Institute of Transport Economics
Norwegian Centre for Transport Research

Summary:

Norway's path to sustainable transport

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Edited by Lasse Fridstrøm and Knut H. Alfsen
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Thanks to the substantial purchase tax levied on new passenger cars, the Norwegian government has a quite powerful climate policy instrument at its hand. Continued application of this instrument may halve the greenhouse gas emissions from Norwegian cars within two or three decades. On account of the higher energy efficiency of electric motors compared to internal combustion engines, the total energy consumption of the Norwegian car fleet may decrease considerably, to the profit of society in general and consumers in particular. Six per cent of Norway's hydropower output would be sufficient to operate the entire passenger car fleet, if completely electrified.

Public transport has an indispensable role to play in the daily life of urban citizens, but a fairly modest potential for greenhouse gas abatement. Even very ambitious packages combining reduced fares with improved level-of-service fail to achieve more than a few percentage points' reduction in CO_2 emissions from travel.

Improving the road network so as to allow for substantially higher speed will increase emission in the short as well as in the long run. Cars become more competitive, and as they speed, per kilometre emissions go up.

Earmarking the environmental tax will enhance its public acceptability, and so will increased faith in the fairness and effectiveness of the tax measure.

Efficient corridors for freight trains may substantially enhance the competitive edge and market share of the rail mode. As transports are transferred from road to rail, greenhouse gas emissions are cut to a fraction.

It appears doubtful whether the mechanisms for achieving climate policy goals carry sufficient weight when meeting with conflicting goals and considerations. A proposal to introduce a climate change act, to enforce and monitor greenhouse gas abatement policies, is pending in the Norwegian Parliament.

Greenhouse gas emissions from Norwegian transport

In 2012, mobile sources in Norway emitted an estimated 17.4 million tonnes of CO_2 equivalents of greenhouse gases (GHG) covered by the Kyoto protocol. The emissions from transport proper, i. e. excluding fisheries and machinery, amounted to 13.8 million tCO_2e, corresponding to 26.2 per cent of all GHG emissions from Norwegian territory.

Between 1990 and 2012, transport emissions rose by 27 per cent (Figure E.1). Emissions from passenger cars, representing 10.6 of the 26.2 per cent due to transport in 2012, rose by 6.6 per cent from 1990 to 2012. Since 2007, however, no increase seems to have occurred, neither from transport in general nor from passenger cars in particular.

