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Book

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Nordic Council of Ministers

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Preface

Road transport contributes about one-fifth of the EU's total emissions of carbon dioxide (CO_2), the main greenhouse gas. While emissions have been falling at the European level they are still higher than they were in 1990. It is therefore of interest to look at what influence the CO_2 emissions from transport and how different economic instruments impacts on CO_2 emissions from the transport sector.

The Nordic Council of Ministers has therefore initiated several projects on this issue and the present report is an update of a report from 2011 looking at taxation and CO_2 emissions from cars in the Nordic countries. The report shows a declining CO_2 intensity in the car use in the Nordic countries. This is due to improvements in the CO_2 intensity in the new car sales, which in all countries have shown significant downwards trends throughout the entire period observed. To what extent this is due to the tax system is difficult to say. Finally, the report points at how tax systems can be adjusted in order to increase the economic incentives to decrease CO_2 emissions from cars.

The report has been written by COWI (DK), COWI (S), COWI (N), DTU Denmark, Goteborg University and Tampere University of Technology.

March 2017

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

Summary

The Nordic countries have different structure for the taxation of passenger cars. In Sweden there is e.g. no purchase or registration tax, whereas Norway and Denmark have the highest such taxes in Europe. These differences have impacts on the choice of vehicle and therefore also the CO_2 impact of the transport.

The Nordic Council of Ministers group for Environment and Economy completed in 2008 the project Traffic Charges and climate impact, which included a survey of taxation related to goods and passenger vehicles and a statement of a number of key characteristics of the transport and vehicle fleet in the Nordic countries. The survey showed that there were big differences across the Nordic countries, both in the taxation of motor vehicles sector and in the composition and use of the fleet and consequently on CO_2 emissions.

To get a better understanding of this problem and to learn more about potential opportunities to reduce carbon emissions, the Nordic Council of Ministers have asked COWI to undertake a new study of the CO_2 emissions from passenger cars as a follow-up of the 2011 study. This report describes the results of this new study and can also be considered as an update and continuation of the previous reports.

The development in the car fleets and their CO_2 intensity have been found by collecting statistics from each of the five Nordic countries. There are a number of differences in the car fleets, which makes it necessary to make assumptions about e.g. what constitutes a "medium sized car" in order to be able to compare between countries. However, the ambition of the report has been to analyse the changes in the CO_2 intensity and to understand why the changes has happened.

The data collected cannot show all the details and differences needed to be able to understand all changes. Moreover, it is difficult to relate the development directly to the tax system or the economic incentives provided in each country. In all countries changes and adjustments in the incentives have been made several times in the periods observed.

It turns out that it is hard to distinguish between the effects of instruments when more instruments are applied at the same time. The evidence we have found from the literature generally agrees about the effects of the instruments, but mostly whether an effect can be reached and also which instruments seem to be most effective. However, most of the literature reviewed either consider a cross section of countries or instruments, but do not reveal any specific elasticities. Moreover, the conditions in the different countries vary with respect to many parameters, and hence these differences are not controlled for. For example the high purchase taxes in Norway and Demark, or the differences in income levels between the Nordic countries and many other countries, which also must be taken into account, when attempts are made to predict the impact of certain instruments.

Overall, the CO_2 intensity in the Nordic countries is declining. Less CO_2 is emitted per kilometre. This is due to improvements in the CO_2 intensity in the new car sales, which in all countries have shown significant downwards trends throughout the entire period observed. In Norway, the increased share of electric vehicles in car sales have further contributed to improving the average CO_2 intensity.

However, taking into consideration the existing car fleets and the use of the cars, the reduction is less pronounced. In Norway the total CO_2 emissions are even slightly increasing according to the figures obtained despite an increasing number of electric vehicles. Indications are that it is a combination of still large (and perhaps older) cars being used and longer distances being driven.

The share of diesel cars is high in the Nordic countries. However, the share of diesel cars in new cars have changed significantly in the past ten years, but in different directions in the countries. Denmark, Norway and Finland have seen declining diesel shares in new cars, whereas Sweden and Norway have increasing diesel shares in the sales. Iceland have varying shares with around 50% of new car sales being diesel cars. The differences can possibly be attributed to changes in taxation seen in the countries. E.g. Denmark made changes in the registration and annual taxes such that diesel cars are now less favourable compared to petrol cars and Norway similarly made significant changes in 2012, which made alternative fuels cars more favourable and diesel cars more expensive due to an increased NOx tax element.

Electric cars are also contributing the reduction in CO_2 intensity in new cars. Especially the Norwegian market has been favourable to electric cars and the share of new electric cars is at 20% in 2014. The shares in the other countries have increased, but to a much lesser degree compared to Sweden.

Much of the results and recommendations made in this report are similar to results and recommendations made in the previous reports. The trends we observed in the 2011 report has continued since. The main difference found is the increased introduction of alternative fuels vehicles (especially electric and hybrid vehicles).

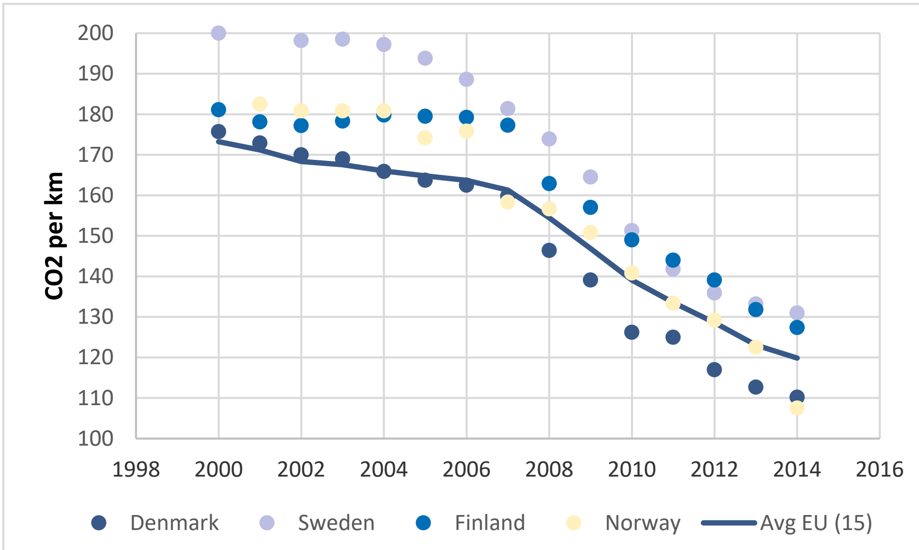
The Nordic countries have in the past five years introduced additional incentives to support further CO_2 reductions. Most of this has however, been related to the purchase of vehicles. E.g. the tax and VAT exemption on vehicle purchase. However, the expenses for fuel is partly covered by the user of the company car. Hence, the CO_2 related taxation of private use of company cars in Finland is an example of an instrument targeting partly the use of the company cars.

Overall, the CO_2 intensity in car use has been reduced in all countries (not only in the Nordic countries, but across Europe). This is driven by the reduced energy use and hence CO_2 emissions in the new cars sold. The main trend is thus a technology development and the impact of the international legislation forcing car manufacturers to make these improvements. However, as the figure shows the changes in legislation in Norway (2006), Denmark (2007) and Finland (2007/8) clearly had an impact.

Sweden has continuously changed and improved on its legislation supporting the "Supermiljöbil" and through the past twenty years, Sweden has seen the most significant decline in CO_2 intensity in the Nordic countries.

Denmark and Norway continue to have the most CO_2 efficient new vehicle fleets. Due to the increase in electric vehicles being sold in Norway due to strong incentives have brought Norway to the front of all countries across Europe in relation to CO_2 intensity.

Figure 1: Average CO_2 emissions per km. for new cars sold



Source: Eurostat, Statistical Pocketbook.

Based on the analysis of the CO_2 development and intensity and the use of economic incentives in the Nordic countries in combination with inputs from the literature, the report gives the following general recommendations:

- The taxation of company cars must to a higher degree depend on CO_2 emissions; this may be done through an increased part of CO_2 dependency in the purchase and annual taxes and by taxing the private use of company cars based on actual use.
- The CO_2 dependent part of taxes and charges should be increased. The differentiation between low and high CO_2 intensive cars must be increased.
- The tax levels and the limits when CO_2 taxes are increased must continuously be adjusted to meet the development in technology. This is necessary to maintain the incentives to buy the cleanest technologies.
- Maintain and extend the economic incentives to buy alternative fuels vehicles (electric vehicles, hybrid vehicles, cars running on modern biofuels); e.g. through tax exemption, no VAT payment on purchase, free parking and no road user charges or fees.
- Use the right combinations of incentives to avoid detrimental effects. E.g. by avoiding the situation where the tax on micro vehicles with low energy consumption has led to a large increase in the number of vehicles and thus am increased energy consumption totally.

Besides these recommendations, there are some areas where knowledge is inadequate. The knowledge for example about how the individual incentive works when applied together with other incentives must be investigated more.

There is also a need to understand how break points in the charges is defined and adapted to new technology to ensure the right composition and development in the car fleet.

Studies which look at incentives in a specific Nordic context is needed. In particular studies taking into account the right income level, the specific use of vehicles and other modes of transport in combination with the existing car fleet.

Finally, the knowledge about company cars must be expanded. Especially the data about company cars is inadequate; it is difficult to distinguish between the uses of company cars (e.g. for leasing companies, as a working vehicles or as a vehicle for private use).

1. Introduction

The Nordic Council of Ministers group for Environment and Economy completed in 2008 the project Traffic Charges and climate impact, which included a survey of taxation related to goods and passenger vehicles and a statement of a number of key characteristics of the transport and vehicle fleet in the Nordic countries. The survey showed that there were big differences across the Nordic countries, both in the taxation of motor vehicles sector and in the composition and use of the fleet and consequently on CO_2 emissions.

In 2011, a follow-up and continuation of the project from 2008 was made. The purpose of this project (2011 study) was to conduct a comparative analysis between the Nordic countries in order to contribute to an understanding of how the transport sector's CO_2 emissions can be reduced through the use of taxes.

The 2011 study was particularly focused on incentives for more fuel efficient vehicles. For example, by introducing more CO_2-correlated car taxation and by aligning the incentives of company car schemes whereby incentives to better support more efficient vehicles. The 2011 study had less focus on other instruments, such as instruments, which better target to reduce transport demand, greater use of public transport, more carpooling etc.

To get a better understanding of this problem and to learn more about potential opportunities to reduce carbon emissions, the Nordic Council of Ministers have asked COWI to undertake a new study of the CO_2 emissions from passenger cars as a follow-up of the 2011 study. This report describes the results of this new study and can also be considered as an update and continuation of the previous reports.

The present mapping has focused on how different taxes on cars and small vans affect CO_2 emissions. The development as well as similarities and differences in taxation in the Nordic countries are listed and compared, including how different types of vehicles are taxed (sizes, uses, vans, company car tax, etc.). The various initiatives and programs that are implemented in the different countries to promote alternative fuels, reduce energy consumption are described in the report described and their effects are tried assessed.

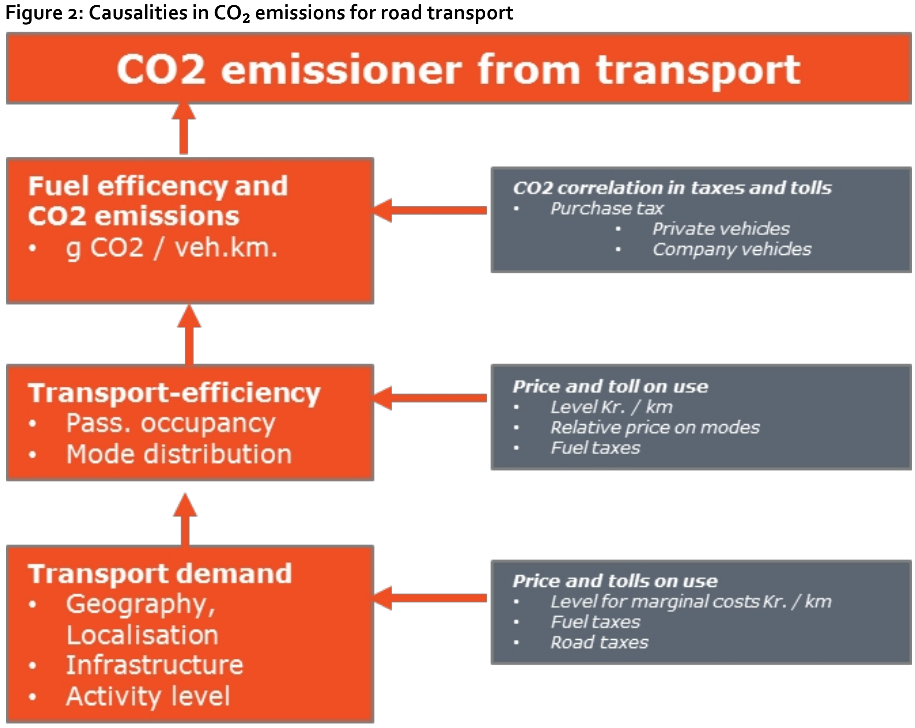
In the report we relate the situation in the Nordic countries with findings from the literature regarding theoretical as well as empirical evidence of successful use of different kinds of economic incentives. We have in particular looked at the following types of economic incentives: purchase taxes, annual taxes, fuel taxes, and road user charges, but we have also considered other instruments in a broader sense.

The report is organised in five chapters including this introduction. We start by outlining our methodological approach to collect updated information about the current situation on the vehicles fleets in the Nordic countries. Then in Chapter 4 we outline the current situation with respect to vehicle fleet composition, recent changes in the use of economic incentives in the Nordic countries including assessments of their expected effects. In Chapter 5 we describe the international findings related to the different types of economic incentives, and relate this to the situation and potentials in the Nordic countries. Finally, in Chapter 6 we present a few recommendations based on the analysis carried out. Some of the recommendations are included already in the chapters preceding this final chapter.

2. Method

Our approach is based on a basic understanding of different economic instruments impacts on CO_2 emissions from the transport sector. The approach is similar to the one the Danish Ministry of Transport use in their action plans for CO_2 emissions and the Road Map- analyses for 2014–2015. Changes in CO_2 emissions can in principle come from demand changes (transport volume), the utilization of vehicles (transport efficiency), fuel use (fuel efficiency) and from technical improvements (fuel efficiency). Figure 2 shows the causalities between the different economic instruments and the impacts on CO_2 emissions.

Figure 2: Causalities in CO_2 emissions for road transport



Generally, the CO_2 emissions from the transport sector depend on:

- The transport volume, i.e. the demand for transport of individuals and goods. The transport volume depend on the private cost for transport, which is determined by a number of factors including purchase and annual taxes as well as variable tariffs e.g. fuel and user taxes.
- Transport efficiency refers to how the demand for transport is met. Factors such as choice of vehicle and the number of passengers in the vehicle determine the

transport efficiency. These factors can be influenced through taxes on vehicles and general economic instruments.

- The composition of fuels used in the vehicles. The emission of greenhouse gases also depend on the fuel source used to drive the vehicle. For instance, the emission of greenhouse gasses from vehicles driving on biofuels is often less than with vehicles driving on petrol or diesel. The choice of fuel type can be affected through taxes and tariffs, which is set according to certain types of fuels.
- Energy efficiency refers to how the demand for transport is met. A range of factors influence the energy efficiency including fuel type and the energy efficiency of the car. These factors can be affected through tariffs and other economic instruments. In some countries, the taxes on cars are determined by how fuel efficient the car is, but the energy tariffs can also vary between different types of fuels and can for instance be set in relation to the CO_2 emission per unit of energy.

Besides, from the economic instruments mentioned above the CO_2 emissions from vehicles are also highly influenced by the regulatory framework for the transport sector. Examples of the regulatory framework are supply of infrastructure and public transport, geographic and urban planning of e.g. population density in urban and non-urban zones. The interaction between economic instruments and the regulatory framework as well as other instruments often have a substantial impact for how large effects and changes that are possible. Another important instrument applied at EU level is the requirement on car manufacturers to meet certain CO_2 levels in the average new cars (e.g. 130 g/km by 2015, 95 g/km by 2020 for at least 95% of the new passenger cars).
In order to determine how the different economic instruments influence the CO_2 emissions from the transport sector, we have done following:

1. Literature review of scientific studies.
2. Mapping of the regulatory framework, the economic instruments and the CO_2 emissions in the Nordic countries.
3. Answered analytic question based on the collected data from the literature review and the mapping of the national framework.

First, we conducted a literature review of scientific studies investigating different transport taxes impacts on CO_2 emissions.

Second, we mapped the regulatory framework and economic instruments in the Nordic countries. The mapping of the regulatory frameworks were based on central elements such as population density, access to public transport, infrastructure, topography etc. The mapping of the applied economic instruments were based on fuel prices, prices on public transport, vehicle tariffs, taxes on company cars, road tolls, subsidies etc.

Based on the literature review and the mapping of the national conditions we answered the following questions:

- The development in the correlation between CO_2 emissions from vehicles and taxes.
- The development in the distribution of tariffs on vehicles, fuel and road use.
- Are there differences in the CO_2 related taxation of passenger and light commercial vehicles.
- How are electricity, gas and biofuels taxed.
- To what degree have programs been established with the aim to accelerate the transition to new technologies e.g. electric vehicles or plug-in hybrid vehicles.
- What part have special arrangements or tax cuts played in the development in CO_2 emissions and new technologies.

2.1 Data

This section describes the data collection method used in the survey. The major source of data collection is a questionnaire with a data template to be filled in by national experts.

The template consists of one excel workbook with a number of empty tables to collect quantitative data and a word file to collect descriptions in text. The templates are shown in Annex A.

The excel template contained data for the following items:

- Average purchase tax.
- Average annual tax.
- Number of cars in car fleet.
- New car sales.
- Number of company cars.
- Number of new company car sales.
- Average fuel consumption.
- Average mileage.
- Average age.
- Share of cars age above 10 years.

All of these data should be provided broken down by fuel/technology and car size and fuel/technology.

The car size was based on the European categorisation.[1] For this study we aggregated this categorization into four main segments.

[1] http://ec.europa.eu/competition/mergers/cases/decisions/m1406_en.pdf

Table 1: Car segmentation

Segment	Typical examples of cars in segment
Mini	For instance: Citroen C1, VW UP, Toyota Aigo, Kia Picanto, Peugeot 108, Hyundai i10
Small	For instance: Citroen C3, Ford Fiesta, Peugeot 208, Toyota Auris, Renault Clio, Hyundai i20
Medium	For instance: Ford Focus, VW Golf, Toyota Avensis, Volvo V40, BMW 3-serie, Renault Megane
Large	For instance: Ford Mondeo, Opel Insigna, Volvo XC60, Mercedes 220, Mazda 6, Audi 4

In practice, there may be some disagreement on which cars belong to which segment. In order to avoid misunderstanding, the examples were explicitly mentioned in the data collection template to give a clear guidance in which segment to place which cars.

The following fuel/technologies was used in the data collection:

- Petrol
- Hybrid petrol
- Plug-in hybrid
- Diesel
- Electric
- Gas

The following table shows an example of a table in the Excel data collection template (Table 2)

Table 2: Data collection template

	Mini	Small	Medium	Large
	For instance: Citroen C1, VW UP, Toyota Aigo, Kia Picanto, Peugeot 108, Hyundai i10	For instance: Citroen C3, Ford Fiesta, Peugeot 208, Toyota Auris, Renault, Clio Hyundai i20	For instance: Ford Focus VW Golf Toyota Avensis Volvo V40 BMW 3-serie, Renault Megane	For instance: Ford Mondeo, Opel Insigna, Volvo XC60, Mercedes 220, Mazda 6, Audi 4
Petrol				
Hybrid petrol				
Plug-in hybrid				
Diesel				
Electric				
Gas				
Total				

In order to evaluate the trends over time the template did also include a breakdown by year. The yearly breakdown did not include the car size, only the break-down by technology/fuels. This was done because we think the most interesting development at present is the expected implementation of new technologies/fuels. The breakdown by year is shown in Table 3.

