Summary

Electrifying the Vehicle Fleet: Projections for Norway 2018-2050

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In the best of cases, some 62 per cent of the Norwegian passenger car fleet could be emission free by 2030, and the total CO_2 emissions from domestic road transportation would shrink by 38 per cent compared to the 2018 level. In a more likely scenario, extrapolating current policies and trends, a 46 per cent share of zero emission cars and a 23 per cent CO_2 cut can be expected by 2030. Both scenarios rely on strong and enduring government incentives for vehicle electrification. The Norwegian policy recipe consists in stiff taxation rather than in generous subsidization. It can be replicated by any country, rich or poor.

Introduction

In 2018, 31.2 per cent of all new passenger cars sold in Norway were battery electric vehicles (BEVs). Another 17.9 per cent were plug-in hybrid electric vehicles (PHEVs), and 11.0 per cent were ordinary (non-plug-in) hybrid electric vehicles (HEVs). Fuel cell electric vehicles (FCEVs) had a market share of 0.034 per cent. The rest was made up by cars equipped with an internal combustion engine (ICE) only, with 22.0 per cent running on gasoline, 17.7 per cent on diesel, and 0.042 per cent on compressed natural gas (CNG).

When the import of second hand cars is taken into account, the BEVs' share of passenger cars receiving Norwegian license plates in 2018 was a full 34.2 per cent. BEVs and PHEVs taken together represent almost 52 per cent of the 2018 cohort (age '1 year' in Fig. E.1).

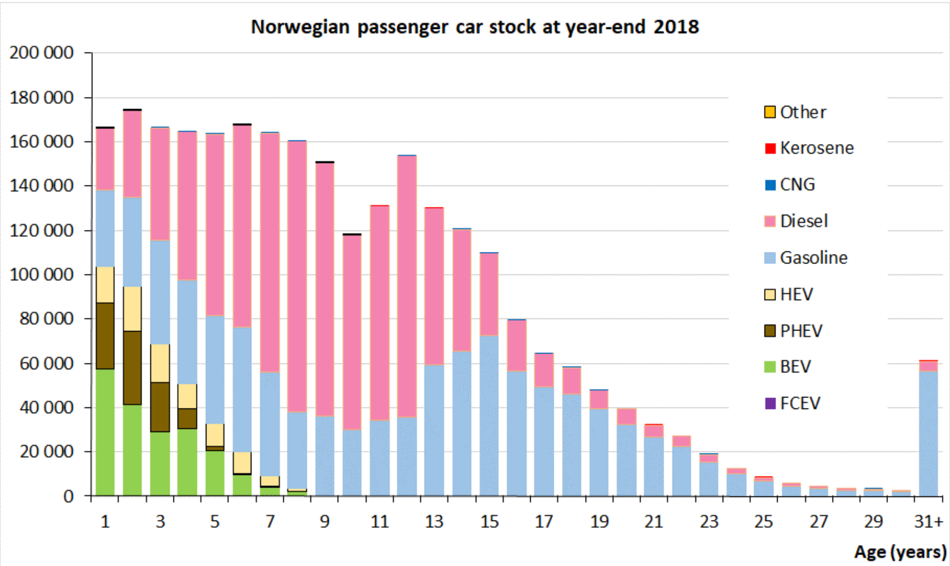

Fig. E.1 Age pyramid of Norwegian registered passenger cars, by powertrain, at year-end 2018.

Electric vehicle incentives in Norway

The high share of zero and low emission automobiles comes as a result of an enduring, no-nonsense government policy, consisting of ten different taxes and regulations of which zero emission vehicles (ZEVs), i.e. BEVs and FCEVs, are wholly or partly exempt:

1. Value added tax (VAT), generally 25 per cent, with ZEVs fully exempt
2. CO_2 and weight graduated, one-off registration tax, with ZEVs fully exempt
3. Reregistration tax on second hand sales, with ZEVs fully exempt
4. Annual circulation (ownership) tax, with ZEVs fully exempt
5. Fuel tax, not applicable to ZEVs
6. Road toll, with ZEVs fully or partially exempt
7. Ferry fares, with strongly reduced rates for ZEVs
8. Public parking fees, often with full exemption for ZEVs and free recharging for BEVs
9. Income tax on private use of company cars, with lower rates for ZEVs
10. Bus lanes, open to ZEVs, although with some exceptions

In general, only BEVs and FCEVs are entitled to special privileges and tax exemptions. But the one-off registration tax includes a CO_2 component distinguishing sharply between low and high emission passenger cars. Also, PHEVs enjoy certain reductions in the registration tax, through a lower weight component. For some light-weight PHEVs, the registration tax may come out at zero. Unlike ZEVs, however, PHEVs are not exempt of VAT.

Contrary to common belief, almost no cash subsidies are being paid out in support of electric cars in Norway. With two minor exceptions, all of the Norwegian incentives take the form of *taxes and regulations affecting vehicles equipped with an internal combustion engine (ICE)*, with full or partial exemptions for zero emission vehicles.

The annual fiscal revenue from registration, ownership, reregistration and fuel tax in 2018 was 47.6 billion Norwegian kroner (NOK), or approximately € 5 billion, corresponding to around € 1000 per capita (Fig. E.2). Road toll – not shown in the diagram – represents another NOK 10 billion or so in annual public revenue.

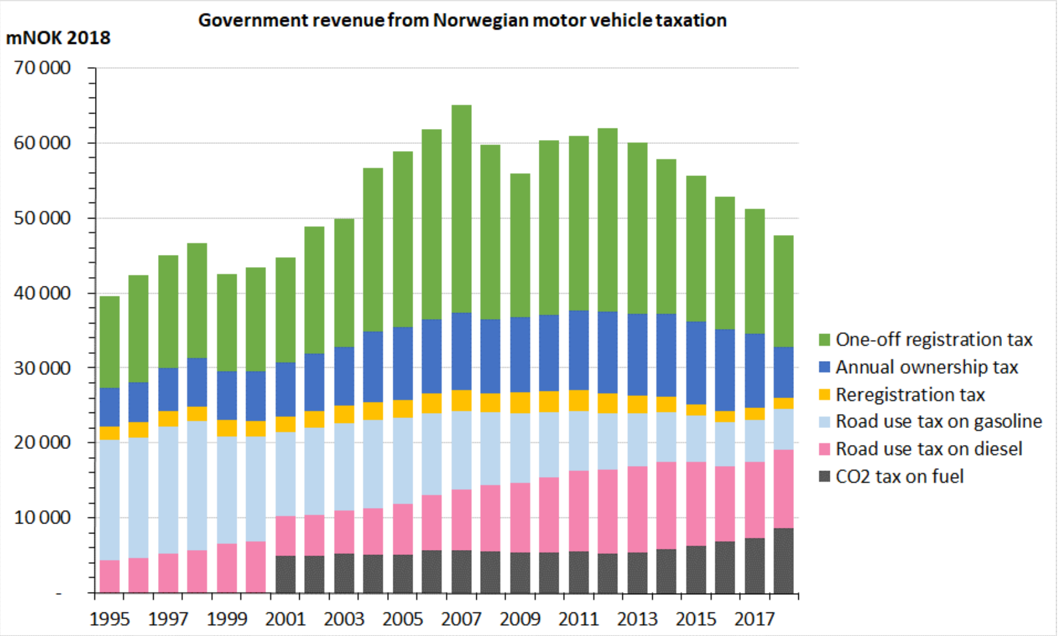

Fig. E.2 Annual fiscal revenue from selected motor vehicle taxes 1995-2018, adjusted to the 2018 price level. Source: Statistics Norway (Statistikkbanken).

