Institute of Transport Economics
Norwegian Centre for Transport Research

Summary

The price of carbon implicit in the Norwegian road, fuel and vehicle taxation system

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The Norwegian automobile fleet is being electrified at an unparalleled speed. Policy makers, stakeholders, journalists and researchers worldwide are asking how and why. It is a sobering and educational fact that the price of carbon facing Norwegian automobile owners and users exceeds 1250 euros per ton of CO_2.

The Norwegian automobile market

The rapid uptake of battery and plug-in hybrid electric cars in Norway is unprecedented. In 2019, 34.6 per cent of all new passenger cars sold were battery electric vehicles (BEVs), while 17.6 per cent were plug-in hybrids (PHEVs) (Fig. E.1). During January through September 2020, these market shares had grown to 50.5 and 20.3 per cent, respectively.

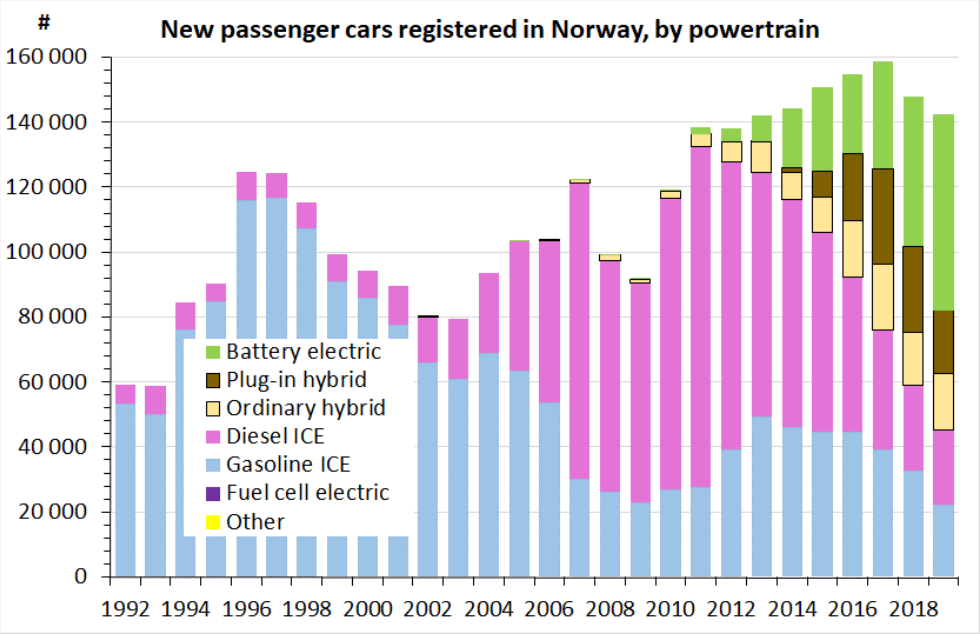

Fig. E.1: New passenger cars registered in Norway 1992-2019, by energy technology.

While in the European Union (EU), the type approval rates of CO_2 emissions from new cars have gone up lately, from 118.1 gCO_2/km in 2016 to 122.4 gCO_2/km in 2019, the rate has been steeply falling in Norway, to a mean of 60 gCO_2/km in 2019 (Fig. E.2).

How did this come about?

