finnish domestic transport performance. After allowing 76t HGVs in 2013, there has been a declining trend in the share of rail, and an increasing share of road transport.

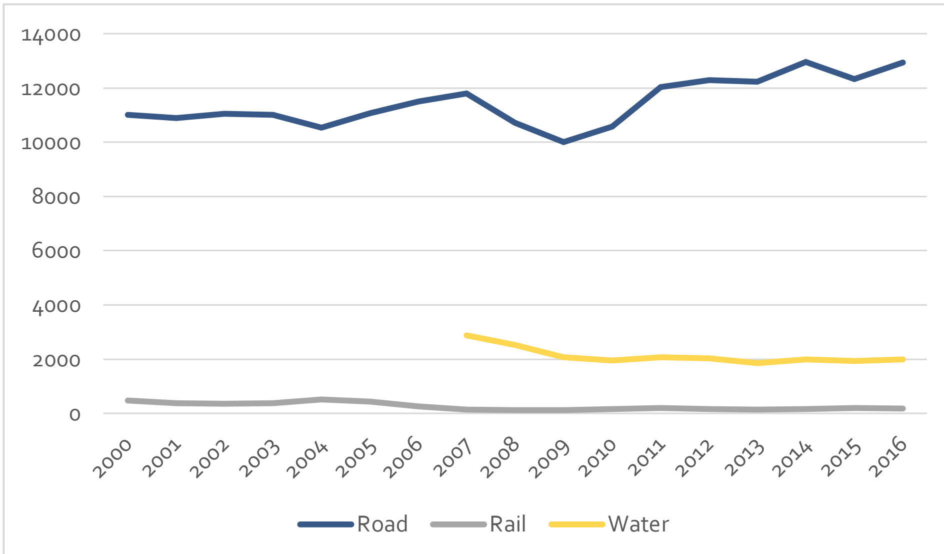
Road freight performance is forecasted to increase from its 2012 level by 7% by 2020, 11% by 2030, 18% by 2040 and 29% by 2050. Hence, the road transport performance would be 25.7 billion tkm in 2030 and 29.6 billion tkm in 2050, and total freight transport around 36 billion tkm in 2030 and 42 billion tkm in 2050 Finnish Transport Agency, 2014). However, in reality, transport performance already grew beyond the forecasted 2030 level in 2017 (26.3 billion tkm). Road freight share was forecasted to grow by 3 percentage points between 2012–2050, but the share had already increased by 9 percentage points in 2012–2017. Hence, the forecast made before any knowledge of the HGV weight increase can be seen to be outdated.

4.2.4 Denmark

For Denmark, data on transport volumes by road, rail, and water are gathered from Statistics Denmark's publications on freight transport (2017a). We gathered data for domestic/national freight transport.

Figure 17 illustrates the development of domestic transport performance in Denmark, for different modes. Unlike for the other Nordic countries, statistics for road transport only cover HGVs with a total weight of over 6 tonnes, so that LGVs are not included in the figure.

Figure 17: Development of domestic transport performance of different transport modes in Denmark, for the period 2000–2016. In million tonne-km's

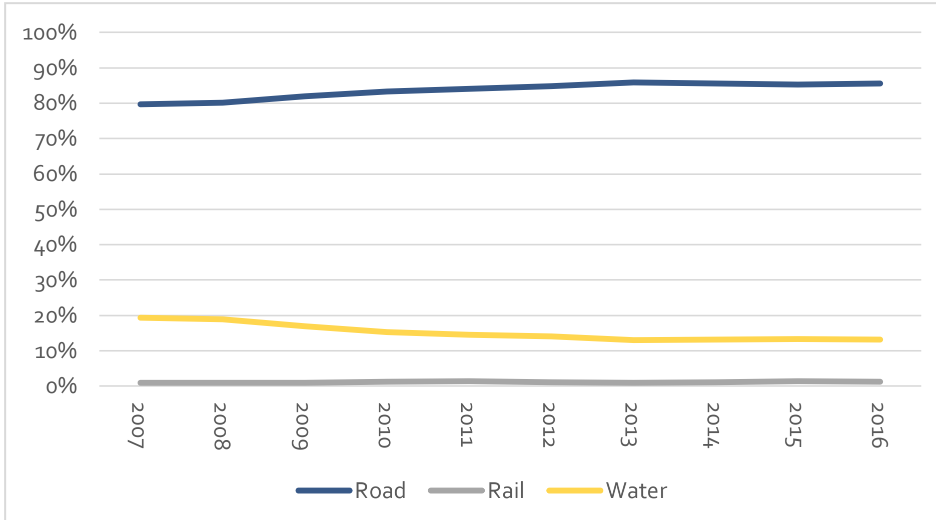


The figure shows that Danish domestic transport performance is dominated by road transport, even when not including LGVs. Since the start of the century, road transport increased until the financial crisis, which caused a sudden and sharp decrease. From 2009 onwards, however, transport performance by heavy HGVs increased again; by 2016, the level was almost 18% higher than in 2000.

For waterborne transport, time series only start in 2007. After a decrease until 2009, domestic transport performance by ship stabilized in recent years. Rail, in turn, only stands for a modest transport performance. Even so, it more than halved since 2000.

Figure 18 shows the same developments, but now in percentage of total transport performance, i.e. it gives a clear view of developments in modal shares performance.

Figure 18: Development in modal shares of different transport modes in domestic transport performance in Denmark, for the period 2007–2016



This figure confirms that road is the dominating mode in Denmark. Even without including LGVs[27], its share increased from roughly 80 percent to around 85 percent in recent years. This has largely gone at the expense of the share of waterborne transport, which dropped from 20 percent to around 13 percent. As seen above, rail only stands for a marginal share domestically.

Historic development in freight transport volumes has historically been closely correlated with economic growth and is expected to be so also in the future. Freight traffic volumes by road, measured as HGV-kilometres, are expected to increase by 19% in 2030 compared to 2017. Forecasts on transport performance are not available for rail and sea, but any modal shift is not expected to reduce road traffic significantly.

4.2.5 Iceland

The main mode of domestic freight transportation in Iceland is HGV transport. In addition, there is probably some coastal transport. Unfortunately, we have not found any statistics on transport performance for freight transport in Iceland.

4.2.6 Country comparison

Figure 19 combines findings from the above sections by illustrating the modal shares of road freight in the domestic transport performance of the Nordic countries.

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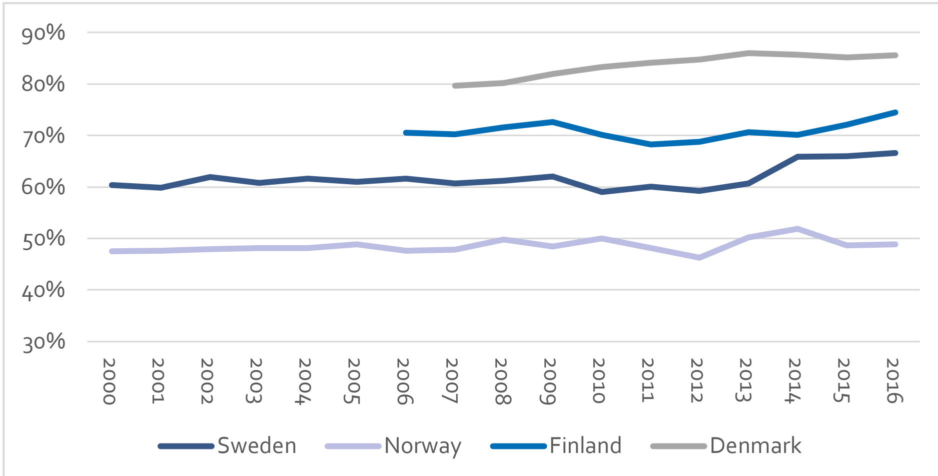
[27] LGVs (between 2.0 and 3.5 tonnes) are used for both passenger transport and freight distribution and constitute a quite significant share of both traffic volumes and CO_2 -emissions. They are accounted for as passenger transport where their total vehicle kilometers contribute significantly (ca. 10%) to total transport volumes (passenger kilometers). Due to on average very small loads in tons their contribution to freight transport performance is limited.'

Figure 19: Development in the modal share of road in domestic transport performance in the Nordic countries, for the period 2000–2016



It can be seen that with just under 50%, the share of road transport in total domestic transport performance has been lowest in Norway, over the past 16 years. In Sweden, this share long remained around 60%, but increased somewhat in recent years. It should be noted that for the remaining freight transport, rail transport makes up a much larger share in Sweden than in Norway, while Norway in turn has a much higher share of waterborne transport.[28]

At the same time, Finland and particularly Denmark feature much higher shares of road transport, with a significant increase in road share in Finland due to allowing 76t HGVs in 2013. The high share for road transport in Denmark is related to the country's significantly shorter distances, which disfavour other modes.

The review in this chapter indicates that in the years to come, road haulage is expected to increase both in volume and in share of total domestic transport for Norway, while for Sweden, the forecasted increase in domestic maritime transport is somewhat higher than for road transport, so that the share of road freight is expected to decline slightly for Sweden.

In Finland, forecasts were made before allowing 76t HGVs, and can be seen to be outdated due to changes that have taken place after this weight increase. Indeed, transport performance and the share of road transport have increased much stronger than already forecasted increases. For Denmark the clear dominance of road transport is not expected to change in the future.

[28] Even when excluding petroleum transport from the continental shelf to the Norwegian mainland.

4.3 Potential for modal shift

We have seen that road transport plays a dominant role in terms of GHG emissions and transport performance, and that this holds true both in a European perspective, and for the Nordic countries individually. Both the European Commission and the Nordic countries therefore consider it desirable to shift mode from road to rail and waterborne transport. Already in its 2011 White Paper, the European Commission for example stated among its main goals for achieving emission reduction targets (European Commission, 2011, p.9):

> "30% of road freight over 300 km should shift to other modes such as rail or waterborne transport by 2030, and more than 50% by 2050, facilitated by efficient and green freight corridors. To meet this goal will also require appropriate infrastructure to be developed."

The reasoning behind the 300-km distinction is that transports over shorter distances are seen as predominantly road-based by default. This is due both to ship and rail links simply not being available, but more importantly, because ship or rail transport generally requires road transport at one or both ends. As the latter requires costly handling and transferring, other modes can usually not compete with road on shorter distances.

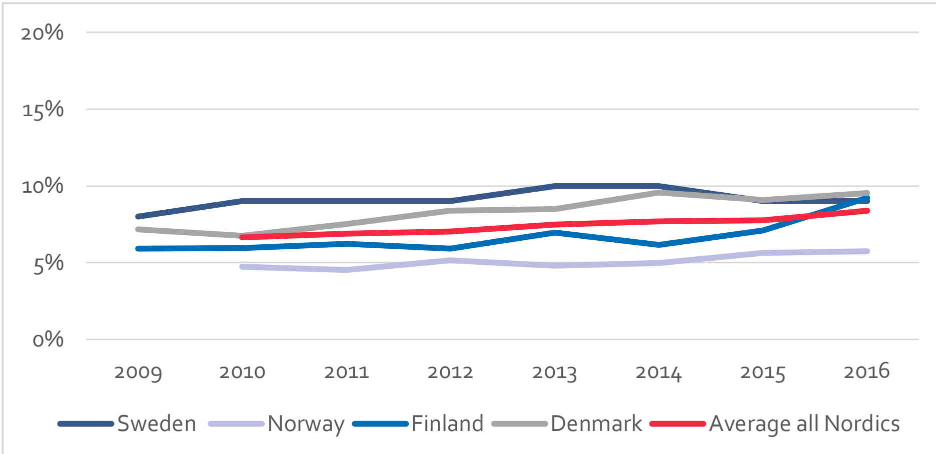
The remainder of this section therefore shortly explores the shares of road transport in transport over 300 km's for the different Nordic countries, while initiatives promoting modal shift are discussed separately in the chapter on policy measures.

Data on the goods volumes and traffic performance by length of haul are based on basic data from the annual lorry surveys carried out in each respective country. For Norway, these data are based on previous edits of the basic data performed by TOI.[29] Similar statistics for Sweden are collected from Transport Analysis (2018), while for Finland, data comes from Statistics Finland (2018) and the Finnish Transport Agency (2017, 2018a). For Denmark, statistics were collected from Statistics Denmark (2017b) but are limited to HGVs with a total weight of over 6 tonnes. In the context of modal shift, it is solely such HGVs (rather than LGVs) that potentially compete with rail and ship.

Figure 20 illustrates developments in the share of domestic goods volume in tonnes transported over more than 300 km's in each of the Nordic countries.

[29] TOI was responsible for compiling base data from Statistics Norway as input for a report by the Auditor General of Norway (2018).

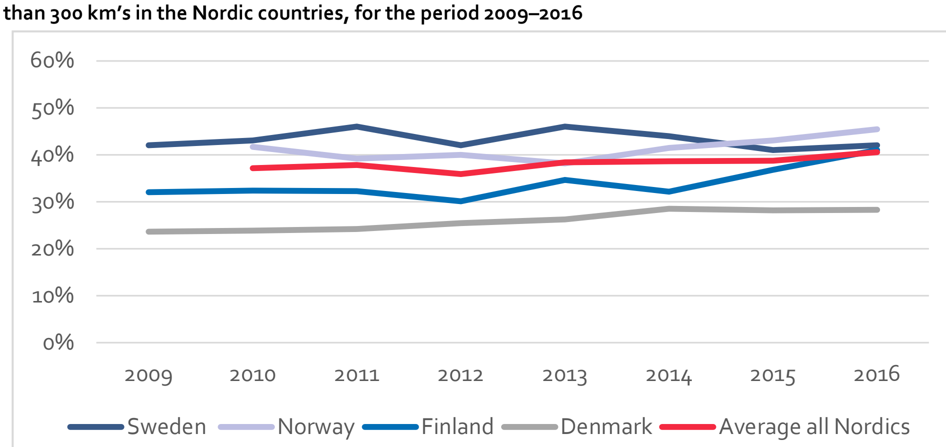
Figure 20: Development in the share of domestic road goods volume in tonnes transported over more than 300 km's in the Nordic countries, for the period 2009–2016



The figure indicates that with respect to the (domestic) road goods volume in the Nordic countries, only a small share is transported over distances longer than 300 kilometres and could potentially be transported by other modes. Depending on the country, this share lies between only 5–10% of the total domestic goods volume for road. For the Nordic countries combined, a slight increase in the share of road goods volume that is transported for distances over 300 km's is visible between 2010–2016.

Looking at transport performance paints a more varying picture, as transport performance is calculated by multiplying the goods volume with the transport distance, which yields a higher weighting of freight transport covering longer distances (Figure 21).

Figure 21: Development in the share of domestic *road* transport performance transported over more than 300 km's in the Nordic countries, for the period 2009–2016



The share of road transport performance on trips >300 km's varies from around 25–30% for Denmark, to ca. 40–45% for Norway and Sweden. The lower share for Denmark can be explained by the fact that Denmark is the smallest of countries. A significant part of road transport performance is thus carried out over distances over 300 km's. Except for Sweden, the share of road hauls over 300 km's has also increased over recent years. On average and for the Nordic countries combined, this share increased from around 37% in 2010 to nearly 41% by 2016. It should also be mentioned that despite of the fact that Norway and Sweden have significantly larger water- and rail-transport shares than Finland and Denmark, the share of transport performance over 300 km distances by road is nevertheless higher in the former countries.

The figures in this section indicate a theoretical maximum potential for modal shift, as much of the freight transport lacks a rail terminal or harbour in close proximity to both ends of the transport chains.

4.4 Adoption of alternative technologies within the road sector

As projections and ambitions for the Nordic countries envision a future with increasing use of alternative propulsion technologies, this section shortly illustrates the recent developments in the adoption of such technologies. Initiatives aimed at speeding up or promoting these developments are discussed separately in the chapter on policy measures.

4.4.1 Norway

In Norway, Statistics Norway (2017b) publishes data on the number of vehicles divided by propulsion technology and vehicle type.

With regard to LGVs, the past ten years have seen an increase in the share of diesel-driven vehicles from around 83 percent in 2008 to around 93 percent in 2017. Over the same period, the share of petrol driven LGVs decreased from around 17 percent to six percent. Although still only making up less than 1% of the total LGV fleet, the absolute number of electrically-driven LGVs picked up rapidly in recent years: at the end of 2017, nearly 3,500 LGVs were electric on a total of about 471,000. Only very few LGVs run on gas or other fuels.

For comparison, about 42% and 48% of the Norwegian passenger cars runs on petrol or diesel respectively. Over the past couple of years, the share of electric or hybrid vehicles in new car sales has increased tremendously, resulting in an electric share of 5.1% in the total passenger car fleet at the end of 2017.

When it comes to HGVs, around 95 percent of the Norwegian fleet is currently diesel-driven, while 4–5 percent runs on petrol (almost exclusively smaller and older vehicles). A small fraction of the roughly 74,000 Norwegian HGVs runs on gas, and even fewer on other fuels. In recent years, only 1–2 electric HGVs were in operation, indicating that a long way is still to go.

4.4.2 Sweden

For Sweden, time series for technology penetration (vehicles in use) within both the LGVs and HGV segments are available for 2008–2017 and come from Transport Analysis (2017b).

Here, the share of diesel LGVs increased from 74% in 2008, to 89% at the end of 2017. Meanwhile, the share of petrol LGVs decreased from 25% to 9% over the same period. By the end of 2017, around 8,000 LGVs were gas-driven, and roughly 1,600 ethanol-based. Although this constitutes a rapid increase since 2008, both technologies still only make up a marginal share of the LGV fleet (1.4% and 0.3% respectively). With nearly 2,000 electric LGVs and a couple of dozen hybrids in 2017, electricity-based LGVs too, still only make up a marginal share, but the recent uptake is rapid.

When it comes to HGVs, diesel is the dominant propulsion technology with a stable share of over 97% since 2008. Over the same period, the share of petrol HGVs decreased slightly. The number of gas-driven HGVs more than doubled since 2008, but still only makes up only ca. 1% of the HGV fleet. Even fewer HGVs are fully biodiesel-based, despite a rapid increase starting in 2015. Finally, at the end of 2017 there were roughly 60 ethanol-based HGVs, and fewer than 30 electric hybrids. Like in Norway, only one fully electric HGV was in operation.

4.4.3 Finland

For Finland, recent statistics on the shares of different technologies within the LGVs segment and HGVs segment is available for 2016 and 2017 (Finnish Transport Safety Agency, 2017).

When it comes to Finnish LGVs, the lion's share is diesel-driven (over 96 percent), while nearly all remaining LGVs run on petrol. At the end of 2017, only a couple hundred out of nearly 320,000 LGVs ran on gas, while around 210 LGVs were electric.

For HGVs, the Finnish diesel share lies around 98 percent, with most remaining HGVs running on petrol. By the end of 2017, only a few dozen HGVs used other fuel types, such as gas or ethanol, while just one out of nearly 96,000 HGVs was electric.

4.4.4 Denmark

Danish data on the shares of different propulsion technologies in the LGVs and HGVs segments are model-based, and come from the Danish Energy Agency's (2018b) "Basisfremskrivning".

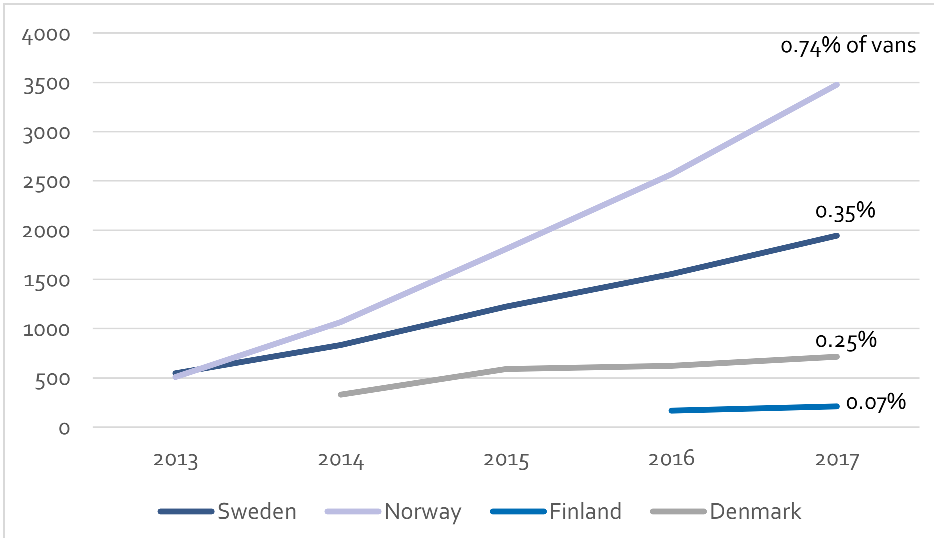
Of Danish LGVs, around 94 percent runs on petrol, while well over 5 percent is petrol-driven. At the end of 2017, around 715 of nearly 286,000 LGVs was electric, while just over a hundred LGVs ran on gas.