Taken together, the value of the tax breaks and bus lane access benefiting ZEV owners was of the order of NOK 6.6 billion in 2017, or around € 700 million. Dividing this figure by the stock of ZEVs at the start of 2017, we arrive at a value of € 7300 per ZEV per annum.

The two cases of cash subsidization are (i) the public support for electric vehicle charging stations and hydrogen refueling infrastructure, administered through the Enova government agency, and (ii) local governments footing the electricity bill at public parking lots (cf. item 8 in the above list). These are costs covered by the taxpayers, that would otherwise be incurred by the users of electric cars themselves.

Compared to the automobile tax revenues, the scope of the Enova subsidies is quite modest. A mere NOK 11 million, or approximately € 1 million, was granted in support of roadside charging stations in 2017, according to the agency's annual report. Another NOK 30 million was granted for hydrogen refueling infrastructure.

The electricity bill at public parking lots is not large either, on account of Norway's generally low prices of electricity and the fact that most BEV owners routinely recharge their vehicle at home.

Two scenarios

Encouraged by their own astonishing success in promoting electric drive in private cars, Norwegian policy makers have laid down some rather ambitious targets for the uptake of zero emission vehicles in the years to come. According to the most recent white paper on the *National Transport Plan (NTP),* approved by Parliament in 2017 and covering the period 2018-2029, all *new* passenger cars and urban buses registered *in 2025* are to be emission free, i.e. BEVs or FCEVs. *By 2030*, the same should apply to all *new* light commercial vehicles (cargo vans), 75 per cent of all *new* interurban buses and coaches, and 50 per cent of all *new* heavy duty freight vehicles (trucks and semitrailer tractors). We shall refer to this set of assumptions as the *NTP scenario*.

Another, rather more pragmatic framework is presented in the Government's *National Budget for 2019*, whose long-term projections assume a 75:25 split between *new* battery and plug-in hybrid electric cars *in 2030*. ICE cars and HEVs are supposed to be entirely phased out by then. Among *new* light commercial vehicles (LCVs), the ZEV share is assumed to be half as high as for passenger cars, i.e. 37.5 per cent by 2030. No specific assumptions are made concerning heavy duty passenger or freight vehicles. We shall refer to this setup as the *NB19 scenario*.

The BIG-5.2 stock-flow projection model of the vehicle fleet

To study the long-term development of the Norwegian road vehicle fleet and its climate footprint, a bottom-up stock-flow cohort model, named BIG, has been developed. The model distinguishes between seven categories of vehicles: passenger cars, cargo vans, heavy trucks, semi-trailer tractor units, buses and coaches, motorhomes, and combined passenger/freight vehicles. For each type of vehicle, the stock is subdivided by weight, age, and powertrain (i.e., energy technology), forming a four-dimensional matrix of more than 11 000 cells.

In its latest (5.2) version, the BIG model is based on stock data evaluated at year-end 2018 and flow intensities calibrated on register data for the 2012-2017 period. For each cell, the net flow intensity from one year to the next is determined by the sum of positive and negative gross flows due to scrapping, de- and reregistration, and first and second hand import and export.

We have used the BIG-5.2 model to calculate, on to the 2050 horizon, the stocks of passenger and freight vehicles and their traffic performance, energy consumption and CO_2 emissions under the NTP and NB19 scenarios, respectively.

Projection model input: new vehicles 2019-2050

The assumptions of the NTP and NB19 scenarios, respectively, relate primarily to the yearly flows of new and imported second hand vehicles as shown in Fig. E.3 through E.9.

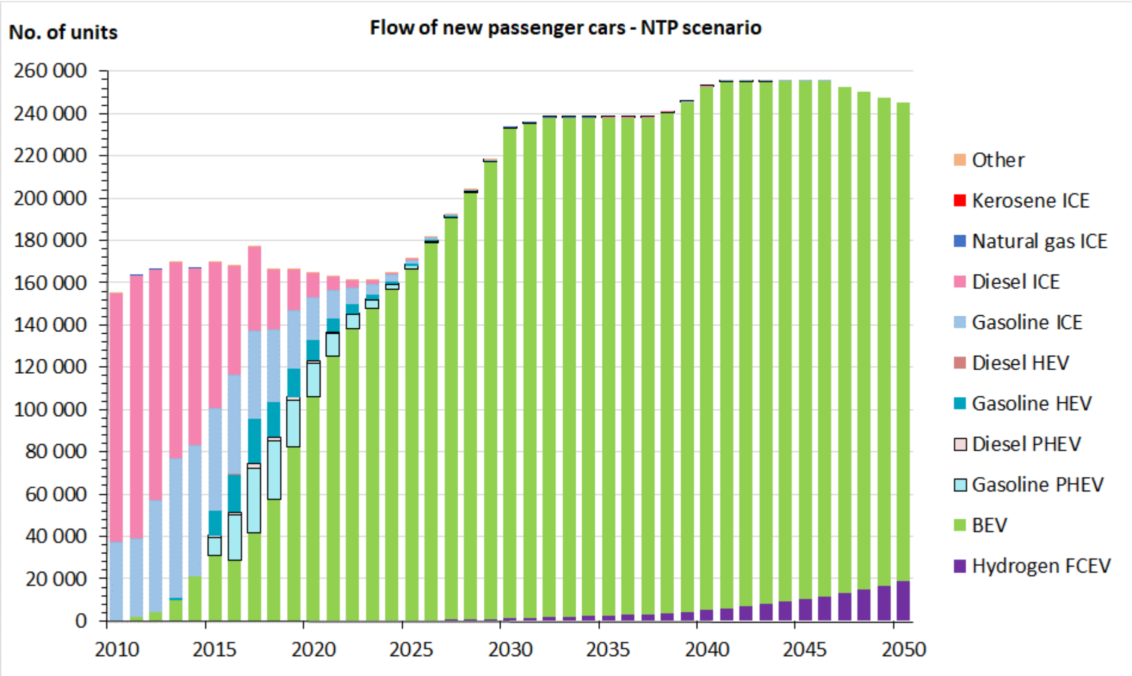

Fig. E.3 Annual flows of new passenger cars 2010-2050 under the NTP scenario, by powertrain.

