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Reaching 30% plug-in vehicle sales by 2030: Modeling incentive and sales mandate strategies in Canada

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ABSTRACT

Plug-in electric vehicles (PEVs) could play a strong role in decarbonizing the transportation sector, leading some governments to set the goal of PEVs accounting for 30% of new sales by 2030 (e.g., the "EV30@30" campaign). To explore the feasibility of this goal, we use a behaviourally-realistic vehicle adoption model (REPAC) to simulate the impacts of incentives and vehicle mandates on PEV sales over this time frame, using the case study of Canada. We consider a range of technology assumptions, including optimistic and pessimistic battery cost scenarios ($CDN 85/kWh and $CDN 125/kWh, respectively, by 2030). We find that the country's present policies can only induce PEVs to reach 5–11% new market share by 2030. Without changes in PEV supply, we find that purchase incentives can boost PEV new market share, where a $CDN 6000/vehicle subsidy is needed for 13 years to reach the 2030 goal (in the median technology assumption scenario). We also model ZEV mandate scenarios where automakers must reach 30% or 40% PEV sales by 2030, finding that compliance with both is achievable even in pessimistic technology scenarios, through a combination of increased PEV model availability and intra-firm cross-price subsidies. While incentive-based or mandate-based strategies (or some combination thereof) can achieve 2030 goals, results demonstrate the high government expenditure involved in an incentive-based strategy – $CDN 15–48 billion undiscounted ($10–28 billion discounted), or around $9000–10,000 per added PEV sale. Policymakers ought to consider these tradeoffs, among others, when designing PEV-supportive policies to achieve long-term climate goals.

1. Introduction

Research and real-world experience demonstrate that strong policy can encourage plug-in electric vehicle (PEV) sales to approach the levels needed to achieve long-term greenhouse gas targets. Research on the North American vehicle market suggests that strong policies that remove both demand side and supply side barriers can boost future PEV market shares to 24–40% by 2030 (Lin and Greene, 2011; Sullivan et al., 2009; Tran et al., 2013). Globally, we see that the regions with the strongest PEV supportive policies—Norway, the Netherlands, and the State of California—also have the highest PEV new market shares (Melton et al., 2017; Mock and Yang, 2014; Sierzchula et al., 2014). In this paper we explore and compare the ability of PEV purchase incentives and sales mandates to induce substantial PEV sales. In particular, we focus on the goal of PEVs accounting for at least 30% of new light-duty vehicle sales by 2030, as set by the Clean Energy Ministerial in their "EV30@30" campaign, organized by the International Energy Agency (2017a). This target is in line with a trajectory to meet the 40% by 2040 PEV sales indicated in one of the International

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Energy Agency's 2 °C warming scenarios (IEA, 2017b).

A wide range of policies can stimulate uptake of PEVs. In general, PEV policies can be categorized as demand-focused or supply-focused (Melton et al., 2017). Demand-focused policies aim to support or encourage consumer demand for PEVs, for example by offering purchase incentives, PEV-supportive building codes or supporting the deployment of charging infrastructure at home, work or public locations. In contrast, supply-focused policies encourage or require suppliers such as auto manufacturers, dealerships and fuel suppliers to develop and sell PEVs. One example of supply-focused policy (which is examined in this study) is the zero-emissions vehicle (ZEV) mandate implemented in California and 10 other "ZEV States" as well as the Canadian Province of Québec, a policy that requires a certain share of vehicles sold in the jurisdiction to have zero (or the potential for zero) tailpipe emissions.

Many policymakers and stakeholders want to forecast the sale of PEVs, in particular to understand how to influence those sales through policy. However, as noted by Greene and Ji (2016) and Al-Alawi and Bradley (2013), most PEV adoption models do not explicitly model supply-focused policies, likely due to the inherent complexity and limited available data regarding automaker decisions and innovation processes. The few examples of studies that focused on supply-focused policies include technology adoption models exploring how fuel economy and GHG standards will impact or interact with PEV sales in the US (Sen et al., 2017; Xie and Lin, 2017), and simulation models of a ZEV mandate (Greene et al., 2014; Sykes and Axsen, 2017; Wolinetz and Axsen, 2017) and low-carbon fuel standard (Lepitzki and Axsen, 2018). However, the majority of PEV adoption models only include scenarios with demand-focused policies such as purchase incentives and the deployment of charging infrastructure. Thus, there remains a gap in the literature in supply-focused policy modeling, and especially in the comparison of supply- and demand-focused policy scenarios.