When it comes to HGVs, nearly the whole Danish fleet is diesel driven, with around 150 gas-driven vehicles and no electric vehicles.

4.4.5 Country comparison

Figure 22 summarizes the developments described above for both the number of electric LGVs and the share in the fleet.

Figure 22: Development in number of electric LGVs and their share in the total number of LGVs in the Nordic countries, for the period 2013–2017



The figure makes clear that all in all, electric LGVs still only make up a minor share of the LGV fleet in Nordic countries, varying from 0.07 percent in Finland to 0.74% in Norway. However, the absolute number of electric LGVs has increased rapidly over the last few years, particularly in Norway and Sweden. Meanwhile, the uptake of electric HGVs is still in a very early phase in all the Nordic countries.

4.5 Summary

The development in CO_2-emissions from freight transport in the period from 2005 and up until 2016 has differed between the Nordic countries. While data from Sweden and Denmark shows drops in emissions from freight transport (both around -19%, although the change for Sweden is somewhat uncertain), Norway and Finland have been at a relative standstill. Forecasts for the different countries indicate that CO_2-emissions from freight transport in Norway will further increase towards 2030, while emissions in Denmark are expected to lie around the same level in 2030 as they do today. Sweden and Finland expect reductions, but not sufficient either, if the non-ETS target for 2030 is applied verbatim to freight transport.

Developments in CO_2-emissions are, among other things, determined by the underlying developments in freight transport, such as transport volumes, distances, and modal shares. As such, it is important to notice that freight transport modal shares differ between the Nordic countries. In Denmark and Finland, freight transport by road is the dominating mode with over 85% and 70% of the total domestic transport performance, respectively. The same goes for Sweden, where the share of freight domestic transport by road in recent years increased from around 60% to roughly 66%, while in Norway, road transport makes up nearly 50% of domestic transport performance. Interesting are also differences in the role of waterborne transport, which is most important in Norway (ca. 45% of domestic transport performance). In Finland and Sweden, the shares of water transport are around 19% and 11% respectively, while in Denmark, waterborne transport only plays a marginal role. Freight transport by rail, in turn, makes up a share of about 20% of domestic transport performance in Sweden and Finland, around 5% in Norway, and only a fraction in Denmark.

As a way to reduce emissions, the European Commission and the Nordic countries consider it desirable to shift freight volumes from road to rail and waterborne transport. In this regard, it is generally assumed that transport over distances shorter than 300 km is road-based by default. For transport over longer distances, other modes can be an alternative, but will at a minimum require a rail terminal or harbour in close proximity to both ends of the transport chains. The illustrations of developments of transport over distances <300 and >300 km, discussed in this chapter, should therefore be seen as absolute maximum and is put into perspective in a discussion on measures promoting modal shift, later in this report.

Finally, we looked at the adoption of alternative propulsion technologies with lower- or zero emissions in the Nordic countries. All in all, all the countries show significant increases in the adoption of alternative propulsion passenger cars in recent years. Meanwhile, electric LGVs still only make up a minor share of the LGV fleet in Nordic countries, varying from 0.07% in Finland to 0.74% in Norway. However, the absolute number of electric LGVs has increased rapidly over the last few years, particularly in Norway and Sweden. At the same time, the uptake of electric HGVs is still in a very early phase in all the Nordic countries.

5. Policy Measures

5.1 Introduction

In the previous chapters, we identified gaps in achieving required or agreed reduction targets for CO_2, for each of the Nordic countries. In this chapter, we address the existing and planned policy measures that these countries employ or consider employing to reduce emissions.

Rather than grouping policy measures purely by type (e.g. economic measures, technical measures, etc.), we choose to group the measures by the main channel through which they contribute to reducing CO_2-emissions from freight transport:

- Reducing transport demand.
- Increasing transport mode efficiency.
- Moving towards modes with higher energy efficiency per unit transported (modal shift).
- Transferring to fuels with lower carbon content.
- Moving towards lower-carbon vehicle technologies.
- Other measures.

Within these groups, we focus on areas that can be influenced through policy measures. Even so, many policy measures work through multiple channels simultaneously and overlap. Taxes and fees for example increase the price of transport, thereby reducing transport demand. At the same time, their effect can vary between fuel use/type, thereby changing the playing field for technologies vis-à-vis.

5.2 Reducing transport demand

The most obvious way to reduce emissions from freight transport is to reduce the demand for this type of transport. However, the forecasts on freight transport discussed earlier suggest that this is no easy task: freight transport in the Nordic countries is expected to keep increasing, driven by such factors as GDP growth, population growth, and evolving purchasing patterns.

Several types of policy measures can nevertheless contribute to at least dampen demand for freight transport. The main examples are taxes and duties, registration fees, zoning regulation, and transport- and area planning.

In the Nordic countries, taxes and duties come in several forms and are usually applied to road use and/or fuel use. Road use taxes (time-based, distance-based, location/congestion-based) increase the cost of transport. Depending on the policy measure, this could contribute to reducing demand but can also influence mode choice.[30]

Taxes on fuel use also make transport more expensive, but are generally set-up differently than road use charges. Rates are set within the framework of the European Energy Taxation Directive, which prescribes minimum levels for diesel and petrol. In their report on emission reductions from passenger cars, Jordal-Jørgensen *et al.* (2017) found that all EU countries, except for the UK, tax diesel at lower rates than petrol, both per litre and when taking into account the relative energy and carbon contents.

In addition to taxing road use or fuel use, also the ownership or purchase of vehicles can be subject to varying fees, such as annual registration and ownership fees or one-off purchase fees. Unlike for passenger cars or LGVs, however, none of the Nordic countries charges purchase fees for HGVs.

Further, freight transport by road in all Nordic countries is governed by restrictions and standards on local pollutions that are set at the European level, particularly the so-called Euro Directives: For new heavy vehicles, the newer Euro VI-restrictions (459/2012/EC) were implemented in 2014 (Hagman *et al.,* 2015). This framework has its bearing on the European vehicle fleet, while an increasing number of European and Nordic cities has or is in the process of implementing local restrictions on heavy vehicles with more polluting engines.

Although the types of measures described above generally prioritize other objectives than reducing CO_2-emissions, they all affect the demand for transport by making it more expensive, less convenient, or less attractive. This can in turn also affect modal shifts and air pollution.

5.2.1 Norway

In Norway, road use charging is applied through a toll system. Tolls are charged on the main roads, a number of tunnels and bridges, and around the largest cities. The system is primarily fiscally motivated (financing infrastructure and in some cases public transport), but is also used to address congestion and, to a lesser extent, local emissions.

Toll levels vary depending on location and vehicle type/weight, while most electric or hydrogen-powered vehicles currently are exempt. In some cases (e.g. around the cities of Oslo, Bergen and Trondheim), a rush-time component is charged on top of the regular toll. For a recent overview of toll rates, see e.g. Autopass (2018).

In addition to road use charges, Norway makes use of a fuel tax. This tax consists of two components, a road use charge ("veibruksavgift"), and a CO_2-component. Table 2 gives an overview of the 2018-levels of these taxes for different fuel types.

[30] For toll charges, it is for example uncertain to what extent transport demand is reduced, as transport costs make up only a small share of the goods' value.

Table 2: Overview of Norwegian fuel taxes and their components for a selection of fuel types. Figures in NOK/litre fuel, 2018-levels

	Road use tax (NOK/litre)	CO_2 tax (NOK/litre)	Total (NOK/litre)
Diesel	3.75	1.33	5.08
Biodiesel	3.75	-	3.75
Petrol	5.17	1.16	6.33
Bioethanol	5.17	-	5.17

Source: Norwegian Government (2018b).

The table shows that the per litre road use tax on petrol and bioethanol is higher than the tax on (bio)diesel. The CO_2-tax, in turn, is slightly higher for fossil diesel than for fossil petrol, because of the slightly higher carbon content of diesel.[31]

Further, biodiesel and bioethanol are exempt from the CO_2-tax, because they are seen as "carbon neutral".

When it comes to fees on the ownership of HGVs, Norway charges a so-called "vektårsavgift" (annual weight fee) and an environmentally differentiated yearly fee. The level of the annual weight fee depends on the type of suspension, the number of axles, and the weight of the vehicle combination. For most vehicles, this yearly fee is well below NOK 6,000, and the maximum yearly charge is NOK 11,735.

The environmentally differentiated yearly fee varies according to weight class and Euro class (or zero-emission characteristics). For most vehicles, this implies a yearly cost of several hundred to a few thousand NOK. Only the heaviest vehicles with lower Euro classes pay somewhat more, but this difference is not very significant. For a full overview of current levels of both fees for different vehicles, see the Norwegian Tax Administration (2018).

For LGVs, the purchase fee is set at 20% for the weight component and 75% for the NOx component of the passenger car fee, while the CO_2-tax component can vary compared to passenger cars. This illustrates that the purchase tax for LGVs is higher than for HGVs, but nevertheless significantly lower than for passenger cars in Norway. Because the fees in addition are subject to VAT, and VAT-compliant firms can subtract inbound VAT, the difference with passenger cars is even larger.

From January 2018, the annual fee was replaced by a traffic insurance fee. The fee is required by the insurance companies together with the insurance premium. It is mandatory to have valid insurance for all registered vehicles.

Norway currently does not employ zoning regulation aimed at the reduction of local or GHG emissions. Oslo is the first city to have introduced environmentally differentiated tolls for heavy vehicles, where vehicles with Euro VI-engine pay reduced rates compared to older vehicles. Zero-emission LGVs and HGVs are currently exempt from paying toll in Oslo, but also for all other Norwegian toll stations. According to a

[31] The CO_2-tax on petrol and diesel is equal per unit of carbon.

major transport operator, savings from this exemption can amount to up to 100,000 NOK for zero-emission distribution HGVs in Oslo.

In Norway's National Transport Plan for 2018–2029, a total of NOK 933 billion is earmarked towards transport over a 12-year period. Of this budget, about 58% is attributed to road objectives, such as the improvement of traffic flow on the road network. More specific freight measures are for example the adaptation of the road network for European Modular Systems ("modulvogntog"), and a small subsidy scheme (NOK 50 million annually over 6 years) for bottlenecks in timber transport.

Although ca. 34% of the total budget is set aside for rail projects, the lion's share of this funding is aimed at passenger transport (94%). The remaining "freight package" consists of improvements to railway terminals, measures improving capacity, reliability and efficiency (better rail connections, domestically and to Europe, and reducing the backlog in maintenance), and replacing diesel operation on two routes by zero-emission alternatives. This diesel phase-out should lead to an annual reduction in CO_2-emissions of around 51,000 tonnes CO_2, while the "rail freight package" as a whole is expected to reduce CO_2-emissions by ca. 123,000 tonnes a year (Norwegian Government, 2016b).

Meanwhile, around 3.5% of the Transport Plan budget is aimed at waterborne transport and coastal management. Most of this budget goes to larger projects in general, but around NOK 2 billion is reserved for more environmentally-friendly harbours and harbour cooperation, while a smaller amount is reserved for subsidies towards shifting freight from road to sea.

5.2.2 Sweden

In Sweden, road use is taxed in a number of ways. When it comes to interurban transport with heavy HGVs, Sweden applies, as Denmark and the Benelux, the Euro vignette as road infrastructure fee (see e.g. Vierth *et al.*, 2017). The Euro vignette applies to HGVs with a gross vehicle weight of over 12 tonnes, and is governed by the Euro vignette Directive, which does not allow simultaneous use of time- and distance-based charges. Currently, Sweden therefore applies a time-based Euro vignette.[32]

As such, Swedish HGVs with a gross vehicle weight of over 12 tonnes that use the Swedish Euro vignette network (all Swedish highways and a number of other routes), are charged an annual fee. HGVs from other countries have a choice between an annual, monthly, weekly, or daily vignette. Annual charges vary from EUR 750 (1–3 axles, higher Euro classes) to EUR 1,550 (4 or more axles, lower Euro classes), and monthly and weekly charges are calculated proportionally (see e.g. Euro vignettes, 2018). Daily charges are equal regardless of HGV type, and therefore do not incentivize the use of HGVs that cause less local pollution. A revision of the fees is discussed (Swedish Government, 2018a).

Further, Sweden levies a vehicle tax on all registered road vehicles. For vans/LGVs, this tax is differentiated based on CO_2-emissions, but this is not the case for HGVs, for

[32] As do Denmark and the Benelux countries, while countries like Germany, Austria and Poland, with high shares of transit transports, currently employ distance-based charges (see Vierth *et al.,* 2017).

which tax levels mainly depend on their weight and whether the vehicle is due to pay the Euro vignette charge or not. Other factors affecting the level of this tax are fuel type, number of axles and coupling/hanger type (Swedish Tax Agency, 2018a,b). A new bonus-malus policy measure affecting this tax is further described in section 5.6.2.

In recent years, the Swedish government started seriously considering replacing the Euro vignette with a distance-based km-charge ("vägslitageskatt").[33] However, this plan caused a lot of discussion, and has not been implemented so far. Meanwhile, experiences in a number of other European countries that introduced distance-based per km fees show that this generally increases the costs for the relevant road users significantly compared to the current Euro vignette (see e.g. Vierth *et al.*, 2017).

Neither the Euro vignette nor distance-based km-charges address CO_2-emissions directly. However, the increase of the Euro vignette fee or the introduction of a kilometre-tax lead to higher road transport costs that in turn can contribute to modal shifts from road to rail or waterborne transport.

In addition, Sweden uses congestion charges in Stockholm and Gothenburg, with the main purpose to limit congestion and to obtain fiscal resources (Swedish Transport Agency, 2018a and 2018b). Table 3 gives an overview of the charges in both cities. Both light and heavy HGVs are included in the system, and the maximum daily charges per vehicle are SEK 105 and SEK 60 for Stockholm and Gothenburg respectively. In the summer of 2012, toll exemptions for zero-emission vehicles were removed. Unlike in Norway, zero-emission vehicles have therefore been subject to paying tolls (Swedish Transport Agency, 2018c).

Table 3: Overview of congestion charges in Gothenburg and Stockholm. Figures in SEK

Gothenburg		Stockholm - City centre		Stockholm - Essinge bypass	
Times	Charges (SEK)	Times	Charges (SEK)	Times	Charges (SEK)
06:00–06:29	9	6:30–6:59	15	6:30–6:59	15
06:30–06:59	16	7:00–7:29	25	7:00–7:29	22
07:00–07:59	22	7:30–8:29	35	7:30–8:29	30
08:00–08:29	16	8:30–8:59	25	8:30–8:59	22
08:30–14:59	9	9:00–9:29	15	9:00–9:29	15
15:00–15:29	16	9:30–14:59	11	9:30–14:59	11
15:30–16:59	22	15:00–15:29	15	15:00–15:29	15
17:00–17:59	16	15:30–15:59	25	15:30–15:59	22
18:00–18:29	9	16:00–17:29	35	16:00–17:29	30
18:30–05:59	0	17:30–17:59	25	17:30–17:59	22
		18:00–18:29	15	18:00–18:29	15

Source: Swedish Transport Agency (2018a and 2018b).

Although several studies have been conducted on the impact of these congestion charges, little focus is put on the effects on freight transport specifically. The few

[33] The government proposed the "vägslitageskatt" or "road wear tax" for vehicles over 3.5 tonnes. This should amongst others level the playing field of Swedish and foreign transport operators, as well as reduce emissions from freight transport. In its proposal in March 2018, the Swedish government opened for introducing a kilometre-tax for driving on primary roads, Europe roads and other highways (in total over 26,000 km's of the Swedish road network). Differentiation is intended based on the vehicles' characteristics (e.a. emissions and number of axles) and the geographical region (Swedish Government, 2018b).

studies that have looked at this show a decrease of light and heavy HGVs in Stockholm's city centre (6–8%), but an increase outside the city centre on the Essinge bypass (4–5%) (Swedish Transport Administration 2016a; Börjesson and Kristoffersson, 2017). Börjesson and Kristoffersson also estimated price elasticities for light and heavy HGVs during the peak: for the cordon in the city centre, this elasticity is -0.22, while for the Essinge bypass, it is 0.09. Jordal-Jørgensen *et al.* (2017) add that particularly Stockholm (and Oslo) are well suited for toll rings, because of infrastructure characteristics that make it difficult to avoid the toll.

In addition to the Euro vignette and congestion charges, Sweden also applies a fuel tax. Like for Norway, the tax consists of two different components; the energy tax (introduced in the 1950s), and the CO_2 tax (introduced in 1991). Table 4 gives an overview of the level of these taxes for different fuel types.

Table 4: Overview of Swedish fuel taxes and their components for a selection of fuel types, September 2018. Figures in SEK

Fuel	Energy tax SEK/litre SEK/Nm3	CO_2 tax SEK/litre SEK/Nm3	Total SEK/litre SEK/Nm3
Gasoline	3.87	2.57	6.44
Diesel (MK1)	2.34	2.19	4.53
Natural gas	0	2.42	2.42
Biogas	0	0	0
Ethanol (E5)	3.87	2.57	6.44
Ethanol (E85)	0	0	0
Ethanol (ED95)	0	0	0
FAME *	2.34	2.19	4.53
FAME **	0	0	0
HVO *	2.34	2.19	4.53
HVO **	0	0	0

Note: * Low blend-in.
** Pure or high blend-in.

Source: Lönnqvist (2017), Swedish Tax Agency (2018a,b,c,d).

The table above illustrates that biofuels are taxed at a reduced rate compared to their fossil counterparts. As such differentiation is considered state aid under EU regulations, reductions or exemptions may only be granted by Member States if biofuels are more expensive to produce than their fossil equivalents. The granted exemptions and reductions have to be reviewed on at least an annual basis (Lönnqvist, 2017, European Commission, 2014b).

When it comes to zoning regulation, Sweden has been using low emission zones since 1996. These zones do not focus on reducing CO_2-emissions, given that CO_2 is a global pollutant, but rather on reducing local pollution and improving air quality. Today, environmental zones for busses and HGVs are used in Stockholm, Gothenburg, Malmö, Mölndal, Uppsala, Helsingborg, Lund and Umeå. The environmental zones state that (all) vehicles may drive within them during the first 6 years from registration, with the following exceptions (Swedish Transport Agency, 2018d):

- Vehicles with Euro class 3 may drive within in the zones for their first 8 years.
- Vehicles with Euro class 4 may drive within in the zones until the end of 2016.
- Vehicles with Euro class 5 may drive within in the zones until the end of 2020.
- Vehicles with Euro class 6 may drive within the zones without limitations.

From the year 2020 it will also be possible for municipalities to enforce environmental zones for passenger cars, light HGVs and light busses (Swedish Government, 2018c).

Although the environmental zones do not target CO_2 reductions directly, they do make road transport more expensive or less attractive, and as such may incentivize reductions in road transport or the use of newer vehicles with also lower CO_2-emissions.

Finally, with regard to planning, the National Plan for Transport Infrastructure 2018–2029 sets the financial framework for investments in the transport system (Swedish Ministry of Enterprise and Innovation, 2018). The infrastructure plan does not divide the budget specifically between passenger and freight transport. The total budget is set to SEK 622.5 billion, i.e. including both passenger and freight transport, and is divided into the following main categories:

- SEK 333.55 billion for development of the transport system, including e.g. improvement of current systems, environmental improvements, major infrastructure investments, support to sustainable cities, as well as research and innovation.
- SEK 289 billion for maintenance of the current system, of which SEK 164 billion is dedicated to road objectives, and SEK 125 billion to rail objectives, both including research and innovation.

According to the Swedish Maritime Administration, the national and regional infrastructure plans will in total give investments of around SEK 5.1 billion in shipping, which to a large extent will benefit freight transport (Swedish Maritime Administration, 2018a).

5.2.3 Finland

Finland, meanwhile, is one of the few European countries without any road user charging. The implementation of a time-based charge (vignette) for HGVs has been evaluated, but no decisions on implementation have been made. It was estimated that implementing a vignette would significantly increase the taxation of medium HGVs, even if the price of the vignette was kept at a low level and it was partially compensated by lowering the annual driving power-based vehicle tax (Finnish Ministry of Transport and Communications, 2018a).

Further, although congestion pricing in the Helsinki metropolitan area has been discussed and studied in several evaluations, no decisions have been made on implementing such a scheme.

Finland does, however, employ fuel taxation. This taxation consists of an energy component, a national emergency supply fee, and similar to Norway and Sweden, a CO_2-component (see Table 5).

Table 5: Overview of Finnish fuel taxes and their components for a selection of fuel types. Figures in EUR-cent

Fuel	Energy tax	CO_2 tax	National emergency supply fee	Total
	EUR cent/litre EUR cent/kg (gases)	EUR cent/litre EUR cent/kg (gases)	EUR cent/litre EUR cent/kg (gases)	EUR cent/litre EUR cent/kg (gases)
Gasoline	52.19	17.38	0.68	70.25
Diesel	32.77	19.90	0.35	53.02
Natural gas	9.58	18.74	0.11	28.43
Biogas (RES)	9.58	9.37	0.11	19.06
Biogas (double countable)	9.58	0.00	0.11	9.69
Bioethanol (RES)	34.25	5.70	0.68	40.63
Bioethanol (double countable)	34.25	0.00	0.68	34.93
Biodiesel (RES)	30.04	9.12	0.35	39.51
Biodiesel (paraphenic, RES)	25.95	9.40	0.35	35.70
Biodiesel (paraphenic, double countable)	25.95	0.00	0.35	26.30

Source: Petroleum and Biofuels Association Finland (2018).