Table 3: Data collection breakdown by year

	2009	2010	2011	2012	2013	2014	2015
Petrol							
Hybrid petrol							
Plug-in hybrid							
Diesel							
Electric							
Gas							
Total							

Beyond the above mentioned aggregated data collection, the template did also include a data collection of specific car models. This was chosen in order to get a more detailed picture of how new technologies are prices in the Nordic car markets. This table is shown in Table 4

Table 4: Data collection breakdown on details per type of vehicle

Fuel / Car	Total weight, kg	gCO2/km	litre fuel per 100 km. (l / 100 km)	Electricity consumption per 100 km. (w / 100 km)	Price incl. tax and VAT	Annual circulation tax
Petrol						
VW UP, 1,0						
Peugeot 208, 1,2						
BMW 320, 2,0						
Mazda CX-9						
Diesel						
Hyundai i20 1,1 crdi						
Peugeot 308, 1,6 hdi						
VW Passat 2,0 TDI						
Hybrid						
Toyota 1.5 Hybrid e-CVT						
Toyota Auris Hybrid Hatchback						
Toyota Prius 1.8 Hybrid e-CVT						
Plug-in Hybrid						
BMW i3 REX						
Toyota Prius Plug-in Hybrid						
Golf GTE						
Volvo XC90 AWD PHEV						
Electric						
E-UP!						
Nissan Leaf						
Renault Zoe						
BMW i3						
Renault fluence						
Tesla 85						

Beyond the quantitative data mentioned above the template included a Word file requesting the experts to provide descriptions of the following elements for each of the countries.

The following passenger car tax elements are described for each country:

- Purchase tax.
- Annual tax.
- Subsidies and exceptions for specific cars.
- Company car tax schemes.
- Fuel prices and taxes.
- Road taxes etc.

The description should include a description on how the tax is calculated, the tax base, levels and exceptions e.g. tax deductions for electric vehicles, free parking for electric vehicles, permission for electric vehicles to use bus lane etc.

The questionnaire data described above was supplemented by data collection directly from national sources via the Internet. The supplementary data collection was primarily aiming at filling gabs in the questionnaire data received from the national experts.

The supplementary data collection consisted of data from the statistical offices in Sweden, Norway, Finland and Denmark, Internet based car purchase tax calculator from Norway and Denmark, report on car fleet statistics TRAFA 2016:13 from Sweden, Reports on car mileage from TRAFA Sweden (körsträckor 2015, 2016:32), reports on car taxation from ACEA and car fleet statistics from ACEA.[2]

[2] Example: http://www.acea.be/uploads/press_releases_files/20161028_AFV_Q3_2016_FINAL.XLSX

3. Current situation

This chapter describes current situation and the development in passenger car CO_2 emissions and car taxation in recent years. The aim is twofold. First to see if we can find some evidence for some correlation between the car taxation and the CO_2 emissions in Nordic the countries. Secondly, in order to identify potentials for possible reductions in CO_2 emissions with eventually identified relevant economic measures.

3.1 Mapping economic measures

This section describes the economic measures with focus on measures that are relevant for the CO_2 emissions from passenger cars. The description focuses on the current situation but do also include major changes in recent years that may have had impact on the CO_2 emissions. The economic measures described here contains the following:

- Purchase tax.
- Annual tax.
- Fuel taxes.
- Tax Exemptions.
- Company car taxation.
- Other tax incentives.

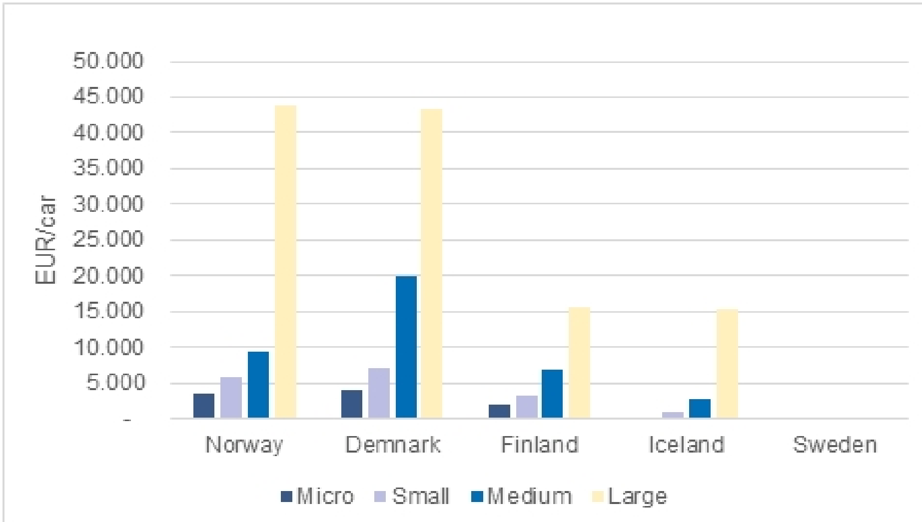
3.1.1 Purchase tax[3]

The purchase tax varies significantly between countries ranging from zero in Sweden to 150% of the car value in Denmark. This section provides a short overview of the incentives in the registration taxes in the Nordic countries. This overview includes the size of the tax and the correlation with the CO_2 emissions of the vehicles.

The figure below shows the purchase tax for new vehicles 2016. The same numbers given in the table below the figure.

[3] Also called registration tax.

Figure 3: Purchase taxes for petrol cars in the Nordic countries, 2016



Source: ACEA, 2016.

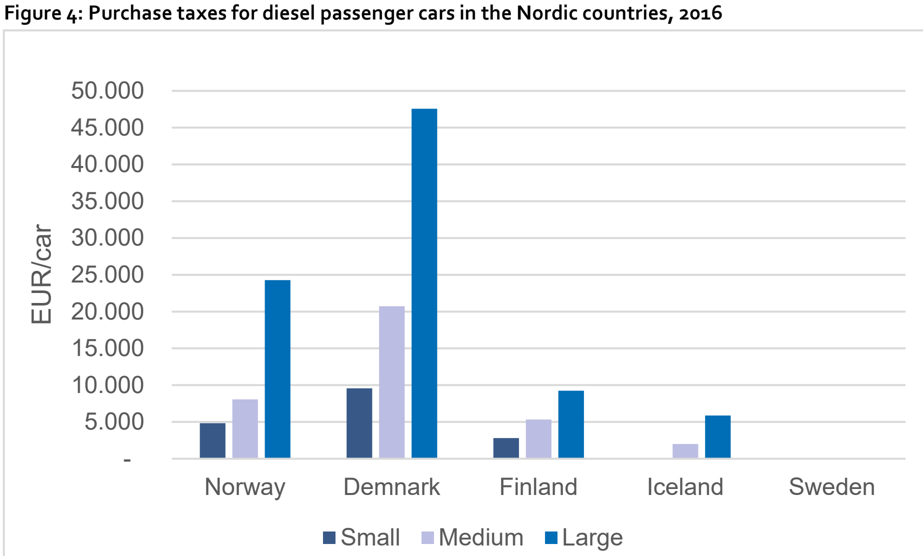
Table 5: Purchase taxes for petrol cars in the Nordic countries, 2016 EUR/car

	Norway	Denmark	Finland	Iceland	Sweden
Micro	3,519	4,040	2,067	-	-
Small	5,748	7,189	3,282	1,038	-
Medium	9,437	19,990	6,893	2,740	-
Large	43,748	43,329	15,558	15,333	-

Note: Purchase tax for Norway and Iceland calculated based on characteristics of Danish cars.

Source: ACEA and own calculations.

Figure 4: Purchase taxes for diesel passenger cars in the Nordic countries, 2016



Source: ACEA and own calculations.

Table 6: Purchase taxes for diesel cars in the Nordic countries, 2016 EUR/car

	Norway	Denmark	Finland	Iceland	Sweden
Small	4,822	9,574	2,798	-	-
Medium	8,073	20,722	5,337	2,004	-
Large	24,276	47,565	9,257	5,874	-

Note: Purchase tax for Norway and Iceland calculated based on characteristics of Danish cars. Currency per 28th September 2016.

Source: ACEA and own calculations.

As can be seen from the tables and charts above, the purchase tax is significantly bigger in Denmark compared to the other countries. At the same time, as can be seen from the table below, the car size is in general smaller in Denmark compared to for instance Sweden. In Denmark there is 10% mini cars and in Sweden there is only 3% of these cars. In the other end we see 32% large cars in Sweden compared to only 8% in this category in Denmark.

Table 7: Average car size in the Nordic countries, 2016[4]

Segment	Sweden	Denmark	Island	Finland
Mini	3%	10%	9%	1%
Small	13%	33%	63%	13%
Medium	52%	49%	14%	37%
Large	32%	8%	14%	49%

Source: ACEA, 2016.

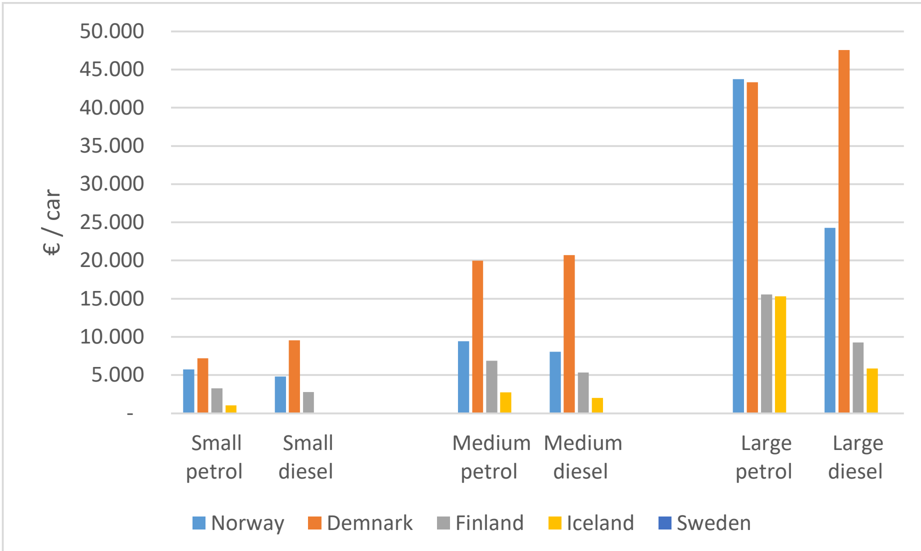
Thus, there seem to be a clear tendency that the structure of the purchase tax is influencing the average size of the vehicles in the car fleet. As can be seen from the below table, the car size is much smaller in Denmark where we have a large purchase tax and very high for large cars. In Finland, we also have relatively large cars compared to Denmark, and here the size of the tax is only approximately 25% of the tax in Denmark.

The chart below shows the average taxation level for petrol vs. diesel cars in the Nordic countries.

Regarding the taxation of different fuels, there is no big difference in the taxation of diesels and petrol fuelled vehicles within the individual countries (Figure 5). Countries with high taxes have high taxes in both petrol and diesel cars.

[4] It has not been possible to obtain this information from Norway.

Figure 5: Taxation of cars of different sizes. 2016 EUR/car



Source: National Statistic bureaus

It is another story with other fuels. Taxation of electric cars vary a lot between countries. In Norway there is a 100 % reduction in the purchase tax for electric vehicles, in Finland it is 70%. In Denmark the reduction is 80% in 2016 and to be phased out completely by 2020.

Table 8: Reduction in registration tax for electric vehicles, 2016

	Norway	Denmark	Finland	Iceland	Sweden
Reduction in tax (%)	100%	80%	70%	100%	0%
Avg. reduction (EUR)	7,000	11,800	3,200	1,500	500

Note: A minimum reduction of 1,300 EUR is included in Danish numbers.

Source: National tax authorities and own elaboration.

The tax reduction for Denmark is valid for 2016. In previous years it has been a reduction of 100%. In 2015, the parliament decided to phase out the tax reduction. It will be faced out gradually until 2020 where it will no longer exist. It should be noted that there will still be a small benefit in terms of a minimum reduction of approx. EUR 1,300 also after 2020.

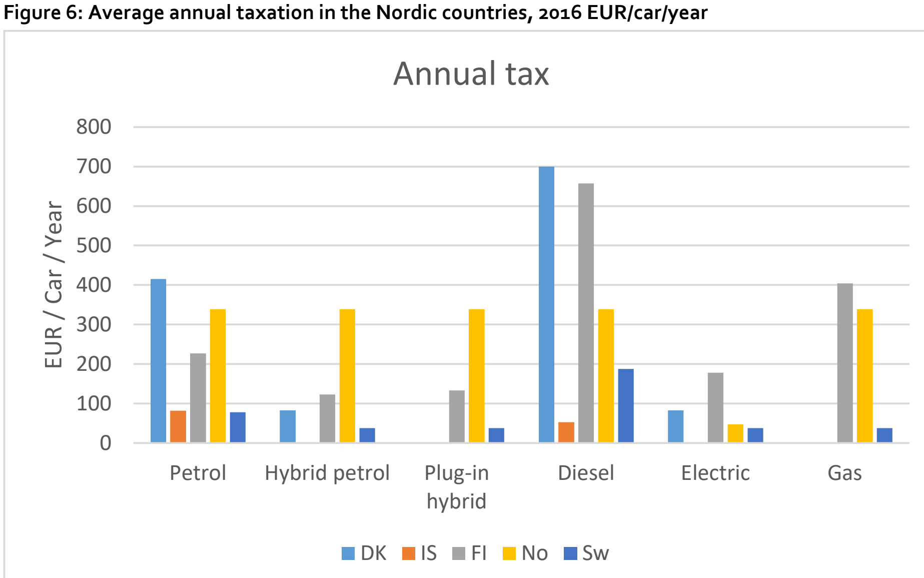
There is typically no technology specific incentives for hybrid vehicles in the Nordic countries. Having said that, the hybrid vehicles are to a large extent favoured by the substantial CO_2 differentiation in the purchase tax and annual tax in Denmark, Norway and Finland.

3.1.2 Annual taxation

Annual taxes/road taxes are charges levied on vehicles in order to use public roads. Typically, the tax is based on vehicle characteristics such as engine size, weight or power, but it is also increasingly linked to CO_2 and other pollutant emissions (Brand *et al.* 2013).

The annual taxation varies considerable between countries. The highest annual tax for traditional petrol and diesel vehicles are in Denmark. Furthermore, in most countries diesel vehicles are taxed significantly higher compared to petrol and other fuels. The exception being Norway, where all vehicles except electric vehicles are taxed the exact same annual rate.

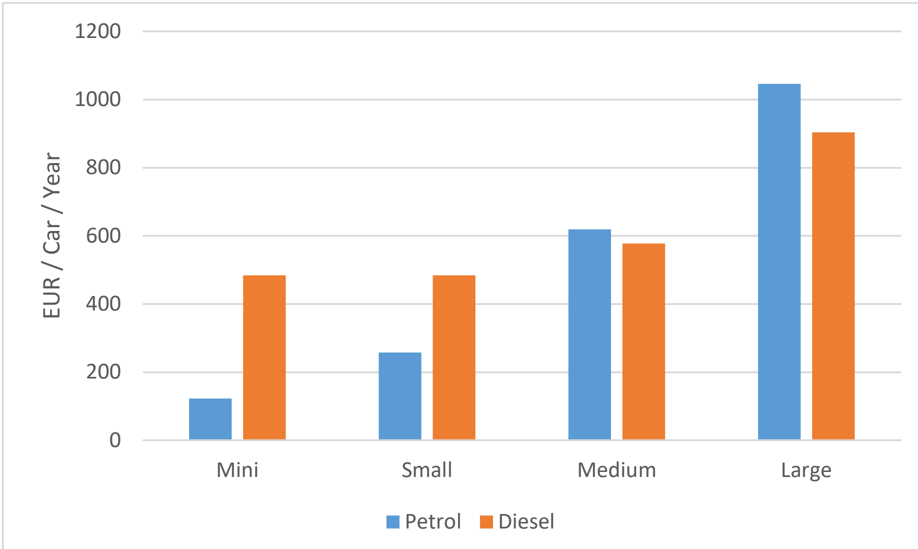
Figure 6: Average annual taxation in the Nordic countries, 2016 EUR/car/year



Source: National tax authorities and own elaboration.

Regarding the differentiation of the annual tax, large vehicles are typically taxed significantly higher compared to smaller vehicles. The chart below shows the annual tax in Denmark. As can be seen this is certainly the case for petrol cars and to some extent also for diesel cars. For diesel cars however, the correlation between car size and annual tax is less pronounced. This is because large diesel driven vehicles are more efficient compared to large petrol cars.

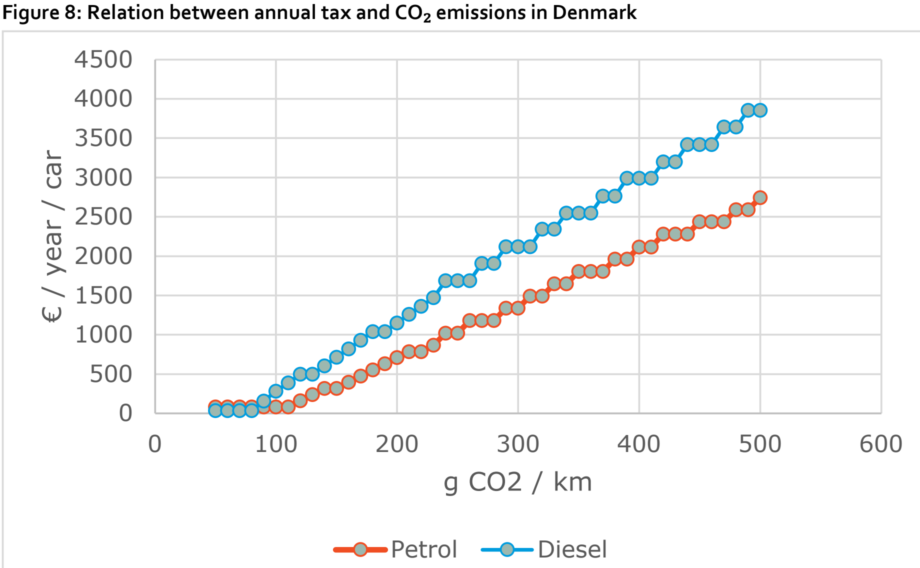
Figure 7: Annual tax Denmark, 2016 EUR/car/year



Source: Danish tax administration and own calculations.

The annual tax in Denmark is directly linked to the energy consumption and therefore also to the CO_2 emissions. The small vehicles use less fuel and will therefore pay a lower annual tax. The chart below shows the correlation between the CO_2 emissions and the annual tax in Denmark. The annual tax increases by approximately EUR 6 per gram CO_2 for petrol vehicles and EUR 9 per gram CO_2 for diesel vehicles.

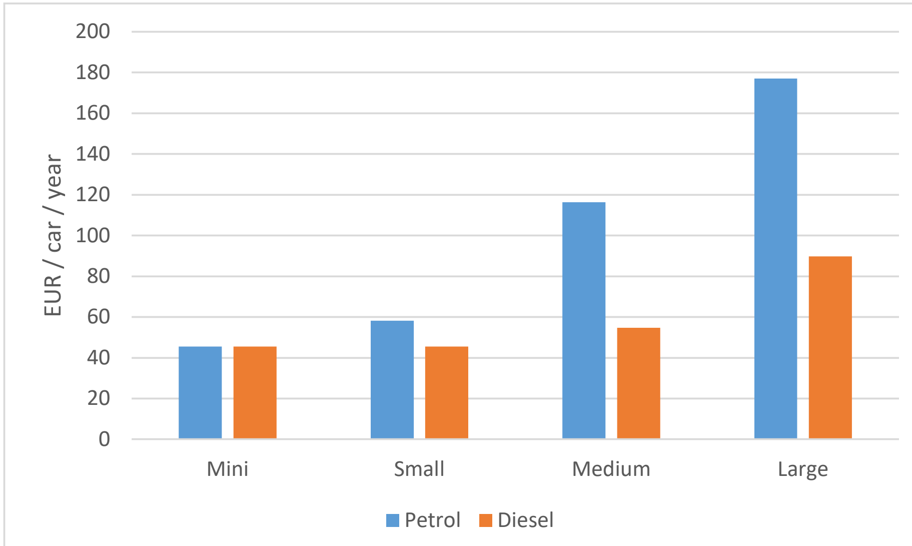
Figure 8: Relation between annual tax and CO_2 emissions in Denmark



Source: Own calculation.