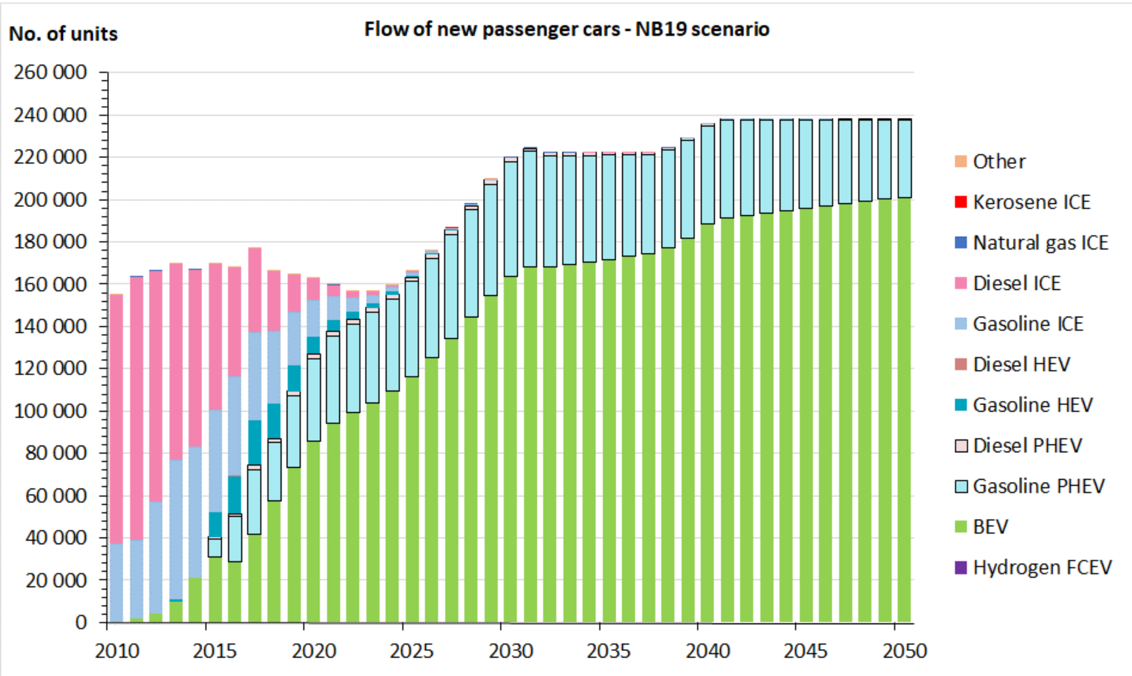

Fig. E.4 Annual flows of new passenger cars 2010-2050 under the NB19 scenario, by powertrain.

Under the NTP scenario, some 97.1 per cent of all *new* passenger cars in 2025 are battery electric. By 2030, the BEV market share has grown to 99.3 per cent (Fig. E.3). Under the NB19 scenario, on the other hand, the BEV market share in 2030 is 74.3 per cent, with 24.6 per cent being PHEVs (Fig. E.4).

As for *new* light commercial vehicles (LCVs), the BEV market share in 2030 is 96.4 per cent in the NTP scenario (Fig. E.5) and 37.6 per cent in the NB19 scenario (Fig. E.6).

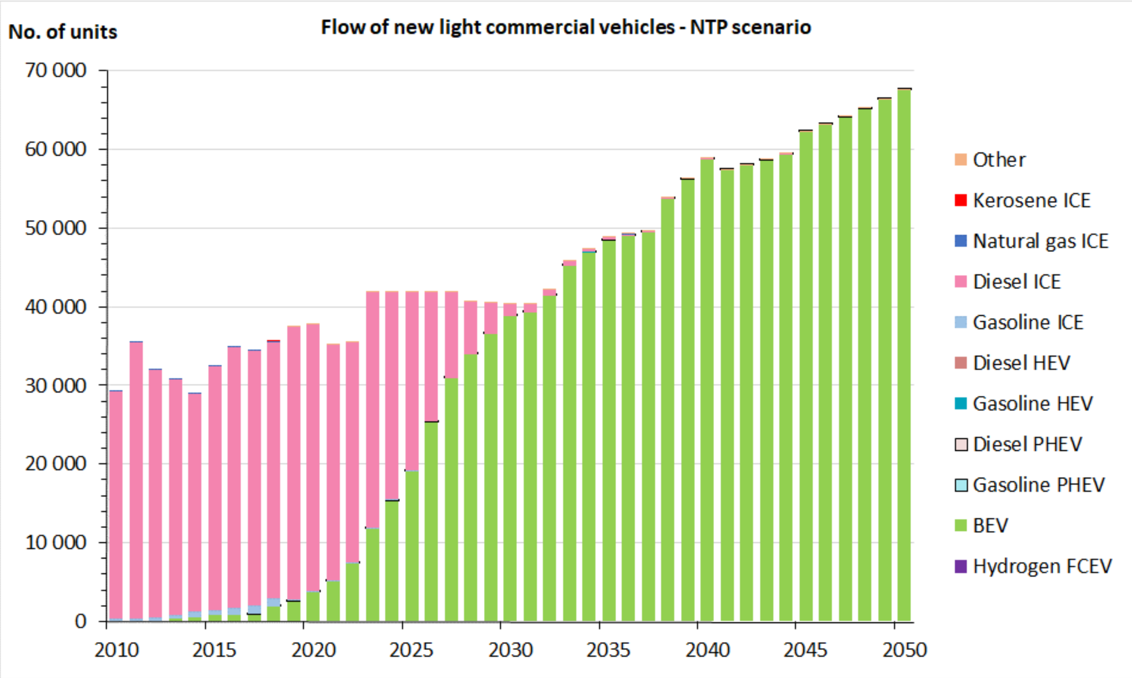

Fig. E.5 Annual flows of new light commercial vehicles 2010-2050 under the NTP scenario, by powertrain.