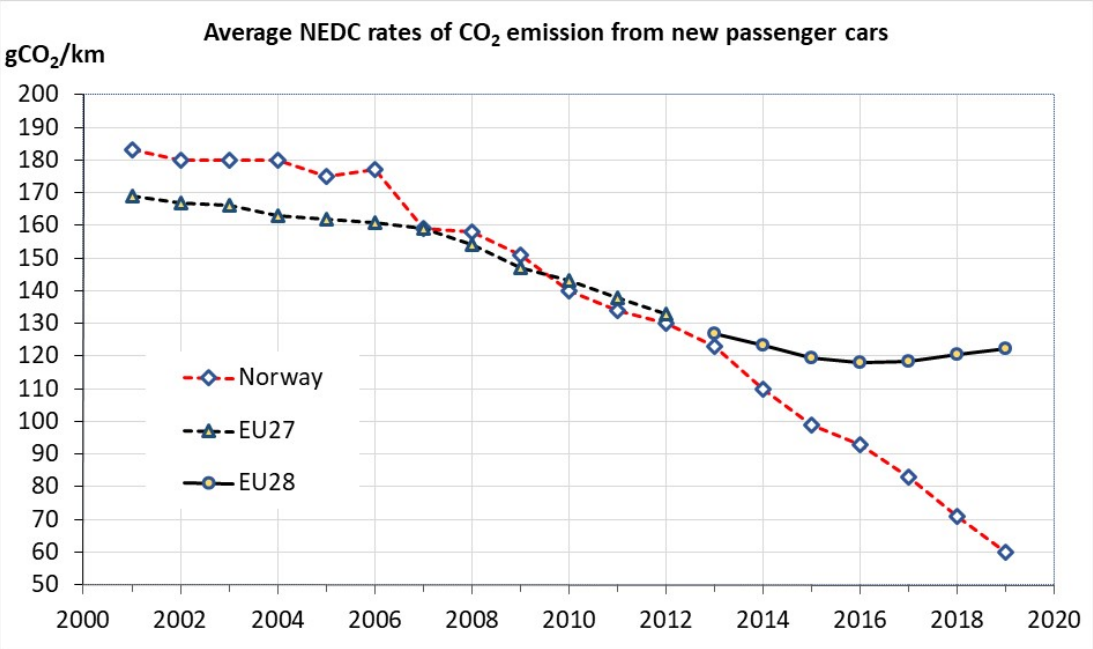

Fig. E.2: Type approval rates of CO_2 emissions for new passenger cars 2001-2019. Source: Fridstrøm and Østli (2020), drawing on ICCT (2020), www.ofv.no and the European Environmental Agency.

The policy instruments

A common misunderstanding is that the Norwegian development is due to massive subsidization, facilitated by the country's petroleum wealth. But in fact, only a negligible share of the Norwegian incentives is made up by subsidies. In essence, the policy consists in taxing internal combustion engine (ICE) vehicles.

There are 14 different fiscal incentives in place bearing on vehicles, fuel or road use. All of them are in some way CO_2-differentiated. Zero exhaust emission vehicles (ZEVs), i.e. battery and fuel cell electric cars, are wholly or partially exempt of the first nine of these:

1. Graduated, one-off registration tax, with ZEVs fully exempt
2. Reregistration tax on second hand sales, with ZEVs fully exempt
3. Annual circulation (ownership) tax, with ZEVs fully exempt
4. Fuel tax, not applicable to ZEVs
5. Road toll, with ZEVs fully or partially exempt
6. Ferry fares, with strongly reduced rates for ZEVs
7. Public parking fees, often with full exemption for ZEVs
8. Income tax on private use of company cars, with lower rates for ZEVs
9. Value added tax (VAT), with ZEVs fully exempt
10. Weight and Euro-class graduated annual ownership tax on heavy duty freight vehicles
11. Government support for fast charging and hydrogen refueling facilities
12. Free recharging of BEVs at public parking lots
13. Subsidy on new battery or fuel cell electric light commercial vehicles
14. Subsidies for zero emission heavy duty vehicles and machinery

The implicit price of carbon

The fuel tax rate in 2019 was NOK 6.43 = € 0.637 per liter of gasoline and NOK 5.16 = € 0.488 per liter of diesel, corresponding to NOK 2770 = ***€ 286*** and NOK 1940 = ***€ 200*** per ton of CO_2, respectively, all figures being net of (25 per cent) value added tax (VAT).

An even more important incentive is the CO_2-differentiated, one-off *vehicle registration tax* (*'purchase tax'*), payable upon first registration of any passenger car or light commercial vehicle with an internal combustion engine (ICE).

The purchase tax is the *sum* of three separate components. In Fig. E.3, the schedules of all of these components are shown, as functions of *10 kg curb weight*, *gCO_2/km* or *$mgNO_X/km$ type approval emission rates*, respectively, each of them plotted along the same horizontal axis. Note that the CO_2 component is negative and hence deductible below 70 gCO_2/km.