The table illustrates that also in Finland, biofuels are taxed at a reduced rate compared to their fossil counterparts.

Although we saw that none of the Nordic countries has in place purchasing taxes for HGVs, there is a registration tax for LGVs. This tax lies between 3.3–50% of the LGV's purchase price, depending on the level of CO_2-emissions (with LGVs emitting more than 360 g/km being charged the maximum tax (Finnish Transport Safety Agency, 2018a; Finlex, 2018).

In addition, both LGVs and HGVs using other fuels than gasoline are subject to an annual tax. For LGVs, this tax is 0.9 EUR-cents per day for each 100kg of gross weight. Moreover, LGVs also pay the basic component of the tax according to gross vehicle weight or CO_2-emissions; this amounts to 106–654 EUR/year (maximum tax for LGVs emitting more than 400 g/km).

HGVs, in turn, pay the following taxes (in EUR-cents per day for each 100kg of gross weight (Finnish Transport Safety Agency, 2016a).

Table 6: Overview of Finnish taxes on HGVs per 100 kg of gross weight, for different vehicle characteristics. Figures in EUR-cent/day

Number of axles	Not used to tow a trailer	Used to tow a semitrailer	Used to tow a trailer or centre-axle trailer
2	<12t: 0.6 >12t: 1.3	2.2	2.1
3	0.8	1.3	1.4
4	0.7	1.2	1.3
5	0.6	1.0	1.2

Source: Finnish Transport Safety Agency (2016a).

There are no environmental zones for road freight vehicles in place in Finnish cities, and Finland does not currently have a long-term national transport plan. There is, however, a consensus between parliamentary parties that Finland should establish 12-year national transport plans in the future. The annual budget of the Ministry of Transport and Communications is approximately EUR 2.5 billion, of which EUR 1 billion is allocated towards the upkeep and maintenance of the current transport network, while 0.5 billion EUR is allocated towards new investments. Both maintenance and investment costs are divided about half and half between the road network and other modes.

5.2.4 Denmark

In Denmark, road use is charged through the Euro vignette system, similar to that in Sweden. As such, HGVs with a gross vehicle weight of 12 tonnes or higher, have to buy the time-based Euro vignette in order to use motorways and toll highways in the Euro vignette countries. Similar to Sweden and Norway, no distance-based taxes are currently charged in Denmark. A politically decided and planned distance-based road pricing scheme for HGVs on the overall road network was abandoned in 2013 due to high administrative costs,

Further, there are no toll charges other than for the "Storebælts bridge" and the "Øresund bridge", both of which primarily have a fiscal motive. Although a (congestion) charge has been discussed for Copenhagen, it has not been implemented, and model-based evaluations projected that a toll ring would increase traffic around the ring. In addition, the expected CO_2-reduction was found to be limited (Jordal-Jørgensen *et al.*, 2017).

One of the reasons for the relatively limited road use charging, is that it is politically difficult to impose national initiatives that induce costs on freight transport, as the Danish transport sector is highly exposed to international competition. Moreover, it is a political concern that isolated Danish increases in transport costs also add to production costs of the Danish industry, thereby weakening its European competitiveness.

Fuel taxes in Denmark are about the same level as in Sweden. The total fuel tax has three components: energy, CO_2 and NOx. The energy component is by far the most important and constitutes about 85% of the total tax for diesel. The energy tax for biofuels is the same as for petrol and diesel when measured by energy content (DKK/MJ). An illustration of current fuel tax levels and components is given in Table 7.

Table 7: Overview of Danish fuel taxes and their components

	Energy tax	CO_2 tax	NOx tax	Total	Total
	DKK/litre	DKK/litre	DKK/litre	DKK/litre	DKK/MJ
Diesel*	2.71	0.43	0.01	*3.15*	*87*
Biodiesel	= diesel per MJ	-	-		*76*
Petrol**	4.22	0.40	0.01	*4.63*	*142*
Bioethanol	= petrol per MJ	-	-		*131*
Natural gas	3.01 per Nm^3	0.38 per Nm^3	0.03 per Nm^3	*3.42 per Nm^3*	*64*

Note: Practically all trucks and vans run on diesel.
* Sulphur-free diesel with 6.8% biofuels.
** Lead-free petrol with 4.8% biofuels.

Source: Mineral oil tax law, CO_2 tax law, Nitrogen oxide law.

The table shows that also in Denmark, biofuels are taxed at a reduced rate compared to their fossil counterparts.

When it comes to vehicle taxation, registration taxes for LGVs are differentiated according to fuel efficiency in the same way as for passenger cars. For HGVs, this differentiation is missing.

Finally, Danish environmental legislation allows municipalities to introduce zoning regulation with the purpose of reducing local pollution with particulate matter in larger urban areas, typically in the city centres. The regulation prohibits diesel-driven trucks above 3.5 tonnes, vans, and busses, to enter the low-emission zone, unless the vehicle meets the Euro 4 standard or has an approved particle filter.

As of today, environmental zones for trucks and busses, but not vans, are employed in the four largest cities: Copenhagen-Frederiksberg (since 2008), Aarhus (since 2009), Odense (since 2010) and Aalborg (since 2010).

5.3 Increasing transport mode efficiency

A second way to reduce emissions from freight transport is to improve the efficiency of transport modes, for example by increasing vehicle capacity (e.g. longer, heavier or higher vehicles), improving capacity utilization (e.g. use of consolidation centres), or better transport planning (which is more difficult for authorities to influence). The (increased) use of digitalization, automatization and platooning also falls in this category, but is harder for authorities to influence other than through facilitating infrastructure and legal changes.

The downside of initiatives that improve the efficiency of road transport, is that they make road transport more attractive compared to other modes; this might counteract efforts to reduce transport demand or modal shift (which is discussed in Section 5.4).

Most influence exerted by Nordic governments, is through relaxing restrictions on physical dimensions. Table 8 summarizes the main vehicle dimensions and restrictions in the Nordic countries.

Table 8: Overview of the main vehicle dimensions and restrictions in the Nordic countries

Norway	Max. 50 tonnes total weight and 19.5 metres in length for regular HGVs. Semitrailers up to max. 50 tonnes total weight and 17.5 metres. Lumber HGVs up to max. 50–60 tonnes total weight (depending on the number of axles) and up to 22 (and 24) metres depending on the road conditions. European Modular Systems (EMS or "modulvogntog") allowed on limited number of routes (max. 60 tonnes total weight and max. 25.25 metres), mainly connected to the border crossings. Max. height of HGVs is currently 4.4 metres.
Sweden	Freight transport by road max. up to 64 tonnes and 25.25 metres. Heavier vehicles (up to 74 tonnes) approved recently, not yet implemented due to discussions on where in the road network they are allowed to operate. Max. height of vehicles is currently 4.00 metres.
Finland	Regular HGVs max. 60–76 tonnes total weight (depending on number of axles) with lengths of max. 22–25.25 on all parts of the road network (if not specifically restricted). Semitrailers up to max. 48 tonnes total weight and 16.5 metres. Ongoing trials with longer and heavier vehicles (up to 104 tonnes total weight). Generally, longer vehicles of up to 34.50 metres are likely to be allowed from the autumn of 2018 onwards.
Denmark	Max. 40 tonnes total weight. Max. 18.75 metres. European Modular Systems (EMS) allowed on large parts of main road network (max. 60 tonnes total weight and max. 25.25 metres). Max. height of vehicles currently 4.00 metres, special permits needed for width over 3.10 metres.

Source: Vegnett (2016), Hovi *et al.* (2014), Norwegian Public Roads Administration (2016 and 2017), NLF (2017), Vierth *et al.* (2018), Swedish Transport Administration (2016b), Swedish Parliament (2017), Finnish Transport Safety Agency (2016b), Finnish Ministry of Transport and Communications (2018b), Retsinformation Danmark (2017a,b).

For Norway, a trial period with EMS (European Modular Systems) prior to full implementation showed that EMS vehicles ("modulvogntog") were only adopted to a limited degree by transport firms. One reason for this was stated to be the limitations in the allowed road network that was limited to border-crossing transports, but also missed access roads to and from terminals.[34]

The small number of firms that did adopt EMS, however, reported significant cost savings (Wangsness *et al.*, 2014), which influences the competitive position of road transport compared to rail and waterborne transport. This is in line with findings by the Norwegian Association of Heavy Equipment Contractors (2016) that EMS facilitate a

[34] Although no new studies are available, it looks like the allowed network has been extended to gradually facilitate traffic around more terminals.

25% capacity increase per trip and particularly show potential for longer-distance transport. Two EMS replace 3 regular trailers.

Allowing EMS also seems to have a positive environmental effect, even when some shifts back to road are taken into account (based on model calculations). A rough estimate states that if half of long-distance transport was carried out using EMS, this could result in an emission reduction of around 0.2 million tonnes CO_2 (Norwegian Association of Heavy Equipment Contractors, 2016).

During the autumn of 2014, the temporary trial allowance of EMS was made permanent on a limited number of roads in Norway (Hovi *et al.*, 2014). Since then, the allowed network for those vehicles has increased to also cover some domestic long-haul relations. This is illustrated in see Figure 23.

Figure 23: Currently allowed road network for EMS-operation in Norway

Source: Norwegian Public Roads Administration (2018).

For Sweden, in addition to Table 8 above, Table 9 shows how maximum vehicle dimensions have developed and expanded over time.

Table 9: Development of Swedish vehicle dimension allowances over time

Year	Maximum length (metres)	Maximum weight (tonnes)
1968	24	37
1974	24	51.4
1990	24	56
1993	24	60
1996	25.25	60
2015	25.25	64
To be implemented 2018	25.25	74*

Note: * Initially proposed only to apply to routes where road transport does compete with rail and shipping (i.e. where potential for modal shifts is limited anyway). However, Swedish Parliament decided to base this allowance on the bearing capacity of the road (BK4) and did not adopt differentiation based on rail/shipping potential (Swedish Transport Administration, 2017d).

Source: Vierth *et al.* (2018)

In addition, Sweden is considering to improve railway infrastructure to allow longer trains (1,000 metre). Several studies (e.g. WSP, 2014; Vierth and Karlsson, 2014) suggest that this would be socio-economically beneficial.

For Finland, a preliminary analysis on the effects of 76t vehicles shows that Finnish haulers adopted higher maximum payloads mostly by replacing 7-axle vehicles with 9-axle vehicles (Liimatainen *et al.*, 2018a). Over 2016, the mileage reduction because of the higher payloads amounted to about 64 million km, which is about 3.5% of the total HGV mileage in Finland. In the same year, cost savings for heavy commercial vehicle operations were about EUR 98 million, while CO_2-savings amounted to around 70,000 tonnes. These savings are significant, but without future increases in savings, they will remain significantly lower than was estimated prior to the change.

Finland further has several ongoing trials with high capacity transport (HCT) vehicles, i.e. vehicles that are longer than 25.25 metres and/or heavier than 76 tonnes. Currently, there are approximately 50 of such vehicles in operation on certain routes, with an exempt permit issued by the Finnish Transport Safety Agency. It has been estimated that allowing HCT vehicles could decrease HGV mileage by 9% and CO_2-emissions by 80,000 tonnes annually, but that at the same time, rail freight haulage might decrease by 5% due to an induced modal shift to road (Lapp and Iikkanen, 2017).

In Denmark, a trial with European Modular Systems on selected sections on the main road network started in 2008. Allowing for EMS required some rebuilding to ensure sufficient space, primarily in junctions and roundabouts. The trial was evaluated in 2011 and led to positive results (Danish Road Directorate, 2011). While the main purpose of the initiative was to reduce transport costs by allowing longer vehicles, energy efficiency (and hence CO_2-emissions) per tonne-km also improved, and the total accident risk was reduced. Consequently, the trial period was extended to 2030, and the parts of the road network where EMS are allowed has gradually been increased; today, virtually all state roads and more than 400 kilometres of municipal roads are currently approved for EMS. There are close to 1,000 EMS-vehicles in Denmark (Danish Road Directorate, 2016).

5.4 Moving towards modes with higher energy efficiency per unit transported (modal shift)

A third way to reduce CO_2-emissions from freight transport is to move transport towards modes with a higher energy efficiency per transported unit. Generally, this will mean moving from road transport to rail and waterborne transport.

Chapter 4.3 discussed the EU's ambition to transfer 30% of road transport over distances >300 km from road to other modes, by 2030, and illustrated the absolute maximum potential for modal shift in the Nordics. Hereby it was noted that in practice, much of the longer-distance freight transport lacks a rail terminal or harbour in close proximity to both ends of the transport chains. In light of this, the current chapter discusses the potential and initiatives regarding modal shifts for the individual Nordic countries.

5.4.1 Norway

For Norway, modal shift has been a stated transport-political objective in all four National Transport Plans since 2002, as well as in State budget proposals from 2005 onwards: freight transport over long distances was to be moved from road to sea and rail to the largest extent possible.

In practice, the domestic modal shift potential is estimated at 5–7 million tonnes transported,[35] of which 2.4 million tonnes (1.4 billion tkm) is considered feasible given measures proposed in the National Transport Plan for 2018–2029. This makes up about 7% of total domestic transport performance overall, or ca. 23% of domestic transport performance over distances >300 km, but requires strong measures that not always are socio-economically beneficial. Domestically, the maximum annual CO_2-reduction is estimated at 0.2 million tonnes, i.e. around 8% of total CO_2-emissions from HGVs (Norwegian Government, 2016b; Haram *et al.*, 2015; Auditor General of Norway, 2018).

One of the main measures to stimulate environmentally-friendly modal shift is a subsidy scheme ("økobonusordningen"). The scheme's objective is to transfer freight transport from road to sea by stimulating the establishment of new routes or the improvement of existing routes. Subsidies can apply domestically as well as for transport from/to abroad if direct shipping reduces land transport in Norway. The subsidy covers the lowest amount of either the net societal benefit of modal shift[36], up to 30% of operating costs for the shipping company, or up to 10% of the required

[35] Based on a study among transport customers and a calculation of freight transport on routes >300 km with proximity to harbours and/or rail terminals.

[36] In practice around 0.19 NOK per tonne-km depending on the location.

investment, for periods of up to three years. The subsidy budget over the first six years of the scheme is NOK 100 million annually (Shortsea Shipping, 2016; Norwegian Government, 2016b; Norwegian Coastal Administration, 2018).

Another initiative with the aim of achieving modal shift in favour of waterborne transport, is the Shortsea Promotion Centre (SPC) Norway. The Centre is part of a European initiative to create a network of national centres for the promotion of short sea shipping and is funded equally by the government and the industry (Askildsen, 2005). Among other things, the SPC has an ongoing dialogue with the industry to promote maritime transport by informing and helping customers to use existing maritime solutions, to contribute to the creation of new solutions, and by removing bottlenecks that prevent intermodal supply chains (Danske Havne, 2016; Shortsea Shipping, 2017).

When it comes to rail, Norwegian infrastructure charges have long been limited in order not to distort the competitive position of rail transport compared to other modes too much.[37] In 2017, however, two new rail charges were introduced. The first new charge ("kapasitetsavgift") consists of a rush-time element for rail traffic around the larger cities, but only applies to passenger trains (freight trains have so far been exempted). The second new charge ("kjørevegsavgift") applies to both passenger and freight trains, and although Norwegian Parliament asked the government to consider fully compensating for this new charge, railway companies have so far been liable to pay the full charge. However, with the current rate of NOK 0.625 per train-kilometre, the charge does not seem to influence competition between rail and road significantly at the moment (as an example, this would add around NOK 340 for a freight train from Oslo to Trondheim), although ongoing discussions suggest that future charging schemes might cause significant increases (Norwegian Ministry of Transport and Communications, 2016, BaneNor, 2017, NHOLT, 2017; Auditor General of Norway, 2018).

Linked to the "kjørevegsavgift" is an incentive scheme ("ytelsesordning") to reduce the incidence of delays. When delays are caused by the infrastructure operator, the train operator can receive a payment of NOK 1,800 per hour of delay per train. For delays that are caused by the train operator (e.g. due to missing personnel, incorrect timing), the train operator in turn has to pay ca. NOK 2,500 per hour of delay per train to the infrastructure operator (BaneNOR, 2017).

Moreover, a temporary compensation scheme has been in use since 2016, in order to deal with cancellations. If technical problems on the rail network cause the cancellation of trains, operators are eligible for a compensation towards their additional costs. The compensation scheme only applies to freight trains, and cancellations (delays are explicitly excluded) have to be caused by circumstances on the Norwegian national rail network. Compensation amounts are made up of two parts: 1). a fixed lump-sum payment of NOK 50,000, which covers fixed operating costs that the train operator is unable to reduce, and 2). a variable compensation based on planned load, and amounting to NOK 1,000 per container/carriage (BaneNOR, 2016).

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[37] Charges for rail freight were largely applicable for trains with an axle pressure > 25 tonnes and trains using the Gardermo-track, but were limited otherwise.

Other measures to reduce the risk of less flexible rail transport were the establishment of seven "emergency stations" where freight could quickly be transferred to trucks during railway blockages, and the purchase of four dedicated "rescue locomotives". In practice, however, these measures have virtually not been used so far, but have added to railway costs. At the same time, rail transporters face challenges of insufficient terminal capacity and inefficient terminal operations, while a number of intended measures for improving the position of rail transport has either been delayed or not implemented at all. In this context, rail transport has been losing market share to road transport (Aftenposten, 2018), and a future outlook by KMPG *et al.* (2018) indicates that if rail is to increase its market share within freight transport, large investments are required in terminals, rolling stock and automatization. This is particularly important given that the freight transport market is very price sensitive, and planned and existing measures are likely to make road transport not only relatively more efficient, but also more environmentally friendly, hereby diminishing some of the main advantages of rail transport.

The Norwegian National Transport Plan (Norwegian Government, 2016b) emphasizes that it is important to improve rail connections and freight operations between North-Western, Central- and Northern Norway and Europe. In addition, freight should be "caught" by rail transport further down in Europe, given that international freight that crosses the border by truck is less likely to be transferred to rail after reaching or leaving Norway, than if the freight was transported by rail in the first place. A study on modal shift with a border-crossing perspective is currently in the start-up phase.

5.4.2 Sweden

In June 2018, the Swedish government presented a freight transport strategy (godsstrategi) clarifying the desired direction for the development of the freight transport system (Swedish Government, 2018d). The strategy aims at a modern transport system where transports are efficient and smart, make use of the full potential of the railways, and use a larger part of the maritime capacity.

In order to make transport by rail more attractive, a so-called "eco-bonus" was therefore introduced this year, partially inspired by experiences in Norway (Transport Analysis, 2017c). The "eco-bonus" scheme has a budget of SEK 389 million and SEK 174 million in 2018 and 2019 respectively (Swedish Government, 2018e). Railway firms are supposed to apply for the subsidy and have to reduce their prices towards the shippers. The subsidy is then paid out retrospectively based on the actual transport performance (tonne-km) that is carried out. The design and potential impacts of this subsidy have been studied by the Swedish Transport Administration (2015).

With regard to waterborne transport, the Swedish government also intends to improve the incentives for modal shifts from road to sea (see e.g. Transport Analysis, 2017d), and is considering the introduction of a similar "eco-bonus". This scheme should promote shipping over a three year-period, at an assumed annual cost of SEK 50 million (Swedish Government, 2018f; Transport Analysis, 2017d). However, the appropriateness of this subsidy is questioned by e.g. the Swedish National Institute of Economic Research, which argues that other (already existing) policy instruments are more suitable if the aim is to reduce CO_2-emissions. An example given is the CO_2-tax (National Institute of Economic Research, 2018).

When it comes to the potential of modal shift in Sweden, a handful of studies has been carried out in somewhat more detail. A literature study (Vierth and Mellin, 2008) finds (i) that economic instruments, correctly designed, are cost-effective in reducing CO_2-emissions and (ii) that there is a great potential for reducing CO_2-emissions within the respective mode. The largest potential for modal shifts is seen from long-distance road transports to combined rail-road transports. Furthermore, the authors find that impediments such as inefficient use of the rail infrastructure and unclear responsibilities in combi-terminals, as well as insufficient co-operation along the transport chain, limit the potential.

As part of a government commission regarding the description of the freight transport system, Transport Analysis (2016a) estimates that less than ten percent of the domestic volume of road freight is transported over distances of 300 km or more and can therefore be relevant for a modal shift to rail or sea. A large share of these long-distance road transports run between Stockholm, Gothenburg and Malmö, and potential shifts from road to rail are limited by the restricted rail capacity between these cities. As such, low departure frequencies and long transport times hamper modal shifts from road to rail. Indeed, Transport Analysis argues that efficient ports and road/rail terminals are crucial for modal shifts.