The following chart shows the annual tax in Iceland broken down by car size and fuel. Statistics on Annual tax in Iceland not available. The chart is applying Iceland tax system on Danish car characteristics.

Figure 9: Annual tax Iceland, 2016 EUR/car/year

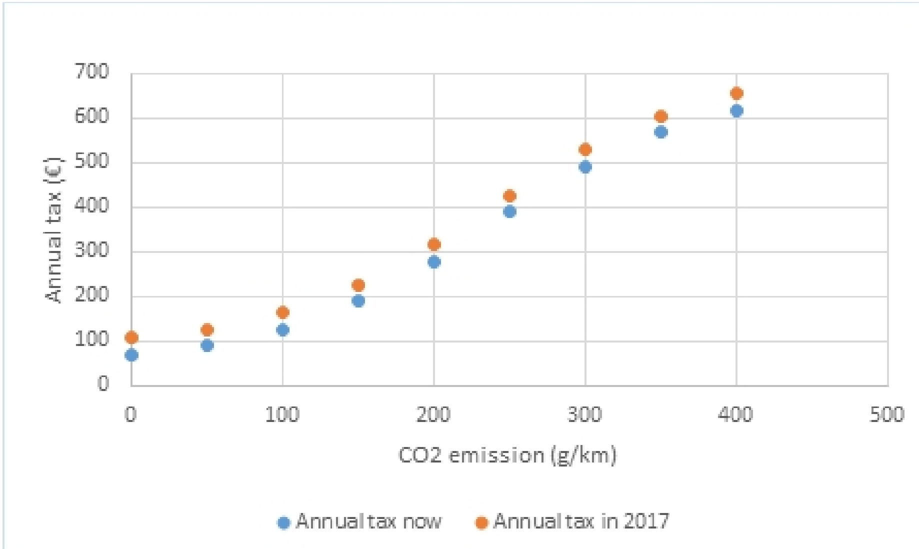


Note: Note: Statistics on Annual tax in Iceland not available. The chart is applying Iceland tax system on Danish car characteristics. No diesel vehicles in "Mini" segment.

Source: Own calculations.

In Iceland the relation between diesel and petrol car tax on diesel cars is different from Denmark. In Iceland, the annual tax for petrol cars is generally lower compared to petrol cars. This is the picture you will see when the tax is bases on the CO_2 emissions, because the diesel cars have less CO_2 emissions per km. In Denmark the CO_2 based annual tax is supplemented with a specific diesel element aiming at balancing the taxation of petrol and diesel cars.

Figure 10: Annual tax in Finland, 2016



Source: Own calculations.

The Finnish annual tax follows an S –Shape curve with most steep increment per CO_2 in the level above 200 g CO_2 per km. The average CO_2 correlation in the central segment is approx. EUR 1.5 per g CO_2. However, nowadays there is only very few vehicles in this segment. Thus the major share of cars is taxed with a lower CO_2 progression.

For all countries mentioned above we see the same tax structure with a relative small tax for low levels of CO_2 emissions and more important with low progression in the tax at low levels. This implies that the annual tax do not provide much incitement for further reductions below approximately 100 gram CO_2 per km. This has not been a problem until now since it is only recently that cars with CO_2 emissions have been common in the market. However, this will create small incentive for further reductions in the future.

3.1.3 Taxes related to fuel consumption

Taxes related to fuel consumption may consist of a number of taxes, for instance Energy tax. CO_2 tax, NO_X –tax etc. The common feature of the taxes in this section is that the calculation of taxes is based on fuel consumption, this way increasing the fuel price proportionally to the fuel price without taxes. Because of this common feature, we denote these taxed "fuel taxes" in the following section. We are aware that the concept fuel taxes may not be well defined. On the other hand, since it is the total price, which is relevant for the consumer, we think it is sufficient to treat all "fuel taxes" as a total addition to the fuel price.

In theory the fuel tax would be the most efficient measure to secure efficient CO_2 reductions.[5] This is because the fuel tax is targeting both car efficiency mileage and mode choice.

However, the theory is assuming rational consumers and it is not sure these assumptions hold in practice. For instance it is a question to what extent fuel expenditure impact on the car choice in practice. Moreover, changes in the transport costs will have both an immediate impact on demand and a more long-term effect, since consumers can also adjust their location, work place and transport mode.

Furthermore, there may be limits to how much one country can deviate from neighbouring countries without causing border trade[6] and in-efficient behaviour. When a country decide to increase its fuel tax, it will make fuel more expensive compared to the neighbouring countries (a sort of fuel price competition). Since, it is possible to drive to the neighbouring country to fuel cheap fuel. Hence, the effect on local driving is reduced. The larger the price difference, the larger this effect will be.

The table below shows the fuel taxes in the Nordic countries.

Table 9: Excise duties on fuels in euro/1.000 litres, November 2016

	Unleaded Petrol	Diesel
Denmark	611	416
Finland	681	506
Iceland	595	474
Norway	657	503
Sweden	673	623

In Sweden the fuel tax for diesel and petrol is almost the same level, while in Denmark, Norway and Finland respectively tax diesel fuel 30 % and 25 % less than petrol fuel.
The historical reason (and to a large extent also the reason today) for having lower diesel taxes compared to petrol taxes was an interest in supporting trade, which required transport using heavy duty vehicles, which was using diesel. Earlier cars were considered a luxury good and was running on petrol. Hence, the easiest way to tax this luxury good was through taxing the fuel (petrol), since this did not influence the freight transport. Diesel cars came to the European market in order for the owners to be able to use the cheaper diesel. Similar patterns are not seen elsewhere in the world.

However, diesel cars also have negative side effects. Local pollution being the main one. Hence, to balance out the support for the freight transport, the lower CO_2 emissions from diesel with the problem of local pollution, there are now countries (including Sweden), who have chosen to align petrol and diesel taxes.

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[5] In principle, the efficient tax should be based on the energy content and combined with energy efficiency for each technology in order to be efficient. In practice the authorities are not willing to let the decision on technology be taken based on the fuel price alone. Therefore, the typical solution is to make the fuel price handle the efficiency with in technology and take other measures to control decisions on technologies.

[6] Border trade is when fuel prices differ between two neighbouring countries. This induces residents in the high fuel price country to drive to the neighbouring country to fuel their vehicles.

3.1.4 *Incentives for low emission and electric vehicle*

Beyond the reduction in purchase tax and annual tax, there is a variety of different incentives to promote low emission vehicles in the Nordic countries.

Finland, Helsinki: low emission cars (electric, petrol and diesel less than 100 g/km, gas and ethanol emitting less than 150 g/km) get 50 % discount on parking fees.

Iceland: Exceptions for electric cars, plug in hybrids and hybrids include free "green" parking spaces in downtown Reykjavik as well as outside bigger stores (Ikea etc.), and free electric charging stations usually in the same spot as these green parking spaces.

Norway: The most impactful incentive incentives for electric vehicles in Norway is the exemption of VAT and registration tax. In addition to low taxes, zero emission cars are allowed in bus lanes (with some exceptions), granted free parking (and free charging where accessible) on parking owned by the municipalities and free of charge on ferries.

Sweden: No vehicle tax first five years for Euro 6, electric, electric hybrid or plug-in hybrid.

Denmark: Reduced purchase tax and free parking for electric vehicles.

3.2 Car taxation in a European perspective

3.2.1 *Magnitudes*

Vehicle purchase tax or registration tax is a levy at the point of purchase of a private vehicle. Countries have different approaches to registration taxes. The regristration taxes are typically based on a combination of factors such as CO_2 emissions, sales price of the car, engine capatity, fuel type, fuel consumption, power or vehicle weight measures (Brand *et al.* 2013 and ACEA, 2016).

Similary, the level of registration taxes varry across Europe. Countries like Sweden, Czech Republic, Germany, Sweden and United Kingdom impose no registration tax, while Spain and France has low purchase taxes but these have become substantially more CO2 sensitive over the period 2001-2010. Countries like Austria, Denmark, Finland, Ireland, Netherlands, Portugal have relatively high purchase taxes (>30%), with a CO2 component that substantially increased over the years, though the countries differ substantially (Gerlagh *et al.* 2015, ACEA, 2016).

- A number of countries including Germany, Denmark, Finland, Greece, Ireland, Luxembourg, Malta, Netherlands, Sweden and United Kingdom have annual taxes based on CO_2 emissions (ACEA, 2016).
- In the Netherlands cars emitting maximum 50 g CO_2/ are exempted from annual circulation tax. In Sweden, a five-year exemption from annual circulation tax applies for green cars (ACEA, 2016).
- In Germany, the annual circulation tax for cars registered from 1 July 2009 is based on CO_2 emissions. It consists of a base tax and a CO_2 tax. The base tax is EUR 2

per 1000cc (petrol) and EUR 9.50 per 1,000cc (diesel) respectively. The CO2 tax is linear at EUR 2 per g/km emitted above 95g/km. Cars with CO_2 emissions below 95 g/km are exempt from CO_2 tax component (ACEA, 2016).

- The annual road taxes was on average 2 percent of the vehicle's (tax-exclusive) purchase price for both diesel and petrol cars. The average elasticity of the annual tax rate with respect to CO_2 emissions has changed from being negative in 2001 to a positive value in 2010. Overall, there is a slight pattern towards lower road tax rates combined with a greater dependence of the tax rate on the emissions of the car (Gerlagh *et al.* 2015).
- Currently (2016) France is the only country in Europe who has a limited scrapping scheme i.e. a bonus of EUR 200 , is given if the purchase or lease of a new vehicle with CO2 emissions of 110 g/km and less is combined with the scrapping of a vehicle aged 15 years or more. Since March 2015, an additional scrapping scheme is in place for diesel cars registered in 2006 or before (the maximum bonus is EUR 3,700 for 20 g CO_2/km or less) (ACEA, 2016).

3.3 Company car taxation

Company cars is a broad term including company owned cars for a variety of purposes. The most interesting is the company cars purchased by a company and made available to their employees to use for free. However, there is also a large proportion of company owned cars that are used for commercial transportation of employees in connection with their work, for instance sales representatives and health care personnel or commercial transportation of passengers, taxies. Regarding the company car taxation, the relevant category is the company cars owned by a company and made available to their employees to private use for free.

The amount of company owned cars in Denmark is approx. 35%. From these, approximately 1/3 is for use in companies, 1/3 for use in service stations, car rental and car dealers. Only approximately 1/3 of company owned cars is cars used for private passenger transport.

The table below shows the share of cars sold to companies in the Nordic countries from 2009 to 2015. As can be seen, the share is very different in the individual countries. Part of this difference is due to differences in the calculation method.

Table 10: Share of company cars of new car registrations

	2009	2010	2011	2012	2013	2014	2015
Denmark	45%	51%	51%	40%	37%	45%	50%
Iceland	46%	71%	68%	68%	66%	63%	61%
Finland	42%	35%	36%	37%	36%	37%	35%
Norway	41%	41%	40%	42%	43%	47%	43%
Sweden	65%	65%	67%	70%	70%	68%	67%

Note: Company cars defined as cars purchased and owned by company.

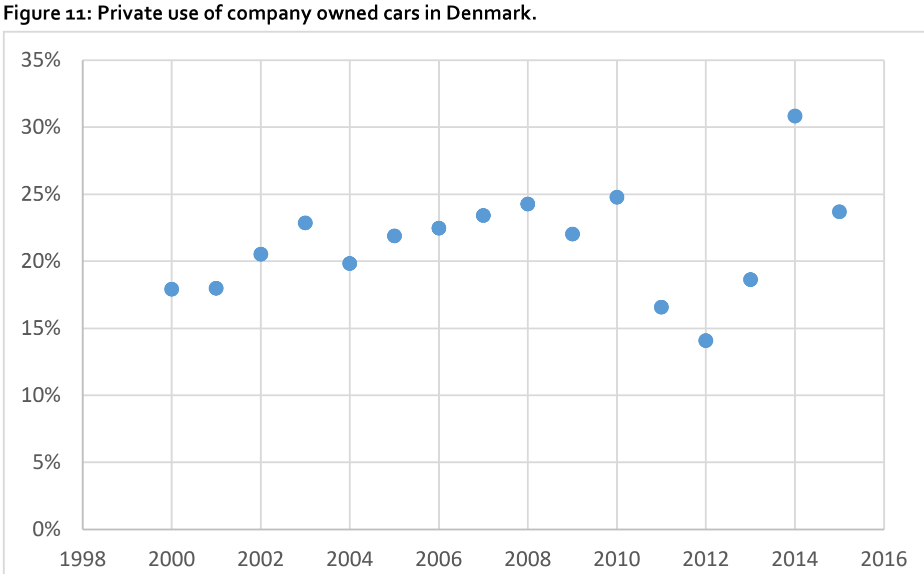
Sweden has the largest company share with approximately 2/3 of all new car registrations.

Table 11: New passenger car ownership in Sweden 2009 – 2015

Owned by	2009	2010	2011	2012	2013	2014	2015
Retail	29%	30%	31%	35%	37%	34%	34%
Company	36%	35%	36%	35%	33%	33%	33%
Private	35%	35%	33%	30%	30%	33%	33%

Approximately half of these is owned by the car retail trade industry. The other half is owned by a company, some of which are made available for employee for private use. As for Denmark, we see a company owned car share of approximately 50%. Approximately 25% of these are company owned cars are used for private transport purpose (Figure 11).[7] It has not been possible to obtain similar information for the other countries.

Figure 11: Private use of company owned cars in Denmark.



Source: Danish car registry.

The diesel share is very high for medium and large company cars compared to medium and large private cars. One reason for this may be that the company cars drive more km and the diesel driven cars are more efficient for people who drive more km. Furthermore, diesel driven cars are more expensive compared to petrol cars. And with the weaker incentive/price signal there is for company cars it may be that the higher price has less influence in the car choice for company cars compared to privately owned cars.

[7] The register has a company as owner and a private person as user.

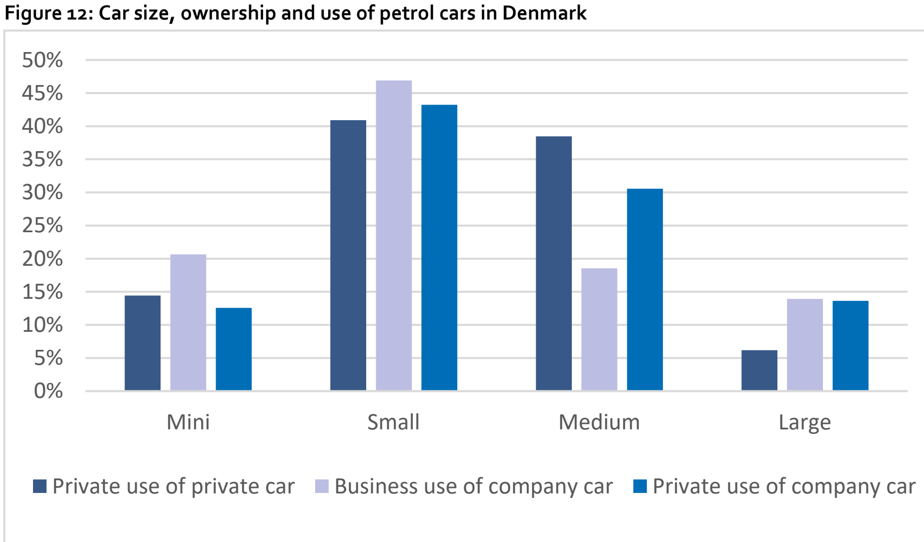
Table 12: Diesel share in private and company cars in Denmark

	Mini/Small	Medium	Large
Private use of private car	9%	42%	40%
Business use of company car	3%	78%	58%
Private use of company car	9%	81%	76%

Source: Statistics Denmark, The car registry.

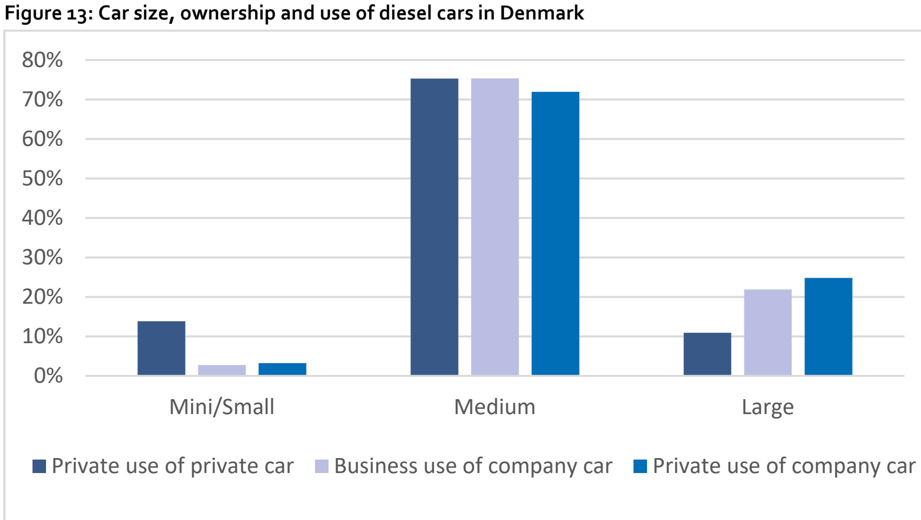
This may also be the reason why we see a tendency that company cars are bigger compared to private cars as we see it in the two following charts.

Figure 12: Car size, ownership and use of petrol cars in Denmark



Source: Statistics Denmark, car registry.

Figure 13: Car size, ownership and use of diesel cars in Denmark



Source: Statistics Denmark, car registry.

As can be seen, for both petrol and diesel cars the amount of large company cars is approximately twice as big as the amount of private large cars.

It should be noted, that this segmentation may not only be caused by the company car incentives. It is likely that people with access to company cars would also have had a large car as private car if the opting for company car had not been available.

Finally we suspect that the increase in company car share is due to more widespread private leasing of ordinary private passenger cars for private use. Thus it is probably not an increase in the company car for private use segment.

Table 13: Incentives in company car taxation

	Mileage	CO2 direct	CO2 reg tax
Denmark		X	X
Finland	(X)		X
Island			
Norway			X
Sweden			

Note: CO_2 Direct for Denmark. The CO_2 based annual tax multiplied by 1.5 is added to the personal tax.

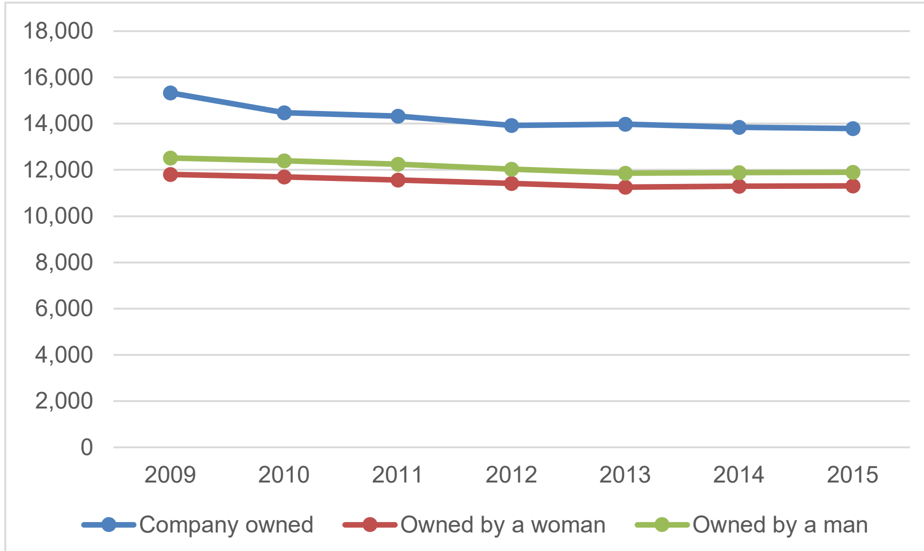
In Table 13 we have shown the type of incentives to reduce CO_2 emissions in the company car taxation in the Nordic countries. Generally, there are not many incentives that directly influence the choice of type (or low CO_2 intensity) car or the use of a company car. Due to the CO_2 elements in the registration taxes in Denmark, Finland and Norway, this also influences the companies' choice of the car. Moreover, it also influences the private users' choice of car, since the higher cost (including the tax) influence the value that the private user is being taxed.

