## Summary

# The climate impact of automobile pricing, taxation and technology

*TØI Report 1820/2021*
*Authors: Lasse Fridstrøm, Vegard Østli*
*Oslo 2021 31 pages Norwegian language*

*Exploiting a generic nested logit model of automobile choice, we derive response functions for car retail prices, energy prices, tax rates and technology enhancements affecting new passenger car sales in Norway 2020. From an initial range of 150 km, the willingness-to-pay for 100 km extended range in a battery electric vehicle is estimated at US$ 27 200. When starting from an initial range of 500 km, the value of another 100 km range drops to US$ 5770.*

Relying on a disaggregate discrete choice model of new passenger car acquisitions, estimated on a data set covering 2.1 million individual transactions between January 2003 and May 2019, we develop a set of counterfactual scenarios for the automobile market in Norway as of 2020. Scenarios differ from the market actually observed in 2020 in terms of automobile retail prices and tax rules, energy prices, and battery and plug-in hybrid electric vehicle technology. Selected scenarios are presented in Figs. E.1 and E.2.

The model predicts market shares under the assumption of a fixed aggregate number of new cars registered each year. That is, the model does not take into account that price changes or quality enhancements in certain segments may engender higher or lower aggregate demand for cars.

For the purpose of comparative scenario assessment, the discrete choice model has been calibrated so as to exactly reflect the markets shares of the five most common powertrains in the Norwegian market in 2020. This year, 54.3 percent of all new passenger cars registered in Norway were battery electric vehicles (BEVs). Another 20.4 percent were plug-in hybrid electric vehicles (PHEVs). Ordinary hybrid electric vehicles (HEVs) represented 8.7 percent. 8.6 percent of all new cars were diesel driven, while 8.0 per cent were gasoline cars. These market shares represent our reference scenario, labeled 'Observed in 2020' and shown at the bottom of Fig. E.1.

The high share of battery and hybrid electric vehicles in Norway comes as a result of an enduring, no-nonsense policy of fiscal incentives, consisting primarily of strongly $CO_2$-differentiated automobile purchase and ownership taxes, of which zero exhaust emission vehicles, be they battery or fuel cell electric cars, are entirely exempt. On top of that, these vehicles are also exempt of the 25 percent value added tax (VAT).

According to our model, a most significant change in the market would result if BEVs were again to become subject to VAT. In such a case, the demand for BEVs is projected to be more than halved, while the market for all other powertrains would expand considerably (Fig. E.1). As a result, the average $CO_2$ emission rate of new passenger cars would increase by more than 60 percent (Fig. E.2).

A reintroduction of registration tax on BEVs would, according to the same model, make the BEV market share drop from 54.3 to 51.6 percent, assuming that BEVs would become

subject to the same tax rules as PHEVs. This relatively modest response is explicable by the fact that PHEVs are already taxed much more leniently than internal combustion engine (ICE) vehicles.