With regard to the potential of modal shifts from road to sea (inland waterways and coastal shipping), the Swedish Maritime Administration (2016) carried out an analysis on behalf of the Swedish government. The analysis focused on trailer and container transports, and found that good conditions for shifts from road to sea exist in terms of available capacity in the fairways and ports. However, despite available capacity, it remains difficult for sea transporters to compete with the land-based modes. Currently, sea transport operators and shippers have few or no economic incentives for developing new transport solutions. For that reason, the Swedish Maritime Administration recommends analysing which policies can improve such incentives, but also recommends ports to consider their pricing strategies.

The ongoing project "Modal shift for an environmental lift, MOSEL", analyses under which conditions the shift of goods from road to rail and waterborne transport can contribute to the fulfilment of the relevant Swedish environmental objectives for 2030 (VTI, 2018).

Further, the Swedish Transport Administration is a funding and active partner in the European Shift2Rail initiative.[38] Shift2Rail is a Horizon 2020 initiative, and seeks research and innovation and market-driven solutions by accelerating the integration of new technologies into innovative rail product solutions. The initiative aims to double the capacity of the European rail system, while increasing its reliability and service

[38] Regeringskansliet, Regeringen beslutar om extra stöd för godstransporter med tåg för miljöns skull. See: https://shift2rail.org/about-shift2rail/structure-of-shift2rail-initiative/governing-board-2

quality by 50 percent. These factors, in turn, are important for the competitiveness of rail vis-à-vis other modes of transport.

Just like Norway, Sweden has a Shortsea Promotion Centre, "Maritimt Forum", with the aim of promoting a modal shift to shortsea shipping. This centre is part of the same European initiative as Norway's SPC, and they are both part of the European Shortsea Network which connects 20 SPCs in Europe. "Maritimt forum" works to engage different actors related to maritime transport in a closer dialogue, in order to create cooperation. Among other things, the Forum works on identifying opportunities for short sea shipping (Maritimt Forum, 2018).

Some other examples of initiatives with the aim to stimulate intermodality are:

- "Dryport - a modal shift in practice". Dryport was a EU-funded project with the aim to develop dryports, i.e. green hinterland freight combi-terminals, fully integrated with freight handling systems. The idea was to move key logistics functions from ports to inland dryport terminals to promote intermodality and green transport solutions (European commission, 2018c). One of the dryports included in the study was the Skaraborg Logistics Centre in Falköping, which is connected to the Port of Gothenburg. This dryport has contributed to companies using intermodal transport for their freight (Skaraborg Logistic Center, 2018).
- The "Mälarprojektet", in turn, has the aim to improve the infrastructure for inland waterway transports to/from lake Mälaren and the Gothenburg Port Line. This facilitates the transport of more freight by rail rather than road to and from the Port of Gothenburg (Swedish Maritime Administration, 2018b; Swedish Transport Administration, 2017e).
- The "Sweden-Poland Sustainable Sea-Hinterland Services III" also promotes intermodality. By additional investments in the Motorways of the Sea link between the ports of Trelleborg and Swinoujscie, the project hopes to facilitate for a larger integration of intermodal freight between Scandinavia, Poland and Central- and Eastern Europe (European Commission, 2015).

For city logistics, one alternative to light HGVs is the use of electric cargo bikes, which so far only make up a very small part of the market share. Although there are currently no specific policy measures for incentivizing a shift to such bikes for city distribution, studies indicate that the potential of cargo bikes can be significant (Rudolph and Gruber 2017; Garme *et al.*, 2017).

While the initiatives, policy instruments and strategies discussed above, all aim to improve the competitiveness of rail and sea transport, a few counteracting developments are taking place alongside. One example is the 2015 extension of the maximum HGV weight from 60 to 64 tonnes, while in 2017, a further extension from 64 to 74 tonnes was decided for part of the road network - but not implemented yet (Adell *et al.* , 2016; Vierth *et al.*, 2018). These developments improve the competitive situation of road freight. In general, this might create a risk that the social benefits from reduced CO_2-emissions through increased vehicle dimensions, are offset by induced traffic and by freight being shifted away from more energy efficient modes, i.e. a risk of rebound effects (Vierth *et al.*, 2018).

5.4.3 Finland

In Finland, there are currently only few policies in place or discussed with the direct aim of achieving modal shifts away from road. On the contrary, extending the maximum allowed vehicle weight to 76 tonnes in 2013 rather seems to have caused a modal shift from rail to road. Over the period 2006–2016, the share of rail in total haulage varied between 19.9 and 23.7 percent, with the highest share found in 2014, and the lowest in 2016. This suggests that the share of rail embarked on a downward trend once the use of 76t-vehicles started to pick up. Although some of the annual variation may be caused by sample issues, the rail share nevertheless seems to have decreased, particularly for forestry haulage (Liimatainen *et al.*, 2018a).

At the same time, as much as 30 percent of HGV mileage, 41 percent of haulage, and approximately 35 percent of CO_2-emissions in Finland, come from HGV transport over distances longer than 300 km (author's own calculations based on data by Statistics Finland). This suggests that a potential exists for modal shifts from road to rail. However, achieving this potential form a challenge given the limited rail capacity due to Finland's largely single-track network. As the major commodities on longer-distance haulage are food products and grouped goods, and delivery of these commodities often is time-sensitive, capacity restraints may effectively limit the potential for using rail transport.

Further, in a 2010 survey, only 12 percent of companies from the food, metal, and other industry sectors, indicated that it was likely that they would use less road transport because of environmental reasons. This percentage was even lower for other sectors (Liimatainen, 2010).

In order to nevertheless stimulate modal shifts from road to rail, freight trains have been exempted from paying rail tax in 2015–2018 (Finnish Transport Agency, 2018b). In addition, the Finnish Transport Agency has improved wood terminals and railways to allow higher axle-loads, with the aim of increasing rail capacity (Hovi, 2017).

Just as Norway and Sweden, Finland also has a Shortsea Promotion Centre with the aim to promote shortsea shipping and intermodal transport. SPC Finland's activities are, among other things, to act as a forum in the transport chain, to influence decision makers, to provide information on intermodal transport solutions, and to identify bottlenecks and intermodal transport solutions (University of Turku, 2018).

5.4.4 Denmark

For Denmark, particularly shifts to rail are relevant in the modal shift discussion. Since 1999, the Danish Government has provided an environmental subsidy to rail freight transport operators in order to offset the effects of rail infrastructure charges. The policy is aimed to promote a modal shift from road to rail, and by doing so to reduce the negative effects of road freight. The aid is paid as a uniform subsidy of DKK 0.0132 per tonne-kilometre, and is only paid in cases where the freight would not have been transported by ship or ferry (European Commission, 2014c; Retsinformation Danmark, 2018).

From 2000 to 2016, freight transport by rail increased by about 25 percent in Denmark. However, this growth can be attributed to the more than a doubling of freight transport with transit trains, primarily from Sweden to Germany.[39] Indeed, both international (to and from Denmark, non-transit) and national figures have been more than halved. National freight transport now constitutes only about 7 percent of total tonne-km's by rail, and less than 2 percent of national domestic freight transport by road (see Chapter 4.2.4). These shares are significantly lower than in the other Nordic countries, and this is first and foremost due to two factors:

- Domestic distances in Denmark are shorter because of the country's small geographical size compared to the other Nordic countries.
- Differences in the commodities that are produced in the Nordic countries.

In an investigation into the potential for shifting freight transport from road to rail, the Danish Transport Authority (2016) estimated that the break-even distance between rail (combi) and road in terms of costs is 350–500 kilometres, depending on whether or not the Great Belt is crossed. This is without taking into account the flexibility that road transport offers. Break-even distances are significantly shorter if a shift to/from HGV can be avoided at one or both ends of the trip. Nevertheless, given today's insignificant share of domestic freight transport, it is hardly realistic that measures will be taken that improve the attractiveness of rail to such an extent that modal shift reaches levels that lead to significant reductions in CO_2 from freight transport.

5.5 Transferring to fuels with lower carbon content

A fourth way to reduce emissions from freight transport is to reduce the carbon content of fuels. This section therefore discusses initiatives around biofuels as supplement or alternative to fossil fuels used in conventional vehicles, while the next section will address lower-carbon propulsion technologies in vehicles.

When it comes to biofuels, a distinction is usually made between biodiesel, bioethanol, and biogas. Biodiesel is produced from plant fats or oils and can be blended into regular diesel or used in its pure form, depending on the vehicle. Bioethanol is made from plants containing sugars or starch and is used as a blend-in to petrol. Biogas can be produced from a number of different inputs, such as waste, manure, or sewage sludge. All biofuel alternatives have in common that they are required to reduce total greenhouse gas emissions by at least 50 percent over their total life cycle compared to regular (fossil) petrol and diesel (European Commission, 2018d).

[39] Part of the increase in transit traffic is transferred from ferries across the Baltic Sea.

Biodiesel, bioethanol and biogas all come in different types or "generations" and with different environmental and product characteristics. In this regard, a distinction is often made between "conventional" biofuels, and "advanced" biofuels. "Advanced" biofuels are made of e.g. waste products, residues, or celluloses, rather than of food crops or through land use that crowds out food farming or increases emissions from indirect land use changes. It is therefore desirable that the use of "advanced" biofuels increases, as these contribute larger carbon emission reductions and do not crowd out food or animal feed production (Norwegian Environment Agency, 2018a).[40]

Nevertheless, today's production costs for biofuels are considerably higher than for fossil fuels. Future cost differentials, however, are subject to developments in both taxation and world market prices, as well as the future maturation of biofuel production technologies. Maturation is expected to reduce, and probably even reverse the price differential between biofuels and regular fuels (Danish Energy Agency, 2016). Meanwhile, strong competition in the road haulier market will remain a severe obstacle for a shift to costlier fuel alternatives, unless policy measures provide economic incentives for using alternative CO_2-neutral fuels rather than their fossil counterparts.

The rest of this section discusses initiatives around biofuels in the Nordic countries.

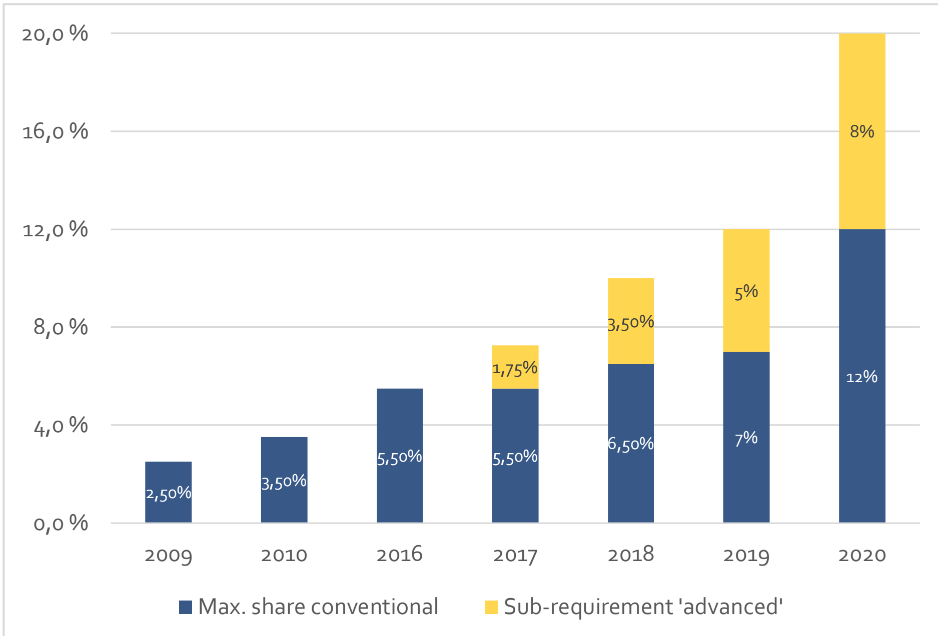
5.5.1 Norway

In Norway, requirements for stimulating the use of biofuels were first introduced in early 2009, when it was decided that 2.5% of the total volume of fuels sold for road transport should consist of biofuels.[41] Figure 24 illustrates how this requirement has evolved since.

[40] See e.g. the Indirect Land Use Change Directive that intends to avoid that biofuel production displaces food production to previously unused forest areas, which in turn may lead to CO_2-increases.

[41] Until a small change in 2017, this requirement applied to the total fuel volume, without specifying whether the requirement was to be fulfilled through biodiesel, bioethanol or a combination of both.

Figure 24: Development of blend-in requirements for (advanced) biofuels in Norway between 2009–2020



Source: Adapted from the Norwegian Environment Agency (2018a).

In 2010, the minimum biofuels percentage was increased to 3.5%, while in 2016, it was set to 5.5% of the total sold fuel volume.

In 2017, the minimum percentage was increased again, together with the introduction of three additional requirements:

- Biogas was excluded, i.e. only liquid biofuels such as biodiesel or bio-ethanol counted towards this percentage.[42]
- Sub-requirements were set for the minimum share of "advanced" biofuels.
- At least 4% of biofuels had to be blended-in in petrol.

In addition, "advanced" biofuels that fulfilled the EU's sustainability criteria could be counted twice (up to a ceiling) to stimulate the production and use of advanced biofuels.

All in all, the minimum percentage for 2017 became 7.25%, with a sub-requirement of 1.75% of advanced biofuels.[43] These requirements were stepped up for 2018 and 2019, to reach 20% biofuel blend-in in 2020 (8% advanced).

[42] The reasoning being that biogas already was excluded from the road use duty, and that in addition counting it towards the minimum percentage was "double" and possibly in violation of EEA-requirements (Norwegian Ministry of Climate and the Environment, 2016).

[43] The new requirement was set from October, so that the law sets weighted year-requirements of 7.25% biofuels and 1.75% advanced biofuels (Lovdata, 2017).

In practice, the Norwegian Environment Agency (2016, 2018a, 2018b) reports that in 2017, liquid biofuels already made up a share of 18.8%, and seem to be well underway to fulfil the 2020 requirement. In early 2017, around 90 percent of the biofuels used in Norway consisted of biodiesel, while around 10 percent consisted of bioethanol and other biofuels that were blended into petrol. Most of these fuels were imported from Germany and France, which, together with the Netherlands, are the largest biofuel producers in Europe. At the same time, only about 1% of biofuels used in Norway was produced from residue from domestic forest activity.

Biofuels are not subject to the CO_2-duties that are charged on fossil fuels and were discussed in section 5.2. Road use duties ("veibruksavgift"), however, have been the same for both fossil and biofuels since a legislation change in the fall of 2015 (Norwegian Ministry of Climate and the Environment, 2016).

Biofuels that are sold beyond the minimum requirements, however, have a somewhat special status in Norway, as road use duties are waived, and compliance with the sustainability criteria does not have to be documented.[44] The waiving of road use duties reduces the price difference between biofuels vis-à-vis their fossil counterparts (Norwegian Environment Agency, 2018b), but at the same time might incentivize importing cheap biofuels from abroad, instead of focusing on the climate effects (Drivkraft Norge, 2018).

Further, the Norwegian ENOVA agency provides support for modifying vehicles (and ships) towards propulsion systems based on biogas (and e.g. LNG for ships), by covering between 30–50% of the cost premium.[45] ENOVA further provides subsidies towards investments in production facilities for biogas and biofuels. The size of these subsidies is determined on a project-to-project basis. Finally, investments in infrastructure for biogas filling can also receive subsidies of up to 40% of the cost premium compared to conventional infrastructure (ENOVA, 2018a).

5.5.2 Sweden

In Sweden, the first stimulants for renewable fuels were introduced already in 2006, when the Swedish Government implemented a requirement for fuel stations over a certain size to provide at least one renewable fuel (Lönnqvist, 2017). Currently, the most recent regulation regards the blend-in of biofuels in petrol and diesel, and was updated from 1 July (Swedish Government, 2018g). This regulation's short-term target is to reduce emissions from petrol by 2.6%, and emissions from diesel by 19.3%. In a longer-term perspective, biofuel blend-in is to reduce GHG emissions with 40% by 2030 (Swedish Energy Agency, 2018).

With regard to blending in biofuels, two impact assessments have been conducted. The first assessment took place when the regulation was still in the proposal phase, and looked at the potential effects on the regulation on consumers, government finances,

[44] In practice, most "overproduction" does fulfil the sustainability criteria.
[45] Depending e.a. on the organisational characteristics of the applicant.

and the environment. The assessment concluded that effects are highly dependent on how the fuel blends are taxed (Swedish Energy Agency, 2016).

The second assessment was carried out after the regulation was implemented, and mainly focused on the regulation's impact on the industry. The assessment concluded that no significant administrative cost increases were expected for the industry, as the regulation was in line with already implemented directives on sustainability requirements for biofuels, as well as the fuel act[46] (Swedish Energy Agency, 2018). Neither impact assessment carries out an analysis on the cost effectiveness of the blend-in regulation.

In addition to blend-in standards, Sweden operates a support scheme for small-scale biogas producers that produce biogas from manure. This support is called "gödselgasstöd", and the idea is to compensate producers for their environmental contributions (Swedish Board of Agriculture, 2018). In addition, the current Swedish government proposed to increase financial support for domestic biogas production by 270 million SEK (Swedish Government, 2018h). Here, a cost-effectiveness analysis has been carried out; the National Institute of Economic Research suggests that the proposed increase in financial support can be a cost-efficient policy instrument for replacing fossil fuels (National Institute of Economic Research, 2018).

Earlier, the production, distribution, and use of renewable transport fuels was supported through a number of investment programs. One example is the climate investment program (Klimp) that provided SEK 1.18 billion to climate investments during 2003–2012.[47] For the area transport and biogas, nearly SEK 560 million was granted to production facilities, gas infrastructure and vehicles (Lönnqvist, 2017).

An assessment of the investment program as a whole states that it will generate a reduction of approximately 11 million tonnes CO_2-equivalents over the lifetime of the measures, i.e. 102 SEK/CO_2-eq. (651 SEK/CO_2-eq. including total financing). Further, the program has generated technology development, particularly in the biogas sector (Swedish Environmental Protection Agency, 2013).

Finally, and related to biofuels, is the establishment of Fossil Free Fuel f3. This Swedish knowledge centre for renewable transportation fuels provides industry, government, and public authorities a broad source of information for strategic planning on fossil free fuels (Fossil Free Fuel, 2018).

[46] Lag (2010:598) om hållbarhetskriterier för biodrivmedel och flytande biobränslen and "Drivmedelslagen (2011:319)".
[47] With total investments including grants amounting to nearly SEK 6 billion.

5.5.3 Finland

In Finland, the national biofuel distribution regulation[48] outlines that the share of biofuels of total energy content of transport fuels must be as follows:

- 6% in 2011–2014
- 8% in 2015.
- 10% in 2016.
- 12% in 2017.
- 15% in 2018.
- 18% in 2019.
- 20% in 2020.

Biofuels made from waste and non-food raw materials may be double-counted towards the target. The National Energy and Climate Strategy for 2030 further outlines that the share of biofuels should be 30% in 2030. These fuels should be renewable fuels and allow use in existing vehicles without restrictions (Finnish Ministry of Economic Affairs and Employment, 2017). It has been estimated that significant investment subsidies are required to biorefineries in order to fulfil the target, but no subsidy decisions have yet been made.

5.5.4 Denmark

In Denmark, petrol and diesel at the pump currently contain 5% bioethanol and 7% biodiesel respectively. The European Commission's current proposal for a revised renewable energy directive sets a 14% renewable target for fuels used in road transport by 2030, with bonuses given for the use of renewable electricity in road and rail transport.

From a social costs and benefits perspective, biogas from degassing slurry and waste products seems to be among the most feasible alternatives for Denmark, as potential volumes of biogas are significant due to Denmark's vast production of pork (Ea Energianalyse, 2016).

However, in a global perspective, available volumes of sustainable biomass for liquid biofuels are very limited compared to the possible demand for a variety of usages. Hence, there are strong strategic arguments for reserving liquid biofuels for applications where high energy density (Wh/kg) is of decisive importance, such as aviation and, secondly, long distance heavy duty road transport. Generally, liquid fuels are further preferable to gaseous fuels, because:

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[48] Lag om främjande av användningen av biodrivmedel för transport, see: https://www.finlex.fi/sv/laki/ajantasa/2007/20070446

- Existing distribution infrastructure can be used to a larger extent.
- The higher energy density of liquid fuels yields longer transport ranges.
- Commercially available gas engines are not yet high-powered, as the heaviest HGVs generally are equipped with diesel engines.

Further, the availability of renewable liquid fuels can also be augmented by electrofuels, e.g. methanol or DME produced from gasified biomass, using the (surplus) electricity from wind turbines. However, electrofuels are currently still significantly more expensive due to a complex production process and energy conversion loss.