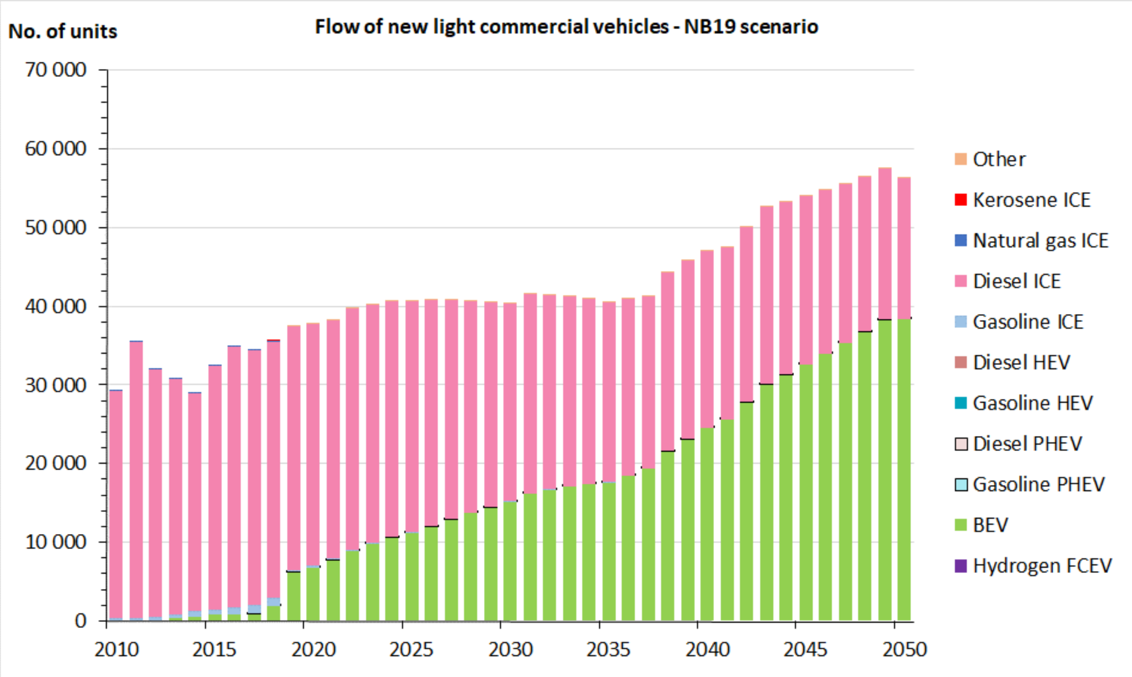

Fig. E.6 Annual flows of new light commercial vehicles 2010-2050 under the NB19 scenario, by powertrain.

Similarly, the acquisition of *new* heavy duty freight vehicles (i.e., trucks and semitrailer tractors) is shown in Fig. E.7 and E.8.

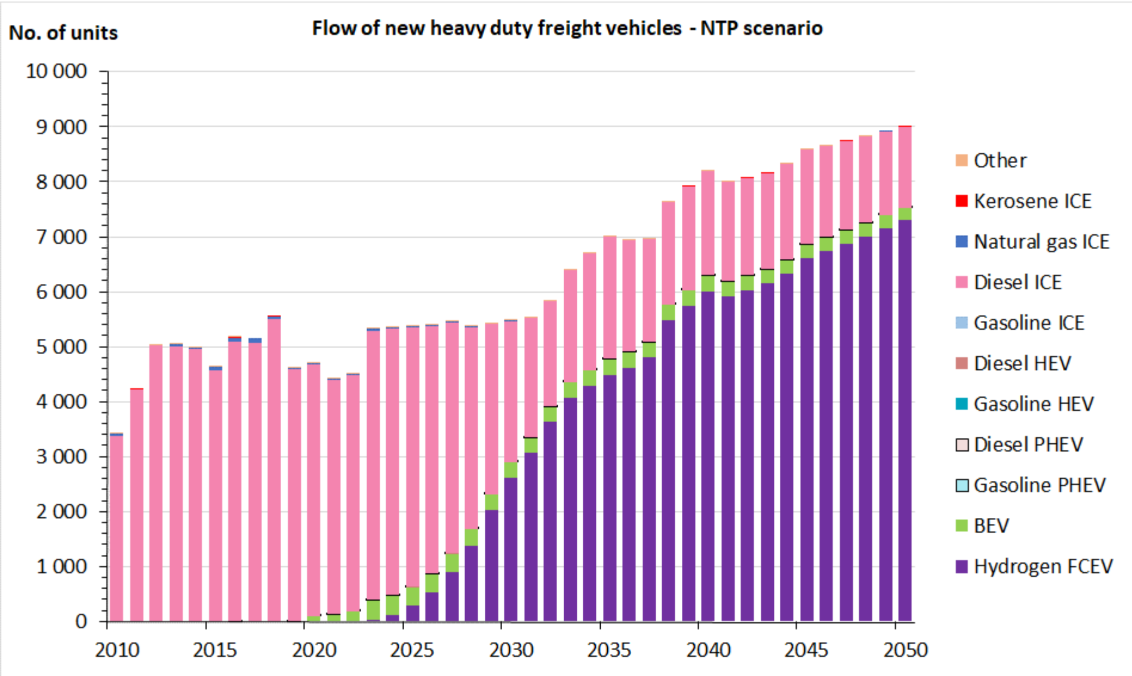

Fig. E.7 Annual flows of new heavy duty freight vehicles 2010-2050 under the NTP scenario, by powertrain.