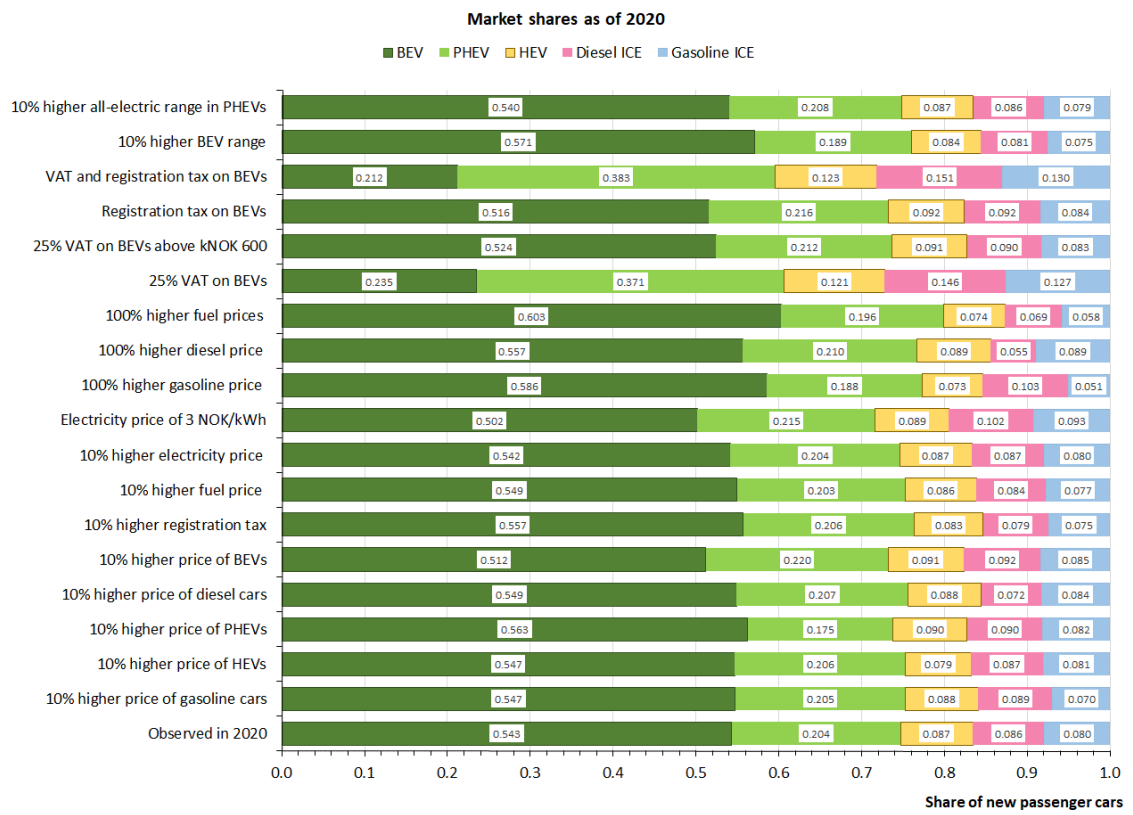


*Fig. E.1. Factual and counterfactual scenarios for new passenger car registrations in Norway 2020. BEV = battery electric vehicle; PHEV = plug-in hybrid electric vehicle; HEV = ordinary hybrid electric vehicle; ICE = internal combustion engine.*

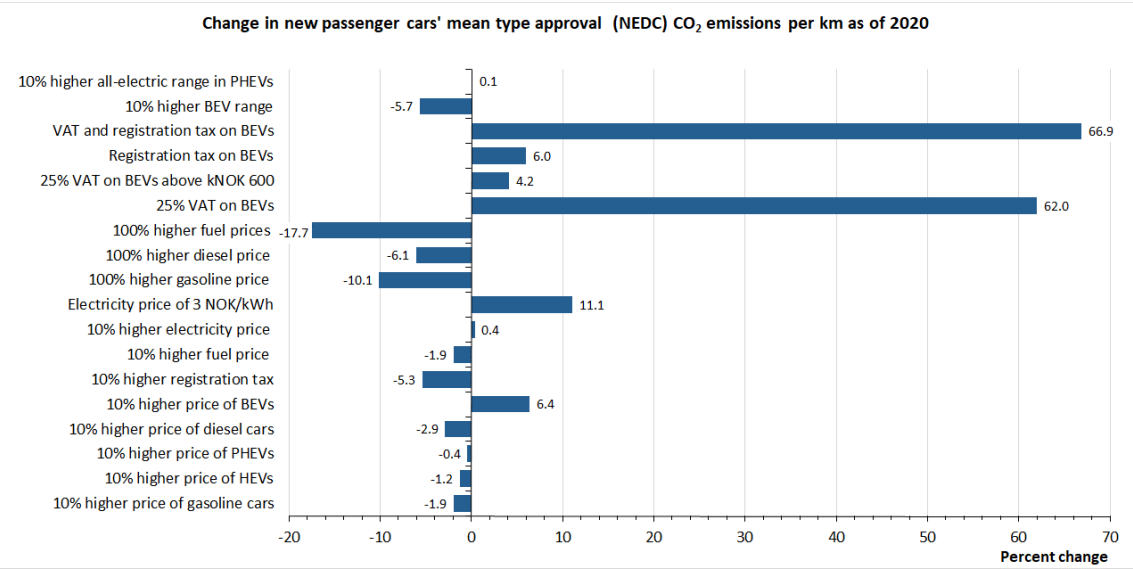


*Fig. E.2. Counterfactual scenarios for new passenger cars' mean per km rate of type approval $CO_2$ emissions in Norway. Predicted percentage change with respect to actual situation in 2020.*

A general 10 percent increase in the one-off registration tax would apparently lead to 1.4 percentage point higher BEV market share and 5.3 percent lower mean $CO_2$ emission rate.

10 percent higher prices of gasoline and diesel would increase the BEV market share by 0.6 percentage points and reduce the mean rate of fuel consumption and $CO_2$ emissions by 1.9 percent. The elasticity of mean fuel intensity with respect to the fuel price is, in other words, –0.19.

If, however, the fuel prices were to double, with the electricity price remaining constant, a 6 percentage point boost in the BEV market share, and an 18 percent drop in the fuel intensity and $CO_2$ emission rate, could be expected.

A pronounced increase in the price of electricity, from NOK 0.78 to NOK 3.00 per kWh, would have an opposite effect: a 4 percentage point decrease in BEV market share, and 11 percent more $CO_2$ emissions from new cars.

