Understanding Feedback in the Transition to Electric Vehicles: Insights from the Markets in Norway and the Netherlands

Sebastiaan Deuten
Trainee EC-JRC Sustainable Transport
sebastiaan.deuten@gmail.com

Jonatan Gomez Vilchez
EC-JRC Sustainable Transport
jonatan.gomez-vilchez@ec.europa.eu

Extended Abstract

Introduction

It is increasingly more evident that the current state of the global car fleet poses a threat to quality of life. Petrol and diesel cars cause CO_2 emissions and air pollution affecting climate change and public health, causing negative externalities to the individual and society (Hoek et al., 2013; Künzli et al., 2000; Lorenzoni & Pidgeon, 2006; Reuveny, 2007; Woodcock et al., 2009). It is globally acknowledged that CO_2 emissions should be decreased (United Nations, 2015), and an increasing amount of environmental policies restrict the sales of diesel cars or its access to urban areas for the sake of cleaner air (Cames & Helmers, 2013: 14–18). Zero-emission vehicles, like battery electric vehicles (BEVs) and fuel cell vehicles (FCVs), are currently reasoned to have the greatest potential to replace vehicles relying on fossil fuels. The market share of BEVs is growing in several countries and the market share of FCVs is expected to grow within the next decade. Plug-in hybrid vehicles (PHEVs), which can both be charged and run on fossil fuels, are believed to be a stepping stone for the transition towards zero emission vehicles, useful in consumer acceptance of electric charging and for cost reductions in the production of BEVs.

Market transition to electric vehicles is widely stimulated and researched (Figenbaum, 2016; Keith, Naumov, & Sterman, 2017; Thiel, Krause, & Dilara, 2015), as well as debated concerning its policy cost effectiveness and cost fairness (Aasness & Odeck, 2015; Holtsmark & Skonhoft, 2014). The aim of this research is to derive useful policies for stimulating the future sales of PHEVs and BEVs for the passenger markets in Norway and the Netherlands. Next to that, it aims for a deeper understanding of the feedback loop complexity that causes yearly sales shares of PHEV's and BEV's till 2030. It makes use of the system dynamics Powertrain Technology Transition Market Agent Model (PTTMAM; Harrison, Thiel, & Jones, 2016; Pasaoglu et al., 2016).

The PTTMAM was built to compare historic and future alternative fuel vehicle scenarios based on data from the European Union (EU). Previous research uses the PTTMAM to perform policy analysis with regards to scenarios at the EU level, as well as within and between individual countries (Harrison & Thiel, 2017a, 2017b; Pasaoglu et al., 2016). The model is developed around the interaction between consumers, producers, infrastructure and authorities. The PTTMAM baseline scenarios are found to be generally conservative in comparison with other models (Harrison & Thiel, 2017a: 171; Pasaoglu, Honselaar, & Thiel, 2012). Recent policy analysis research with the PTTMAM arrived at satisfying replication of historic behavior for the PHEV and BEV markets in the UK and the Netherlands (Harrison & Thiel, 2017b). The PTTMAM version used for this paper consists of all current EU member states plus Norway. Model documentation and elaborate descriptions are available in previous publications (Harrison & Thiel, 2017b: 2–4; Harrison et al., 2016; Pasaoglu et al., 2016).

Methods

We use an updated version of the model which includes Norway. First, the use of automated calibration is explored to discover its added value in validating the model with respect to reflecting the historic data on new registrations of PHEVs and BEVs in Norway and the Netherlands (Oliva, 2003). As part of this we perform statistical fit analysis to historic development in comparison with previous findings (Harrison & Thiel, 2017b). Secondly, based on the high-level overview published by Harrison and Thiel (2017b: 3) two causal loop diagrams are constructed. These causal loop diagrams inform a loop knock-out analysis, which is conducted according to earlier practice (Ford, 1999; Sterman, 2000). Third, policy scenarios for Norway and the Netherlands are compared to show the hypothetical effects of taxes, tax exemptions, and emission penalties to producers, on the sales shares of PHEVs and BEVs (example shown in Figure 1).

Results and Conclusion

Based on the automated calibration procedures we discuss the realism of the current implementation of financial incentives in the model, and the usefulness of automated calibration in general. Part of the automated calibration and financial incentives have found to be of little effect on the endpoint of the future scenarios; only the Norwegian market uptake of PHEV was found to be relatively sensitive to changes in the calibrated parameters. As such most of the produced scenarios are deemed to be useful for policy analysis.

Insights from the loop knock-out analysis support previous findings that earlier technologies can hinder market uptake of later, better technologies. The outcomes of scenarios with various combinations of future policies are discussed, in which the least-emissions scenarios include a combination of 1) the continuation of current circulation and registration tax exemptions, 2) zero emission targets by 2030 for producers, and 3) proportional tax increases to consumers who drive polluting vehicles. Scenarios are described in which both the Netherlands and Norway come close to their respective goals for emissions of passenger vehicle sales in 2030 and 2025 (Fridstrøm & Østli, 2016; Koelemeijer et al., 2017; Norsk elbilforening, 2018; Rutte, van Haersma Buma, Pechtold, & Segers, 2017).