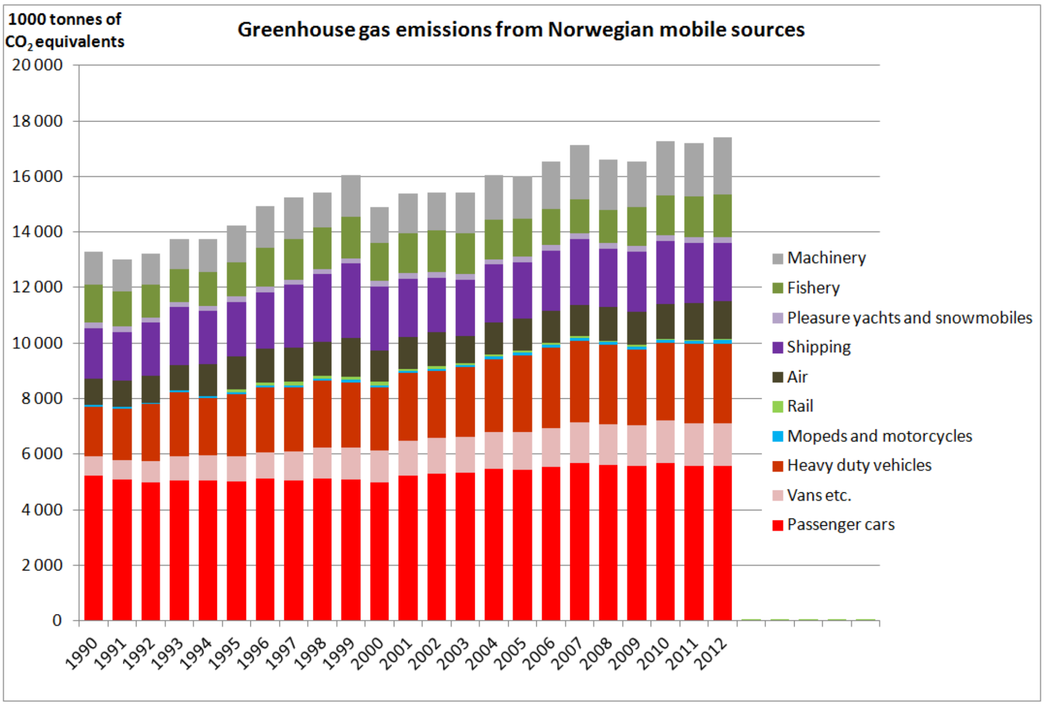

Figure E.1: Greenhouse gas emissions from mobile sources in Norway 1990-2012. Source: Statistics Norway.

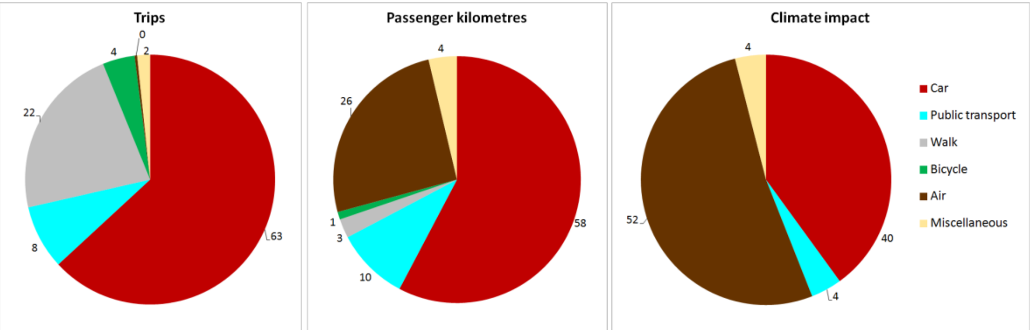

Figure E.2: Norwegians' travel behaviour at home and abroad in 2009, and its climate impact. Per cent of total. Source: Aamaas (2013a).

Aviation accounts for 9.7 per cent of Kyoto protocol emissions in domestic transport. If, however, we take into account all emissions with a climate impact, including contrails and cirrus formation, and include the emissions due to Norwegians' travelling abroad, the picture becomes quite different. From Figure E.2 we note that aviation accounts for more than half the climate impact, while passenger cars represent 40 per cent.

To identify and assess the most efficient policy measures for greenhouse gas abatement in the Norwegian transport sector, a number of relevant instruments and issues have been investigated. These include fuel and vehicle taxation, road tolls, public transport fares and level-of-service, public acceptability of environmental taxes, aviation taxes, improved road infrastructure, rail ports and corridors for freight, as well as policy integration including climate legislation.

Fuel and vehicle taxation

In Norway, passenger cars are more heavily taxed than in most other countries. Automobile ownership and use are subject to (a) fuel tax, (b) vehicle purchase tax, (c) annual registration tax, (d) road toll, (e) scrap deposit tax, and (f) income tax on company cars. In terms of revenue, (a) and (b) are by far the more important. They each bring around € 2.5 billion per annum into the public treasury, or about € 500 per capita.

In general, the purchase tax is made up by four components, one depending on the vehicle's curb weight (kg), a second depending on the combustion[1] engine's power (kW), a third determined by the vehicle's type approval rate of CO_2 emission (g/km), and a fourth determined by its NO_x emission rate. The purchase tax system is summarised in Figure E.3.