Only Finland has introduced a system where the driving cost may depend on the distance driven.[8]

Due to the fact that private users of company cars typically do not pay for fuel and maintenance, the incentive to drive less km is week for these company cars. As can be seen from the figure below, the company cars in Sweden drive on average 20% more km compared to privately owned passenger cars.

[8] The Finnish company-car benefit is either full type or limited type. The first alternative, the unlimited benefit means that the employer pays all car expenses. The second alternative, the limited type of the benefit, means that the user must at least pay for the fuel and the recipient of such payments must not be the employer. Furthermore, the tax office may raise the value of your company car benefit if private kilometres exceed 18,000 per year. Source: The Finnish tax authorities: https://www.vero.fi/en-US/Individuals/Travel_expenses/Driving_a_company_car(37124)

Figure 14: Mileage from Swedish passenger cars according to car ownership



Source: Swedish Statistical Bureau.

3.4 Mapping technologies

The tables below show the new car sales break down of technologies. Starting with Table 14 showing the share of diesel cars

In Sweden the diesel share has increased from 48% in 2009 to above 66% in 2012. Since then there has been a tendency to reducing diesel share. However, this is because the increase in number of diesel cars sold has been lower than the increase in e.g. petrol cars sold. The number of diesel cars sold were the highest ever in 2015 in Sweden, but the increase in petrol cars increased by 150.000 more petrol cars sold in 2015 compared to 2014.

It is interesting to see this high share of diesel cars in Sweden, since the price on diesel is the highest in all the Nordic countries and also in comparison with the petrol price.

In Norway a significant change in the diesel share in new car sales has happened since 2011. This change was due to the significant change in the car taxes in Norway from 2012. It is especially the NO_X tax that influence the diesel cars, but also the significant change with no taxes on electric vehicles has played an important role.

Table 14: Diesel share in car sales

	2009	2010	2011	2012	2013	2014	2015
Denmark	46%	48%	48%	39%	31%	30%	29%
Iceland	31%	31%	46%	53%	48%	50%	45%
Finland	48%	44%	44%	40%	36%	37%	35%
Norway	73%	75%	76%	64%	53%	49%	41%
Sweden	48%	56%	63%	66%	61%	59%	57%

Source: National car registers.

In Denmark there has been a reduction from 48% in 2011 to 29% in 2015. We suspect this tendency is caused by the recent large market share of very cheap small cars (Citroen C1, Peugeot 107, Toyota Yaris, WV UP, Skoda Citigo etc.) which only exist in petrol versions. The new purchase tax introduced in 2007 in fact give the mini cars a relative advantage compared to the small diesel cars.

The decline in Finland is probably also due to a change in the registration taxation in 2008 that has made diesel cars relatively more expensive. A CO_2 based tax, however, in itself will in principle favour diesel cars, where the CO_2 emission per kilometre is smaller in diesel cars compared to similar petrol cars. However, due to the way the CO_2 tax is composed, it can make very small petrol cars very attractive and thus lead to a large increase in these cars and therefore a decline in the diesel car share of new sales.[9]

The general decline in the diesel share in the car fleets indicate that the shift has a closer relation with an international trend in the costs of vehicles and the availability of cheap small petrol cars. The small cars have been responsible for much of the new car sales including the increase in number of cars sold, hence, the share of diesels cars has been reduced, but the total sales have continued to increase.

The share of electric cars sold in the different countries is shown in Table 15. The table shows that the market for electric cars has been increasing over the past years from almost no electric vehicles sold in 2009 to the peak of more than 20% of all new cars sold in Norway in 2015 being electric cars.

The situation is a little special in Denmark. Beginning in 2016 the tax rebate on electric vehicles will be phased out gradually until 2020, 20% reduction of the rebate every year. When this policy became known in 2015 it led to a substantial extra demand of electric especially just before the rebate was reduced. It is not expected that share of electric vehicles will stay at this level in the years to come.

Table 15: Electric vehicle shares in sales

	2009	2010	2011	2012	2013	2014	2015
Denmark	0,1%	0,0%	0,1%	0,3%	0,3%	0,9%	1,9%
Iceland				0,1%	1,3%	2,8%	3,9%
Finland						0,2%	0,2%
Norway	0.0%	0.6%	1.4%	2.9%	5.5%	13.7%	22.3%
Sweden	0,0%	0,0%	0,1%	0,1%	0,2%	0,4%	0,8%

Source: OCM, Norway, Dansk Elbilalliance, Denmark, Statistics Sweden, Statistics Finland, Statistics Iceland.

In Norway there is a very large share of electric cars in recent years. This share should be seen in the light if the many incentives for promoting electric cars in Norway. For instance exemption of purchase tax and VAT, free parking in Oslo, no road toll and permission to driving in the bus lanes. These incentives makes the electric vehicles very advantageous.

9 The purchase tax for the mini petrol vehicles are smaller that the tax for the smallest diesel cars.

Sweden still has a low level of electric vehicles, although there are many incentives, including 5 years free annual tax, exemption from the toll ring tax in Stockholm and Gothenburg free parking and the other parts of the "Supermiljöbil" package.

The above findings suggest that it may be the extra incentive from the reduction in the purchase tax in combination with the other strong incentives like permission to drive in bus lanes and free parking that gives the large share of electric vehicles.

The following table shows the total number of electric vehicles in the Nordic countries.

Table 16: Electric vehicles in the Nordic countries

	2009	2010	2011	2012	2013	2014	2015
Denmark	140	219	296	749	1,243	1,536	2,919
Iceland	5	5	6	6	13	72	214
Finland	13	23	55	233	456	908	1,539
Norway*	1,776	2,068	3,909	8,031	17,770	38,652	69,134
Sweden	157	190	366	1,254	2,647	7,094	14,541

Note: Includes electric vehicles and plug-in hybrid vehicles.

Source: National statistical bureaus.

Although there is a substantial number of new electric cars entering the market in Norway and Sweden, the total share of electric vehicles in the car fleets is still rather small.

The following table shows the total share of electric vehicles in the Nordic country car fleet.

Table 17: Electric vehicles in the Nordic countries

	2009	2010	2011	2012	2013	2014	2015
Denmark	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%
Iceland	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
Finland	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
Norway	0.1%	0.1%	0.2%	0.3%	0.7%	1.5%	2.7%
Sweden	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	0.3%

Note: Includes electric vehicles and plug-in hybrid vehicles.

Source: National statistical bureaus.

Gas vehicles have had a significant share in Sweden in several years. Gas vehicles in Sweden receive a discount in form of 5 years free annual tax to increase the incentive (as part of the "Supermiljöbil" package and there has been an emphasis on setting up infrastructure for gas at the fuelling stations.

Table 18: Gas vehicle shares in sales

	2009	2010	2011	2012	2013	2014	2015
Denmark	0.0%		0.0%		0.0%	0.0%	0.0%
Iceland	0.2%	0.2%	0.2%	0.2%	0.1%	0.0%	0.0%
Finland	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Norway	0,0 %	0,0 %	0,0 %	0,0 %	0,0 %	0,0 %	0,0 %
Sweden	3.3%	2.6%	2.1%	1.8%	1.3%	1.6%	1.4%

Note: Although, the figures indicate that there are no sales of CNG vehicles (e.g. in Norway), this is due to very few vehicles sold, which does not appear in the shown shares.

Source: OCE, Norway, Danske Bilimportører, Statistics Iceland, Statistics Sweden, Statistics Finland.

Hybrid vehicles (Table 19) cover traditional Hybrid, most well known the Toyota Prius and plug-in hybrid cars. In recent years the Plug-in hybrid vehicles are gradually taking over increasing share of the hybrid market. The big advantage with the Plug-in hybrid is that is can run on electricity on all the short trips and will only need the fuel engine for trips above a certain distance. This makes this technology especially advantageous in the city. The problem for these cars is that they are quite expensive, and in countries with a value based purchase tax this disadvantage gets more pronounced.

Table 19: Hybrid petrol vehicle shares in sales

	2009	2010	2011	2012	2013	2014	2015
Denmark							
Iceland	1%	2%	3%	5%	4%	3%	4%
Finland	1%	1%	1%	1%	2%	2%	3%
Norway	0 %	0,%	0%	0%	0%	1%	5%
Sweden	2%	1%	1%	1%	2%	2%	2%

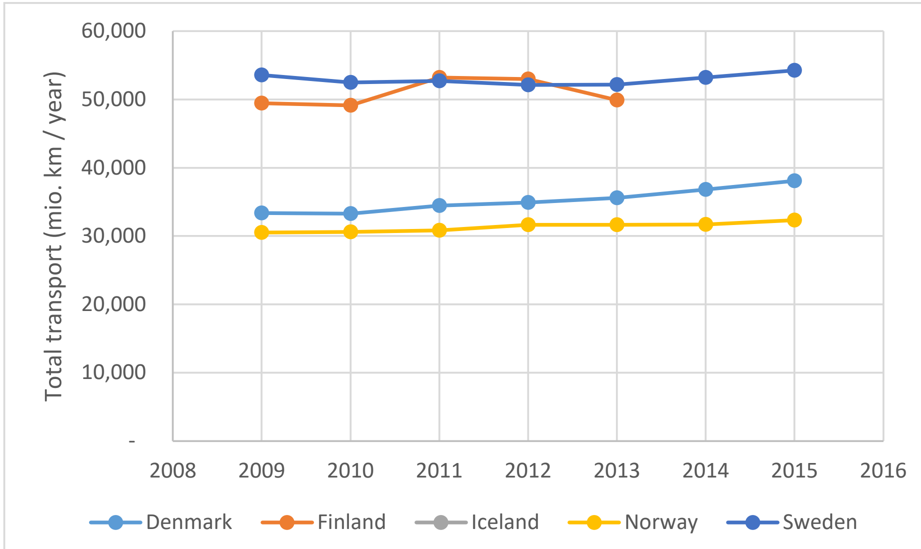
Note: No data available for Denmark. Shares are rounded figures, which is causing the many zero registrations shown.

Source: OCE, Norway, Statistics Iceland, Statistics Sweden, Statistics Finland.

3.5 Mapping traffic amount

The total amount of traffic is calculated as the total number of passenger cars multiplied with the average mileage of all cars. The total amount of passenger transport with passenger cars is shown in the chart below.

Figure 15: Total traffic



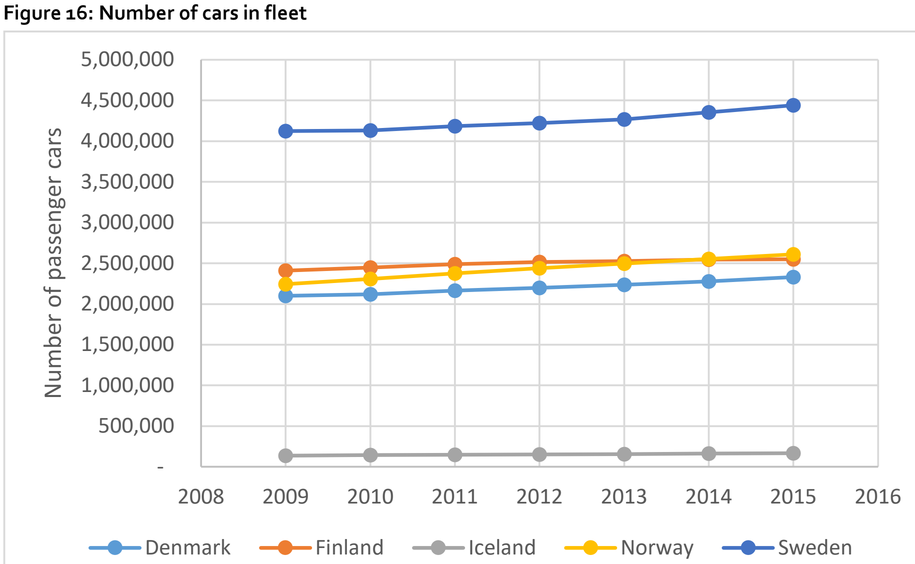
Note: Calculated by multiplying number of vehicles with the average mileage per car.

Source: Own elaboration.

As can be seen from the chart, there is a tendency that the total amount of transport with passenger cars is increasing in the Nordic countries. This is due to the increasing number of vehicles in the car fleets in all Nordic countries.

A can be seen from the chart below, the number of cars has been increasing substantially since 2009 in all Nordic countries.

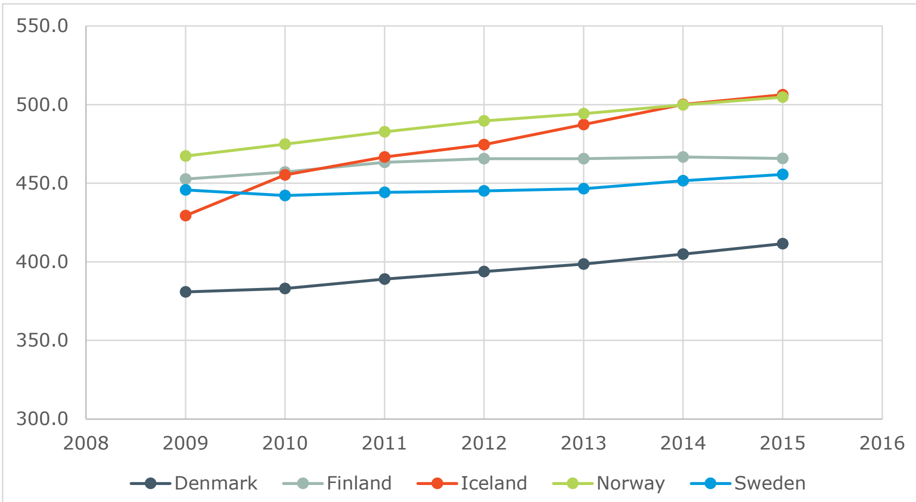
Figure 16: Number of cars in fleet



Source: National statistical bureaus.

The increase in the car fleet is caused by the fact that the car intensity is increasing. Households have more cars today compared to 2009.

Figure 17: Number of cars per1000 inhabitants in the Nordic countries

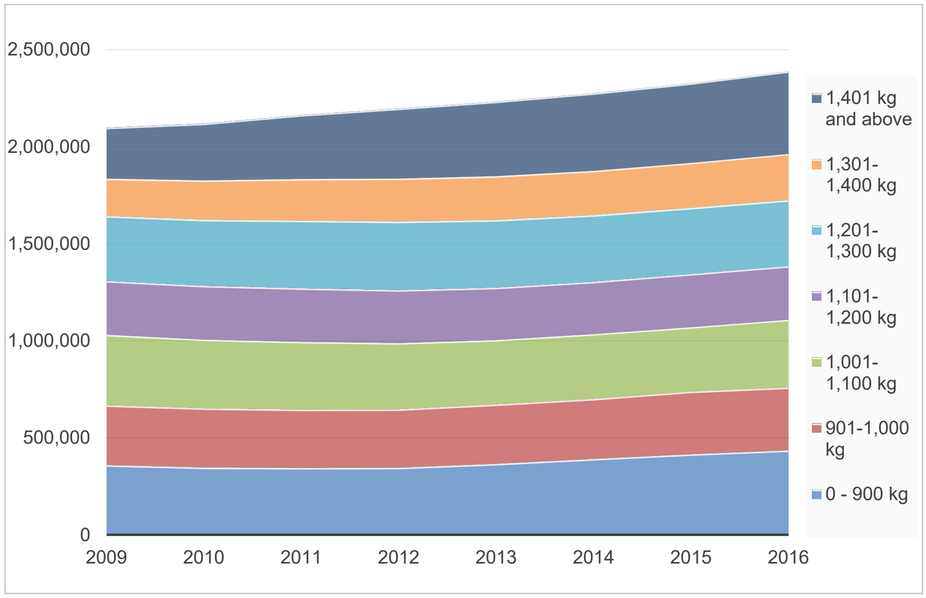


Source: National Statistical bureaus.

Especially in Denmark, Norway and Iceland we see a large increase in the number of cars per inhabitants. For Denmark this situation has taken place simultaneously with the new Registration tax system reducing the registration tax for small and energy efficient cars to a low level. Most of the increase in the car fleet in Denmark is constituted by these small efficient and cheap vehicles. At the same time however, there is also a trend that heavier 4x4 vehicles get more and more popular. In total there seems to be a polarization of the car fleet in Denmark. Very small vehicles and very large vehicles both observes a larger market share. We do not have available information on this issue for the other Nordic countries. This is subject for new data collection.

The charts below shows the break-down of the Danish Passenger after kerb weight in absolute numbers (Figure 18) to illustrate both market share (Figure 19) and growth in car fleet.

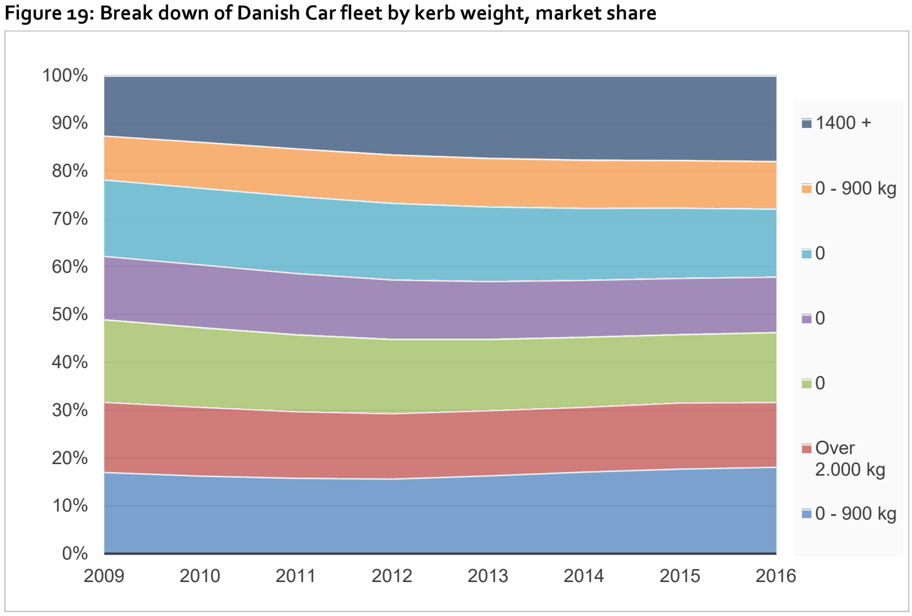
Figure 18: Break down of Danish Car fleet by kerb weight, absolute numbers DK



Note: Ready for driving weight equals Kerb weight + 125 kg.

Source: Statistics Denmark.

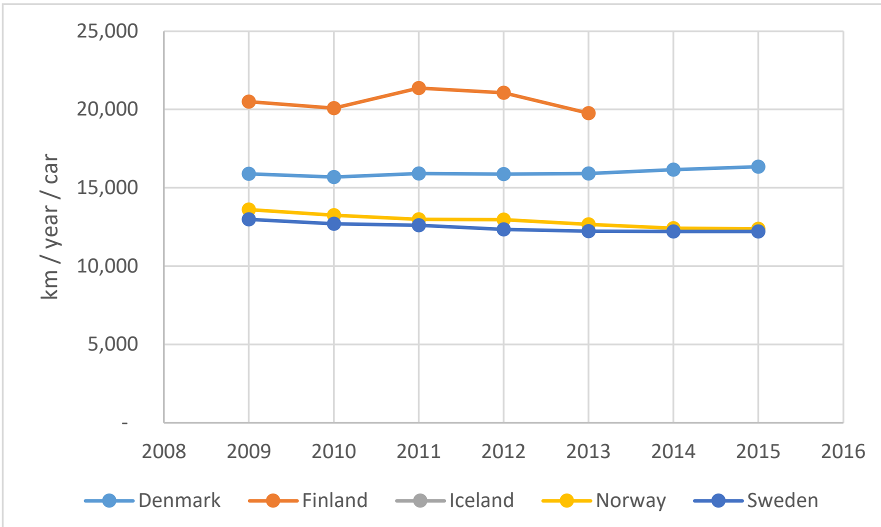
Figure 19: Break down of Danish Car fleet by kerb weight, market share



Source: Statistics Denmark.