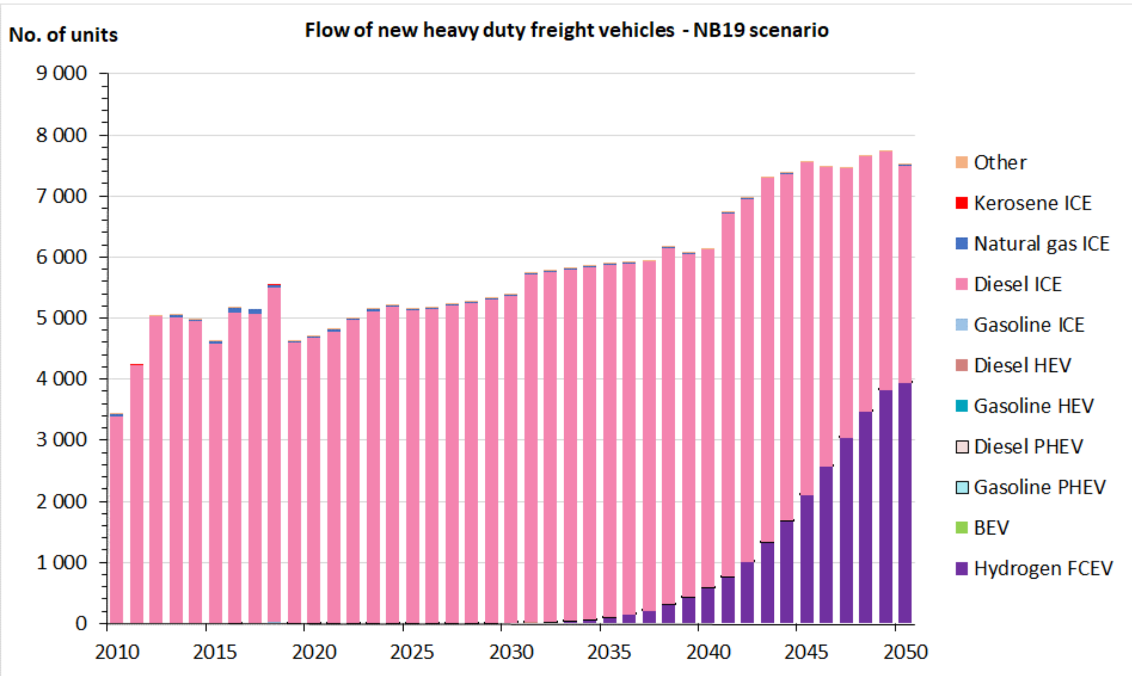

Fig. E.8 Annual flows of new heavy duty freight vehicles 2010-2050 under the NB19 scenario, by powertrain.

Finally, in Fig. E.9, we present the flows of *new* buses and coaches formed by extrapolation of the 2012-2017 trend, as defined by the log-odds ratios corresponding to the market shares of the various powertrains. According to this trend, when CNG-driven vehicles (running on bio-methane) are counted as emission free, some 63 per cent of all new buses and coaches in 2030 will be ZEVs. By 2035, their share will have reached 76 per cent. Although not quite as high a share as implied by the targets laid down in the National Transport Plan, we use this trend as an approximate NTP scenario for buses and coaches, coinciding, in this case, with the NB19 scenario.

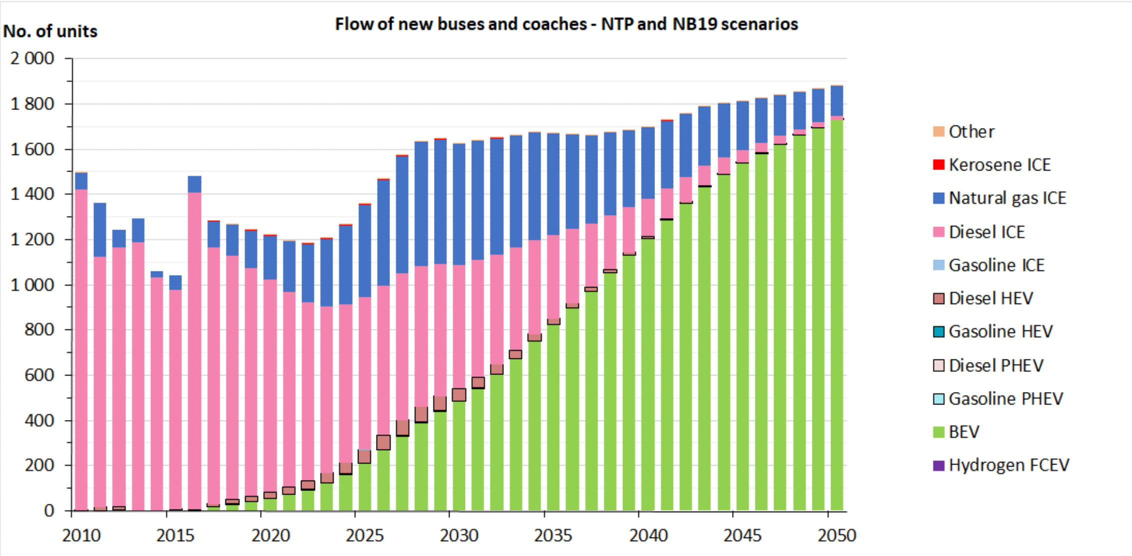

Fig. E.9 Annual flows of new buses and coaches 2010-2050 under the NTP and NB19 scenarios, by powertrain.

Greening the vehicle fleet – how fast can it be done?

Under the rather optimistic NTP scenario, more than three quarters – or, more precisely, 77 per cent – of all new passenger cars sold in 2021 will be emission free (Fig. E.3).

But it takes time before the new technology has penetrated into the vehicle stock and affected its traffic performance, energy use and emission level. A 77 per cent share of emission free passenger car traffic does not occur until 12 year later – in 2033 (Fig. E.10).

Under the more moderate NB19 scenario the corresponding time lag is at least 17 years – from 2034 to beyond 2050 (Figs. E.4 and E.11).

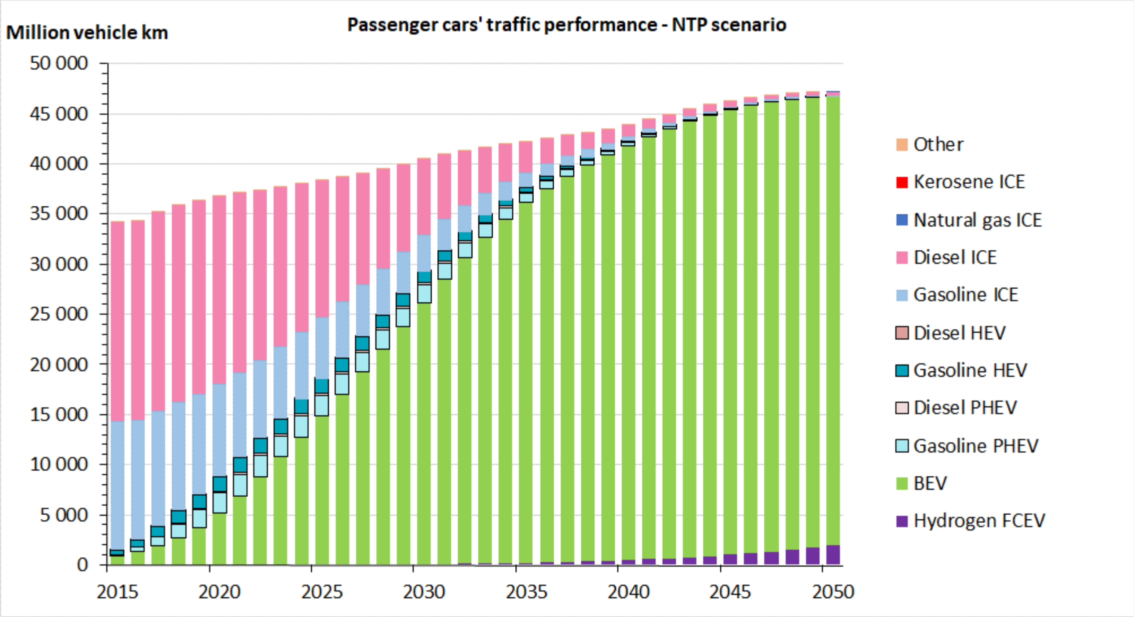

Fig. E.10 Passenger car traffic performance 2015-2050 under the NTP scenario, by powertrain.