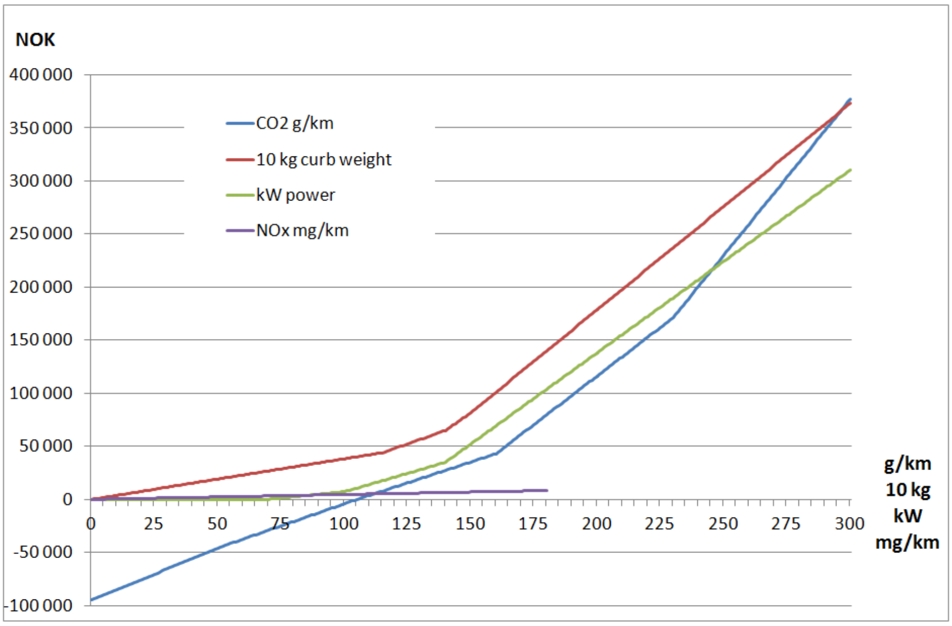

Figure E.3: Vehicle purchase tax as a function of curb weight, engine power, and type approval CO_2 and NO_x emission rates. Norway 2014. €1 = appr. NOK 8.30.

In the fiscal years following 2007, increasing weight has been put on the CO_2 component of the purchase tax, so as to strengthen the incentive to buy low

[1] The electric motor power of hybrid vehicles is not subject to tax. Also, for hybrid vehicles the basis for calculating the weight component of the purchase tax is 15 per cent lower than the curb weight, meaning to leave the batteries out of the tax calculation.

emission cars. Cars emitting more than 105 grams of CO_2 per km are subject to a progressively increasing tax, while cars releasing less than this actually obtain a subsidy, in the form of a certain deduction in the tax levied on weight and engine power.

From 2006 until 2013, the average type approval rate of CO_2 emission among new cars had dropped by 30 per cent, to 123 grams per km (Figure E.4). In the 1st quarter of 2014, the rate had come down to 109 grams per km, helped to a large extent by the generous privileges granted to battery electric vehicles (BEVs). These cars are exempt of value added tax, vehicle purchase tax, road tolls and public parking charges. They benefit from strongly reduced annual registration tax and reduced ferry fares. Moreover, BEVs are allowed to travel in the bus lane and may be recharged for free in many public parking lots.