5.6 Moving towards lower-carbon vehicle technologies

After discussing the reduction of the carbon content of *fuels*, a fifth way to reduce emissions from freight transport is through the adoption of lower-carbon *vehicles*.

The adoption of lower-carbon vehicles can be incentivized in different ways. At the European level, for example, overarching standards are set for the fuel efficiency and CO_2-emission performance of new passenger cars and LGVs (collectively LDVs). These standards are operationalized through type-approvals and have shown to be an important driver for innovation and efficiency improvements in the automotive sector.

Heavy duty vehicles (HDVs) on the other hand, have so far only been subject to European standards with regard to (local) air pollution, i.e. fuel efficiency or CO_2-emission standards do not apply. In 2014, the European Commission identified this as a problem, but recognized that a knowledge gap existed for HDVs, because CO_2-emissions were not measured in a standardized way across the EU. As such, emissions were also not certified or recorded upon the registration of new vehicles.

Earlier this year, however, the European Commission proposed a set of standards for CO_2-emissions from HDVs, as part of its third mobility package and as follow-up to its 2016 Strategy for Low-Emission Mobility. The set of standards includes an overall and legally binding 15% reduction target for new HDVs by 2025, compared to 2019. For 2030, a preliminary target is set of 30% compared to the same base year.[49] The regulation further includes a number of incentives for cost-effective implementation and "super-credits" for zero- and low-emission vehicles (European Commission, 2014a, 2016b, c).

As such, the European Union pushes manufacturing and demand towards more efficient conventional propulsion vehicles, while further incentivizing newer alternative propulsion technologies.

The alternative to liquid or gaseous fuels is electric propulsion, for which three alternatives exist: 1) battery-electric propulsion, 2) hydrogen-electric propulsion, and 3) "electric roads". Of these, battery-electric propulsion is primarily seen as solution for

[49] 2019 is set as base year because no certified CO_2-emissions data is currently available yet for HDVs. The standards apply to most HDVs, with a few exceptions (such as garbage HGVs). The target for 2030 is to be reviewed and finalized in 2022.

shorter distances, while the latter two alternatives could in future also be relevant for long-distance transport.

The main advantages of electric propulsion are improved energy efficiency (85–90% compared to ca. 25–40% in fossil-based combustion engines), significantly cheaper fuel, reduced maintenance needs (very few moving parts compared to conventional vehicles; no oil changes), and faster acceleration (Norwegian Association of Heavy Equipment Contractors, 2016; Transport & Environment, 2017 and EV Norway (2017).

So far, limited battery capacity prohibitively limited the range of heavy vehicles. For electric busses, this problem has become smaller in recent years, as driving distances are generally relatively short and operation takes place in a limited geographical area, allowing more centralized charging infrastructure. As such, the market for electric busses has reached a relatively mature stage, with extensive (trial) operation in cities around the world.[50]

For heavy freight transport over long distances however, limited driving ranges are currently still restrictive. We saw in Chapter 4.4 that while the number of electric LGVs has started to pick up in Nordic countries, heavy-duty vehicles with alternative propulsion systems are still scarce. In addition to limited driving ranges, reasons for this are the lack of serial production until now, and the current price and incentive barriers.

However, a number of vehicle manufacturers has promised to start serial production of electric HGVs in 2019 (see e.g. ZERO, 2018). Moreover, significant technological improvements are expected towards 2030, e.g. with respect to battery capacity, but also in the context of so-called electric roads, where power is dynamically transferred to the vehicle (through catenaries and in the future potentially through inductive coils embedded in the road pavement).

Nevertheless, the case for the adoption of LGVs and particularly cars indicates that, while the general trend for the Nordic countries is an increase of alternative propulsion vehicles, differences exist due to different incentive levels and structures. In the remainder of this chapter, we therefore discuss the main initiatives promoting the adoption of lower-emission vehicles and vehicles with alternative propulsion systems.

5.6.1 Norway

For Norway, we saw that the share of electric vehicles is highest among the Nordic countries. Indeed, Norway is often discussed as example of offensive and successful policy-making in this regard (e.g. Jordal-Jørgensen *et al.* , 2017).

When it comes to LGVs and HGVs, the most recent National Transport Plan sets the following ambitions (Norwegian Government, 2016b):

[50] Oslo will for example receive 70 new battery-electric busses in 2019, adding to the 6 electric busses that have been in pilot operation so far (Ruter, 2018).

- By 2025, all new lighter LGVs are zero-emission vehicles.
- By 2030, all new heavier LGVs and 50% of new HGVs are zero-emission vehicles.

A study by Fridstrøm and Østli (2016) suggests that these goals will not be achieved under business-as-usual, and that a very disruptive scenario might be required. For that reason, it remains the question whether strong enough measures are feasible in practice.

Currently, general instruments aimed at the forced phase-in of low- and zero-emission vehicles, such as exemptions of purchase fees and VAT, are much weaker means for LGVs and HGVs, than for passenger cars. This is due to the fact that unlike for passenger cars, exemptions from VAT and purchasing charges do not affect the cost differentials of owning and operating an electric HGV or heavy LGV.

Businesses registered in Norway can, however, apply for subsidies towards the cost premium of zero-emission LGVs and HGVs, such as electric, hydrogen, or biogas vehicles. The size of these subsidies is determined on a project-by-project basis. For large firms, up to 40% of the cost premium of zero-emission vehicles can be subsidized; for small and medium firms, this is 50%. In the section on lower-carbon fuels, we saw that comparable subsidies are also available for the modification of vehicles towards higher environmental standards (ENOVA, 2018a).

5.6.2 Sweden

In Sweden, the share of electric goods vehicles is low compared to other countries, such as Norway. One of the main policies directed at a transition to lower carbon vehicles is the bonus-malus scheme, which entered into force on 1 July this year. This implemented scheme applies to passenger vehicles, light busses (up to 3.5 tonnes), and light HGVs (up to 3.5 tonnes), but not HDVs. The scheme incentivizes the purchase of new vehicles with CO_2-emissions below 60 g/vkm through a bonus of up to SEK 60,000. At the same time, the malus is made up of an increase in the vehicle registration tax over the first three years from the purchase of a new vehicle (Swedish Transport Agency, 2018e).

In addition to the above, and as part of "Vision 45", the Swedish Transport Administration set have fossil-free ferries by 2045, in line with the set target of having no net greenhouse gas emissions. This ambition means that investments are and will be made in climate-neutral ferries, i.e. hybrid, electric, and biofuel ferries (Swedish Transport Administration, 2018a).

Further, the implemented "Klimatklivet" policy aims to increase emission-reducing actions on a local level. This means that it is possible to apply for grants, e.g. to build charging stations for electric vehicles, or to invest in fossil fuel-free heavy trucks (Swedish Environmental Protection Agency, 2018).

Further initiatives in this regard include platooning pilots and electric roads for heavy transport. So far, two demonstration projects are running: E-road Arlanda, and Elväg Gävle (VTI, 2017; Kristoffersson *et al.* , 2017; Swedish Transport Administration 2018b). According to Transport Analysis (2016b), future automated platooned road transport with long vehicles can operate at higher costs than current rail transport, but at lower costs than traditional road transport.

5.6.3 *Finland*

In Finland there is a EUR 2,000 purchasing subsidy in place for electric passenger cars from 2018 to 2021, but there are no such incentives for LGVs or HGVs. Although the goal is to have 250,000 electric vehicles (battery electric or plug-in hybrid) by 2030, this goal has not been allocated between cars, buses and HGVs.

A recent study (Liimatainen *et al.*, 2018b) found that Finland has a very limited potential for using electric trucks, even with advanced battery and charging technology, due to the use of long and heavy truck-trailer combinations. Indeed, countries that primarily use semitrailers are likely to be able to electrify a much larger share of road freight tonne-kilometres using battery electric trucks. The Finnish electrification potential further varies considerably between commodities, as commodities which are constrained by payload volume rather than weight, and are to large extent carried using medium-duty or <26t rigid trucks, seem to provide a high potential for electrification even with the current technology. The study by Liimatainen *et al.* (2018b) estimates that with current technologies, the maximum market potential for electric trucks in Finland lies around 6,700 battery-electric HGVs.

5.6.4 *Denmark*

In Denmark, there are few concrete initiatives focusing on speeding up the adoption of low- or zero-emission vehicles. There are for example currently no general subsidies towards these types of vehicles, or their additional costs, such as e.g. is the case in Norway. Although a few municipal trials with electric distribution trucks are being launched, this is only happening a very small scale. Trials with electrified HGVs have so far not been conducted in Denmark

5.7 Other measures

So far, this chapter discussed five main channels through which authorities can approach the challenge of reducing CO_2-emissions from freight transport. Before moving to a general discussion of cost-effectiveness, it is worth mentioning a few remaining and miscellaneous initiatives or approaches.

In addition to general policy measures for the transport sector, authorities can directly influence CO_2-emissions through requirements set in public tenders or through public procurement of goods and services. Examples for Norway are requirements regarding sustainability or emissions set in tenders for waste collection services (e.g. low-emission vehicles and current pilots with electric propulsion systems) or publicly financed ferry routes (for which currently around 50–60 electric ferries and the first hydrogen ferry have been ordered or are planned, see e.g. ABC Nyheter (2017) and

KPMG *et al.* (2018)). Moreover, public bodies could require the goods they buy to be distributed or delivered using lower- or zero-emission vehicles or transport solutions, e.g. own consumption in offices, or deliveries to publicly financed schools, kindergartens, etc.

In addition to the previously discussed measures, Norway is further considering the introduction of a so-called "CO_2-fund" for the transport industry, modelled after the successful NOx-fund equivalent. The idea behind this fund is that rather than paying the CO_2-tax on every litre fuel consumed, participants to the fund will pay a (lower) participation fee in exchange for committing to measures that reduce CO_2-emissions. The proceeds from the fund's participation fees will then be used on (partial) subsidies towards the additional investment costs for renewable-based rolling stock and infrastructure, such as filling stations. The Norwegian National Transport Plan for 2018–2029 envisions that such a fund should contribute a reduction in CO_2-emissions of 2 million tonnes CO_2-equivalents yearly, by 2030 (Norwegian Government, 2016b).

Although the specifics and scope of such a CO_2-fund are still under discussion,[51] but a specific study and scenario analysis by Pinchasik and Hovi (2017) indicated that it is most cost effective to support investments in vehicles using biodiesel. Because the availability of sustainable fuel can pose a challenge, the fund should also focus on providing subsidies towards vehicles using more expensive technologies, such as biogas, electricity and hydrogen. As technologies for these latter two options have not yet reached maturity for heavy trucking, a CO_2-fund could contribute to increasing demand for these technologies and help achieve a critical mass.

Finally, the Norwegian organization ZERO established a forum for renewable transport, after over 80 parties signed a declaration committing them to reducing emissions from their own transport, as well as to demand emission-free solutions. The forum showcases which low- and zero-emission solutions are available for different types of vehicles, technologies, and fuel types, and spans parties from the entire value chain, such as suppliers, transporters, ordering customers, and public authorities. As such, the forum has as objective to induce change, put focus on framework conditions and to bring together important parties which together can contribute to a green transition in the transport sector (ZERO, 2018).

In Sweden, other initiatives include the establishment of the Swedish network KNEG (Klimatneutrala Godstransporter på Väg). KNEG is a joint initiative of private and public stakeholders with the aim of reducing CO_2-emissions from the Swedish freight transport industry (KNEG, 2017).

Moreover, the Ministry of Enterprise, Energy and Communication is leading a group called "The next generation's mobility and transports".[52] Amongst others, one action is addressing digitalization as a means for increasing logistical efficiency, a task led by a national freight transport platform called CLOSER.[53]

[51] E.g. per litre membership cost, sectors that are covered (only the transport industry or a broader selection), etc.
[52] Nästa generations resor och transporter.
[53] CLOSER is a national platform for increased transport efficiency, https://closer.lindholmen.se/

Further, a new research and development platform for fossil free freight transports has recently been founded, called Triple F. This platform is financed through the Swedish Transport Administration.[54]

Apart from these platforms and networks for more sustainable transports, Swedish authorities are also employing measures to increase load factors and reduce the number of vehicles in city centres through increased consolidation. Positive societal impacts of these kinds of measures are demonstrated in projects such as DenCity (see e.g. Olsson *et al.*, 2018) and "Stadsleveransen", a consolidation system for more sustainable urban freight transports that was established in Gothenburg (Göteborgs stad, 2018).

In Finland, the Transport Safety Agency has established a "Responsibility model" for haulers. This voluntary scheme provides guidelines for haulers to measure and improve their management from economic, safety and quality, but also environmental aspects. Firms that participate in the scheme receive a responsibility certificate that can be used as an assurance of responsible management practices. There are currently only 12 companies participating in the responsibility model scheme (Finnish Transport Safety Agency, 2018).

In Denmark, a public scheme called "Den grønne klimapulje" provides support to initiatives which promote a green transition (Danish Ministry of Energy, Utilities and Climate (2017). So far, financial support to an energy-saving asphalt project and a grant for a biorefining project are the only transport-related projects. Between 2009–2016, a previous scheme called "Forsøgspuljen til fremme af energieffektive transportløsninger" granted financial support to several demonstration projects related to freight transport.

Recently, the Danish Parliament agreed to make additional funding available for supporting green solutions in the transport sector. From 2020 to 2024 a yearly amount of DKK 100 million is set aside for projects that promote green mobility and transport in a broad sense, including also public transport and individual transport.

5.8 Cost-effectiveness

As many policy-measures overlap, assessments of the cost-effectiveness of isolated measures are generally scarce. In this report, we have discussed cost-effectiveness aspects in the context of policy measures where this information was available. The current chapter discusses a number of remaining cost effectiveness findings for the different countries.

5.8.1 Norway

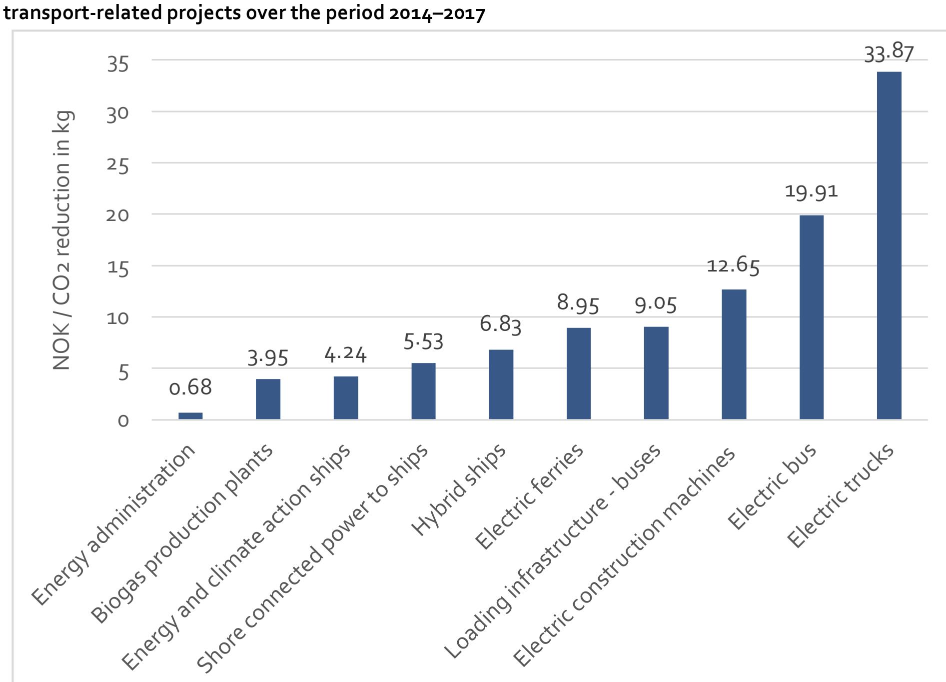
For Norway, the National Transport Plan 2018–2029 is expected to reduce CO_2-emissions from the transport sector as a whole, by around 57,000 tonnes annually

[54] Trafikverket – Krafttag för ett fossilfritt godstransportsystem, see: https://www.trafikverket.se/resa-och-trafik/forskning-och-innovation/aktuell-forskning/trafikslagsovergripande/fossilfria-godstransporter

by 2030. This is a reduction of only 0.3% of CO_2-emissions from the transport sector as a whole (i.e. 16.7 million tonnes in 2015, including fishery and construction). The Transport Plan further states that the largest emission reductions are expected to come from developments in technology and fuels (beyond the measures included in the plan), with a reduction of 9 million tonnes CO_2 or around 54% of total transport emissions (Norwegian Government, 2016b).

Given the importance attributed to technology, we further looked at the cost-effectiveness of different types of transport-related projects supported by ENOVA. This was done based on information on subsidy amounts and expected CO_2 reductions (ENOVA, 2018b), and calculated as the subsidy costs per expected CO_2-reduction in terms of NOK/kg CO_2 reduction, over the period 2014–2017. The result is shown in Figure 25, and each ENOVA project is categorized into a thematic group.

Figure 25: Subsidy amounts from ENOVA per CO_2 reduction in terms of NOK/kg CO_2, for different transport-related projects over the period 2014–2017



Source: Author calculations based on ENOVA (2018b)

The figure makes clear that there are large differences in the subsidy costs per kg CO_2-reduction between the different project types, and that all project types exceed the quota price of 500 NOK/tonne CO_2. As mentioned in previous chapters, subsidies vary from 30% to 50% of additional costs, depending on the size of the applying organization, and the program that the organization applies for.

The measures giving the largest CO_2-reduction per NOK in subsidies are energy management and biogas production, while support for electric busses and HGVs, on the other hand, are the most expensive measures to support compared to the expected savings in CO_2. In comparison, it is cheaper to provide support to ships per reduced unit CO_2. This is largely due to the fact that projects and measures for ships are largely about rebuilding, whereas for vehicles, the measures are largely about investment in new equipment.

5.8.2 Sweden

Where information was available, the cost-effectiveness of Swedish policy measures has been addressed in the discussion of these measures. Beyond this, there are no in-depth studies addressing the cost effectiveness of policy measures with the target to reduce CO_2-emissions from freight transport or transport in general.

While there are some qualitative discussions on the measures suggested in the transition plan towards a fossil-free transport sector (Swedish Energy Agency, 2017a), and on how feasible these measures are to implement (Swedish Energy Agency, 2017b), these discussions do not include much specific information on cost-effectiveness, although its importance is emphasized.

Other than this, cost-benefit analyses have been conducted for the discussed infrastructural measures in the Infrastructure Plan 2018–2029, indicating an overall negative socio-economic benefit. CO_2-emissions from the overall transport sector are only expected to decrease by 1 percentage point, compared to if the Infrastructure Plan was not implemented.

As costs of the different measures in the Infrastructure Plan are not specified for passenger vs. freight transport, the Swedish Transport Administration (2018c) finds that in order to reduce CO_2-emissions from the Swedish transport sector by 70% in 2030 (compared to 2010), new policy instruments have to be developed that drive developments towards improved energy efficiency, electrified vehicles, an increased renewable energy share, and a transport-effective society.

5.8.3 Finland

For Finland, Liimatainen and Viri (2017) found that the 2030 emissions reduction target requires a reduction of emissions from overall transport of 3 million tonnes CO_2, compared to 2005, of which freight transport is to account for about 1.1 million tonnes. Liimatainen and Viri estimate that this requires a reduction of 0.5 million tonnes CO_2 through the use of renewable diesel, 0.3 million tonnes CO_2 from improving the energy efficiency of freight transport by increasing average load and decreasing empty running, 0.15 million tonnes CO_2 from the use of LNG and electric HGVs, and 0.13 million tonnes CO_2 from reducing the energy consumption of HGVs through improvements in aerodynamics, lightweight materials, and engines and powertrains.

Over the period 2015–2050, reductions in CO_2-emissions should be approximately 68 million tonnes, and freight transport should account for about 21.5 million tonnes, with 12.2 million tonnes from the use of alternative energy (renewable diesel, LNG) and 9.3 million tonnes from improving the energy efficiency of freight transport (improved vehicles and loading). The cumulative costs of improving the energy efficiency of HGVs and LGVs were estimated to be EUR 2.5 billion and benefits due to decreased energy costs to EUR 1 billion, yielding a CO_2 abatement cost of 161 EUR/tonne CO_2. Regarding the use of alternative energy, costs are estimated to lie around EUR 0.6 billion due to higher price of renewable diesel compared to fossil diesel, and around EUR 1.3 billion for the construction of infrastructure for LBG (liquefied biogas) for use in road freight and waterborne freight. Here, CO_2 abatement costs amount to 156 EUR/tonne CO_2 (Liimatainen *et al.*, 2015).

5.8.4 Denmark

For Denmark, the Danish Council on Climate Change has analysed the economic costs and the effect on greenhouse gas emissions of a broad range of alternative so-called "elements of transition" across the non-ETS sectors (Danish Council on Climate Change, 2017). The council proposes a selection of elements of transition facilitating cost-effective attainment of the 2030 target, while taking into consideration Denmark's more ambitious 2050 target.