To conclude, there has been a significant increase in car fleet and a large number of new small energy efficient vehicles has entered the market. However, these small vehicles seems to be an addition to the existing car fleet. These small cars do not seem to have replaced any of the large vehicles. We do not have specific information to support this conclusion for all Nordic countries, but the development seen in Denmark supports this finding.

Figure 20: Annual mileage



Source: National statistical bureaus.

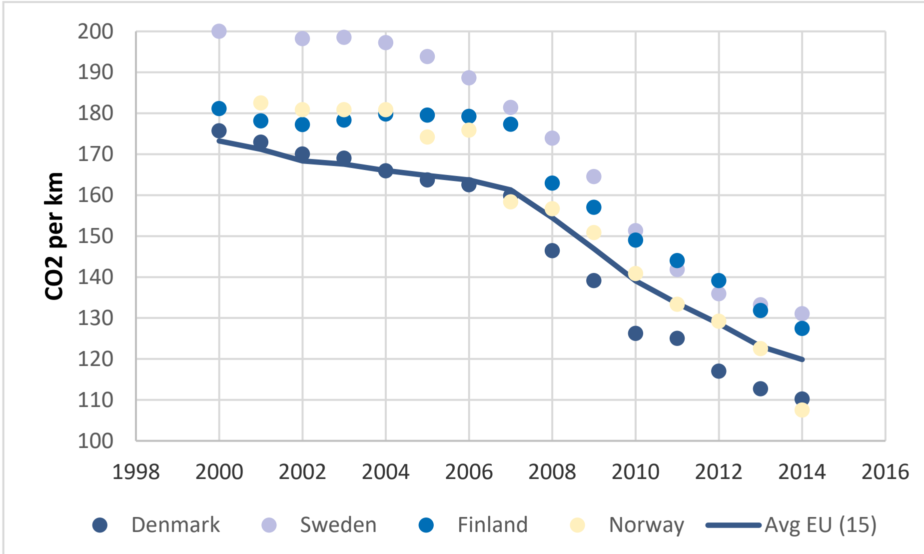
Figure 20 shows the average mileage per car and year in the Nordic Countries. As can be seen, the mileage is rather stable. In Norway and Sweden we see a weak tendency to reduction in annual mileage. In Denmark we see a small increase in the average mileage per vehicle. Especially for Denmark this trend is surprising because one would expect, that when the number of cars per inhabitant increase then the average mileage should be reduced, because the marginal number 2 cars would be expected to have smaller mileage. It is an interesting question whether this observation may be caused by the rebound effect. When cars gets more fuel efficient, people will exchange some of the savings to more mileage.

3.6 CO_2 emissions

3.6.1 Long term CO_2 emissions

The long term fuel efficiency and CO_2 emissions of the car fleet is determined by the fuel efficiency and CO_2 emissions of the new vehicles entering the fleet. Figure 21 shows the average CO_2 emissions of the new vehicles entering the car fleet.

Figure 21: Average CO_2 emissions from new passenger cars



Source: European environment agency (EEA) and EU Commission services.

As can be seen from the chart, there are some specific points in time where the change takes place.

Denmark

Substantial reduction in average CO_2 emissions from 2007 to 2008 and still ongoing. The decrease occurs simultaneously with an introduction of a rebate for energy efficient vehicles.

Finland

Substantial reduction in average CO_2 emissions from 2007 to 2008 and still ongoing. The decrease in CO_2 emissions occurs simultaneously with the introduction of a CO_2 based purchase tax from beginning 2008.

Norway

Substantial reduction in average CO_2 emissions from 2006 to 2007. The decrease in CO_2 emissions occurs simultaneously with the introduction of a CO_2 element replaces the engine volume from 2007. For Norway there is furthermore a substantial further decrease in the CO_2 emissions between 2013 and 2014. This decrease is caused by a large share of electric vehicles. This trend will continue in the following years, where sales of electric vehicles in Norway has increased its share even further.

Sweden

No big changes, but a series of different initiatives over the years.

Overall the CO_2 intensity in car use has been reduced in all countries (not only in the Nordic countries, but across Europe). This is driven by the reduced energy use and hence CO_2 emissions in the new cars sold. The main trend is thus a technology development and the impact of the international legislation forcing car manufacturers to make these improvements.

3.7 Total CO_2 emissions

Although CO_2 intensity in new cars has improved significantly, the impact on the overall CO_2 intensity in the entire fleet has not changed in the same pace. The turnover of the vehicle fleet is very long (typically a car is found in the vehicle fleet for 15–25 years). The following table shows the average car age in the Nordic countries. As can be seen, the car age is lowest in Denmark with 9 years.

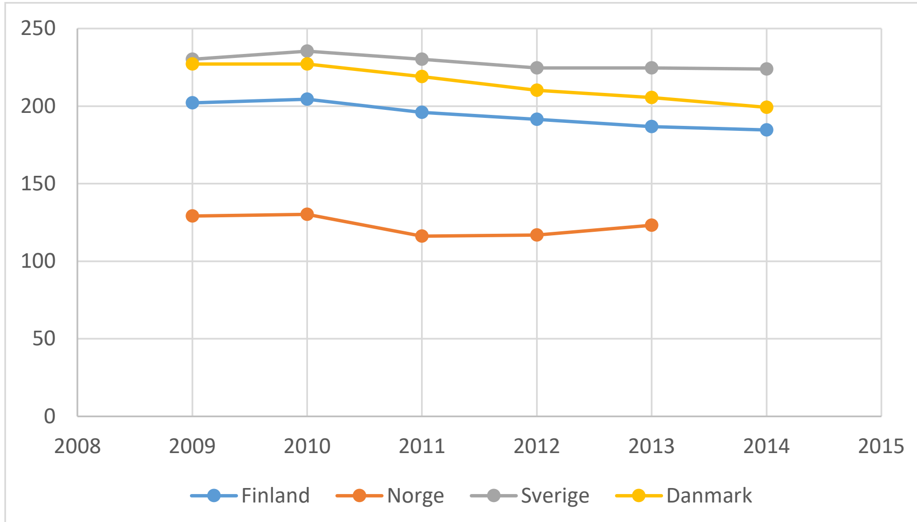
Table 20: Average car age in the Nordic countries, 2014

	Average age (years)
Denmark	9
Iceland	N/A
Finland	11.7
Norway	10.5
Sweden	10.2

Source: ANFAC vehicles in use report (2009–2014).

The CO_2 emissions are calculated as the total vehicle km multiplied with the average CO_2 emissions per km. In principle the figure should be calculated as the actual fuel consumption for use in passenger cars and from this the CO_2 emissions should be calculated. This requires data that has not been available for the present study for all countries. Hence, instead we have used the kilometres driven and multiplied by average CO_2 emissions per km as mentioned. However, for Denmark the CO_2 per km is calculated based on the "real" fuel consumption, since this data was available. We cannot say if this is the reason for the larger decrease in average CO_2 emissions in Denmark compared to the other countries.

Figure 22: Average CO_2 emissions for passenger vehicles in car fleet. gram CO_2/km

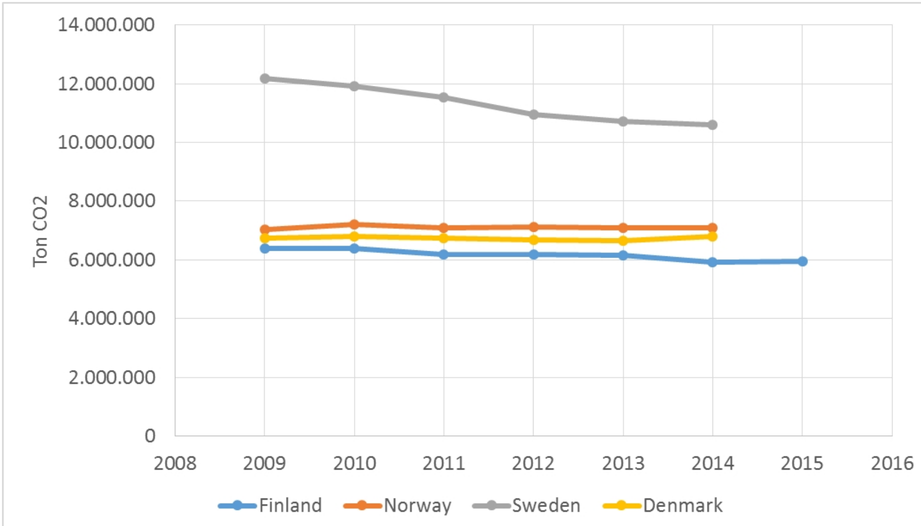


Source: EEA.

Combining the total vehicle km with the average CO_2 emissions we can calculate the total CO_2 emissions from passenger cars. Although there is a weak tendency that the total transport with passenger cars is increasing, the total CO_2 emissions are stable or marginally decreasing. The pattern is rather different, though with a large decrease in the Swedish CO_2 emissions, a slight decrease in the Finnish figures and relatively stable levels of emissions in Norway and Denmark.

These figures illustrate the importance of having incentives that also influence the use of the vehicles. As shown above, the average CO_2 intensity in the new cars are the lowest in Norway and Denmark, but taking into consideration the use of vehicles the picture changes. This may be due to a relatively larger use of cars with higher CO_2 emissions in these countries compared to e.g. Finland or it may be caused by longer distances driven in these countries or a combination.

Figure 23: Total CO_2 emissions from passenger cars



Note: Calculated from national consumption of transport fuels.

Source: Eurostat.

Since 2001 average type-approval CO_2 emission values of new European passenger cars have decreased by 27 percent. The rate of decline quadrupled after the EU introduced CO_2 emission standards in 2009.

But the official vehicle CO_2 emission values are determined by laboratory tests. As previous "From Laboratory to Road" reports, published in 2013 and 2014, showed, there is a gap between the real-world and official fuel consumption and CO_2 values that has been increasing over time. The 2015 update[10] to a series begun in 2013 analyses eleven data sources covering fourteen years, six countries, and almost 600,000 vehicles. The analysis shows that in the EU the gap between official vehicle fuel consumption or CO_2 emissions and real-world CO_2 emissions continues to grow—from 8 percent in 2001 to 38 percent in 2014.

For an average consumer the gap now translates into additional fuel expenses on the order of EUR 450 per year. Since vehicle-taxation schemes and incentive schemes for low-carbon cars are based on official CO_2 values, the gap may also lead to significant losses of tax revenue and a misallocation of public funds.

[10] ICCF (2015) *From laboratory to road – A 2015 update of official and "real-world fuel consumption and co2 values for passenger cars in Europe*.

3.8 Examples

This section shows the sales prices of a selection of specific cars with different technology for comparison between countries.

First, we shows the actual numbers in Table 21 and then illustrate the numbers in graphs to show the differences.

Table 21: Examples of car prices in the Nordic countries, 2016, EUR per car

Fuel / Car	DK	FI	IS	NO	SE
Petrol					
VW UP, 1,0	14,784	13,796	13,593	16,437	14,433
Peugeot 208, 1,2	21,504	16,396	24,224	21,592	11,753
BMW 320, 2,0	62,137	38,733	49,283	46,136	33,016
Mazda CX-9					24,732
Diesel					
Hyundai i20 1,1 crdi	21,908	16,990	20,427		19,887
Peugeot 308, 1,6 hdi	37,767	22,254	30,299	29,610	20,619
VW Passat 2,0 TDI	56,142	36,407	44,727	46,136	34,320
Hybrid					
Toyota 1.5 Hybrid e-CVT	21,774	19,989	24,528	23,408	18,557
Toyota Auris Hybrid Hatchback	34,273	26,128	31,590	29,443	21,124
Toyota Prius 1.8 Hybrid e-CVT	56,450	34,981	40,626	32,160	32,361
Plug-in Hybrid					
BMW i3 REX	49,395	43,585		40,379	35,041
Toyota Prius Plug-in Hybrid	69,686	40,287	40,626		37,670
Golf GTE	72,417	41,991	39,411	38,296	38,763
Volvo XC90 AWD PHEV	110,030	92,166	105,477	104,777	53,814
E-UP!	25,201	28,925	22,705	23,040	28,753
Nissan Leaf	35,614	34,990	30,299	28,395	27,494
Renault Zoe	34,261			21,704	22,258
BMW i3	39,987	39,067		29,788	35,041
Renault fluence					
Tesla 85	104,945	111,121	107,831	86,893	97,938

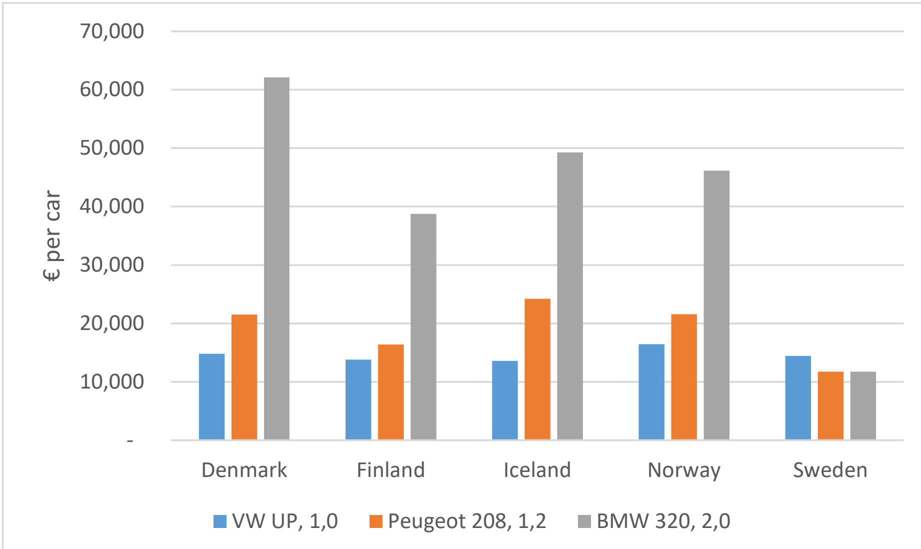
Note: Figures based on publicly available sales prices collected in the different countries.

Source: Own data collection.

The following charts shows these numbers to better illustrate differences and similarities.

In Figure 24 the sales price on petrol vehicles is shown with the prices on other fuel type vehicles in the subsequent figures.

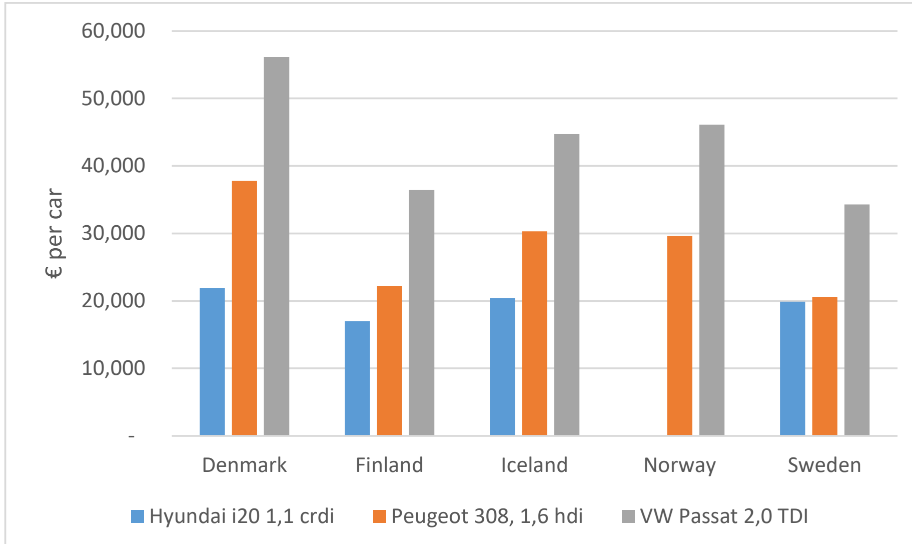
Figure 24: Car prices petrol vehicle, 2016



Source: Own data collection.

The first conclusion that can be derived from the figures is that the prices are in the same order of magnitude in Denmark, Finland, Iceland and Norway. In Sweden prices of the VW UP is similar to the other Nordic countries. But bigger vehicles are much cheaper in Sweden compared to the other countries. This difference is found in the difference in the purchase tax in the countries. For the small vehicles the purchase tax is very small since it is related to the absolute price of the vehicle (without tax) and there are reductions in the tax due to a low energy consumption (e.g. in Denmark), which makes the price comparable for small cars. Generally, the price including tax per car is also lower in Finland compared to Norway and Denmark. This is again attributable to the purchase tax.

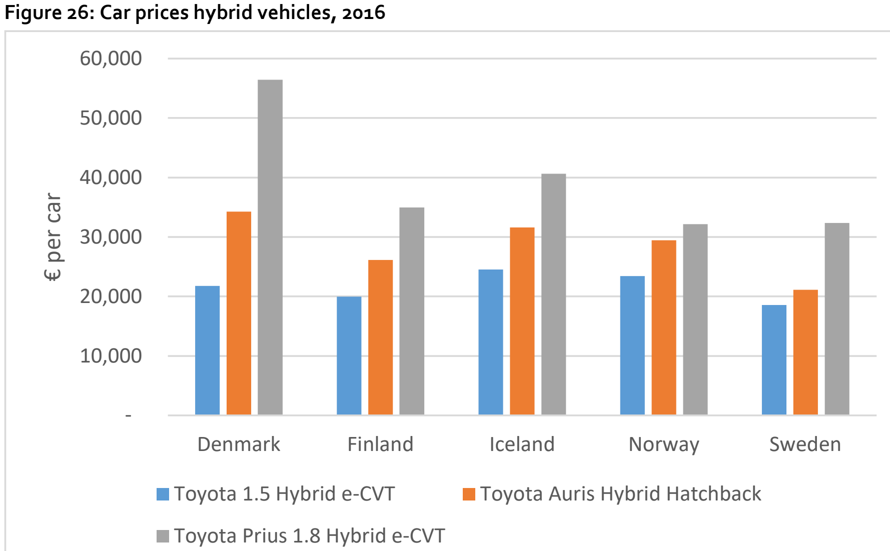
Figure 25: Car prices diesel vehicles, 2016



Source: Own data collection.

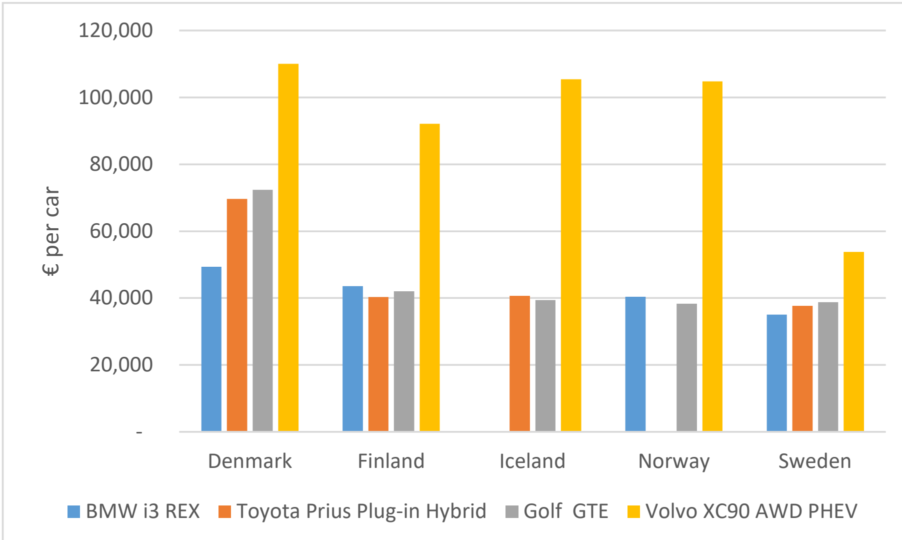
Although we see this general pattern, there are some differences; especially when alternative fuels or energy efficient cars are considered. In Figure 26 and Figure 27 we see for example that some specific hybrid cars may be cheaper, or at least at the same level, in Denmark compared with the other Nordic countries. There are exceptions, though. In Denmark the hybrid cars are treated as conventional cars with an auxiliary battery power in taxation. This means that the price of the car increases significantly since the price without taxes is typically high. In the other Nordic countries hybrid cars are treated similar to e.g. electric vehicles.