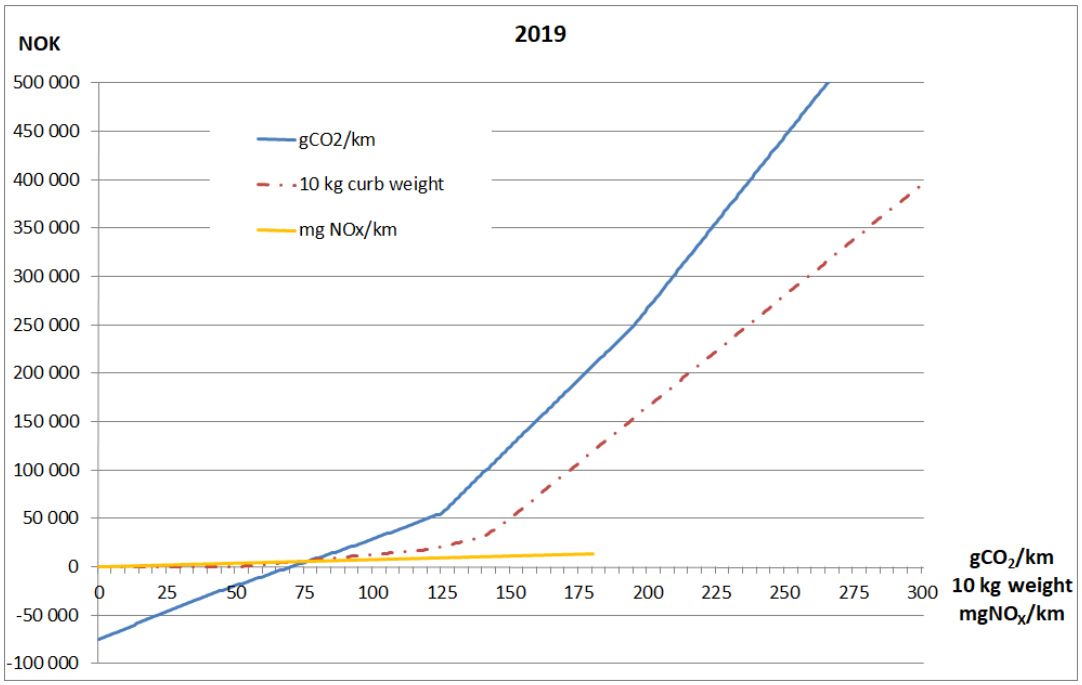

Fig. E.3: Norwegian automobile purchase tax 2019, in Norwegian kroner (NOK) per vehicle, as a function of curb weight and type approval CO_2 and NO_X emission rates. As of July 1, 2019, € 1 = NOK 9.70. Source: Fridstrøm (2019b).

To fix ideas, consider a couple of examples. For a hypothetical car weighing 1500 kg (including 75 kg driver), with type approval emission rates of 50 gCO_2/km and 50 $mgNO_X$/km, the purchase tax components in 2019 would sum to NOK 50 260 − 19 330 + 3 657 = NOK 34 587, corresponding to ***€ 3566*** at the mid-2019 exchange rate.

As a second example, a car weighing 2000 kg, with type approval emission rates of 150 gCO_2/km and 50 $mgNO_X$/km, would incur purchase tax components of NOK 165 375, NOK 124 540 and NOK 3 657, summing to NOK 293 572, or ***€ 30 265***, i.e. a more than eight times higher tax than in the previous example.

The convex weight and CO_2 components mean that heavy, gas guzzling cars are subject to a disproportionately higher purchase tax compared to smaller and leaner vehicles.

The minimum purchase tax in Norway is zero. Even if the negative CO_2 component should be larger in absolute value than the sum of the two positive components, the total

purchase tax rate would not turn into a subsidy, as in the French bonus-malus system (see D'Haultfoeuille et al. 2013, Wappelhorst et al. 2018).

Certain special tax breaks apply to plug-in hybrid vehicle (PHEVs). The taxable curb weight of PHEVs is reduced by up to 23 per cent prior to calculating the weight component. This essentially means that for PHEVs, every point on the red curve in Fig. E.3 is shifted up to 29.9 per cent to the right (since $1/(1 - 0.23) = 1.299$).

Only cars exhibiting an all-electric driving range of at least 50 km are eligible for a full 23 per cent weight reduction. If the range is $r < 50$ km, the weight deduction is set at $23 \cdot r/50$ per cent.

To convert the CO_2 curve shown in Fig. E.3 into a price on carbon, we compute the mean slope between 0 gCO_2/km and some point in the upper range of automobiles sold. For gasoline cars such a point is 150 gCO_2/km, while for (the generally larger) diesel cars we use 200 gCO_2/km as our numerical example.