The council's recommended cost-effective package of measures towards 2030 only includes one minor initiative regarding freight transport: the promotion of natural gas (CNG) in heavy road transport. In line with a previous report (Ea Energianalyse, 2015), the Council estimates it to be realistic that by 2030, 7% of total HGV transport can be based on natural gas. Although this will only lead to a rather insignificant (0.2%) short-term reduction of the CO_2-emissions from freight transport, the initiative is considered as preparatory step for a large-scale transition to biogas in the longer run – in 2050, road transport will have to be based fully on renewable energy in order to achieve Danish climate objectives.

At the moment, natural gas propulsion systems yield lower fuel costs, but higher vehicle costs, so that with current prices, per kilometre costs are a few percent higher for natural gas HGVs than for diesel HGVs. The CO_2 reduction potential is only about 5% per kilometre, but much higher if the gas is extracted from sustainable biomass (COWI, 2014, p.11 and p.65).

The cost-effectiveness of Danish policy measures has further been assessed by a cross-ministerial working group. In 2013, this working group published a catalogue with an overview of possible national policy instruments that could be used to achieve the national target of a 40% reduction of the greenhouse gas emissions by 2020 compared to 1990. Focus was on measures that could be implemented at the national level. The catalogue analysed the reduction potential and cost effectiveness in terms of social costs per tonne CO_2-e, for 47 different instruments, describing another 33 instruments in qualitative terms. Table 10 lists the working group's 15 instruments related to transport.

Table 10: Overview of instruments related to transport, from the Danish Energy Agency's instruments catalogue ("Virkemiddelkatalog")

Policy instrument	Reduction potential in 2020 1000 t CO^2	CO_2 Shadow price DKK per ton CO^2
Kilometre-based road user charging for passenger cars and LGVs (0.25 DKK/km)	1,315 (11%)	4,181
Higher fuel taxes (+0.40 DKK/litre)	743 (6.3%)	2,663
Green R&D tax on fossil fuels	186 (1.6%)	2,409
Higher biofuel blend-in percentage in 2020	163 (1.4%)	1,499
Removal of tax credit for commuting	130 (1.1%)	4,167
Adding 1 percent 2nd generation bioethanol in petrol from 2020	85 (0.7%)	4,455
Lower speed limit (130 to 110 km/h) on motorways	63 (0.5%)	13,460
Energy efficiency demands on public sector purchase of transport	42 (0.4%)	235
Subsidy to blend-in of higher concentrations of biofuels for heavy vehicles	39 (0.3%)	1,581
Funding for cooperation between municipalities and enterprises about green industrial transport	30 (0.3%)	-585
Obligatory driving school education in energy efficient driving technique	17 (0.1%)	1,189
Continued tax exemption for electric cars	16 (0.1%)	4,462
Tax exemptions for plug-in hybrid cars 2013–2015	7 (<0.1%)	5,012
Tax reduction for gas for heavy vehicles	2 (<0.1%)	1,798
Subsidy to gas-driven heavy vehicles	0.3 (<0.1%)	941

Note: For comparison, total GHG emissions from the Danish transport sector are expected to be about 11.7 million tonnes CO_2-e, according to the "Energi- og Klimafremskrivning 2014" by the Danish Energy Agency (2014). Figures in brackets are percentages of this total.

Source: Danish Energy Agency (2013): "Virkemiddelkatalog".

In the table above, the policy instruments are ranked according to their reduction potential, and instruments relating to freight transport are further highlighted with italic font. For the sake of comparison, it can be noted that at that time, total greenhouse gas emissions for the Danish transport sector were projected to lie around 11.7 million tonnes CO_2-e in 2020. This means that only the instruments regarding taxes on driving and fuel, had an estimated reduction potential of more than 2%, while the reduction potential for the majority of other instruments lies below 0.5%.

In addition, almost all instruments have high costs compared to the typical costs of the catalogue's policy instruments (not listed) in other sectors. Exemptions are the "soft measures" related to cooperation between public sector and enterprises and public sector transport purchases.

For freight, it can be noted that, apart from the fuel taxes, instruments are estimated to have a CO_2-reduction potential of below 0.3%, for 2020. However, CO_2 reduction effects and cost-effectiveness will be higher for 2030 due to technology-driven cost reductions. Either way, results from the 2013 catalogue are much in line with the finding from the Danish Council for Climate Change, that cost-effective achievement of the Danish non-ETS reduction target would include hardly any initiatives focusing on freight transport. If this conclusion is valid, it implies that CO_2-reductions in freight transport should be governed by the 2050 target of a practically 100% transformation of road transport energy consumption to renewable energy.

5.8.5 Border-crossing effects of policy measures

Although driven by international developments, many of the policy measures discussed in this report are primarily directed at domestic markets in the respective Nordic countries. This means that a lack in harmonization or international coordination can lead to unintended policy outcomes or a sub-optimal effectiveness of policy measures.

Earlier, for example, we discussed national initiatives to promote modal shift. Highly relevant in this regard is the observation that the mode of choice for border-crossing legs is an important determinant of the modal shift potential further down the transport chain. Freight that arrives in Norway by rail, for example, has a higher likelihood to continue by train domestically, than freight that enters Norway by truck. This again has implications for freight transport in Sweden and other transit countries, so that modal shift initiatives may benefit from a more internationally coordinated approach.

An example of unintended border-crossing effects are Swedish measures to promote the uptake of plug-in hybrids and electric passenger cars. Although these policies were intended to boost the Swedish adoption of alternative propulsion systems, Transport Analysis (2017e) showed that relatively new cars were deregistered after just a few years in Sweden. These cars were then exported to Norway and other countries that subsidize the purchase of used plug-in hybrids. Although this trend currently involves a small number of cars relative to the entire vehicle fleet, and corresponding data for LGVs and HGVs have not been analysed yet, Transport Analysis found that the export of these cars can significantly hamper the growth in the Swedish share of cars with alternative propulsion systems in the long run.

Another example of how climate policy instruments in the transport sector give rise to unintended incentives is the fact that most EU-countries subsidize the production of biogas to a higher extent than Sweden. This implies that Swedish biogas plants face tough competition from imported biogas (Avfall Sverige, 2017; Takman *et al.*, 2018). Imported biogas from Denmark is one of the major competitors due to the fact that the biogas in Denmark is subject to production aid, but it also receives the tax exemption in Sweden (when sold on the Swedish market) (Takman *et al.*, 2018). However, as mentioned earlier, the current government has proposed an increased financial support to biogas production in Sweden.

Although the observations above are but a few examples, they make clear that considering border-crossing effects and coordination to a larger extent, may benefit the effectiveness of policy-making.

5.9 Summary

In the previous chapters, we identified gaps in achieving required or agreed reduction targets for CO_2, for each of the Nordic countries. This chapter addressed the main existing and planned policy measures used by the Nordic countries for reducing emissions from (freight) transport.

5.9.1 Reducing transport demand

The first and most obvious way to reduce emissions from freight transport is to reduce the demand for this type of transport. This is no easy task, with forecasts indicating that freight transport in the Nordic countries continues to increase. Nevertheless, main examples of policy measures that may contribute to dampening transport demand are taxes and duties, registration fees, zoning regulation, and transport- and area planning. Table 11 summarizes the most important policy instruments in the different Nordic countries.

Table 11: Summary of main policy instrument use for reducing transport demand in the different Nordic countries

	Norway	Sweden	Finland	Denmark
Toll/road pricing	+	+	–	–
Euro vignette	–	+	–	+
Road use tax ("veibruksavgift") on fuel	+	–	–	–
CO_2-/NOx-tax on fuel	+	+	+	+
Energy tax on fuel	–	+	+	+
Emergency supply fee on fuel	–	–	+	–
Reduced tax on biofuels	+	+	+	+
One-off tax on HGVs	–	–	–	–
Environmental zones	–	+	–	+

In Norway, road use charging is applied through a toll system, which is largely fiscally motivated and in part congestion-focused, rather than focused on reducing CO_2-emissions. Fuel use, in turn, is taxed through two components, a road use charge (veibruksavgift) and a CO_2-component. Both components make transport more expensive, but biofuels are taxed at a reduced rate compared to their fossil counterparts, as they are exempt from paying the CO_2-component. Norway does not employ purchasing taxes for HGVs. Purchasing taxes do apply for LGVs, but are much lower than is the case for passenger cars, a difference that is exemplified due to VAT-exemptions. Yearly ownership charges for goods vehicles are also relatively low compared to those for passenger cars, and (local) environmental differentiation does not yield materially different cost levels. Norway currently does not employ zoning regulation aimed at the reduction of local or GHG emissions. Finally, the current National Transport Plan (2018–2019) has a budget of NOK 933 billion in total. About 58% of this budget is allocated to road objectives, but much less is specifically earmarked for freight. Of the 34% of the total budget that is set aside for rail projects, the lion's share is allocated to passenger transport. Only a few percent of the total budget is aimed at waterborne transport.

In Sweden, road use is taxed in a number of ways. When it comes to interurban transport with heavy HGVs, Sweden applies, as Denmark and the Benelux, the Euro vignette as road infrastructure fee for HGVs with a gross vehicle weight over 12 tonnes. Sweden also employs congestion charging in Stockholm and Gothenburg, while the introduction of a distance-based kilometre-tax has been under consideration, but is controversial and has not yet been introduced. However, neither the Euro vignette, congestion charging, or a distance-based tax address CO_2-emissions from freight directly. Fuel use, in turn, is taxed through two components, an energy component, and a CO_2-component, with biofuels being taxed at a reduced rate via both components, compared to their fossil fuel counterparts. Unlike for passenger cars, Sweden does not employ purchasing taxes for HGVs. Environmental zones are used in a number of cities, but are aimed at reducing local pollution, not CO_2-emissions. Finally, the current National Plan for Transport Infrastructure for 2018–2029 features a total budget of SEK 622.5 billion, of which SEK 333.55 billion for development of the transport system and SEK 289 billion for maintenance (SEK 164 billion for road objectives, SEK 125 billion for rail objectives). National and regional infrastructure plans are further expected to give total investments of around SEK 5.1 billion in shipping, which to a large extent will benefit freight transport.

In Finland, no road user charging, and no congestion charging is applied. The current fuel tax consists of three components, an energy component, a national emergency supply fee, and a CO_2-component. Also here, biofuels face reduced rates. Finland does not employ purchasing charges on HDVs. Further, there are currently no environmental zones, and no long-term national transport plan. However, the annual budget of Ministry of Transport and Communications is approximately EUR 2.5 billion, of which EUR 1 billion is allocated towards the upkeep and maintenance of the current transport network, while EUR 0.5 billion is allocated towards new investments. Both maintenance and investment costs are divided about half and half between the road network and other modes.

Denmark, like Sweden, employs the Euro vignette for HGVs over 12 tonnes gross weight. There are no distance-based road taxes and no toll charges (except for 2 bridges, for which charges are primarily fiscally motivated). Fuel taxes in Denmark are about the same level as in Sweden. The total fuel tax has three components: energy, CO_2 and NOx. Of these, the energy component is by far the most important. Finally, Denmark employs zoning regulation in the four largest cities, but this is aimed at local pollution, not CO_2.

5.9.2 Increasing transport mode efficiency

A second way to reduce emissions from freight transport is to improve the efficiency of transport modes, for example by increasing vehicle capacity (e.g. longer, heavier or higher vehicles), improving capacity utilization (e.g. use of consolidation centres), or better transport planning (which is more difficult for authorities to influence).[55] The (increased) use of digitalization, automatization and platooning also falls in this category, but is harder for authorities to influence other than through facilitating infrastructure and legal changes.

[55] Examples are a combination of better-automated goods terminals which in conjunction with autonomous vehicles have the potential to make freight transferring operations more efficient (KPMG *et al.*, 2018).

Indeed, the Nordic countries are showing a trend of relaxing restrictions on the physical dimensions of road vehicles used for freight transport (particularly weight and length). While a few studies and evaluations suggest that this yields efficiency improvements and cost reductions, the downside of such initiatives is that they make road transport more attractive both in general and compared to other modes, which may counteract efforts to reduce transport demand or modal shift. In addition to physical restrictions for road transport, Sweden is considering improving railway infrastructure to allow longer trains, improving efficiency of this mode.

5.9.3 Moving towards modes with higher energy efficiency per unit transported (modal shift)

A third way to reduce CO_2-emissions from freight transport is to move (longer-distance) transport towards modes with a higher energy efficiency per transported unit. Generally, this will mean moving from road transport, to rail and waterborne transport. Main policy instruments are taxation and subsidies, as well as facilitating infrastructural measures (terminals, sufficient infrastructural capacity, connection roads).

For Norway, the modal shift potential is estimated at 5–7 million tonnes transported, of which 2.4 million tonnes is considered feasible. This makes up about 7% of total domestic transport performance overall, or ca. 23% of domestic transport performance over distances >300 km, but requires strong measures that are not always socio-economically beneficial. Domestically, the maximum annual CO_2-reduction is limited, and estimated at 0.2 million tonnes, i.e. around 8% of total CO_2-emissions from HGVs. The main policy measure that is used to incentivize modal shift from road to waterborne transport, is a subsidy scheme/"økobonus".

Sweden too, aims at incentivizing modal shifts from road to rail and water. Here, the main policy measures are an "eco-bonus" for rail, which was introduced in 2018, while a similar scheme for waterborne transport is currently under discussion. When it comes to the potential of modal shift in Sweden, a handful of studies has been carried out in somewhat more detail. Although there is a theoretical potential for modal shifts, there are also capacity barriers, as well as counteracting policies, such as the permission of heavier road vehicles.

In Finland, there are currently only few policies in place to promote modal shift. Rather, the opposite seems to be true, as there are indications that the relaxing of physical restrictions for road transport has gone at the expense of the modal share of rail. Although the share of HGV transport on long-haul trips suggests that there should be potential for modal shift, the major commodities within Finnish longer-distance haulage are food products and grouped goods. As the delivery of these commodities may be time-sensitive, the potential for using rail transport may be limited. Another aspect that hampers modal shifts from road to rail is the limited rail capacity stemming from Finland's largely single-track network.

For Denmark, particularly shifts to rail are relevant in the modal shift discussion, and in order to offset the effects of rail infrastructure charges, the Danish Government has been providing an environmental subsidy to rail freight operators since 1999. In an investigation into the potential for shifting freight transport from road to rail, the Danish Transport Authority (2016) estimated that the break-even distance between rail (combi) and road in terms of costs is 350–500 kilometres, depending on whether or not the Great Belt is crossed. This is without taking into account the flexibility that road transport offers. Break-even distances are significantly shorter if a shift to/from HGV can be avoided at one or both ends of the trip. Nevertheless, given today's insignificant share of domestic freight transport on relevant routes, it is hardly realistic that measures will be taken that improve the attractiveness of rail to such an extent that modal shift reaches levels that can lead to significant reductions in CO_2 from freight transport.

5.9.4 *Transferring to fuels with lower carbon content*

A fourth way to reduce emissions from freight transport is to reduce the carbon content of fuels. Driven by the EU, all Nordic countries are stepping up biofuel blending requirements in fossil fuels. Focus is also put on gradually increasing the share of advanced biofuels, which are more sustainable in production.

In Norway, the modification of vehicles, ships, and filling infrastructure with more environmentally friendly characteristics is (partially) subsidized through the ENOVA scheme. In Sweden, it is proposed to increase financial support to domestic biogas production, alongside some other programs improving the position of biofuels. In Finland and Denmark, measures are currently largely limited to the blend-in requirements. Denmark, however, has a vast biogas production potential from the production of pork. This potential is seen as a medium- to longer term contribution to the reduction of CO_2-emissions. All Nordic countries employ lower fuel taxation for (pure) biofuels compared to their fossil counterparts, as described in section 5.2.

5.9.5 *Moving towards lower-carbon vehicle technologies*

After discussing the reduction of the carbon content of *fuels*, a fifth way to reduce emissions from freight transport is through the adoption of lower-carbon *vehicles.* At the European level, overarching standards are set for the fuel efficiency and CO_2-emission performance of new passenger cars and LGVs. Earlier this year, the European Commission further proposed a set of standards for CO_2-emissions from HDVs, including an overall and legally binding 15% reduction target for new HDVs, by 2025, compared to 2019. For 2030, a preliminary target is set of 30% compared to the same base year.

As such, the European Union pushes towards more efficient conventional propulsion vehicles, while further incentivizing newer alternative propulsion technologies. Meanwhile, the alternative to liquid or gaseous fuels is electric propulsion, for which three alternatives exist: 1) battery-electric propulsion, 2) hydrogen-electric propulsion, and 3) "electric roads". Of these, battery-electric propulsion is primarily seen as solution for shorter distances, while the latter two alternatives could in future also be relevant for long-distance transport.

For the Nordic countries in general, a trend is visible of an increasing uptake of passenger cars (and to a smaller extent vans) with alternative propulsion technologies, with Norway in the lead. At the same time, the uptake of alternative propulsion technologies for heavier goods vehicles is still very limited.[56]

When it comes to LGVs and HGVs, the most recent Norwegian National Transport Plan sets the following ambitions:

- By 2025, all new lighter LGVs are zero-emission vehicles.
- By 2030, all new heavier LGVs and 50% of new HGVs are zero-emission vehicles.

Despite subsidy schemes for firms, it seems unlikely that these ambitions will be achieved under business-as-usual, as general instruments aimed at the forced phase-in of low- and zero-emission vehicles, such as exemptions of purchase fees and VAT, are much weaker means for LGVs and HGVs, than for passenger cars.

Sweden, in turn, as its main measure employs a bonus-malus scheme incentivizing CO_2-efficient vehicles, but this only applies to passenger cars, light busses and goods vehicles up to 3.5 tonnes, and not HDVs.

In Finland there is a EUR 2,000 purchasing subsidy in place for electric passenger cars from 2018 to 2021, but there are no such incentives for LGVs or HGVs. A recent study moreover found that Finland has a very limited potential for using electric trucks compared to other countries, and that the Finnish electrification potential further varies considerably between commodities.

In Denmark, there are few concrete initiatives focusing on speeding up the adoption of low- or zero-emission vehicles.

5.9.6 Other measures

In addition to the measures described above, we noted that authorities have the possibility to influence CO_2-emissions through requirements set in public tenders or through public procurement of goods and services. Other initiatives in multiple Nordic countries include demonstration projects (e.g. platooning and electric roads in Sweden) intended at reducing CO_2-emissions, and the establishment of knowledge and networking platforms. Finally, Norway is working on the introduction of a so-called CO_2-fund after the model of the successful NOx-fund.

5.9.7 Cost-effectiveness of policy measures

Where possible, indications of the cost-effectiveness of different policy measures were presented in the discussion of said measures. In addition, cost-effectiveness findings

[56] Most trucks with alternative propulsion technologies are only slowly leaving the pilot stage, although busses with alternative propulsion systems have or are nearing a commercial market situation.

were discussed more generally for the different Nordic countries, where information was available.

For Norway, the National Transport Plan 2018–2029 is expected to reduce CO_2-emissions by around 57,000 tonnes annually (i.e. a reduction in CO_2-emissions of only 0.3% when looking at the transport sector as a whole). The Transport Plan further states that the largest emission reductions are expected to come from developments in technology and fuels (beyond the measures included in the plan), with a reduction of 9 million tonnes CO_2 or around 54% of total transport emissions.

Data from ENOVA showed that the measures giving the largest CO_2-reduction per NOK in subsidies are energy management and biogas production, while support for electric busses and HGVs are the most expensive measures to support compared to the expected savings in CO_2. In comparison, it is cheaper to provide support to ships per reduced unit CO_2. This is largely due to the fact that projects and measures for ships are largely about rebuilding, whereas for vehicles, measures are largely about investment in new equipment.

For Sweden, specific information on cost-effectiveness is limited. Cost-benefit analyses for the discussed infrastructural measures in the Infrastructure Plan 2018–2029 indicate an overall negative socio-economic benefit, and CO_2-emissions from the overall transport sector are only expected to decrease by 1 percentage point, compared to if the Infrastructure Plan was not implemented.

For Finland, Liimatainen and Viri (2017) found that the 2030 emissions reduction target requires a reduction of emissions from overall transport of 3 million tonnes CO_2, compared to 2005, of which freight transport is to account for about 1.1 million tonnes. Liimatainen and Viri estimate that this requires a reduction of 0.5 million tonnes CO_2 through the use of renewable diesel, 0.3 million tonnes CO_2 from improving the energy efficiency of freight transport by increasing average load and decreasing empty running, 0.15 million tonnes CO_2 from the use of LNG and electric HGVs, and 0.13 million tonnes CO_2 from reducing the energy consumption of HGVs. A cost-benefit analysis of improving the energy efficiency of HGVs and LGVs yielded a CO_2 abatement cost of 161 EUR/tonne CO_2, while with regard to the use of alternative energy for use in road and waterborne freight, CO_2 abatement costs were found to amount to 156 EUR/tonne CO_2 (Liimatainen *et al.*, 2015).