In this paper, we use the REspondent-based Preference And Constraints Model (REPAC) to simulate the effects of different demand- and supply-focused policy packages on PEV new market share sales out to 2030, using Canada as a case study. REPAC is a model that represents the PEV preferences and constraints of consumers using data collected via a 2013 representative survey of new-vehicle buying households, which is described in more detail in Wolinetz and Axsen (2017). While the previous study simulated policy scenarios in the Canadian province of British Columbia, the present paper extends the model to include survey respondents from the entire English-speaking population of Canada and to explore different research objectives and policy scenarios. Specifically, our present research objectives are to simulate:

1. the effects of Canada's current suite of climate policies (as of Spring 2017) on 2030 PEV new market share;
2. the stringency and duration of financial incentives needed to meet the 30% by 2030 target (and required government expenditure); and
3. the feasibility of automakers' compliance with a ZEV mandate requiring 30% or 40% PEV new market share by 2030 (with some supportive policies in place).

One contribution of this study is our test of the notion that short-term subsidies might provide enough of a "trigger" to induce long-term PEV sales—for example, that purchase incentives in place from 2017 to 2020 would be enough to meet the 2030 sales goal. We examine this potential using a model that provides realistic representations of both consumer preferences (albeit static ones) as well as supply side constraints. A further novelty is that this is the first study to use a behaviourally-realistic modeling approach to produce quantitative comparisons of the effectiveness of incentive-based and mandate-based policy strategies. Also, of the few studies that have modeled a ZEV mandate, none have represented specific mechanisms of automaker compliance. We represent two such mechanisms: increasing PEV make and drivetrain availability, as well as an intra-firm cross-price subsidization scheme where automakers increase the price of non-PEVs to reduce the price of PEVs in order to achieve the sales requirement.

Our focus is on PEVs, including both plug-in hybrid vehicles (PHEVs) and pure battery electric vehicles (BEVs), in the light-duty vehicle sector for private use, which accounts for over 80% of light-duty vehicle sales in Canada (Canadian Automotive Fleet, 2016; Statistics Canada, 2016). Admittedly, our analysis focuses on only one criteria of policy analysis: effectiveness, or impact on PEV new market share (relative to the 2030 sales goal). We also report government expenditure (money given out by the government as purchase subsidies) related to incentives, as this is an important consideration to most policymakers. However, a policymaker will typically want to consider a range of additional policy evaluation criteria, such as fairness, equity impacts, political acceptability and administrative complexity.

2. A brief review of PEV adoption models

Al-Alawi and Bradley (2013) provide one of the most insightful literature reviews on models that simulate PEV market share, which has been updated to an extent by Wolinetz and Axsen (2017). Both articles identify a number of attributes that would characterize an ideal or excellent PEV market share simulation model—which we presently collapse into three broad attributes. First is behaviour realism, where an excellent model is based on consumer data, ideally a large, representative sample. Consumers should be represented not as simplistic agents that make "optimal" decisions based on financial costs, but rather as complex human beings with preferences or perceptions that might value symbolic, societal or other non-financial aspects of PEVs (Axsen et al., 2013; Heffner et al., 2007; Turrentine and Kurani, 2007). Further, a behaviourally realistic model would account for the fact that some car buyers might have little or no awareness or understanding of PEVs (Axsen et al., 2017; Caperello and Kurani, 2012) and that such awareness can change as markets develop, and also represent the substantial heterogeneity in consumer perceptions and preferences (Axsen et al., 2015a; Mohamed et al., 2016).

The second desirable attribute is the explicit representation of vehicle supply, namely how there might be lack of variety and availability in PEV makes and models in the near term, which is typical for emerging technologies. For example, several studies