Figure 26: Car prices hybrid vehicles, 2016



Source: Own data collection.

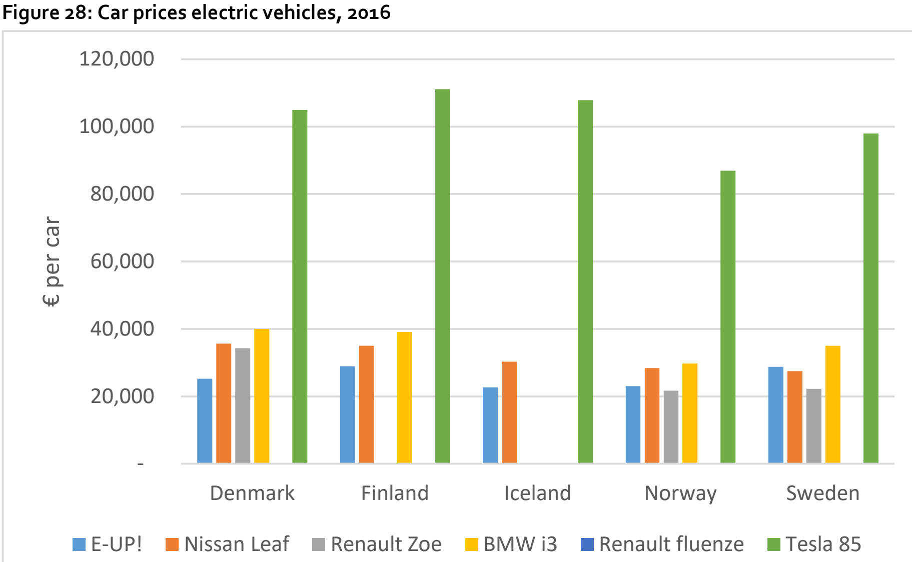
Figure 27: Car prices hybrid plug-in vehicles, 2016



Source: Own data collection.

When considering electric vehicles, the price of cars show a different pattern. Although the prices are generally still higher in Denmark, they are much closer to the other Nordic countries. However, the prices are lower in Norway due to the exemption of both taxes and VAT. The price of electric vehicles in Sweden are not significantly different from the prices in the other countries.

Figure 28: Car prices electric vehicles, 2016



Source: Own data collection.

4. Observations from scientific surveys

Having looked at the development in the CO_2 intensity in the Nordic countries and having made preliminary hypothesis about what have caused the observed changes, we have further carried out a literature screening to find evidence of the impact of applying different types of economic incentives.

In this chapter we highlight the main observations from the screened literature. Our approach to the identifying relevant literature have been based on own first experiences with literature, consultation in the project group to identify relevant literature. From this first base of literature we have searched further using references to and from the identified literature. Our strategy has not ensured that all relevant literature have been identified, but we believe that it has enabled us to find much of the interesting contributions made in recent years.

We have mainly been looking in the literature for empirical evidence, which we could translate to a Nordic contexts. This implies that we have not screened the vast theoretical literature on economic incentives.

The main problem in the empirical literature is data. It is hard to find data rich enough to estimate all relevant effects and at the same time controlling for e.g. national aspects, which may to a large extent influence results.

We have organised the literature according to the economic incentives typically used within the transport sector having a section on each. In each of these sections we have highlighted the main results in the literature and then related this to the Nordic countries using some of the findings already discussed in Chapter 3.

Summarising the main conclusions from the literature we find that:

- Many countries include a CO2 emission component in their tax structure as well as tax exemptions for certain kinds of alternatively fuelled vehicles.
- Countries often introduce a combination of tax incentives to induce consumers to buy more fuel-efficient cars. It can therefore be difficult to isolate the effect from a specific tax initiative. However, in general some countries mainly impose registration taxes while others mainly impose annual taxes.
- Using registration tax it is possible to target the choice of car directly (Meerkerk *et al.* 2014). Registration taxes are more effictive compared to annual taxes (Klier and Linn, 2012).
- Annual taxes only have limited impacts on vehicle purchase (Gerlagh *et al.* 2015).
- Higher fuel taxes lead to the purchase of more fuel efficient cars, but it may have adverse effects; e.g. that larger diesel or LPG cars are bought and general impact

on vehicle purchase is much less (Gerlagh et al 2015) and moreover, that there is a rebound effect through increased use of the vehicless partly off-setting the savings in emissions per km.

- Studies on the effect of taxation of company cars are relatively limited and it is only few countries that include CO_2 emission directly in the taxation of company cars: Belgium, the Netherlands and the UK. However, in countries where the registration tax includes an element of CO_2 taxation this of course spill over on the taxation on individual company car users, but it does not influence the use of the cars.
- Scrapping schemes induce consumers to substitute to more fuel-efficient cars, but the effects are small. Scrapping schemes which target fuel efficient cars are more efficient at reducing CO_2 emissions (Lehyada and Verboten 2014, OECD/ITF 2011 and Brand et al 2013), especially when scrapping is associated with the purchase of a new fuel efficient vehicles (such as the French *Feebate*).
- Reducing taxes for small, fuel-efficient cars can lead to scale effects (i.e. more cars) and intensity-of-use effects (i.e. more kilometres per car). According to Jägerbrand et al (2014) the existence of these effects is undisputed, but its magnitude remains an issue of debate. Jägerbrand *et al.* (2014) have compared different studies estimating rebound effects. The short and long run effects vary greatly between the different studies. For the short run the rebound estimate varies between 3–87 % and for the long run the rebound estimate varies between 5–105 %.

4.1 Purchase/registration taxes

In general, studies indicate that with CO_2 differentiated registration taxes it is possible to target the choice of car directly. Several studies also find that CO_2 differentiated registration taxes are more effective compared to annual taxes (Klier and Linn 2015, and Gerlagh et al 2015).

Based on data from 2001 to 2010 for 15 EU countries Gerlagh *et al.* (2015) find that the increased CO_2 intensity in registration taxes led to a 1.3% decrease in CO2/km in new registered vehicles. However, 0.9 percentage point of this overall effect was due to an increase in the share of diesel cars (6.5% increase). An explanation for this modest effect is that the large countries with major domestic car industries (e.g. Sweden, Germany, Italy, and United Kingdom) have relatively low or no registration taxes and that these are almost independent of CO_2 intensities. The study also finds that a one percent increase in the CO_2 sensitivity of vehicle purchase taxes reduces the CO_2 intensity of the average new vehicle by 0.04 to 0.13 %. However, the effect is weaker when the diesel share is controlled for and thus implying that some of the effect goes through the change in diesel share.

Hennesy and Tol (2011) also find that differentiated CO_2 purchase and annual taxes can lead to a substitution between petrol and diesel cars. According to their study the differentiated CO_2 purchase and annual road taxes in Ireland has increase the sales of diesel cars at the expense of large petrol cars.

In France a bonus-malus scheme (a feebate)[11] was introduced in 2008. Boutin *et al.* (2013) investigates the effect the feebate has had on the purchase of new cars. Based on data from 2003 to 2009 the study finds that the introduction of the feebate did lead to a significant shift towards vehicle classes benefiting from the rebates. However, the feebate did not lead to a decrease in CO_2 emissions instead it led to an increase, as the feebate increased total car sales with 13% leading to an increase in manufacturing and traveling emissions. According to the study the main problem was that the French rebates were too generous. Consequently, Boutin *et al.* (2013) conclude that the feebate can be an efficient tool for reducing CO_2 emissions, but they should be designed carefully. Klier and Linn (2015) have also investigated the effects of the French feebate system. They find based on a simple reduced-form regression with registration data from 2005 to 2010 and elasticity of vehicle registrations to vehicle taxes of about -0.4. The study also investigates the effect on the average emissions rate. They find that the tax systems reduced the emission rate by 7.95 g CO2/km in France. It has not been possible to find similar studies for the Nordic countries, though.

Most of the studies reviewed, considered specific settings in specific countries. Many of the findings do not take into consideration differences between countries (e.g. income levels or tax levels in the base situation). Hence, results or parameters and elasticities cannot be directly transferred, but many of the qualitative findings are relevant also in other countries.

4.1.1 Purchase taxes in the Nordic countries

As described in Section 3.1.1 the level of the purchase tax varies significantly between the Nordic countries. Sweden imposes no purchase tax, while Denmark and Norway on the other hand have a very high purchase tax. The purchase tax in Finland and Iceland is relatively low compared to Denmark and Norway. In all four countries the purchase tax is differentiated according to the car size, hence the purchase tax is higher for larger cars.

The experience in the Nordic countries complies with the findings in literature, i.e. there is a clear tendency that the structure of the purchase tax influence the average car size of the vehicles in the car fleet. The car size in Denmark, where there is a very high purchase tax especially for large cars, is in general smaller compared to the other Nordic countries.

The purchase tax for diesel and petrol cars does not differ significantly in the Nordic countries. However, in all the Nordic countries electric vehicles receive a tax reduction in the registration tax. This has had a significant impact on the number of electric cars, which has increased substantially, especially in Norway, whereas the development is still rather modest in the other countries, which has the highest reduction rates for electric cars.

Similar to the experience in France with the rebate system the number of cars per inhabitants has increased considerably. In Denmark, this situation has taken place

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[11] The subsidy and tax change discretely with the emission rate. Vehicles emitting below 100 grams of CO_2 per kilometre receive a subsidy of EUR 1,000, while vehicles emitting above 250 g CO_2 /km have to pay a tax of EUR 2,600.

simultaneously with the new registration system, which was introduced in 2007 and reduced the registration tax for small and energy efficient cars to a low level. Small and efficient vehicles constitute the major part of the increase in the car fleet in Denmark.

A small rebound effect is observed in Denmark, i.e. there has been a small increase in the average mileage per vehicle. In Norway and Sweden on the other hand there is a weak tendency that the annual mileage is reduced.

4.2 Annual taxes

Several studies find that higher annual road taxes have no or only a small effect on the vehicle type choice (see Meerkerk *et al.* 2014 and Gerlagh *et al.* 2015). However, the literature is quite weak regarding possible explanations for this small effect on vehicle type choice. Two possible explanations given in the literature is that the annual taxes are not as salient from a consumer perspective compared to registration taxes (Gerlagh *et al.* 2015) and that consumers only include variable costs in vehicle choice for the first three years of use (Greene *et al.* 2013 and Gerlagh *et al.* 2015).

Klier and Linn (2015) have compared the effects of taxes on registrations and average emission rates across three countries: France, Germany and Sweden. France primarily taxes and subsidies vehicle purchases and the amount changes discretely with the vehicle's emission rate. Germany and Sweden on the other hand have registration taxes close to zero instead they impose annual taxes that increase linearly with the emission rate. Based on a simple reduced-form regression with registration data from 2005 to 2010 for each country, the study finds a large and statically significant negative short-run effect of taxes on vehicle registration for France. The baseline estimates imply an elasticity of vehicle registrations to vehicle taxes of about −0.4. Taxes also affected registrations negatively in Germany (elasticity -0.3), although the size of the effect is smaller and varies somewhat more across alternative estimation methods than the effect for France. The study also finds an effect in Sweden, but the Swedish tax reforms appear to be correlated with other market trends, making it difficult to isolate the effects of the tax reforms. Finally, the study investigates the effect on the average emissions rate. They find that the tax systems reduced the emission rate by 7.95 g CO2/km in France, 1.56 g CO2/km in Germany, and 0.57 g CO2/km in Sweden.

The paper gives three possible explanations for why the French tax system has had greater impact on car sales. One possible explanation is that the French tax is nonlinear contrary to the linear systems in Germany and Sweden. Studies have shown that consumers in vehicle markets are more responsive to tax and price changes that are more noticeable. The nonlinearity of the French system may increase its prominence and hence increase the effect from a proportional change in the tax on a vehicle's registrations. Another explanation for the difference is that consumers respond more to registration taxes than to annual taxes due to uncertainty about the future annual tax. A third possibility is that consumer preferences simply differ across countries.

4.2.1 *Annual taxes in the Nordic countries*

As described in Section 3.1.2 the annual tax varies considerable between the Nordic countries. Denmark has the highest annual tax, while Sweden has the lowest. In most of the Nordic countries diesel vehicles are taxed significantly higher compared to petrol and other fuels. The exception being Norway, where all vehicles except electric vehicles are taxed the exact same annual rate.

Regarding the differentiation of the annual tax, large vehicles are typically taxed considerably higher compared to smaller vehicles in the Nordic countries. However, despite this differentiation the annual taxes only represents a small part of the total cost related to the car even for large cars.

In the Nordic countries, no independent effect from annual taxes on the vehicle type choice can be found. As highlighted in the last section this may be due to the fact that the annual taxes are not as salient from a consumer perspective compared to registration taxes and that consumers do not take full account of the variable costs in vehicle choice (see e.g. Mulalic and Rouwendal, 2015) .

An interesting finding is that Finland has the highest share of large cars even though the registration and annual tax are higher compared to Sweden. This difference may be due to that Sweden is more urbanized compared to Finland and people who lives in cities prefer to have smaller cars. However, no studies have been made to explain this observation and we have not found any indications in the data available.

4.3 Fuel taxes

Fuel taxes affect a number of aspects related to CO_2 emissions. In the short run they affect whether to travel, distance travelled, driving behaviour and car occupancy and over a longer time-frame they affect car choice (Gross *et al.* 2009).

Brons et al, (2008) have based on different studies for USA, UK, Canada, Egypt, Australia, Denmark, Korea, Taiwan, Kuwait, Mexico, and India made a meta-analysis of the fuel price effect on car choice, car ownership and car use. Nijland *et al.* (2012) have summarized the results from the Brons et al (2008) study. Table 22 shows the results. For all the impacts, the long-term elasticities are higher than the short-term elasticities. According to the study this meta-study accounts for the regional/country differences. Hence, the results shown in the table are averages across countries, but do not specifically inform on the elasticity in a particular country.

Table 22: Short and long term elasticities of fuel taxes

	Short term (1 year)	Longer term (5 – 10 yr.)
Car possession	-0.08	-0.24
Kilometres driven per car	-0.12	-0.29
Total kilometres driven	-0.2	-0.53
Fuel efficiency	0.14	0.31
Fuel use	-0.34	-0.84

Source: Nijland et al 2012 and Brons et al, 2008.

Fuel taxes differ between countries in relation to whether the tax differentiate between diesel and petrol cars. The United Kingdom place the same tax rate on diesel and petrol cars, while e.g. the Netherlands and Belgium tax diesel fuel about 40 % less than petrol. Many other countries e.g. France, Germany and Spain tax diesel fuel 20 % less than petrol (ACEA 2016, Klier and Linn 2013).

A higher petrol tax may have adverse effects, e.g. that larger diesel or LPG cars are bought, which lead to higher NO_2 emissions. Based on data from 2001 to 2010 for 15 EU countries Gerlagh et al (2015) find that higher petrol fuel taxes tend to increase the diesel share and hence reduce the CO_2 emissions, while diesel fuel taxes tend to decrease the share of diesel cars leading to higher CO_2 emissions.

4.3.1 Fuel taxes in the Nordic countries

In Denmark and Finland, the tax on diesel fuel is 25–30% less than on petrol fuel. However, to ensure that the differentiated tax does not lead to adverse effects to buy large diesel cars, the annual taxes in Finland and Denmark are higher for diesel cars than for petrol cars.

In Sweden, on the other hand the tax rate for petrol and diesel vehicles is nearly the same. In spite of that, Sweden has the largest share of diesel vehicles of the Nordic countries. This is mainly because Sweden has no registration taxes and hence it is cheaper to buy a diesel car, as it can drive longer per mileage.

4.4 Use taxes (road pricing, tolling etc.)

Use taxes such as road pricing and tolling are mainly used to address congestion with CO_2 impacts as a derived effect. Singapore was the first country to implement an Electronic Road Pricing system in 1998. In London, Stockholm and Milan similar schemes were introduced in 2003, 2007 and 2008 respectively. The reduction in car traffic amounts to 15% to 20% in all four cities (Nijland 2012). The effect on CO_2 emissions differs across studies. ICCT (2010) report a reduction in the CO_2 emissions on 15–20 % for London and 15 % for Stockholm. Nijland (2012) on the other hand state based on a study by Kelly et al (2011) that there is no consistent evidence of improved air quality in London due to the congestion charge.

Nijland (2012) furthermore presents an overview of the effects of different congestion charging schemes based on Li and Hensher (2012). We have included their table here for easy reference. Basically the main effects are on the amount of traffic during peaks. However, the results do not reveal the final impact on CO_2 emissions, but due to the relatively large decrease in traffic reductions in CO_2 can be expected to be at the same level or slightly below due to various rebound effects (higher speeds and more traffic on orbital roads etc.).

Table 23: Effects of congestion charging schemes

Impacts of the projects	Congestion charging schemes			
	London	Stockholm	Milan	Singapore
Reduction in traffic (vehicles four or more wheels) entering the zones in charging hours	18%	Trial: 22%. After implementation 18%	14.2% (23% during morning peak hours)	40–45% (area licensing scheme) 15% electronic road charging
Reduction in cars entering the zones in charging hours	22%	N.a.	N.a.	70%
Change in traffic beyond charging hours	Observed peak traffic after charging hours in first year, normalised in the following years	Observed peak traffic after charging hours in the first year, normalised in following years	Observed peak traffic after charging hours	23%
Change in traffic round the charging zone	-5%	10%	-3.6%	N.a
Change in traffic in the inner road	4%	5%	N.a.	N.a
Increase in speed inside the charging area	30% (from 14 km/h to 18 km/h	30–50% (33% in the morning peak hours)	4%	20%
Change in speed in the inner road	N.a.	N.a.	N.a.	-20%
Increase in bus speed inside charging area	6%	N.a.	7.8% attributed to charging zone in combination with bus lanes	N.a
Increase in the use of public transport	Above 7% totally, 37% in bus passengers entering the zone	9%	6.2% totally, 9.2% in metro passengers	21%

Source: Nijland (2012).

A number of cities including Stockholm, Milan and Berlin have started to differentiate the road taxes in order to incentivise the purchase of more environmental friendly cars (ICCT 2010). Studies find that incentive-based policy can increase the demand for energy efficient vehicles (Whitehead et al 2014).

Congestion charging example: Stockholm

In 2006, congestion charges were introduced in Stockholm as a seven-month trial as well as an exemption from the congestion tax for all alternatively fuelled energy efficient vehicles e.g. vehicles running on ethanol, electricity and biogas etc. After the trial, there was a 12-month period in which neither policy was active. The government reintroduced the congestion tax and the exemption for EEV permanently in August 2007. The charging system covers an area of 34 km² with a time-differentiated toll being charged with a maximum amount per vehicle a day of 60 SEK (ICCT 2010).

Eliasson (2014) has summarised the effects of the congestion tax. According to the paper the congestion tax reduced the traffic in the charging cordon by approximately 20% and there are no signs that the effect of the charges is wearing off, instead it appears to be increasing somewhat over time. The number of vehicle kilometres driven in the inner city has decreased by around 16 %. Outside the inner city traffic volumes has decreased by just over 5 %. These effects have also remained roughly constant. The reduction in vehicle kilometres travelled have reduced emissions from traffic. The reduction has been largest in the inner city, between 8 and 15 % depending on the type of substance. The change in NO_X was the smallest with an 8.5% reduction. The overall CO_2 reduction for the entire Stockholm county was 2–3%

Whitehead *et al.* (2014) have estimated the effects of the exemption for alternatively fuelled EEV from the congestion tax. By calculating vehicle shares from the vehicle choice model and then comparing these estimates to a simulated scenario where the congestion tax exemption was inactive, the study estimates that the exemption has increased the share of newly purchased, private, exempt EEVs in Stockholm by 1.82 % to a total share of 18.8 %. However, the policy of exempting alternatively fuelled EEVs from the congestion tax was so successful that policy-makers became concerned that the congestion reduction effectiveness of the greater pricing scheme was being weakened. Consequently, the tax exemption was phased out for all new EEVs purchased from the 1st of January 2009, less than 18 months after its introduction. The policy did, however, remain valid for all existing EEVs that were already exempt until the beginning of August 2012.