In Denmark, the Council on Climate Change's recommended cost-effective package of measures towards 2030 only includes one minor initiative regarding freight transport: the promotion of natural gas (CNG) in heavy road transport. Although the resulting reduction in CO_2-emissions is expected to be rather insignificant, the initiative is considered as preparatory step for a large-scale transition to biogas in the longer run – in 2050. The cost-effectiveness of Danish policy measures has further been assessed by a cross-ministerial working group. Here, it was found that only instruments regarding taxes on driving and fuel had an estimated CO_2-reduction potential of more than 2%, while the reduction potential for the majority of other instruments lies below 0.5%. In addition, almost all instruments for the transport sector have high costs compared to typical costs in other sectors. All in all, cost-effective achievement of the

Danish non-ETS reduction target would include hardly any initiatives focusing on freight transport.

Finally, although they are driven by international developments, many of the policy measures discussed in this report are primarily directed at domestic markets in the respective Nordic countries. This means that a lack in harmonization or international coordination can lead to unintended policy outcomes or a sub-optimal effectiveness of policy measures due to leakages and spill-overs.

6. Conclusions

Both passenger cars and freight transport by road are significant causes of CO_2-emissions in the Nordic countries. While for passenger cars, policy measures aimed at reducing CO_2-emissions have started to sort effect, this is much less the case for freight transport. This poses a challenge in light of the ambitious climate objectives to which both the EU and the Nordic countries have committed, and resulted in a call by the Nordic Council of Ministers.

Although the Nordic countries vary in the degree to which climate objectives are translated from the economy as a whole to the transport sector, it is clear that transport is counted upon to contribute to significant CO_2-reductions in both the medium-term (2030) and the long-term (2050 and beyond). Sweden and Finland have for example set ambitious objectives through official statements, aiming at 70% and 50% reductions in CO_2-emissions by 2030, compared to 2010 and 2005 respectively, while Norway wants the transport sector to contribute a "sufficient share" in light of the Paris Agreement and Norway's objective of reducing non-ETS CO_2-emissions with 40% by 2030, compared to 2005. Although climate commitments with a focus on freight transport are less concrete, e.g. Norway's National Transport Plan includes ambitious objectives for the future share of alternative propulsion systems in new freight vehicle sales, whereas this is not the case for the other countries. For the longer-term however, all Nordic countries have a Climate Change Act, outlining a set of climate objectives towards 2050. Common for these Acts is the objective to turn the countries into lower-emission societies by 2045 (Sweden) and beyond 2050.

The ambitious climate objectives discussed above beg the question whether the Nordic countries are on the way to achieving them. Looking at freight transport, developments in CO_2-emissions have differed between the countries. While data from Sweden and Denmark shows drops in emissions from freight transport (both around 19%, although the change for Sweden is somewhat uncertain), Norway and Finland have been at a relative standstill.

Forecasts, however, indicate that freight transport will continue to increase in the Nordic countries, particularly by road. Although the CO_2-intensity per unit transported is expected to decrease over the coming decades, forecasts nevertheless show that with current trends and adopted policies, all Nordic countries will face sizable CO_2-emission reduction gaps by 2030, compared to what transport in general, and freight transport in particular, should contribute by 2030. In other words, without a trend change, existing and planned policy alone seems insufficient to achieve 2030 CO_2-objectives. Of the Nordic countries, Norway is the country with the expected largest increase in CO_2-emissions from freight transport by road, while Sweden shows the largest decrease in CO_2-emissions from trucks, and also the most CO_2-efficient road transport compared to the domestic transport performance volume. The most recent explanation for this is the increase in allowed maximum dimensions for trucks in Sweden in recent years.

At the moment, the modal share of road transport in domestic transports is lowest in Norway, with just under 50%, followed by Sweden, with around 66%. In Finland, the road share currently lies around 75%, while in Denmark, even without including LGVs, the share increased from 80% to ca. 85% in recent years. This high share is related to Denmark's significantly shorter distances, which disfavor other modes. For comparison, the share of rail is highest in Sweden (over 20%), while Norway has the highest share of waterborne transport among the Nordic countries (between 45–50%).

In looking at policy measures for reducing CO_2-emissions from freight transport, we distinguished between five main channels: reducing transport demand, increasing transport mode efficiency, modal shifts, transferring to fuels with lower carbon content, and moving towards lower-carbon vehicle technologies.

When it comes to addressing increases in transport demand, the Nordic countries show some variation in how they tax road use, fuel use, and vehicle purchases/ownership. All in all, however, measures are not strong enough to stop expected increases in particularly road transport, let alone to reduce transport demand.

With regard to developments in transport mode efficiency, Norway and Sweden attempt to improve the efficiency of rail transport. At the same time, however, all Nordic countries show a strong trend towards allowing longer and heavier road trucks, amongst others EMS, on an increasing part of the road network. While this development contributes to reduced emissions per unit transported by road, it also counteracts initiatives promoting modal shifts to rail and waterborne transport, by improving the competitiveness of road transport. Indeed, it seems that this trend has led to an increased share of road transport.

Regarding modal shifts, we found that Norway has a relatively modest domestic potential, and fulfilling this potential requires strong policy measures. In Sweden, there seems to be potential for modal shifts, but also a number of barriers, while in Finland, very few initiatives are developed to stimulate modal shifts. Indeed, the trend towards longer and heavier trucks has rather resulted in an increase of the road share. Finally, Denmark faces particularly much transit traffic, and today's insignificant share of domestic freight transport on relevant routes for modal shifts, imply that no significant reductions in CO_2-emissions from freight transport can be expected in this regard. However, note should be taken of the observation that the mode of choice for border-crossing legs is an important determinant of the modal shift potential further down in the transport chain. Freight that arrives in Norway by rail, for example, has a higher likelihood to continue by train domestically, than freight that enters Norway by truck. This again has implications for freight transport in transit countries, such as Denmark and Finland. Because of this transit traffic and border-crossing effects, policy measures aimed at modal shifts may benefit from a more internationally coordinated approach.

When it comes to transferring to fuels with a lower carbon content, all Nordic countries are stepping up mandatory biofuel blend-in requirements, driven by EU Directives. Focus is also put on gradually increasing the share of advanced biofuels. All Nordic countries tax (pure) biofuels at lower rates compared to their fossil counterparts.

Norway and Sweden further stimulate respectively the modification of vehicles, ships and filling infrastructure with more environmentally-friendly characteristics, and domestic biofuel production. Especially for advanced biofuels, however, challenges remain with regard to sufficient availability, as well as cost differences compared to fossil alternatives.

With regard to the transition towards lower-carbon vehicles, the European Commission recently decided to introduce CO_2-emission standards for HGVs, starting in 2025. This measure incentivizes vehicle manufacturers to reduce the emissions of their vehicles, as well as the development of newer, alternative propulsion systems. In recent years, the Nordic countries, with Norway in the lead, show a trend of an increasing uptake of passenger cars and to a lesser extent vans with low- or zero-emission propulsion systems. Meanwhile, battery-electric LGVs still only make up a minor share of the LGV fleet in Nordic countries, varying from 0.07% in Finland to 0.74% in Norway. However, the absolute number of electric LGVs has increased rapidly over the last few years, particularly in Norway and Sweden. An explanation for the limited share of battery-electric vans is that the selection of available vehicle models is very limited and that loading capacity (as well as charging infrastructure) is limited, although more models are launched and expected to enter the market starting in the late autumn of 2018 and continuing through 2019. At the same time, the uptake of electric HGVs is still in a very early phase in all the Nordic countries. In addition to limited driving ranges, reasons for this are the lack of serial production until now and the current price and incentive barriers: currently, general instruments aimed at the forced phase-in of low- and zero-emission vehicles, such as exemptions of purchase fees and VAT, are much weaker means for LGVs and HGVs, than they are for passenger cars. This is due to the fact that unlike for passenger cars, exemptions from VAT and purchasing charges do not affect the cost differentials of owning and operating electric HGVs or LGVs. In Norway, zero-emission vehicles have so long been exempting from toll charges (an exemption which in Sweden was removed in 2012), and have access to public transport lanes, while government agency ENOVA provides (partial) subsidies towards the cost-differential with conventional vehicles. Another way to stimulate the adoption of alternative technologies is through environmental requirements in public tenders. In Norway, this has had an impact on the phasing-in of low-emission vehicles (such as biogas vehicles) for waste management transports, and for distribution, for example of deliveries to schools and kindergartens (Jordbakke *et al.*, 2018; Mjøsund *et al.*, 2018).

All in all, the Nordic countries show both similarities and differences in their approach to reducing CO_2-emissions from freight transport. The countries further have in common that with current trends, existing and planned policies do not result in sufficient reductions in CO_2-emissions in light of 2030 climate objectives. Where the cost-effectiveness of measures has been studied, it further seems that a significant number of policy measures comes with relatively high social costs and only limited reductions in CO_2-emissions. Of the cost-effective policy-measures within the transport sector, only few currently focus on freight transport. The above implies that more is needed if 2030 objectives are to be achieved. In this regard, measures aimed at reducing transport demand, improving the efficiency of transport modes, and stimulating modal shifts, may contribute to emission reductions, but likely only to a limited degree. New measures with the largest CO_2-emissions reduction potential will likely be aimed at the increased use of fuels with lower carbon content, and the use of alternative propulsion technologies.

7. Policy recommendations

In order for the Nordic countries to reach their CO_2-emission reduction targets in the years to come, a strong trend change is needed. This report pinpoints that it is obvious that changes must come from within several areas. The policy review shows that it is difficult to achieve a greater reduction in transport demand. The same applies to the extent to which authorities can influence the utilization of vehicles, unless physical framework conditions such as vehicle length and maximum permissible total weight, are increased. The latter instrument will, however, improve the competitiveness of road compared to rail and waterborne transport, which in turn could lead to more goods being transferred from rail and sea, to road transport. Analyses for Norway and Sweden show that there currently is a limited feasible potential for modal shifts. In Norway, for example, the maximum feasible annual reduction in CO_2-emissions is estimated at 0.2 million tonnes, or around 8% of total CO_2-emissions from heavy goods vehicles.

Therefore, in order to achieve agreed emission reduction targets, it is clear that a technological change is necessary. This change may in part come from increased use of lower-carbon fuels, such as biodiesel, biogas, and bio-ethanol. Although there is still a potential to expand the supply of biofuels, the availability (and often price) of such biofuels is expected to remain a bottleneck, as demand will likely materially outweigh supply, particularly for advanced biofuels. Remaining CO_2-reductions will therefore have to come from vehicles with low- or zero-emission propulsion technologies. Currently, such vehicles are expensive, and only available to a limited extent on the market. Particularly for heavier trucks, the few currently available trucks are rebuilt versions of combustion engine vehicles, to electric powertrains.

To achieve a change of trend, alternative solutions have to be attractive and cost-effective compared to today's transport solutions. Of the abovementioned policy measures, it is primarily only increased vehicle dimensions that provide a cost-incentive in itself. For all other measures, incentives are needed, at least in an early phase. This applies both to freight transfers through modal shifts, but also to low-carbon fuels or alternative propulsion systems. For vehicles using either lower-carbon fuels or alternative propulsion systems, there is currently an additional cost element that is either distance-dependent (biofuels) and/or time-dependent, as investment costs for alternative propulsion vehicles are much higher than corresponding vehicles with internal combustion engines.

Norway, which has the highest number of battery-electric vehicles of the Nordic countries, also in terms of freight vehicles, has a rather expansive electric vehicle policy. As pointed out in the report, the most important instruments for the phasing-in of electric passenger vehicles, are not available for vans and trucks. In particular, this regards exemptions of purchase taxes and VAT, which are either small or do not apply in the case of vans and trucks, and therefore give much weaker incentives. It is therefore important that in an early phase, instruments such as public investment support towards additional costs, exemptions of toll charges and/or the allowance to use public transport lanes for this type of vehicles, are used to compensate for their additional costs.

Finally, the report presented a number of examples where a lack in harmonization and/or coordination between countries has led to unintended policy outcomes. Although these observations are only a few examples, they make clear that considering border-crossing effects and coordination to a larger extent is important when considering new policy instruments. A greater harmonization of policies between the Nordic countries (and other countries) may benefit the effectiveness and reduce the costs of policies. In this regard, the importance of evaluating implemented policy measures should also be emphasized. To improve policy-making and learn from good/bad examples in other (Nordic) countries, a better understanding of the cost-effectiveness of measures is desirable.

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Sammendrag

Introduksjon

Både personbiler og godstransport på veg står for betydelige CO_2-utslipp i de Nordiske land. Mens virkemidler rettet mot reduksjoner i CO_2-utslipp fra personbiler har begynt å vise effekt, er dette i mindre grad tilfellet for godstransport. Dessuten viser framskrivninger at etterspørselen etter godstransport i de Nordiske land vil øke også i fremtiden. I lys av dette utlyste Nordisk Ministerråd en studie av virkemidler for å redusere CO_2-utslippene fra godstransport i de Nordiske land, med fokus på vegtransport.

Denne rapporten diskuterer det (inter)nasjonale klimarammeverket og -målene til de Nordiske land i lys av godstransportutvikling i de Nordiske land. Vi finner at ved dagens trender vil alle Nordiske land stå ovenfor betydelige utslippsreduksjonsgap i forhold til de klimamålene som er satt for 2030. I en diskusjon av ulike typer virkemidler illustrerer vi hva de ulike Nordiske land gjør for å redusere CO_2-utslippet fra godstransport, og diskuterer likheter og forskjeller mellom landene. Der hvor mulig diskuteres også kostnadseffektiviteten til de ulike virkemidlene.

Klimamål og -ambisjoner

Norge, Sverige, Finland, Danmark og Island har alle ratifisert, og dermed forpliktet seg til Parisavtalen. I tillegg er de Nordiske land en del av klimarammeverket som settes på EU-nivå. EU har som mål å redusere utslipp av klimagasser fra ikke-kvotepliktig sektor (som omfatter brorparten av transportutslippene) med 30 prosent innen 2030, sammenliknet med 2005. Under EUs "Effort Sharing Mechanism" har dette målet blitt oversatt til litt ulike delmål for EU-medlemmene Sverige, Finland, og Danmark, mens EØS-land som Norge og Island har som intensjon å bidra på tilsvarende måte som EU-medlemmer.

Til tross for disse klimamålene fastslår hverken "Paris" eller EU-rammeverket hvordan utslippsreduksjoner kan oppnås. Dette betyr at hvert land må ha sine egne nasjonale planer og reduksjonsmål. I de siste fem årene lovfestet alle Nordiske land en rekke klimamål på vei til 2050, som del av en egen Klimalov. Disse ulike Klimalovene har til felles at de har som mål at samtlige land skal bli lavutslippssamfunn innen 2045 (Sverige) og 2050.

Når det gjelder spesifikke mål for utslippsreduksjoner fra transportsektoren, viser rapporten forskjeller mellom de Nordiske land. Sverige og Finland har satt ambisiøse mål gjennom offisielle uttalelser, og sikter på å redusere CO_2-utslipp fra transportsektoren med 70 % og 50 % innen 2030, sammenliknet med hhv 2010 og 2005. Norge har uttalt at transportsektoren skal bidra med en "tilstrekkelig andel" i lys av både Parisavtalen og Norges klimamål for 2030, og har videre satt som mål at innen 2025 skal alle nye lette varebiler være nullutslippskjøretøy, og innen 2030 skal alle nye tyngre varebiler og 50 % av nye lastebiler være nullutslippskjøretøy. I tillegg skal varedistribusjonen i de største bysentra være tilnærmet nullutslipp innen 2030. Dette er i tråd med ambisjonene i EUs White Paper (European Commission, 2011).

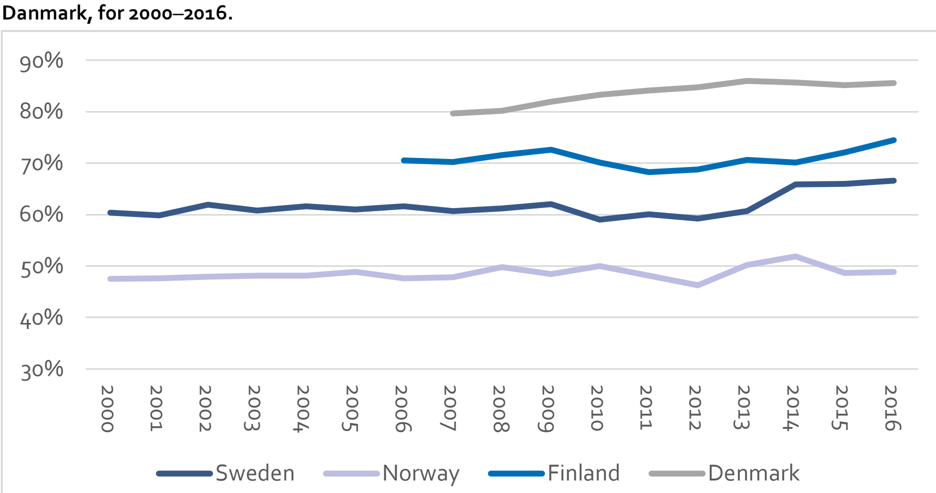
Danmark har foreløpig ikke vedtatt offisielle utslippsreduksjonsmål for transportsektoren, men vil publisere et veikart senere i år, om hvordan 2030-målene innen ikke-kvotepliktig sektor skal innfris.

Utviklinger i godstransport

Når det gjelder CO_2-utslipp fra godstransport, viser de Nordiske land ulike utviklinger for det siste tiåret. Mens Sverige og Danmark rapporterer en tydelig nedgang i utslipp fra godstransport (rundt -19 % i begge land, selv om endringen for Sverige er noe usikker), har Norge og Finland stått relativt stille. Framskrivninger tyder på at CO_2-utslippene fra godstransport i Norge vil øke mot 2030, mens utslippene i Danmark forventes å ligge rundt samme nivå i 2030, som i dag. Selv om Sverige og Finland forventer utslippsreduksjoner, vil de i likhet med Norge og Danmark ikke oppnå reduksjonsmålene for ikke-kvotepliktig sektor, hvis disse overføres direkte til godstransport.

Ettersom utviklinger i CO_2-utslipp påvirkes av underliggende faktorer, har vi videre sett på utviklinger i innenriks godstransport i hvert av landene. Her er det viktig å bemerke at andelene til de ulike transportformer varierer betydelig mellom de Nordiske land. Dette illustreres i Figur 26.

Figur 26: Utvikling i andelen vegtransport i innenriks transportarbeid for Norge, Sverige, Finland og Danmark, for 2000–2016.



Figuren viser at i Danmark og Finland dominerer godstransport på veg, med hhv drøyt 85 % og 70 % av innenriks transportarbeid. Det samme gjelder for Sverige, hvor andelen vegtransport ligger rundt 66 %, mens i Norge utgjør vegtransport nærmere 50 % av innenriks transportarbeid. Interessant er også forskjellene når det gjelder sjøtransport. I Norge står sjøtransport (ekskludert transport av petroleum fra kontinentalsokkelen til fastlandet) for hele 45 % av innenriks transportarbeid. I Finland og Sverige ligger sjøtransportens andel på hhv 19 % og 11 %, mens i Danmark spiller sjøtransport kun en liten rolle i innenrikstransport. Godstransport på bane står imidlertid for ca. 20 % av innenriks transportarbeid i Sverige og Finland, ca. 5 % i Norge, og mindre enn 1 % av innenriks godstransport i Danmark.

Virkemidler for å redusere CO_2-utslipp fra godstransport

Redusert transportbehov

Når det gjelder politiske virkemidler er den første og mest åpenbare måten for å redusere CO_2-utslipp fra godstransport, å redusere etterspørselen etter transport. Selv om framskrivninger tyder på at det er vanskelig å redusere transportetterspørselen, er de viktigste eksempler på virkemidler i denne konteksten skatter og avgifter, registreringsavgifter, soneregulering og transport- og arealplanlegging. Tabell 12 gir en oversikt av de viktigste virkemidler.

Tabell 12: Oversikt over de viktigste politiske virkemidlene for å redusere transportetterspørsel i de ulike Nordiske landene

	Norge	Sverige	Finland	Danmark
Bompenger/vegprising	+	+	–	–
Euro vignette	–	+	–	+
Veibruksavgift på drivstoff	+	–	–	–
CO_2-/NOx-avgift på drivstoff	+	+	+	+
Energi-avgift på drivstoff	–	+	+	+
Nødavgift på drivstoff	–	–	+	–
Lavere beskatning av biodrivstoff	+	+	+	+
Engangsavgift på tyngre lastebiler	–	–	–	–
Miljøsoner	–	+	–	+

Tabellen illustrerer at Norge og i noen grad Sverige bruker bompenger/vegprising, men at dette ikke er tilfellet i Finland og Danmark. Sverige og Danmark har videre innført Eurovignett for tyngre lastebiler.