A hypothetical 10 percent increase in the range of all BEVs would enhance their market share by an estimated 2.8 percentage points. The mean $CO_2$ emission rate of new cars is projected to drop by almost 6 percent.

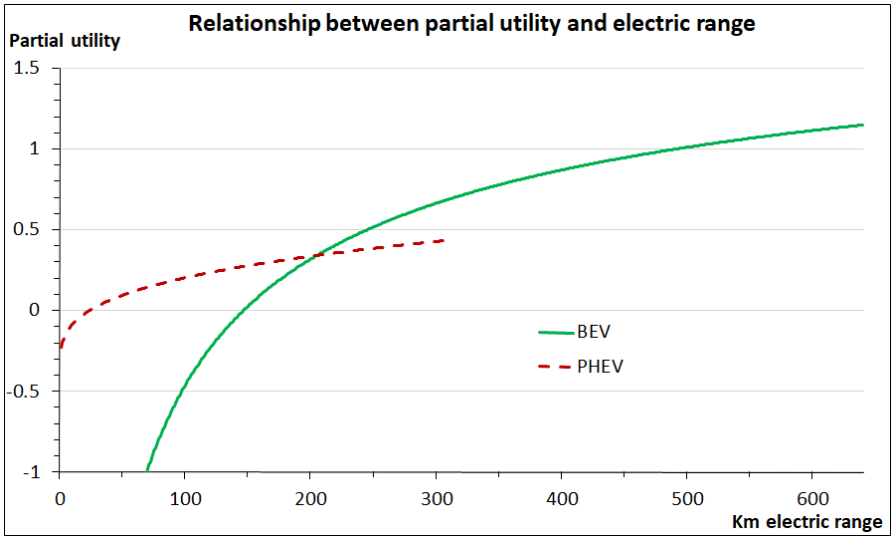


*Fig. E.3. Estimated relationship between partial utility and all-electric range of BEVs or PHEVs.*

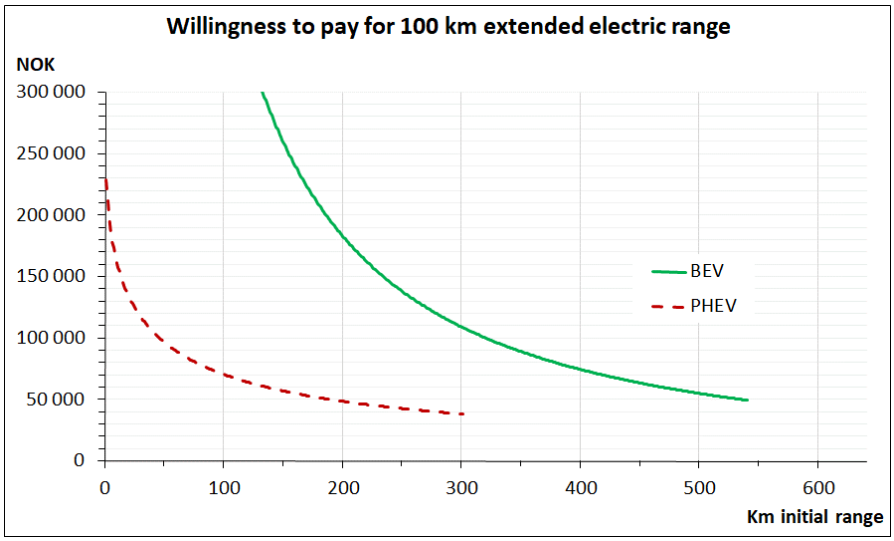


*Fig. E.4. Estimated willingness-to-pay for 100 km extended all-electric range in BEVs or PHEVs.*

The effect of electric range on utility is non-linear. To investigate this, the electric ranges of BEVs and PHEVs were specified, in our generic nested logit model, as flexible form Box-Cox functions. The Box-Cox parameter determines the curvature of the relationship. To find the best-fit pair of Box-Cox parameters for BEVs and PHEVs, a grid search was performed, resulting in Box-Cox parameters of –0.5 for BEVs and +0.3 for PHEVs. The Box-Cox functions are depicted in Fig. E.3.

Relating the marginal utility of range to the nested logit model's price coefficient, we derive the willingness-to-pay for marginal improvements in range. By integration under the marginal willingness-to-pay curve, we calculate and plot the value of a 100 km extended range.

Results are shown in Fig. E.4. At 150 km initial BEV range, the value is NOK 259 000 = US$ 27 200 = € 24 200, as converted at the July 1, 2020 exchange rates. At 500 km initial BEV range, the value of a 100 km further extension has dropped to NOK 55 000 = US$ 5770 = € 5140.