4.4.1 Use taxes in the Nordic countries

Sweden and Norway are the only Nordic countries, who have introduced tolling/congestion taxes in the large cities. However, it is worth to mention, that especially the infrastructure in Stockholm and Oslo are particularly well suited for toll rings, where it is rather difficult to avoid the toll. In a city like Copenhagen a toll ring has been shown to increase traffic around the ring and moreover the CO_2 effect of a toll ring was shown only to be limited.[12]

Road pricing is quite limited in the Nordic countries. Only on a few selected highways and bridges exists where road pricing has been introduced. Furthermore, the main objective with the road pricing systems introduced is to finance the roads and reduce congestion rather than affect the CO_2 emissions.

Besides from tolling and road pricing the Nordic countries have introduced a number of incentives to induce the number of low emission cars, including reduced or free parking, reduced purchase and annual taxes as well as allowing low emission vehicles to drive in bus lanes.

As stated in the literature congestion taxes in the large cities and exemption from the congestion tax for all alternatively fuelled energy efficient vehicles can be an effective tool to reduce congestion and thereby also to some extent the CO_2 emission, although these are not in a 1:1 relation. However, if the main purpose is to reduce the CO_2 emission and not congestion it is more effective to raise the taxes on fuel than implement a tolling zone.

[12] Tetraplan (2011) Trængselsafgfiter i Hovedstaden and the Road Directorate (2012) Trængselsafgifter i hovedstaden – miljøundersøgelse.

4.5 Company cars

Company cars is a broad term including company owned cars for a variety of purposes. The most interesting is the company cars purchased by a company and made available to their employees to use for free. However, there is also a large proportion of company owned cars that are used for commercial transportation of employees in connection with their work, for instance salesmen and health care personnel or commercial transportation of passengers, taxies.

In most countries, employees are taxed for the private use of a company car based on the value of the vehicle. The treatment of fuel used during private trips by company cars is therefore an important element that can compensate for the lacking differentiation. Only a few countries include CO_2 emissions directly in determining the tax from the personal use of a company car (e.g. Belgium, the Netherlands and the UK). The value of the vehicle is still the starting point, but the CO_2 emission levels (and the fuel type) determine the percentage of that value that is added to the employee's taxable income. Denmark and Sweden also account for environmental qualities of the vehicles, but in an indirect way where the registration tax element is adjusted according to energy consumption and through this included in the taxation (Essen et al 2012).

Studies on the effects of taxation of company cars on CO_2 emissions are relatively limited. One of the latest studies on company cars is a COWI study from 2011. In the study, COWI examines the following hypothesis: All the Nordic countries subsidize company cars indirect, which increase the CO_2 emissions compared to the case, where CO_2 emissions are included in the taxation and thus leading to reductions in the driven distances.

Based on earlier studies (e.g. Copenhagen Economics 2010) and own data collection the study concludes following:

- Nordic company car schemes for passenger cars include a *subsidy* element of 10–20 per cent, which has a significant impact on the composition and use of the passenger car fleet.
- Cars purchased as company cars are typically *larger* than private cars and emit on average more CO_2 per kilometre.
- Company cars account for a *large share* of the car fleet, as 30 to 60 per cent of cars start as company cars in the Nordic countries.
- Company cars *drive more kilometres* per year than private cars as fuel and other operating costs are free or subsidised, with the result that variable driving costs are low or equal zero.
- Large *potential for change* as the company car market is a relatively sensitive market, in which amendments to the legislative framework, including society's attitudes, may influence company decisions and have a rapid impact on car choices, and thereby on the composition of the car fleet.

High private use is most often encouraged in countries where fuel use or km driven are not taken into account in calculating employee tax base: Austria, Estonia, Denmark, Finland, Germany, Hungary, Luxembourg, Portugal, Romania, Slovakia, Slovenia, and Spain (Copenhagen Economics, 2008, ACEA, 2016). In these countries, a percentage of the purchase price is the basis for calculating the benefit in kind. Though in France, Sweden and Czech Republic the tax systems do take fuel costs into account, however more intense private use does not have a significant effect on diminishing the level of subsidy. Five of the countries (Austria, Belgium, France, Netherlands, and UK) have CO_2 components in their taxation on company cars (ACEA, 2016).

4.5.1 Company cars in Nordic countries

The data on company cars in the Nordic countries is relatively limited. In order to investigate how company cars effect the car choice and the use of the company cars more detail data are needed on the share of company cars used for private transport and the share used in companies.

4.6 Scrapping schemes

Scrapping schemes are a financial incentive for vehicle owners to trade in their old vehicles for new, usually more fuel-efficient ones. Scrapping schemes are mainly introduced to support the automobile industry, reduce CO_2 emissions and to improve road safety. Generally, studies find that scrapping schemes induce consumers to substitute to more fuel-efficient cars, but the effects are small (Lehyada and Verboten 2014, OECD/ITF 2011 and Brand et al 2013).

There are typically two broad categories of scrappage schemes: (1) Cash-for-Scrappage, which is a payment offered to consumers for their vehicle regardless of how the consumer replaces the scrapped vehicle, and (2) Cash-for-Replacement, which is a payment conditional upon the consumer replacing the scrapped vehicle with a specific type of vehicle, typically, but not necessarily, a new car. Most of the scrappage schemes in Europe are designed as cash-for-replacement. Only a few schemes in Europe are designed as cash-for-scrappage (Lehyada and Verboten, 2014).

Besides, from these two broad categories the schemes can differ in relation to a number of aspects:

- Duration of the scheme.
- Available budget for the scheme.
- Maximum number of cars there can be purchased under the scheme.
- The size of the subsidy.
- Age of targeted vehicles.
- Class of targeted vehicles.

- Complexity of the schemes (same incentive for all new car purchased or system of subsidies depending on the type of vehicle).

During the financial crisis, many European countries introduced temporary scrapping schemes to foster car purchases. Also the US and Japan introduced scrapping programs. Studies find that the main effect of the scrapping schemes introduced around 2009 were to temporarily stabilize total car sales, while their impact on the demand for fuel-efficient cars and related environmental benefits in the form of improved fuel economy were very limited.

Lehyada and Verboten (2014) use a country difference-in-differences approach based on a data set of all car models sold in nine European countries, observed at a monthly level during 2005–2011 to estimate the impact of the different European scrapping programs on car sales. Based on the model they find that the scrappage schemes increased the car sales considerably, however the effects on fuel-efficiency was limited. In countries with targeted schemes[13] for low emission vehicles, average fuel consumption would have been 1.3 % higher while in countries non-targeted schemes, average fuel consumption of new cars would have been only 0.5 % higher in the absence of the schemes. An additional aspect, which has not been included in the assessment by Lehyda and Verboten is the life-cycle aspect, where also the production of vehicles and fuels should be included. This would increase due to the forced or earlier replacement of cars and thus make scrapping schemes less attractive.

OECD and ITF (2011) investigates the fleet renewal schemes implemented in the United States (CARS program), Germany (Umweltprämie) and in France (Prime à la Casse) in 2009 effectiveness in reducing CO_2 and NO_2 emissions. These three schemes were selected because they each display different designs and they have enough detailed data to undertake disaggregated analysis. Consistent with Lehyada and Verboten (2014) the study finds that the effect on CO_2 emissions were limited. Based on the analysis the study highlights some important aspects of the scheme design. First of all, schemes seeking principally to reduce CO_2 emissions or improve fleet wide fuel economy should target more recent vehicles. This is because newer cars would accumulate much higher mileage over their remaining life if they were not scrapped than older vehicles and this factor outweighs the per-kilometre emissions of older vehicles. Secondly, is it important to control for the type of replacement vehicle chosen in the fleet renewal scheme. For instance, the French scheme imposed a CO_2 limit for new cars, which led to a very high share of diesel cars with associated consequences for PM10 and NOX emissions. Finally, the study stresses the need to design schemes that target older vehicles that are still in use, as retiring vehicles that are not used provides no benefit.

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[13]Targeted schemes put conditions on a new vehicle that can be purchased, in terms of maximum CO_2 emissions, engine displacement, or price.

4.6.1 *Scrapping schemes in the Nordic countries*

Most of the Nordic countries have introduced scrapping schemes (temporarily) to ensure that vehicles are scrapped in an environmentally friendly manner. However, the scrapping premiums are relatively low. In Denmark, for instance the car owner only receives EUR 200 in compensation, when he scraps his car. This amount does not cover the total cost associated with scrapping, hence the scheme does not affect when people choose to scrap their car.

By linking, the scrapping schemes to the purchase or lease of a new vehicle, which is more energy efficient, the CO_2 emissions could be slightly reduced according to the findings in the literature. However, it is important that the scrapping scheme targets vehicles still in use and ensure that the scrapped vehicles are replaced by energy efficient vehicles. Moreover, as has been observed in the French feebate system, the compensation can be too generous and thus lead to purchase of too large cars and too high energy consumption in the new cars.

4.7 Other incentives

In addition to the above discussed national schemes, also local taxes and/or subsidies may play a role for the choice of vehicle and the use of vehicles. These include toll rings as already discussed and parking fees.

To use the scarce space in the inner city efficiently and to improve urban quality, most European cities have a scheme of parking fees in their (inner) cities. A variety of different schemes exists, such as with or without free parking for electric vehicles, and reduced tariffs for inhabitants or handicapped (Nijland, 2012). Reducing access to parking give car drivers an incentive to choose alternative modes of transportation especially in congested urban areas, whereas it is of limited use outside inner urban areas.

Hence, parking fees is mainly assisting in reducing congestion, but of course also to reduce the number of kilometres driven. However, it is also found that reducing number of parking areas may lead to unnecessary driving in search for a parking lot. We have not investigated the issue further, but only mention that using parking fees may be a complementary measure supporting e.g. introduction of alternative fuel vehicles (such as in Norway and Sweden, where electric vehicles can park for free).

Another support that is seen both nationally and at EU level is the installation of high-power charging stations across the EU. A European network is set up to remove the range anxiety that many people have with respect to electric vehicles. Similarly many demonstration projects and other projects aiming at making people aware of the green alternatives in transportation have influence on the development in CO_2 emissions and other emissions.

In e.g. the USA there are so-called HOV schemes introduced on some motorways. The concept is that high occupancy vehicles are allowed to use separate lanes on the motorways, which therefore can reduce travel time. This scheme facilitate not only a reduction in congestion, but also reduces the amount of kilometres driven.

In Norway a similar approach has been introduced, but where the access to the bus lanes is possible for electric vehicles. This scheme provides the car buyers and user with incentives to buy and use CO_2 friendly vehicles.

The impact of these HOV or bus lane access schemes on car choice is not known, but it do support the choice together with other incentives.

5. Conclusions and recommendations

Based on the above analyses, we have selected a few topics, where we see a specific potential in the Nordic countries. In this chapter we outline why these are interesting and try to show what the implications can be for the Nordic countries. The recommendations complement the previous reports and most of the earlier recommendations remain relevant.

5.1 Company cars are problematic

Company cars were also a main topic in the previous report from 2011, but despite the awareness that there is a potential to support CO_2 reductions, as we have shown in the report not much has happened to change regulation in the Nordic countries.

The reason why company cars are interesting is twofold. First of all, the company cars are a special way for the cars to enter the car fleet. The prices and incentives for the companies may vary from private car purchasers. In some cases, the companies may weigh comfort and reliability higher than the car price in order to secure their employees are satisfied with the car they use in their daily work. After serving some years as company cars, these cars are sold to private persons and will live the rest of their life as private cars. Since the company cars are sometimes bigger than typical private cars, this means that there is an over-supply of bigger cars relative to the needs of the private car users. Thus it may be considered if the CO_2 incentive in the taxation of company cars is sufficiently strong keeping in mind that many of these cars will be used most of the time they are in use as private cars.

The other issue relates to the private use of company cars. In most cases the employee private use of the company car is free in the sense that the cost (or tax value) of the employee does not depend on the mileage driven. Only in Finland there is a correlation between the employee cost and the mileage driven since the cost is increased if the mileage exceed 18,000 km annually. A similar element was also part of the Swedish company car taxation earlier, but has been removed since (ACEA, 2016).

Including a stricter km based cost for the user would reduce the mileage of company cars and thereby also reduce the CO_2 emissions from this segment of vehicles. Even better, a stronger incentive would be to link the user taxation to fuel use – e.g. by accounting for the fuel purchased by the user (using a company credit card or fuel card) similar to the system used in e.g. France or the Netherlands.

When considering the choice of the CO_2 element in the private use of company cars, it will be necessary to understand how it can be included in the company taxation with the specific taxation used in each country. Moreover, as part of this an analysis of the impact of the choice of instrument would also be needed to set, the right level of tax.

5.2 CO_2 differentiation of taxes

The findings in the literature as well as the development in the Nordic countries show that differentiated taxes have a positive effect on the share of energy efficient vehicles.

One of the most effective methods to increase the share of low emission cars is to differentiate the tax according to fuel consumption or the emission of CO_2 per mileage. There should be a clear breakpoint between the energy efficient vehicles and the less efficient vehicles, similarly to the system for registration taxes in Denmark and France:

- In Denmark, the registration tax for vehicles increases with DKK 1,000 for each kilometre the vehicle runs below 16 km/l for petrol cars and 18 km/l for diesel cars, while the registration tax is reduced with DKK 4,000 for each kilometre that the vehicle runs over these thresholds.
- In France, the registration tax change discretely with the emission rate. Vehicles emitting below 100 grams of CO_2 per kilometre receive a subsidy of EUR 1,000, while vehicles emitting above 250 g CO_2 /km have to pay a tax of EUR 2,600.

It is important to take the technological development in the car industry into account when determining the threshold value. If the threshold value is too low, it may give people an incentive to buy more cars and drive more, which will have negative effect on the CO_2 emissions. On the other hand a too high threshold value, it may be too preventive in the choice of cars. The feebate system in France, where a generous subsidy to the purchase of a new car is paid if an old car is discarded (scrapped). This has led to a too large number of cars being bought and also that larger cars were bought with higher CO_2 emissions compared to the cars scrapped.

The effect of a CO_2 differentiated purchase tax scheme may decline over time as e.g. the energy efficiency of new cars is improving as has been the case in all Nordic countries (Figure 21). This means that fixed levels of discounts in the purchase tax related to the CO_2 emissions will have less and less impact, since all cars can satisfy the requirements set up. So for a continuing effect and pressure on the choice of CO_2 friendly cars to continue the reduction in CO_2 intensity in the cars sold, the required CO_2 levels must be adjusted.

5.3 Incentives to further introduction of alternative fuelled cars

The literature review has shown us that the interest in alternatively fuelled cars is high interest in many countries. The CO_2 differentiated taxes of various types already mentioned all make alternatively fuelled cars cheaper. However, there are a number of incentives directly aimed at alternatively fuelled cars.

In the EU, there is a particular focus on alternative fuels in the regulation. Renewable fuels for example entitle to not only contributing to the CO_2 targets, but moreover also specifically contribute to the fulfilment of the Renewable fuels Directive (RED), where Member States must meet a 10% share of renewable transport fuels. Hence, using wind powered electric vehicles support the achievement of this target; also biogas can contribute to both CO_2 and RED targets.

The additional or specific taxes aimed at supporting introduction of alternatively fuelled vehicles are:

- Tax exemptions (purchase tax, annual tax.
- VAT exemptions.
- Subsidies to purchase of new vehicles.
- Exemption from road tolling.
- Exemption of parking fees.
- Accessibility to high occupancy vehicle lanes (e.g. bus lanes, lanes for vehicles with more than 2 passengers).
- Free charging.

One or more of these incentives are already present in the Nordic countries in various forms. Some of the incentives only apply to certain types of alternative vehicles, where electric vehicles in all Nordic countries are the subject of at least two of these incentives in each country.

5.3.1 Purchase tax

Especially the exemption of purchase tax is an effective instrument in countries with relatively high tax rates (e.g. Denmark and Norway), but even in countries with lower tax rates the exemption is a strong support in the purchase situation.

Norway has introduced most of the mentioned incentives for electric vehicles and hybrid vehicles and as a result the number of electric vehicles is very high. Also Denmark has a relatively high share of electric vehicles, which is also a consequence of the large reduction in purchase tax. However, the sales have dropped significantly in 2016 (from 4500 new electric vehicles in 2015 to 653 new electric vehicles in the first nine months in 2016) due to a reduction in the tax exemption (from 100% to 80% of the tax can be deducted with a continuous decline to 0% in 2019). This further supports that the tax exemption is an important instrument.

The purchase tax has the advantage that it is:

- a significant amount.
- that it is paid as a one off tax, which therefore is having a higher influence on the car choice in the purchase situation compared to e.g. fuel taxes or annual taxes, which are small amounts to be paid in many years into the future.

Not all alternative fuelled vehicles will in the short run lead to CO_2 reductions. For example car running on natural gas will only lead to rather small CO_2 reductions and natural gas is a fossil fuel, this is because the engine efficiency of the gas fuelled vehicle is lower than a comparable diesel or petrol car. Also considering other emissions there is only a marginal effect. With a further infusion of biogas the CO_2 potential could become very significant.

The markets for alternatively fuelled cars is not yet mature. In recent years and in the coming years many car manufacturers are introducing alternatively fuelled vehicles to the market. Presently most of these cars remain relatively expensive, even with the significant tax exemptions found in many countries. Hence, there may thus be a need to continue the support through the tax system to give incentives for the purchase of e.g. electric or hybrid vehicles.[14]

The results found in the literature supports the success also of introducing exemptions in many of the fees, taxes or charges that must be paid in transport (road user charges, parking fees, taxes on vehicles). It has been demonstrated that the exemption from e.g. the road user charges in Sweden has led to an increased purchase of cars falling under the "Supermiljöbil" group, which do not have to pay the charge. A similar impact may be found in Norway, where there are many simultaneous incentives working, which makes it hard to tell the effect of each instrument by itself.

Hence, there is no doubt that the tax exemptions and the other supporting measures do influence the choice of alternative fuelled cars. What remains to be clarified, is the balance between how strong the introduced incentives need to be in order to obtain a desired effect. Indications can be seen by comparing Norway with Denmark. Both countries have significant car registration taxes for conventional cars, but in Norway electric vehicles are exempted from both this tax and VAT (25%). The sales of electric vehicles in Norway is ten times higher than in Denmark in 2014 (Table 15), but this has happened with a very large difference in the economic incentive. Hence, the costs of introducing the supporting measures is a factor that must be considered.[15] TØI (2016) however, report that many of the electric vehicles are small vehicles, which also in a comparable ICE version (or size) would be almost free of purchase taxes due to the way the tax is composed. Hence, this reduces the costs of using this instrument.[16]

[14] See for example COWI (2015), State of the art, alternative transport fuels. Report prepared for DG MOVE and the Expert Group for Future Transport Fuels.

[15] Which it also is in all countries. In Norway some critique against the exemption is that it is mainly a subsidy for those being able to buy the very large an expensive Tesla, which is a choice not made for CO_2 reasons, but mainly because it is a luxury car.

[16] TØI (2016) has calculated a total cost of 200 million NOK of this policy given that the tax regime has a point of reference is a tax regime in which low and zero emission vehicles already enjoy very much lower tax rates.

5.4 A variety of measures are necessary

In order to present a strong incentive for car buyers and users to choose CO_2 friendly vehicles and too reduce the use of these vehicles, a variety of measures are needed. As shown in the reviewed literature some of the measures are more effective in influencing the car purchase (especially registration taxes, but road user charges may also play a role), than other (e.g. the annual tax).