Også når det gjelder drivstoffavgifter er det både likheter og forskjeller mellom de Nordiske land. Den norske drivstoffavgiften består for eksempel av to komponenter (en veibruksavgift og en CO_2-avgift). I Sverige og Danmark består drivstoffavgiften av en energiavgift og en CO_2-avgift, og i sum ligger drivstoffavgiften på omtrent samme nivå. Også i Finland har drivstoffavgiften en energikomponent og en CO_2-komponent, men her brukes det i tillegg en "nødavgift". Alle Nordiske land opererer med lavere avgifter for biodrivstoff sammenlignet med konvensjonelle fossile drivstoff.

Videre bruker ingen av de Nordiske land kjøpsavgifter på lastebiler, og der det brukes miljødifferensiering gjennom årlige avgifter (Norge: vektårsavgift; Sverige og Danmark: Eurovignett) fører dette ikke til store kostnadsdifferanser.

Miljøsoner er i bruk i et antall byer i Sverige i Danmark, men er stort sett rettet mot reduksjoner i lokale utslipp, ikke CO_2-utslipp. Oslo og Bergen i Norge har nylig introdusert bompengesatser som er differensiert etter Euro-klasse, som også er rettet mot lokale utslipp.

Effektivitetsforbedringer

En annen måte å redusere CO_2-utslipp fra godstransport på, er å øke effektiviteten av transportmidler (f.eks. ved å øke kapasiteten på kjøretøy), bedre kapasitetsutnyttelse (f.eks. bruk av konsolideringssentra) eller bedre transportplanlegging. De Nordiske land viser en trend mot å gradvis tillate tyngre og lengre kjøretøy. Dette gjelder særlig for Sverige (64 tonn, 25,25 meter) og Finland (60–76 tonn og 22–25,25 meter avhengig av antall aksler; forventes ytterlige utvidelse). Da økte kjøretøydimensjoner øker lastmengde pr kjøretøykm og dermed reduserer kostnader per tonnkm, medfører det også økt konkurranseposisjon for vegtransport sammenliknet med andre transportformer. Dette kan motvirke tiltak rettet mot redusert transportetterspørsel eller godsoverføring til sjø og bane.

Godsoverføring

En tredje måte å redusere CO_2-utslipp fra godstransport på, er gjennom overføring av godstransport til transportmidler med en bedre energieffektivitet per transportert enhet. Både EU-kommisjonen og de Nordiske land ønsker å overføre (langdistanse)godstransport fra veg til sjø og bane. De viktigste eksisterende virkemidler er avgifter og tilskudd, samt tilretteleggende tiltak (terminaler, infrastrukturkapasitet, lengre tog, samt utbedring av tilførselsveier).

For Norge anslås godsoverføringspotensialet til 5–7 millioner transporterte tonn, hvorav 2,4 millioner tonn anses som gjennomførbart. Dette utgjør ca. 7 % av innenriks transportarbeid, eller ca. 23 % av innenriks transportarbeid over distanser >300km, men krever sterke virkemidler som ikke alltid er samfunnsøkonomisk lønnsomme. Den årlige CO_2-reduksjonen er dessuten begrenset, og anslått til ca. 0,2 tonn, dvs rundt 8 % av det årlige CO_2-utslippet fra lastebiler. De viktigste virkemidlene rettet mot godsoverføring er en "økobonus"-/tilskuddsordning for sjøtransport, og ordninger som skal redusere forsinkelser og innstillinger på jernbane.

I Sverige er en av de viktigste virkemidlene for å oppnå godsoverføring, en "økobonus" for jernbanetransport, som ble implementert i 2018. En tilsvarende "økobonus" for sjøtransport er under diskusjon. Når det gjelder det svenske godsoverføringspotensialet, finnes det noen få mer detaljerte studier. Selv om det ser ut til å være et teoretisk potensiale for godsoverføring, finnes det også kapasitetsutfordringer, samt motvirkende utviklinger, som f.eks. utvidelsen av vekt- og lengdebegrensninger for lastebiler.

I Finland brukes kun noen få virkemidler rettet mot godsoverføring. Samtidig viser statistikken at utvidelsen av tillatte kjøretøydimensjoner for lastebiler har gått på bekostning av jernbanetransport. Selv om den høye andelen langdistansetransport som går med tunge lastebiler tyder på et visst potensiale for godsoverføring, er det særlig matvarer og stykkgods som utgjør en stor andel av slike transporter. Leveringen av disse typer produkter er gjerne tidssensitive, noe som kan begrense overføringspotensialet. En annen utfordring for godsoverføring fra veg til bane er kapasitetsbegrensninger, ettersom det finske jernbanenettet stort sett er enkeltsporet.

For Danmark har transportmyndighetene anslått at break-even-distansen for å kunne overføre gods fra veg til bane er relativt høy, selv om man ser bort fra den ekstra fleksibiliteten som vegtransport tilbyr. Break-even-distanser er betydelig mindre når man unngår tilbringertransport med lastebil i en eller begge ender av transportrelasjonen. Gitt dagens ubetydelige andeler av innenriks jernbanetransport på aktuelle relasjoner, er det ikke realistisk at eventuelle tiltak rettet mot godsoverføring vil føre til betydelige reduksjoner i CO_2-utslippet fra godstransport.

Overgang til drivstoff med lavere karbon-innhold

En fjerde måte å redusere CO_2-utslippet fra godstransport på, er å redusere karboninnholdet i drivstoff som brukes i konvensjonelle biler. Drevet av EUs politikk øker alle Nordiske land sine krav for innblanding av biodrivstoff i fossile drivstoff. Det fokuseres videre på en gradvis økning av andelen avanserte biodrivstoff, som produseres på en mer bærekraftig måte.

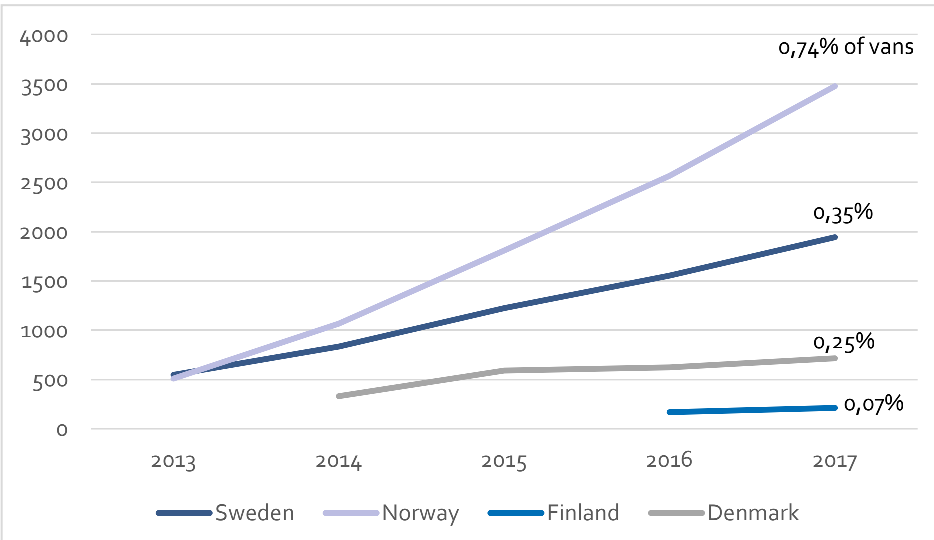
I Norge gir ENOVA (delvis) tilskudd til modifisering av kjøretøy, skip og fylleinfrastruktur med bedre miljøegenskaper, som går på f.eks. biogass, bioetanol, LNG eller LBG. I Sverige foreligger et forslag for å øke støtte til svensk biogassproduksjon, i tillegg til noen andre programmer som skal forbedre posisjonen til biodrivstoff. I Finland og Danmark er virkemidler i hovedtrekk begrenset til innblandingskravene. Alle Nordiske land bruker lavere drivstoffavgifter på (ren) biodrivstoff, sammenliknet med fossilt drivstoff.

Overgang til framdriftsteknologier med lavere karbonutslipp

En femte måte å redusere utslipp fra godstransport, er gjennom en overgang til lavutslippskjøretøy. På EU-nivå settes overordnede standarder for drivstoffeffektiviteten av nye personbiler og lette godsbiler. Tidligere i år foreslo EU-kommisjonen et lovfestet reduksjonsmål for nye tyngre kjøretøy: Innen 2025 skal CO_2-utslippet fra nye kjøretøy ligge 15 % lavere enn i 2019, mens det ble foreslått et reduksjonsmål på 30 % for 2030.

Gjennom disse standarder gir EU insentiver til å øke effektiviteten for konvensjonelle framdriftsteknologier, samt for å utvikle alternative framdriftsteknologier. Generelt er trenden i de Nordiske land at andelen nye personbiler med alternative framdriftsteknologier øker, særlig i Norge. Samtidig utgjør elektriske varebiler fremdeles en liten andel av kjøretøybestanden i de Nordiske land, og varierer fra 0,07 % i Finland til 0,74 % i Norge. Det absolutte antallet elektriske varebiler har imidlertid økt raskt i de siste årene, særlig i Norge og Sverige (Figur 27).

Figur 27: Utvikling i antall elektriske varebiler andelen i varebilbestanden i de Nordiske land, for 2013–2017



Samtidig er det fremdeles kun svært få tyngre kjøretøy med alternative framdriftsteknologier i bruk.

Når det gjelder godsbiler, er Norges ambisjoner uttrykt i nyeste Nasjonal Transportplan:

- Innen 2025 skal alle nye lettere varebiler være nullutslippskjøretøy.
- Innen 2030 skal alle nye tyngre varebiler og 50 % av nye lastebiler være nullutslippskjøretøy. I tillegg skal godsdistribusjon i de største bysentra være tilnærmet utslippsfritt innen 2030.

Til tross for Norges tilskuddsordninger for bedrifter, og andre insentiver som f.eks. bompengefritak og tilgang til kollektivfelt, virker det usannsynlig at disse ambisjonene oppnås gitt dagens trender. En av de viktigste grunnene til dette er at generelle virkemidler rettet mot innfasingen av lav- og nullutslippskjøretøy, som fritak for kjøpsavgifter og MVA, slår mye mindre ut for varebiler og lastebiler, enn for personbiler.

I Sverige er det viktigste virkemidlet en bonus-malusordning for CO_2-effektive kjøretøy, men denne ordningen gjelder kun for personbiler, lette busser, og godsbiler opp til 3,5 tonn i vekt, og ikke for lastebiler.

I Finland finnes det et kjøpstilskudd for elektriske personbiler. Tilskuddet brukes mellom 2018 og 2021, og ligger på EUR 2.000 pr bil. Tilsvarende tilskudd mangler imidlertid for varebiler og lastebiler. En nylig studie konkluderte i tillegg med at potensialet for elektriske lastebiler er betydelig mindre i Finland enn i andre land, og at elektrifiseringspotensialet videre varierer betydelig avhengig av hvilke typer gods som transporteres.

Andre virkemidler

I tillegg til virkemidlene beskrevet over, kan myndigheter påvirke CO_2-utslippene gjennom krav de setter i offentlige anbud eller gjennom offentlige innkjøp av varer og tjenester. Andre initiativer i de Nordiske land er demonstrasjonsprosjekter (f.eks. platooning og elektriske veier i Sverige), og etablering av kunnskaps- og nettverksplattformer. I Norge er næringslivet i dialog med Staten om etablering av et "CO_2-fond" for næringslivet, etter modell av det eksisterende NOx-fondet.

Kostnadseffektivitet for ulike virkemidler

Der mulig er kostnadseffektiviteten av de ulike virkemidlene diskutert i omtalen av disse virkemidlene. For Norge er Nasjonal Transportplan 2018–2029 anslått til å redusere CO_2-utslippene med ca. 57 000 tonn årlig (dvs. en reduksjon i CO_2-utslipp på ca. 0,3 % når en ser på utslippene fra hele transportsektoren). Nasjonal Transportplan beskriver videre at de største utslippsreduksjoner forventes å komme fra utviklinger innen teknologi og drivstoff (utenom selve Transportplanen), og at disse vil stå for en reduksjon på 9 millioner tonn CO_2 eller ca. 54 % av alle utslipp fra transport.

Data fra ENOVA viser videre at virkemidlene som gir de største reduksjoner i CO_2-utslipp per støttekrone, er energistyring og biogassproduksjon, mens støtte til elektriske busser og lastebiler er dyrest per forventet kg reduksjon i CO_2.

I tillegg kommer det fram at støtte til skip er billigere enn støtte til kjøretøy. Forklaringen til dette er i hovedsak at skipsprosjekter og -tiltak gjerne handler om ombygging av eksisterende fartøy, mens for kjøretøy er det ofte nødvendig med investering i nytt materiell. Ettersom det pr nå ikke finnes serieproduksjon av lastebiler med batteri-elektrisk eller hydrogen-brenselcelle, er dette i hovedsak kjøretøy som ombygges til elektrisk framdrift fra et konvensjonelt kjøretøy med forbrenningsmotor.

For Sverige er informasjon om kostnadseffektivitet begrenset. Analyser av infrastrukturtiltak i Infrastrukturplanen for 2018–2029 tyder på en negativ samlet samfunnsøkonomisk nytte, og det er anslått at implementeringen av planen vil redusere CO_2-utslippene med 1 prosent, sammenliknet med å ikke implementere Infrastrukturplanen

For Finland fant Liimatainen og Viri (2017) at utslippsreduksjonsmålet for 2030 krever en utslippsreduksjon fra hele transportsektoren på ca. 3 millioner tonn CO_2, sammenliknet med 2005. Herav vil godstransport måtte stå for ca. 1,1 millioner tonn. Forfatterne anslår at dette krever en reduksjon på 0,5 millioner tonn CO_2 gjennom bruk av biodiesel, 0,3 millioner tonn CO_2 gjennom forbedringer i energieffektiviteten på godstransport gjennom større gjennomsnittlig last og mindre tomkjøring, 0,15 millioner tonn CO_2 gjennom bruk av LNG og elektriske lastebiler, og 0,13 millioner tonn gjennom redusert drivstofforbruk for lastebiler. En kostnytteanalyse konkluderer at forbedringer på energieffektiviteten på varebiler og lastebiler har en kostnad på EUR 161/tonn CO_2, mens kostnaden for bruk av alternative energiformer på veg og sjø ligger rundt 156 EUR/tonn CO_2 (Liimatainen *et al.*, 2015).

I Danmark inneholder Klimarådets anbefalte kostnadseffektive tiltakspakke mot 2030 kun ett mindre initiativ som er rettet mot godstransport: økt bruk av CNG i tungtransport på veg. Selv om reduksjonen i CO_2-utslipp av dette tiltaket er anslått til å være liten, anses initiativet som et forberedende steg for en storskala overgang til biogass mot 2050. Kostnadseffektiviteten av danske politiske virkemidler har videre blitt vurdert av en tverrministeriell arbeidsgruppe. Denne arbeidsgruppen fant at det kun er virkemidler som avgifter på kjøring og drivstoff som vil kunne føre til utslippsreduksjoner som er større enn 2 %, mens effekten av de aller fleste andre analyserte tiltak var relativt liten (under 0,5 %). I tillegg viste analysen at nesten alle virkemidler rettet mot transportsektoren var relativt dyre, sammenliknet med virkemidler med tilsvarende utslippsreduksjon innenfor andre sektorer. Alt i alt vil en kostnadseffektiv tilnærming for å oppnå Danmarks reduksjonsmål innenfor ikke-kvotepliktig sektor inneholde få virkemidler rettet mot godstransport.

Til slutt er de fleste virkemidlene som er omtalt i denne rapporten, rettet mot innenriks markeder i de Nordiske land. Dette medfører at manglende harmonisering eller internasjonal koordinering kan gi uønskede effekter eller suboptimal effektivitet av virkemidler på grunn av lekkasjer og ringvirkninger.

Konklusjoner og policyanbefalinger

For at de Nordiske land skal kunne nå klimamålene for 2030 innen transport, kreves det et taktskifte. Denne rapporten synliggjør at det er nødvendig med endringer innenfor flere områder for at man skal kunne oppnå målene om utslippsreduksjoner. Virkemiddeldiskusjonen viser at det er vanskelig å oppnå større reduksjoner i transportetterspørsel. Det samme gjelder i hvilken grad myndigheter kan påvirke kapasitetsutnyttelsen for transportmidlene, med mindre de fysiske rammebetingelser som kjøretøyvekt og -lengde, økes. En slik økning vil imidlertid forbedre posisjonen til vegtransport sammenliknet med sjø og jernbane. Dette kan føre til at gods som nå transporteres på sjø eller bane, istedenfor vil havne på veg. Analyser for Norge og Sverige viser at det finnes et begrenset potensiale for å overføre gods fra veg til sjø og bane. I Norge anslås den maksimale gjennomførbare årlige CO_2-reduksjonen til 0,2 millioner tonn, eller rundt 8 % av CO_2-utslippene fra tyngre lastebiler.

Det er derfor tydelig at for å nå avtalte reduksjonsmål, kreves det teknologiske endringer. Disse endringer kan til dels komme fra økt bruk av drivstoff med lavere karboninnhold, som f.eks. biodiesel, biogass, og bioetanol, men tilgjengeligheten (og ofte prisen) av slike biodrivstoffer vil være en utfordring, ettersom etterspørsel er forventet til å være mye større enn produksjonen. Dette gjelder særlig for avanserte biodrivstoff. Gjenstående CO_2-reduksjoner vil derfor måtte komme fra kjøretøy med lav- eller nullutslippsteknologi. Fortsatt er slike kjøretøy dyre, og utvalget er lite. Særlig for tunge lastebiler er de få lastebiler som finnes i dag, ombygget fra konvensjonelle lastebiler med forbrenningsmotor, til elektrisk framdrift.

For å oppnå et taktskift må alternative løsninger være attraktive og kostnadseffektive sammenliknet med dagens transportløsninger. Av de virkemidlene som er nevnt ovenfor er det stort sett kun økninger i kjøretøydimensjoner som medfører et kostnadsinsentiv i seg selv. Alle andre tiltak krever ytterlige insentiver, i hvert fall i oppstartsfasen. Dette gjelder både for godsoverføring, for drivstoff med lavere karboninnhold, og for alternativ framdriftsteknologi. Kjøretøy som bruker drivstoff med lavere karboninnhold eller alternative framdriftsteknologier har i dag en ekstra kostnad som enten er distanseavhengig (biodrivstoff) eller/og tidsavhengig, ettersom investeringskostnadene er mye høyere ved alternative framdriftsteknologier enn ved tilsvarende kjøretøy med forbrenningsmotorer.

Norge fører en relativ ekspansiv elektrifiseringspolitikk, og har det største antallet batterielektriske kjøretøy av de Nordiske land, også når det gjelder godsbiler. Som vi nevnte i rapporten er de viktigste virkemidlene for innfasingen av elektriske personbiler ikke tilgjengelig for godsbiler. Særlig gjelder dette fritak for kjøpsavgifter og MVA, som enten er mye lavere enn for personbiler, eller mangler, og dermed er mye svakere virkemidler. Dette gjør det viktig at virkemidler som offentlig investeringsstøtte for merkostnader, fritak for bomavgifter eller/og bruk av kollektivfelt for denne type kjøretøy, brukes som kompensasjon for merkostnaden, særlig i oppstartsfasen. Videre bør miljøaspekter få større vekt vis-à-vis kostnadsaspekter i offentlige anbud. Dette vil kunne bidra til å øke etterspørselen mot en kritisk masse, slik at kjøretøyprodusenter vil kunne starte serieproduksjon, og senere storskala produksjon. Over tid vil dette bidra til å redusere kostnadsdifferansen mellom godsbiler med alternativ framdriftsteknologi og konvensjonelle godsbiler.

Til slutt omtalte vi i rapporten et antall eksempler på hvordan manglende harmonisering eller/og koordinering mellom ulike land, har ført til uønskede effekter. Disse eksempler illustrerer at det ved implementering av nye virkemidler er viktig å ta mer hensyn til internasjonale effekter og koordinering. Bedre harmonisering av policy mellom de Nordiske land (og andre land) vil kunne bidra til mer effektive virkemidler. I denne forbindelsen må det også understrekes at det er viktig med bedre evaluering av implementerte virkemidler. For at virkemidler skal forbedres og det kan tas lærdom av gode/dårlige eksempler i andre (Nordiske) land, er det ønskelig med en bedre forståelse av kostnadseffektiviteten av ulike tiltak.

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Reducing CO2 emissions from freight

Passenger cars and road freight are significant causes of CO_2-emissions in the Nordic countries. While for passenger cars, CO_2-reducing policy measures are sorting effect, this is much less the case for freight transport. Meanwhile, demand for freight transport is expected to keep rising.
The current report discusses the (inter)national climate framework and objectives of the Nordic countries in light of freight transport developments (CO_2-emissions and transport volumes). At the current rate, all Nordic countries will face sizable emission reduction gaps given their 2030 climate commitments. In discussing several types of policy measures, we show what the Nordic countries are currently doing to reduce CO_2-emissions from freight, and illustrate differences and similarities. Finally, we discuss the cost-effectiveness of different measures, and provide a set of policy recommendations.

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