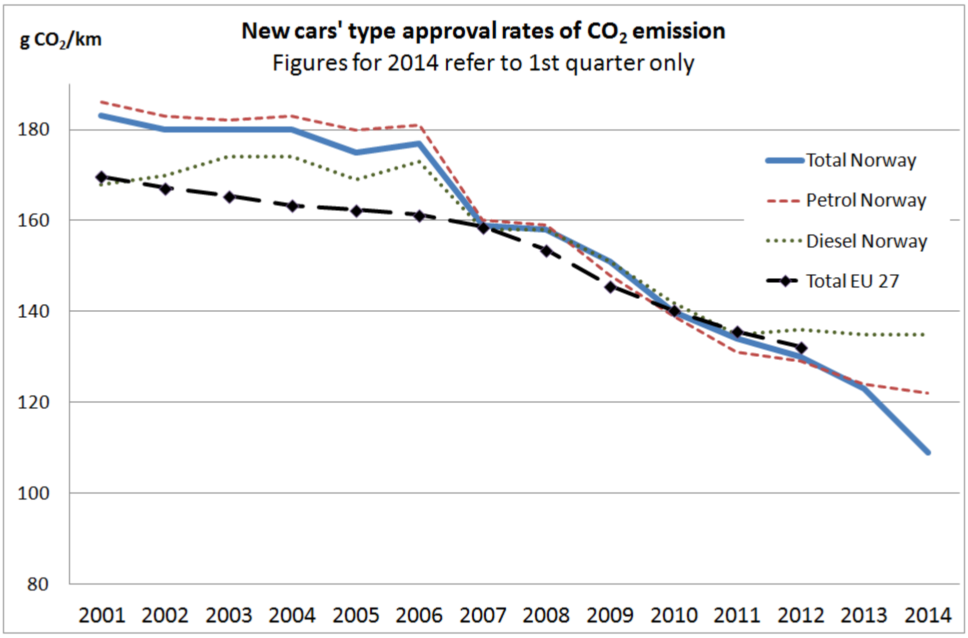

Figure E.4: Average type approval rates of CO_2 emission from new cars registered in Norway, by fuel type, and in EU 27. Electric vehicles are included in total.

As a result, Norway probably has the largest share of electric vehicles of any country. As of 30 April 2014, there are more than 28 000 rechargeable vehicles on Norwegian roads, corresponding to more than one per cent of the passenger car fleet. BEVs constitute the overwhelming majority of rechargeable vehicles, only about 5 per cent being plug-in hybrids (PHEV).

What are the long term effects of this policy in terms of greenhouse gas (GHG) abatement? How do they compare with a policy emphasizing fuel tax rather than vehicle tax? If and when the massive privileges enjoyed by battery electric cars are abolished, how much will their market share drop? What kind of tax incentives are needed in order for plug-in hybrid vehicles to obtain a larger share?

To answer these questions, a nested logit model of vehicle choice has been developed, using a data base covering all new car acquisitions in Norway between January 1996 and mid-2011. A total of 38 491 different vehicle models have been identified and their annual sales recorded. The results of this choice model were fed into a dynamic spreadsheet model, in which each cohort of cars is followed through its life span. In the model, each year's 'population' of cars is calculated from that of the preceding year, as modified by new car sales, second hand import, scrapping, and deregistration. By means of this framework, several paths of development, differing in terms of vehicle taxation, were simulated up to the 2050 horizon.

In the reference path, in which the privileges enjoyed by battery electric cars are gradually phased out during 2018-2022, while all other tax rates are kept unchanged, the mean *type approval* rate of CO_2 emission from *new cars* comes down to 102 g/km in 2020, to 92 g/km in 2030, and to 75 g/km in 2050 (see left part of Figure E.5, green curve). The corresponding mean rate of the *car fleet* lags 12-15 years behind (red curve). The *real-world emissions on the road* (blue curve) are even higher than this, by more than 20 per cent at the 2020, 2030 and 2050 horizons.

In the more aggressive fiscal scenario labelled 'Advantage plug-in hybrids', the CO_2 component of the vehicle purchase tax is increased by NOK 75 per CO_2 gram/km each year from 2015 on. Also, the deduction applicable to low emission cars (emitting less than 105 gram/km) is doubled from 2016 on. The 'Advantage plug-in hybrid' policy seems liable to halve the mean real-world emission rates of Norwegian cars, to less than 100 g/km, before 2037. Between 2013 and 2050, the emission rate may come down by some 63 per cent, from 195 to 73 g/km (Figure E.5, right part).