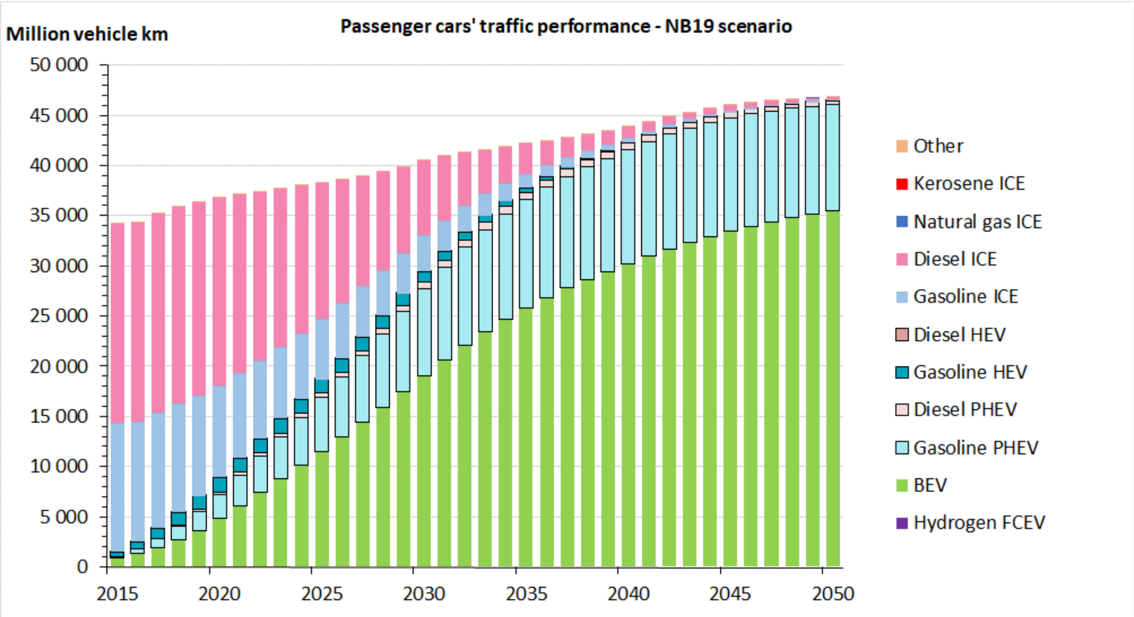

Fig. E.11 Passenger car traffic performance 2015-2050 under the NB19 scenario, by powertrain.

Decoupling traffic growth from emissions

As shown in Figs. E.10 and E.11, traffic volumes are expected to grow. Even so, CO_2 emissions will come down, in both scenarios (Figs. E.12 and E.13). Our model predicts a substantial decoupling between traffic performance and emissions – most notably, of course, in the NTP scenario, where emissions will be down by 38 per cent between 2018 and 2030, when a 16 per cent deduction is made for assumed biofuel use. But even the more moderate NB19 scenario is compatible with a 23 per cent emissions reduction by 2030.

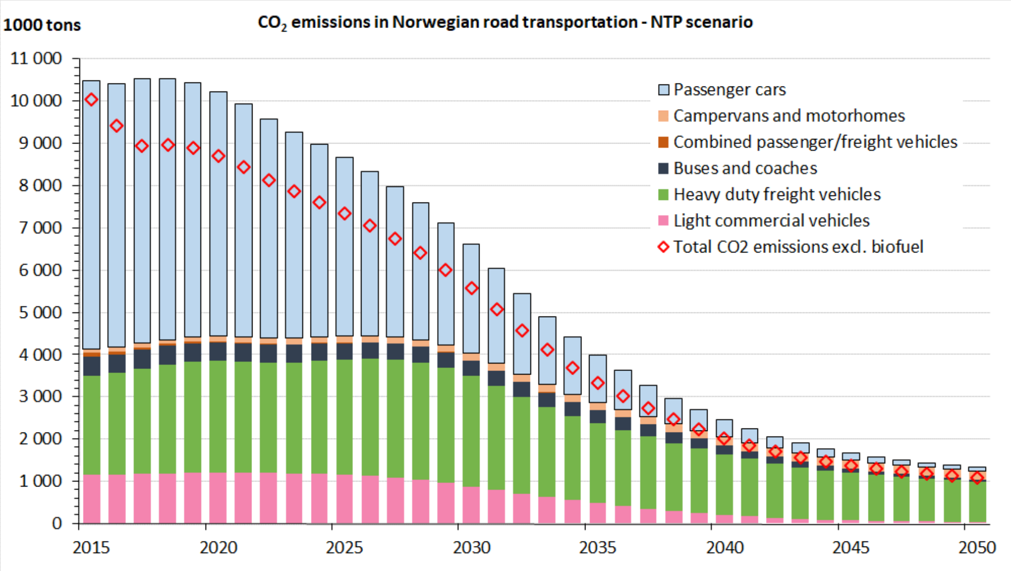

Fig. E.12 CO_2 emissions from road transport 2015-2050 under NTP scenario, by vehicle class.

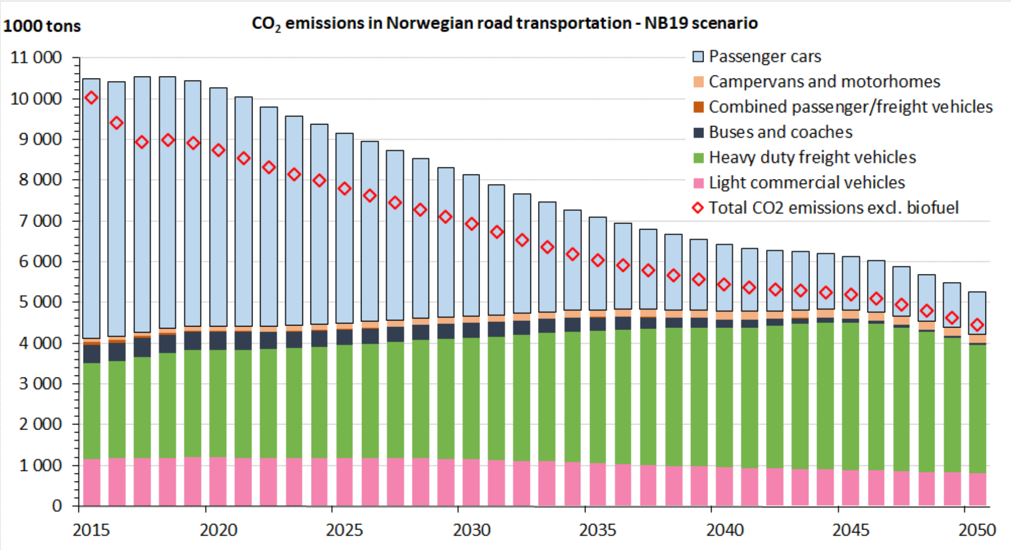

Fig. E.13 CO_2 emissions from road transport 2015-2050 under NB19 scenario, by vehicle class.