This results in a slope of NOK 1328 = € 137 per gCO_2/km for gasoline cars and NOK 1708 = € 176 per gCO_2/km for diesel cars.

Assuming a lifetime mileage of 260 000 km for each car and a 40 per cent higher rate of emissions in real traffic than in the laboratory (Tietge et al. 2019), these figures translate into tax rates for gasoline and diesel cars, respectively, of NOK 3650 = ***€ 376*** and NOK 4690 = ***€ 484*** per ton of CO_2. A conservative ballpark number for passenger cars in general would be ***€ 400*** per ton of CO_2.

To assess the impact of the weight component of the registration tax, we invoke certain previous analyses (Fridstrøm and Østli 2018), which show an about 14 per cent increase in the mean type approval rate of new passenger cars in the event of an abolished weight component (Fig. E.4). This compares to a 32 per cent estimated effect of dropping the CO_2 component. Thus we estimate the carbon price associated with the weight component at € 400 x 14/32 = ***€ 180*** per ton of CO_2.

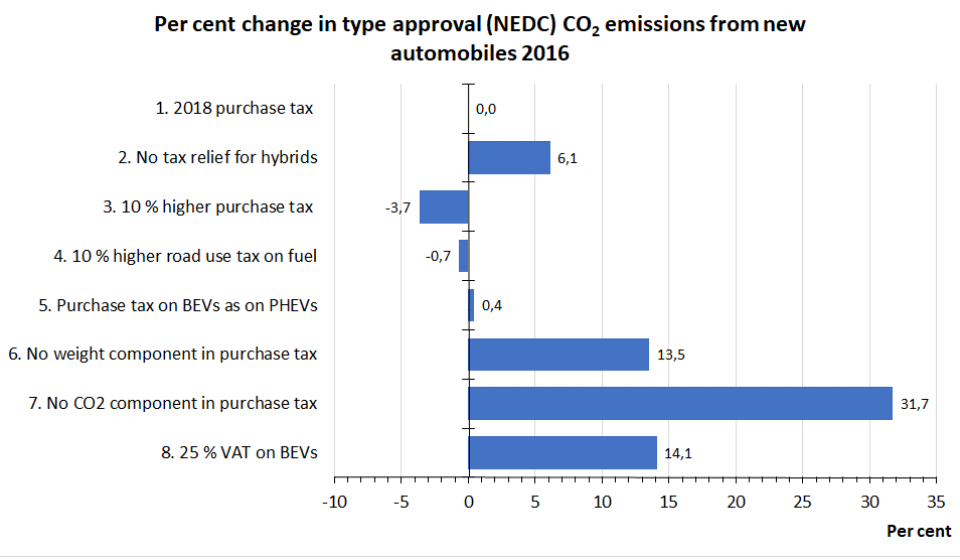

Fig. E.4: Estimated responses to hypothetical changes in the Norwegian automobile taxation system, in terms of mean type approval rate of CO_2 emissions for new passenger cars as of 2016. Source: Fridstrøm and Østli (2018).

To calculate the carbon price implicit in the VAT exemption for ZEVs, we relate the average amount of VAT paid on ICE vehicles to their average mean type approval

emission rate, arriving at NOK 75 862/104 = kr 728 per gCO_2/km, which translates into ***€ 200*** per ton of CO_2 through a vehicle's lifetime.

Taken together, the purchase tax incentives for ***passenger cars*** , i.e. the one-off registration tax and the VAT exemption, amount to a carbon price of € 400 + 180 + 200 = ***€ 780*** per ton of CO_2.

The ownership tax amounts to NOK 2909 = appr. € 300 per annum for most ICE cars. With an estimated average CO_2 emission of 2.145 tons per annum, we calculate the carbon price implicit in the ZEVs' exemption from car ownership tax at NOK 2909/2.145 = NOK 1350 = ***€ 140*** per ton of CO_2.

Similarly, the carbon price implicit in the full toll exemption applicable to ZEVs in 2018 is calculable as NOK 3000/2.145 = NOK 1400 = € 140 per ton of CO_2, NOK 3000 being the estimated mean annual toll expenditure for ICE automobile owners.

As of 2019, the full ZEV exemption from toll has been replaced, in many places, by a 50 per cent discount for BEVs. Hence we reduce the estimated carbon price due to tolling to a ballpark figure of ***€ 100*** per ton of CO_2.