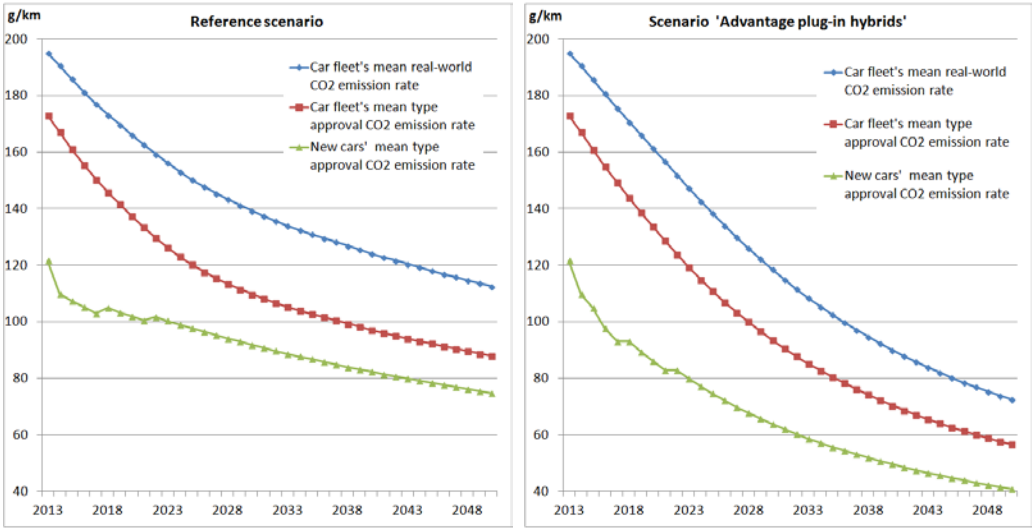

Figure E.5: Mean CO_2 emission rates from Norwegian passenger cars 2013-2050, measured in three different ways, in two separate scenarios.

Finally, using the national Norwegian travel demand forecasting apparatus, we calculate travel demand and GHG abatement effects (i) of a 50 per cent increase in petrol and diesel prices, and (ii) of halving the (fossil) fuel consumption per vehicle kilometre, as forecast for 2037 under the 'Advantage plug-in hybrid' scenario.

The fuel economy improvement has by far the largest effect. On short trips, halving the emission rates of passenger cars results in a 42 per cent reduction in the cars' CO_2 emissions. There is thus an 8 percentage points' rebound effect: vehicle kilometres travelled go up as fuel costs go down.

On long haul trips, the car rebound effect is estimated at 24 per cent. However, in this case there is a second order rebound effect working in the opposite direction. Part of the increase in vehicle kilometres travelled consists of trips transferred from the air mode. Thus, the overall reduction in CO_2 emissions on long distance trips comes out at 44 per cent of the cars' initial emissions, resulting in a 'final' rebound effect of only 6 percentage points.

According to the same set of models, a 50 per cent increase in the fuel prices results in an estimated 11 per cent reduction in CO_2 emissions on shorter trips. For long haul trips, the effect is practically zero, since the air mode is taking over most of the road trips cancelled.

Thus, the potential of the vehicle purchase tax as a climate policy instrument far exceeds that of the fuel tax. Improving the fuel efficiency of cars is likely to be economically profitable, since it entails large energy savings in the long run. The fuel efficiency of the electric engine is roughly three times superior to that of the internal combustion engine.

The benefits of electrifying the Norwegian passenger car fleet is enhanced by the fact that the country's electricity supply is almost 100 per cent based on hydropower. Six per cent of the domestic hydropower output would be sufficient to operate the entire passenger car fleet, if completely electrified.

Public transport

The travel demand models were also used to assess the effects of changing public transport fares and level-of-service. In general, the GHG abatement potential of cheaper or improved public transport appears to be modest.

We simulate a package of policy measures consisting of 10 per cent faster long distance trains, 25 per cent increase in air fares, 50 per cent increase in road toll rates, 50 per cent more frequent departures by bus, metro and tramway, and 50 per cent lower fares by bus, metro, tramway and train. This fairly potent combination of carrots and sticks is estimated to result in a 9 per cent increase in passenger kilometres travelled on short haul trips, and an 8 per cent decrease in car use. CO_2 emissions go down by 6 per cent on all short haul trips taken together.

On long haul trips the CO_2 abatement effect is 4 per cent, due mostly to the projected 16 per cent reduction in travel by air.

Road network

A third set of modelling exercises was done in order to assess the impacts of drastically improved roads and of marginally reduced speed, respectively.

A motorway system connecting the country's four largest cities is assumed to reduce car travel times by 25 per cent along the corridors affected. This is projected to result in an 8 per cent increase in car kilometres travelled on long haul trips in Norway as a whole. CO_2 emissions from cars would go up by a full 13 per cent, on account of the increased fuel consumption consistent with higher speed. Travel by air would shrink by about one per cent, and the total long haul emissions across all modes would go up by an estimated 4 per cent.

Reducing the road speed by 9 per cent on all origin-destination pairs in Norway would result in a 6 per cent reduction in long distance car travel and emissions. But total CO_2 emissions on long haul trips would go down by a mere one per cent, since the bus, rail and air modes all receive a 2 to 3 per cent traffic growth.