Energy savings are coming

Conversion to electric drive saves energy, since the electric motor is three to four times more energy efficient than the internal combustion engine (ICE). Under the NTP scenario, the total energy consumption on Norwegian roads is due to shrink by 26 per cent between 2018 and 2030 (Fig. E.14), despite a 15 per cent traffic growth. Energy will be saved even in the NB19 scenario, by 15 per cent between 2018 and 2030 (Fig. E.15).

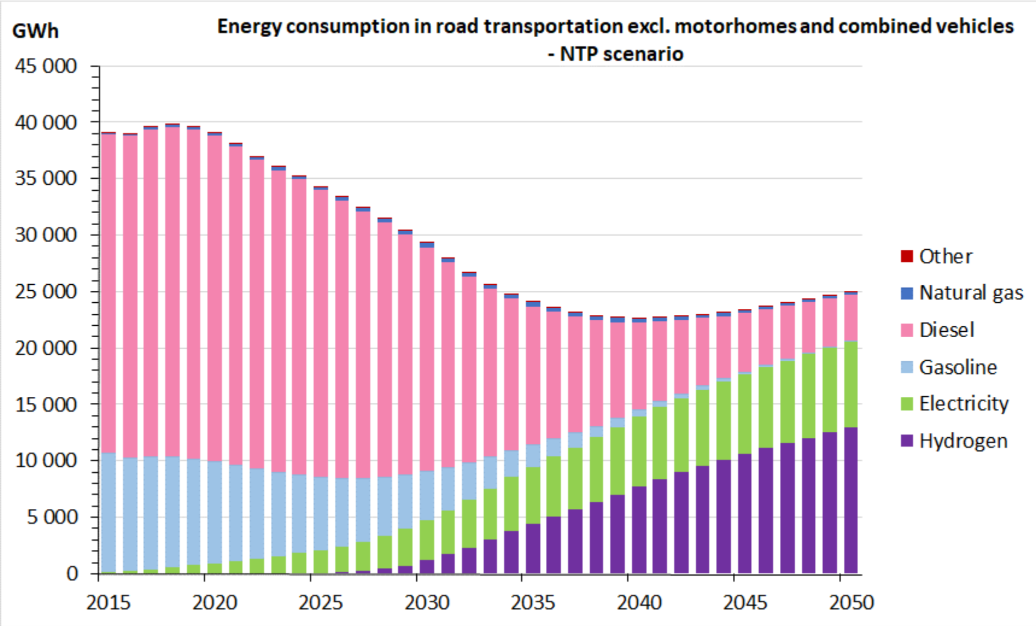

Fig. E.14 Energy consumption on Norwegian roads 2015-2050 under NTP scenario, by energy carrier. Motorhomes and combined passenger/freight vehicles not included.

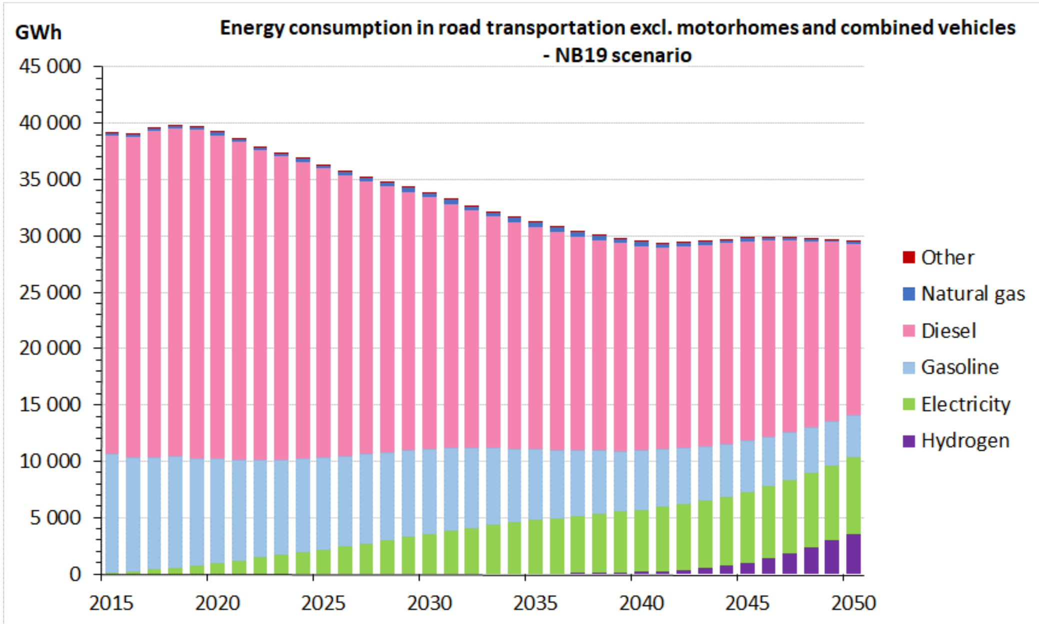

Fig. E.15 Energy consumption on Norwegian roads 2015-2050 under NB19 scenario, by energy carrier. Motorhomes and combined passenger/freight vehicles not included.

Replacing the vehicle stock – a long-term endeavor

The various fiscal and regulatory incentives in force in Norway have led to an unparalleled growth in the market uptake of battery and hybrid electric vehicles. These new vehicles are durable assets, with service lives that may exceed 15 or 20 years.

Hence, in evaluating an incentive scheme directed at new vehicle acquisition, a long-term perspective is called for. The full effect of a policy designed to affect new vehicle technology will materialize only after a couple of decades.

In Fig. E.16, we show, under the NTP scenario, how fast zero emission technology is expected to penetrate (i) into the *flows* of new passenger cars, cargo vans and trucks, and (ii) into the corresponding *stocks*. From the time (2019) when ZEVs constitute 50 per cent of all *new* passenger cars until the same is true of the passenger car *stock* (2028), 9 years will have passed. At the 90 per cent penetration level, the corresponding time lag is 16 years (2023-2039).