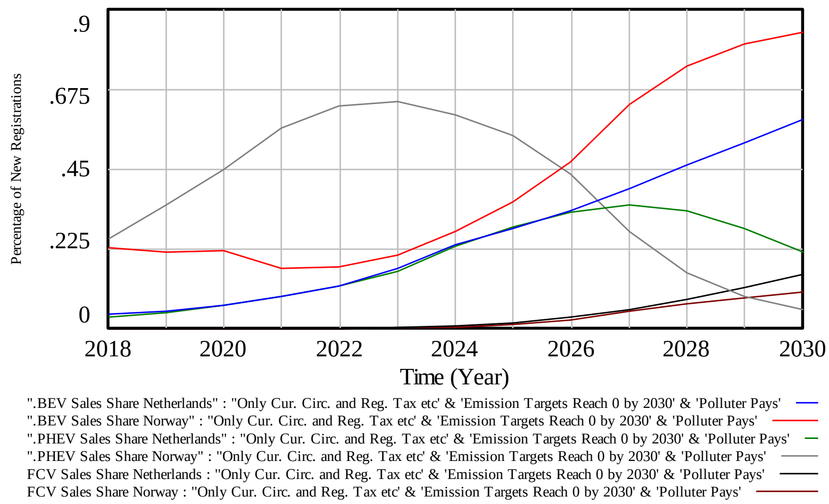

Figure 1. Scenarios concerning the hypothetical effects of a combination of tax exemptions, pollution taxes, and emission penalties (assuming these start in 2020, and all else stays equal)

Aasness, M. A., & Odeck, J. 2015. The increase of electric vehicle usage in Norway—incentives and adverse effects. ***European Transport Research Review***, 7(4). https://doi.org/10.1007/s12544-015-0182-4.

Cames, M., & Helmers, E. 2013. Critical evaluation of the European diesel car boom - Global comparison, environmental effects and various national strategies. ***Environmental Sciences Europe***, 25: 1–22.

Figenbaum, E. 2016. Perspectives on Norway's supercharged electric vehicle policy. ***Environmental Innovation and Societal Transitions***, 25: 14–34.

Ford, D. N. 1999. A Behavioral Approach to Feedback Loop Dominance. ***System Dynamics Review***, 15(1): 3–36.

Fridstrøm, L., & Østli, V. 2016. ***Vehicle fleet forecasts based on stock-flow modeling***. Oslo.

Harrison, G., & Thiel, C. 2017a. An exploratory policy analysis of electric vehicle sales competition and sensitivity to infrastructure in Europe. ***Technological Forecasting and Social Change***, 114: 165–178.

Harrison, G., & Thiel, C. 2017b. Policy insights and modelling challenges: The case of passenger car powertrain technology transition in the European Union. ***European Transport Research Review***, 9(3): 1–14.

Harrison, G., Thiel, C., & Jones, L. 2016. ***JRC Technical Reports: Powertrain Technology Transition Market Agent Model (PTTMAM)***. https://doi.org/10.2790/719385.

Hoek, G., Krishnan, R. M., Beelen, R., Peters, A., Ostro, B., et al. 2013. Long-term air pollution exposure and cardio- respiratory mortality: a review. ***Environmental Health***, 12(1): 43.

Holtsmark, B., & Skonhoft, A. 2014. The Norwegian support and subsidy policy of electric cars. Should it be adopted by other countries? ***Environmental Science and Policy***, 42: 160–168.

Keith, D. R., Naumov, S., & Sterman, J. 2017. Driving the Future: A Management Flight Simulator of the US Automobile Market. ***Simulation and Gaming***, 48(6): 735–769.

Koelemeijer, R., Daniëls, B., Boot, P., Koutstaal, P., Kruitwagen, S., et al. 2017. ***Analyse Regeerakkoord Rutte-III : Effecten op Klimaat en Energie***. Den Haag.

Künzli, N., Kaiser, R., Medina, S., Studnicka, M., Chanel, O., et al. 2000. Public-health impact of outdoor and traffic-related air pollution: a European assessment. ***The Lancet***, 356: 795–801.

Lorenzoni, I., & Pidgeon, N. F. 2006. Public views on climate change: European and USA perspectives. ***Climatic Change***, 77(1–2): 73–95.

Norsk elbilforening. 2018. ***Norwegian EV Policy***. https://elbil.no/english/norwegian-ev-policy/.

Oliva, R. 2003. Model calibration as a testing strategy for system dynamics models. ***European Journal of Operational Research***, 151(3): 552–568.

Pasaoglu, G., Harrison, G., Jones, L., Hill, A., Beaudet, A., et al. 2016. A system dynamics based market agent model simulating future powertrain technology transition: Scenarios in the EU light duty vehicle road transport sector. ***Technological Forecasting and Social Change***, 104: 133–146.

Pasaoglu, G., Honselaar, M., & Thiel, C. 2012. Potential vehicle fleet CO2reductions and cost implications for various vehicle technology deployment scenarios in Europe. ***Energy Policy***, 40(1): 404–421.

Reuveny, R. 2007. Climate change-induced migration and violent conflict. ***Political Geography***, 26(6): 656–673.

Rutte, M., van Haersma Buma, S., Pechtold, A., & Segers, G. 2017. ***Vertrouwen in de toekomst: Regeerakkoord 2017-202***. Den Haag.

Sterman, J. D. 2000. ***Business dynamics: systems thinking and modeling for a complex world***. Boston: Irwin/McGraw-Hill.

Thiel, C., Krause, J., & Dilara, P. 2015. ***Electric vehicles in the EU from 2010 to 2014 - is full scale commercialisation near?*** https://doi.org/10.2790/921495.

United Nations. 2015. Paris Agreement. ***21st Conference of the Parties***. https://doi.org/FCCC/CP/2015/L.9.

Woodcock, J. W., Edwards, P., Tonne, C., Armstrong, B. G., Ashiru, O., et al. 2009. Public health benefits of strategies to reduce greenhouse-gas emissions: urban land transport. ***Lancet***, 374(April): 1930–43.