Disregarding the relatively minor incentives due to reduced ferry fares and parking fees for ZEVs, and also the reregistration tax on second hand sales, we arrive at a total carbon price for passenger cars of ***€ 1250*** per ton of CO_2. In Table E.1, the 'fixed' components, shown in blue, are those determined, once and for all, through the choice of vehicle energy technology. The 'variable' components are those dependent on vehicle use.

Table E.1: Calculated fixed and variable components of the price of carbon facing Norwegian motorists. Euros per ton of CO_2 as of 2019.

	Passenger cars	LCVs	Heavy duty trucks
Fuel tax	>200	200	200
Registration tax: CO_2 component	400	100	0
Registration tax: weight component	180	45	0
VAT exemption for ZEVs	200	≈0	0
Ownership tax	140	100	≈0
Toll	100	70	>0
Ferry fares, parking fees, etc.	>0	>0	>0
Government subsidies	≈0	>0	≈0
Sum	>1250	>500	>200

Most ***light commercial vehicles*** (LCVs) are diesel driven and hence subject to the same fuel tax as diesel driven automobiles – ***€ 200*** per ton of CO_2. LCVs are subject to a set of registration tax rules that are roughly speaking 25 per cent of the rates applicable to passenger cars. Thus for these vehicles, we estimate the CO_2 and weight components of the one-off registration tax at roughly ***€ 100*** and ***€ 45*** per ton of CO_2. The VAT exemption for ZEVs is of almost no consequence, since most LCV buyers are VAT registered companies. The ownership tax and toll rates are the same for LCVs as for passenger cars. However, their ICE emission rates are generally higher, resulting in a lower price per ton of CO_2. In total, the carbon price for LCVs is at least ***€ 500*** per ton of CO_2.

For ***heavy duty freight vehicles***, the only important tax is the fuel tax, amounting to approximately ***€ 200*** per ton of CO_2.

Policy conclusions

The Norwegian automobile fleet is being electrified at an unparalleled speed. Policy makers, stakeholders, journalists and researchers worldwide want to know how and why. It is a sobering and educational fact that the price of carbon facing Norwegian automobile owners and users exceeds ***€ 1250 per ton of CO_2***.

For light and heavy duty commercial vehicles the corresponding prices have been conservatively estimated at ***€ 500*** and ***€ 200 per ton of CO_2***.

These carbon prices probably come a long way to explain the record fast market uptake of zero emission passenger cars, the slower penetration of electric LCVs, and the relative lack of innovation within the heavy duty freight vehicle segment.

Can the Norwegian recipe be replicated elsewhere? The answer is a conditional yes.

The recipe consists in taxing internal combustion engine vehicles rather than subsidizing electric ones. In every European country except Denmark, introducing a Norwegian style set of fiscal incentives in place of the present automobile taxation and subsidization regime would likely bring massive amounts of new revenue into the public treasury (Østli et al. 2020). Public finance constraints are, in other words, no argument against the Norwegian incentives.

But the introduction of electric vehicles in Norway is facilitated by a number of circumstances not necessarily present in other countries:

1. The electricity supply is based on hydropower and quite abundant. The per capita output is more than three times larger than e.g. in Germany. The consumer price level is roughly three times lower, typically around € 0.10 per kWh.
2. The local grids are strong, as most office buildings and homes are heated by electricity, and winters are cold. With the help of smart demand response systems, the grids will without much difficulty be able to accommodate large-scale vehicle recharging through outlets in private homes.
3. A relatively large share of the population live in detached houses with a driveway, garage or other designated parking, where a private charging point can be mounted.
4. There is ample space. Fast charging stations can be set up along most major highways.
5. Toll roads and ferry crossings are almost ubiquitous. Through the exemption of BEVs from toll and ferry fares, forceful incentives are created.
6. Roads are slow. This improves the driving range and makes it less of an issue. Going by car from the Norwegian capital to any one of the other three major cities takes about seven hours, for an about 500 km distance. On a 7-hour trip, most people do not mind a 30-minute break for recharging etc. On European motorways, the same distance could be covered in about four hours, turning a 30-minute inescapable stop into a nuisance.
7. Norway has no domestic auto industry that might lobby against ICE vehicle taxation.

For a more detailed analysis of the Norwegian automobile market we refer the reader to Fridstrøm and Østli (2020), upon which parts of this text are based.