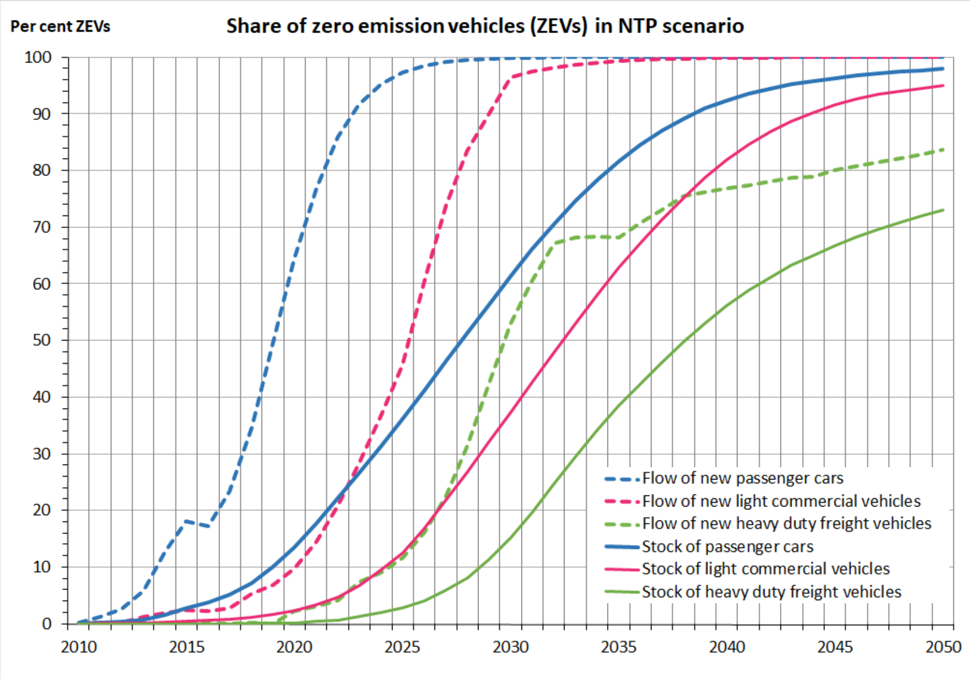

Fig. E.16 Share of zero emission vehicles in flow of new units and in existing stock 2010-2050, under NTP scenario, by vehicle class

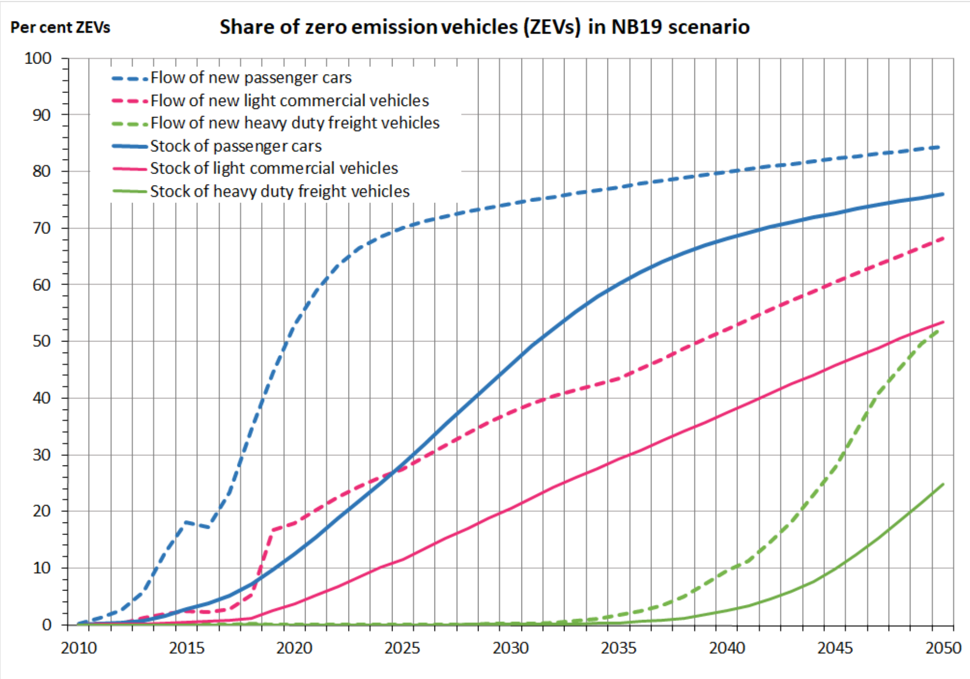

Fig. E.17 Share of zero emission vehicles in flow of new units and in existing stock 2010-2050, under NB19 scenario, by vehicle class.

For cargo vans (light commercial vehicles), the time lag can be read off as 8 years at the 50 per cent level and as 15 years at the 90 per cent level of penetration.

In Fig. E.17, corresponding results are shown for the more moderate NB19 scenario. Here, a somewhat longer time lag applies for passenger cars: 12 years at the 50 per cent level, but shorter for cargo vans: 9 years.

In general, the length of the energy transition time lag depends on the fleet turnover, on the speed of market uptake of new technology, and on the target level of penetration – say 50 or 90 per cent. As shown by our BIG model, it may take anywhere between 8 and 16 years before innovations affecting the supply of new vehicles have penetrated similarly into the vehicle stock.

Electrification and cap-and-trade – perfect complements

The European Union's Emissions Trading System (EU ETS) encompasses all important power plants in the European Economic Area (EEA, i.e. EU, Norway, Iceland and Liechtenstein). But gasoline and diesel consumption is not covered by ETS. Hence, by electrifying the vehicle fleet, we move certain sources of emission *into* the cap-and-trade system. The cap itself is not affected. In essence, this means that the marginal emission from another battery electric vehicle entering EEA roads is zero, no matter what kind of power plant generates the electricity.

In fact, a massive electrification of the European vehicle fleet would significantly affect the price of emission allowances, making energy conservation and decarbonization more profitable throughout the ETS sector. As seen from a climate policy angle, electrification and cap-and-trade are perfect complements.

Can the Norwegian recipe be copied? Yes!

The unprecedented speed at which Norwegian automobile buyers have embraced battery electric technology has taken observers, policy makers, stakeholders and even protagonists by surprise. Foreign delegations are visiting Norway in droves, seeking first-hand knowledge of the policy incentives behind the record fast growth of the battery electric car fleet.

A widespread misconception is that these incentives have something to do with the country's petroleum wealth. Only a rich government – so it goes – can afford the degree of subsidization necessary for an immature technology like electric cars to exhibit such an accelerated market uptake.

But this news is fake. The fact of the matter is that vehicle electrification in Norway is brought about, not by generous subsidization, but – quite the contrary – by stiff taxation.

Hence, any country – rich or poor – could, in principle, copy the Norwegian recipe, introducing some or all of the 10 taxes and regulations listed at the start of this summary, with exemptions for battery and fuel cell electric cars. Far for draining the public treasury, such a policy would generate considerable government revenue, strengthening public finance in whatever country implements the scheme.