Public acceptance

Fuel taxes and congestion charging are examples of economically sound, indirect taxes, that can be used to internalise the marginal external cost caused by certain activities, in this case by car use, causing global or local environmental degradation and/or time delays on the road.

A questionnaire survey was conducted in order to assess the acceptability of environmental taxes to combat such external effects. Most people appear sceptical of the efficiency of such taxes, unless the revenue is somehow earmarked for a purpose consistent with the tax's rationale.

Public acceptability is generally higher when the tax is perceived as an effective means to reduce local pollution and congestion, and when the equity effects are not perceived as unfavourable.

An effective strategy to boost the public acceptance of environmental taxes may be to earmark the revenues for environmental measures. Such a strategy might facilitate the implementation of ambitious climate policies. It might, however, also be a costly strategy. The exact cost of earmarking depends on which measures the revenues are earmarked for, as well as on the degree of fungibility of the government budget.

Congestion charging has been put to the public vote in several European cities, with widely differing results. The differences in outcome between Stockholm and Edinburgh underscore the importance of voters' personal experience with the benefits of congestion charging. With respect to changing the public mind, third party information about the charges seems far less effective than personal experience.

The revenues from congestion charging will typically be several times larger than the (monetized) welfare gains. A key question, with a large impact on public acceptance, is therefore how the revenues are spent.

Rail freight corridors

Freight accounts for some 40 per cent of the domestic GHG emissions from transport in Norway. While the rail mode has a nationwide market share of only 7 per cent, it remains fairly competitive on the three main domestic corridors, between Oslo and Bergen, Trondheim and Stavanger, where it carries more tonne kilometres than he road mode.

On border crossing transports, however, the rail market share is quite low – less than 10 per cent on the Gothenburg-Oslo relation. By removing a bottleneck through the construction of a 25 km railway line between the Swedish city of Strömstad and Halden in south-eastern Norway, one could establish a markedly more competitive rail corridor into Norway from Gothenburg and Malmö near Copenhagen. Large synergies are probably to be reaped when the Fehmarn belt subsea tunnel between Rødby in Denmark and Puttgarden in Germany is opened, probably in 2021. From then on, an efficient rail corridor may extend all the way to Oslo from European rail ports near Lübeck and Hannover. It will allow for a much higher rail market share on international transports to and from Norway, strengthening the railway's competitiveness even on the connecting domestic transports.

There is, however, a need to upgrade the Norwegian rail network and freight terminals. Climate policy considerations may suggest a higher priority for freight trains also on the domestic network.

Policy integration

Despite the promising development towards markedly lower GHG emissions from the passenger car fleet, it does not seem likely that Norway will reach its own self-imposed target of cutting 2.5 to 4 million tonnes of CO_2 emission from transport by 2020. Nor does it appear feasible to reduce transport emissions by 70 per cent within the 2050 horizon, in line with the recommendations by the UN Intergovernmental Panel on Climate Change.

Despite several consensus documents establishing the necessity of integrating climate policy goals into all sectors of government, and indeed into the transport sector, it appears doubtful whether the mechanisms for enforcing these policies carry sufficient weight when met with conflicting goals and considerations. A proposal to introduce a climate change act, to enforce and monitor GHG abatement policies, has been put forward by five parties in the Norwegian Parliament.

Decoupling

The large scale substitution of low and zero emission cars for conventional, petrol and diesel driven ones would, if accomplished, qualify as a major achievement in terms of *decoupling*, a term used by the OECD to characterize the breaking of the link between 'environmental bads' and 'economic goods'. If society is unwilling and/or unable to curb consumption or economic growth, sustainability must be achieved through pervasive decoupling.

Decoupling emissions from growth in the aviation and freight sectors is, however, not straightforward. In aviation, conversion to biofuel may seem like the least difficult solution. Even this will, however, not do away with contrails and cirrus formation, which represent almost as large a climate impact as the combustion of jet fuel.

In the freight sector, decoupling could, in principle, be achieved by transferring transports to rail, by improving the load factor and/or the fuel efficiency of vessels and vehicles, or by introducing (more) climate neutral energy carriers, such as electricity, biofuel or hydrogen. There is a pressing need for improved knowledge on the most efficient policy instruments and solutions available to the freight sector.