In the choice of incentives it is relevant to consider a range of measures to support the reduction of CO_2 emissions. The choices of measures should work together rather than work against each other, since this may lead to no effect or in some cases even increases in CO_2 emissions. The study by Fosgerau and Jensen (2013)[17] showed that introducing road user charges aimed at reducing the mileage, but if combined with a reduction in the registration tax could in fact lead to increases in CO_2 emissions although the scheme may lead to welfare gains. The savings in purchase costs are used to buy larger cars and drive more in the cars.

The example from Norway on the number of measures supporting electric cars is a good example on how applying many incentives at the same time have significant impact on the choice travellers make.

We have in this report not considered economic incentives supporting changes in transport mode and supporting use of public transport. However, such measures obviously also play an important role in reducing the CO_2 emissions from the transport sector. However, the elasticities on choice of public transport due to changes in e.g. ticket prices or increases in fuel use are very small. The measures supporting public transport is thus another example of incentives that should be complemented by other measures and incentives in order to be effective.

Considering the incentives related to the use of cars, a road user charging can be designed such that CO_2 friendly vehicles will pay a lower charge compared to less friendly cars. This is already seen in the schemes where electric cars are exempted from paying the charges. The same type of approach is used also in the road user charges for heavy duty vehicles, where Euro V and Euro VI vehicles pay lower charges compared to older less environmentally friendly Euro I-IV vehicles.

However, exemptions or reductions in the charges paid have a negative side-effect on one of the main objectives of road user charges, which is reducing congestion (road user charges are often called congestion charges for the same reason). Hence, if the main objective is only on reducing CO_2, using fuel taxes is more effective, since it directly influence the choice. This is also found in the literature (Section 4.3).

In relation to fuel taxes another issue must also be mentioned. The difference in taxing diesel and petrol. The CO_2 emissions are smaller in diesel cars compared to petrol cars. Diesel is also taxed less in many countries, but not in e.g. Sweden. Nevertheless, the number of diesel cars in Sweden is high. On the other hand, diesel has other negative effects such as local pollutants being higher than petrol cars.

[17] M. Fosgerau and T.C. Jensen (2013) A green reform is not always green. Transportation Research. Part C: Emerging Technologies, 30, 210–220.

Changing the tax on diesel may however, lead to other non-wanted side effects such as an increase in small petrol cars and more driving being undertaken – obviously depending on how the changes are made.

5.5 Some areas where more knowledge is needed

The literature review has identified a number of theoretical contributions to the understanding of specific types of economic incentives as well as several empirical studies covering single countries or as meta studies across more countries. It is however, only in relatively few cases that specific parameters and magnitudes of impacts have been analysed. Some of the studies proved a general overview across countries on the importance of taxes on the CO_2 intensity. These studies do not take into account the specific conditions present in any individual country. For example the present level of vehicle taxes (the combination of taxes of various types and magnitudes) or the income level differences. The literature is therefore difficult to transfer from one case to another without careful interpretation.

Hence, knowledge about the specific impact of a particular type of tax must be viewed in more detail to be able to give better indications of the impact of this tax. It is for example important to know the current price and tax level of not only the tax considered, the vehicles and fuels, but also the income levels in the country and general price levels in order to show control for the purchase ability of the potential car buyers.

Some taxes include elements of discounts when e.g. the energy consumption is better than a certain number (in Denmark it is for example 16 km/l for a gasoline car). The particular point where a discount is introduced and the size of the discount must also be taken into account. We lack knowledge about the impact of changing the threshold where discounts are obtained and the impact of increasing the size of the discount.

So overall, we need more knowledge about the specific taxes and impacts in the given conditions existing in each country. This can be accommodated by a general analytical model, but it is necessary that such a model includes the factors mentioned here. The study by Gerlach et al (2013), which has been mentioned several times in this report, has looked at the average impact of the different types of taxing schemes on the CO_2 intensity in car purchase. The study is a cross section analysis and therefore does not reveal the impact of these more specific differences.

The strong element in the study by Gerlach *et al.* is that it combines the different types of taxes within the same model, and by this are able to control for the joint impacts of different taxes.

An open question that remains to be understood is to understand the impact of the individual taxes in the specific settings we find in the Nordic countries on the one hand, and on the other hand we also need to understand how the individual taxes jointly influences the purchase decision as well as the vehicle use.

The trade-off between fixed costs (and taxes) and use related taxes remains uncertain in many aspects. Analysis in Denmark have looked at a budget neutral change from registration taxes to use taxes (distance based road charging) and reached the conclusion that such a reform of the taxing system may not necessarily be environmentally friendly.[18] Studies like this with analysis of the effects of proposed combinations of taxes using the characteristics of the Nordic countries will as mentioned be of high value.

The knowledge about the purchasing behaviour with respect to alternative fuels remains rather limited. Which incentives that are the main drivers for the individual choices have been investigated (as also mentioned in Section 5), but the data basis for the analysis has often been limited. This is also related to the still limited supply of alternatives in the market. However, in recent years more and more alternative fuel vehicles are offered to the market and this will also open this market. The analysis of this can be carried out as cross-section analysis looking at differences between countries taking into account the different incentives introduced (see also the discussion in the previous section).

A particular interesting topic, where knowledge is very limited is the regulation of company cars. As we have discussed in this report, the information about company cars and their use is very limited. Therefore, the knowledge about how the regulation on company cars will in general influence the choice of car, the CO_2 intensity and the use of company cars is not very well established. As we have shown, company cars are a large share of new cars in all the counties. Hence, influencing the choice of company car will play an important role in the composition of the car fleet in general. We therefore recommend that this topic is analysed. Specific data collection to establish the actual use of company cars (as registered in the different countries) on private use, as a working vehicle or for lease out. An analysis on how a further regulation of the use of the company cars may influence both choice of vehicle and the use is essential for designing incentives leading to CO_2 reductions in this segment of cars.

Given that the aim is to reduce the CO_2 emissions, the focus on new data collection and surveys should focus on the large company cars, both company cars owned by companies and used for commercial purposes and company cars owned by companies and used for private transport purposes. The survey should shed light over two important questions:

1. How does the car prices and other incentives influence companies' choice of their vehicles for commercial use.
2. How does the price signal (the personal tax increase) influence the private user of the company cars.

[18] Fosgerau, M; Jensen, T. C.. A green reform is not always green. In: Transportation Research. Part C: Emerging Technologies, Vol. 30, 05.2013, p. 210–220.

Finally, it is important to continuously monitor the development in the car sales and the choices users make in this decision. The availability of new technologies may have impacts on how an economic incentive is working. Hence, it remains relevant to follow up on these impacts and try to understand what is driving the changes that can be observed. The present report has made some steps in this direction by updating the development in CO_2 intensity in the Nordic countries as well as a number of other variables.

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Sammenfatning

De nordiske lande har forskellige strukturerer til beskatning af personbiler. I Sverige er der f.eks. ikke nogen registreringsafgift, mens Norge og Danmark har nogle af de største afgifter i Europa. Disse forskelle har betydning for bilkøbernes valg af bil og derfor også for størrelsen af CO_2 emissionerne fra transportsektoren.

Nordisk Ministerråds Miljø- og økonomigruppe fik i 2008 gennemført projektet *Traffic Charges and Climate Impact*, der indeholdte en gennemgang af beskatningen mht. lastbiler og personbiler samt en oversigt over en række nøglekarakteristika indenfor transport og køretøjsflåderne i de nordiske lande. Oversigten viste, at der var store forskelle mellem de nordiske lande både mht. de anvendte skatter og afgifter og i sammensætningen såvel so mi anvendelsen af bilflåderne; dermed var der også forskelle i virkningen for CO_2 emissionerne. Studiet blev fulgt op i 2011 med endnu en oversigt og en status for CO_2 emissionernes sammensætning i bilparken.

For at få en bedre forståelse af disse forskelle og for at lære mere om de muligheder der måtte være for at reducere CO_2 emissionerne, har Nordisk Ministerråd bedt COWI om at gennemføre et nyt studie af personbilernes CO_2 emissioner. Denne rapport beskriver resultaterne af dette nye studie og kan ydermere opfattes som en opdatering og fortsættelse af de tidligere rapporter fra 2008 og 2011.

Udviklingen i personbilflåderne og deres CO_2 intensiteter er fastlagt med udgangspunkt i indsamlet statistik for hver af de fem nordiske lande. Der er et antal forskelle i bilflåderne, der går det nødvendigt at antage nogle forhold om hvad en standard personbil er. Dette har været nødvendigt for at kunne sammenligne mellem de enkelte lande. Men målet med denne rapport har dog først og fremmest været at undersøge ændringerne i CO_2 intensiteten i bilflåderne og forstå, hvordan disse er opstået.

De indsamlede data kan ikke vise alle detaljer og forskelle. Dermed er det heller ikke muligt at forstå alle de ændringer, der er sket i de senere år. Det er ydermere svært at koble ændringerne sammen med de forskellige skatte og afgiftssystemer eller sammen med de økonomiske incitamenter, der findes i de enkelte lande. Alle landene har der i de seneste ti år været gennemført forskellige ændringer i incitamenterne.

Det har vist sig, at det er svært at skelne mellem effekter af de økonomiske instrumenter, idet mange forskellige instrumenter anvendes samtidigt. Grundlaget for at forstå sammenhængene er derfor også blevet søgt gennem international litteratur. Overordnet set er litteraturen ret enig om de forskellige instrumenters betydning, dog primært om, hvilken type af effekt et instrument har og i mindre grad om størrelsesordenen af effekterne. De fleste af de internationale kilder betragter ser på variationer mellem lande og mellem instrumenterne, men giver ikke konkret elasticiteter. Derudover er der variation i de grundlæggende forhold såvel som de specifikke parametre i de enkelte lande. Dette er der typisk ikke kontrolleret for i de studier, der er gennemgået. For eksempel når man ser på de høje afgifter i Norge og Danmark eller ser på forskelle i indkomst niveauerne i de nordiske lande i sammenligning med de fleste andre lande. Dette er ting, der bør tages hensyn til, når effekter af forskellige instrumenter skal forsøges fastlagt.

CO_2 intensiteten i de nordiske lande er generelt faldende. Der udledes mindre CO_2 per kørt kilometer, Dette skyldes en lavere CO_2 intensitet i de nye biler, der sælges i alle landende. Der er en stærk nedadgående trend i hele perioden, der har været set på. I Norge skyldes en stor del af udviklingen den stadigt stigende andel af elbiler, der nyregistreres.

Men tager man også hensyn til brugen af bilerne og anvendelsen af de ældre biler, er reduktionen i CO_2 mindre udtalt. I Norge ser det endda ud til at CO_2 udledningen er svagt stigende på trods af tilgangen af de helt CO_2 frie elbiler. Der er indikationer af, at det er en kombination af stadig større ældre biler, der benyttes til længere og længere ture, som er årsagen til stigningen.

Andelen af dieselbiler er relativt høj i de nordiske lande. Der er dog observeret en ændring i andelen af dieselbiler i bilsalget set over de seneste ti år. Tendenser er, at Danmark, Norge og Finland har oplevet markante fald i andelen af solgte dieselbiler, mens Sverige lader til at have stigende andele af nye dieselbiler. I Island svinger antallet af nye dieselbiler omkring 50 %. Forskellene kan måske henledes til nogle de ændringer, der er sket i bilbeskatningen. F.eks. i Danmark har ændringerne i afgifterne betydet, at de helt små benzinbiler er blevet så billige, at de kan konkurrere med de små dieselbiler. Der er med andre ord kommet et stort antal af disse minibiler på markedet.

Som nævnt for Norge, bidrager indfasningen af elbiler også til reduktionen i CO_2 intensiteten i nybilsalget. Det gælder i særlig grad det norske marked, hvor afgifterne har været særligt favorable for elbiler med fritagelserne fra både registreringsafgiften og moms. Derudover er der en række andre incitamenter, der fremme salget af elbiler. I Norge er andelen af elbiler i nybilsalget tæt på 20 %. Men også de andre nordiske lande har haft et stigende antal elbiler de senere år. I Danmark har ændringerne i afgifterne på elbiler siden 2015 dog sat en bremse i udviklingen og der er i 2016 registreret ¼ af antallet af nye elbiler sammenlignet med 2015.

En del af resultaterne og de efterfølgende anbefalinger, der nås frem til i rapporten minder om tidligere anbefalinger og resultater. De udviklingstendenser, der blev observeret i 2011 er fortsat i årene efter. Den måske væsentligste forskel er det stigende antal biler med alternative brændstoffer (elbiler og hybridbiler som de mest markante af disse).

De nordiske lande har i de seneste fem år introduceret flere incitamenter til at understørre CO_2 reduktioner. De fleste af disse har do været relateret til anskaffelsen af bilerne. F.eks. afgifts og momsfritagelserne på køb af nye biler. Men et andet instrument, der også kan have betydning er inddragelsen af et CO_2 element i beskatningen af firmabiler som det er set i Finland. Dette er et eksempel på den type af incitamenter, der tales meget om i litteraturen, hvor fokus er på incitamenter, der retter sig mod brugeradfærden som man gerne vil påvirke.

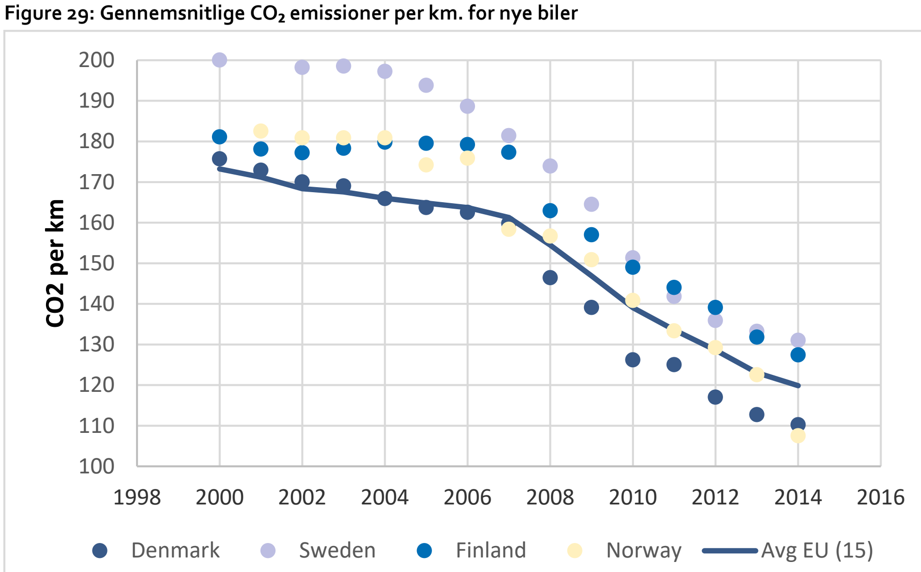
CO_2 intensiteterne i nybilsalget er i hele Europa nedadgående. Dette drives bl.a. af afgifter, der understøtter reduktion i anvendelsen af bilerne, anskaffelse af mere energivenlige køretøjer gennem bl.a. differentierede registreringsafgifter, men også EU's krav om reduktioner i de gennemsnitlige CO_2 udledninger fra nye biler har haft en væsentlig betydning for denne udvikling. En del af udviklingen skal derfor findes i teknologiudviklinger og i den internationale regulering af bilerne. Litteraturen viser dog også, at ændringerne i afgifterne i Norge (2006), Danmark (2007) og i Finland (2007/8) klart har medvirket til den positive udvikling. Sverige har ligeledes gennemført en række ændringer, der har understøttet introduktionen af mere energi- og klimavenlige køretøjer ("Supermiljöbil" programmet).

Den fortsatte forbedring af den svenske lovgivning gennem de seneste tyve år er et eksempel til efterfølgelse. Godt nok er der ingen afgift på nye biler, men de forskellige støtteordninger, fritagelse for bompenge, tilskud til anskaffelsen af biler mv. samt det, at der kontinuert kommer nye ting til, er med til at holde fokus blandt forbrugerne på, at de skal vælge mere klimavenligt, når nye biler anskaffes.

Danmark og Norge har fortsat den mest CO_2 effektive bilflåder. I Norge skyldes som nævnt primært antallet af nye elbiler, mens det i Danmark skyldes væksten i de meget små biler med et lavt energiforbrug. Der er med andre ord kommet en større bilflåde og derfor køres også mere end tidligere. Det har dog ikke kunnet off-sette den positive trend i CO_2 udledningerne.

Trendene i de nordiske lande sammenlignes i figuren nedenfor med det Europæiske gennemsnit.

Figure 29: Gennemsnitlige CO_2 emissioner per km. for nye biler



Source: Eurostat, Statistical Pocketbook.

På baggrund af analyserne af CO_2 udviklingen og intensiteten i de nordiske lande, de anvendte økonomiske instrumenter, der anvendes og en gennemgang af litteraturen, gives i rapporten følgende anbefalinger:

- Beskatningen af firmabiler skal i større grad gøres CO_2 afhængig. Dette bør ske ved dels at lægge en større del af afgiften på i forhold til CO_2 emissionerne i registreringsafgiften og dels ved at beskatte brugen af firmabilen til privatbrug ud fra hvor meget bilen køres privat kørsel.
- Den CO_2 afhængige del af skatter og afgifter på personbilerne skal øges. Differentieringen mellem biler med lav og biler med høj CO_2 udledning skal gøres større.
- Afgiftsniveauer og grænserne for, hvornår CO_2 afgifter pålægges bilerne skal løbende tilpasse den teknologiske udvikling, så incitamenterne til fortsat at vælge de mest energieffektive og CO_2 venlige biler bevares.
- Fastholde og udbygge de økonomiske incitamenter til at købe alternative drivmiddel biler (elbiler, hybridbiler og biler, der kan køre på de nyeste biobrændstoffer). – f.eks. afgifts- og momsfritagelse, fri parkering, ingen bompengebetaling osv.
- Anvende den rette kombination af virkemidler, så effekterne ikke modvirker hinanden. Eksempelvis reduktionen i afgift for meget små (energieffektive) biler, der har ledt til en stor stigning i antallet af små benzinbiler.

Udover disse anbefalinger er der nogle områder, hvor viden stadig ikke er tilstrækkelig. F.eks. er viden om effekten af det enkelte virkemiddel i sammenhæng med andre virkemidler ikke særligt godt fastlagt.

Der er også behov for at forstå, hvordan knækpunkter i afgifterne skal fastsættes og tilpasses teknologien, så den rette sammensætning af bilparken opnås.

Der er behov for at få lavet tilpassede studier, der ser på anvendelsen af de økonomiske instrumenter i en nordisk kontekst, hvor der tages hensyn til indkomst og sammensætningen af befolkningen, kørselsbehovene og den eksisterende bilpark.

Endelig er viden om, hvordan firmabiler kan og skal beskattes begrænset. Særligt er datagrundlaget her meget dårligt, så det er svært at adskille, hvordan de firmaregistrerede biler anvendes (leasingfirmaer, arbejdskøretøjer eller biler, der anvendes til privat brug).

Appendix

Figure 30: Data template

a. Data for car taxation

Country: ________________

Please describe the following passenger car tax elements for your country. The description should include how the tax is calculated, tax base, levels, exceptions etc.

i. Purchase tax

ii. Annual tax

iii. Subsidies and exceptions for specific cars

[e.g. tax deductions for electric vehicles, free parking for electric vehicles, permission for electric vehicles to use bus lane etc.]

iv. Company car tax schemes

v. Fuel prices and taxes

vi. Road taxes etc.

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CO_2 emissions and economic incentives

The CO_2 emissions from passenger cars is declining. Some changes are due to ever improved technology provided by car manufacturers and others induced by political regulation.

The report investigates the recent changes in CO_2 intensity in the car fleets in the Nordic countries. The trends in the car sales are presented and the impacts on overall CO_2 intensity are outlined.

All Nordic countries have in the past ten years changed the national regulation of passenger cars through different economic incentives and various schemes making low emissions vehicles more favourable. The report describes these changes and complement with an overview of international empirical findings concerning the main tax instruments (purchase-, annual-, fuel tax and road user charges). The potential impact of these taxes are reviewed and recommendations for future uses of the various instruments are provided.

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