Author: Jonn Axsen ***Submitted: July 2, 2020***

Written Submission: Policy Brief – Zero-emission Vehicle (ZEV) Mandate

Submitted to: Hong Kong Legislative Council's (LegCo) Subcommittee to Study Issues Relating to the Development of Electric Vehicle

Prepared by: Jonn Axsen, Director of the Sustainable Transportation Action Research Team (START), Associate Professor at Simon Fraser University (CV attached at bottom)

Date: July 2, 2020

This submission is in response to the Hong Kong Legislative Council's (LegCo) Subcommittee to Study Issues Relating to the Development of Electric Vehicles. This Subcommittee has invited written submissions regarding EV-supportive policy for light-duty vehicles. Here, I focus on the zero-emissions vehicle (ZEV) sales mandate or ZEV standard – which I refer to simply as "ZEV mandate". Following the definition of existing ZEV mandates, a ZEV includes pure battery electric vehicles (BEVs), plug-in hybrid vehicle (PHEV), and hydrogen fuel-cell vehicles (HFCVs) [1].

To start, there is strong support for the policy goal of dramatically increasing light-duty ZEV sales around the world. The goal of reaching 30% ZEV sales by 2030, which is stated by the Clean Energy Ministerial, is consistent with research by the International Energy Agency demonstrating the sales pathway needed to achieve 2°C warming scenarios[2,3]. Further, there is extensive evidence that transportation electrification (especially ZEV uptake) can contribute to both climate and air quality goals in a variety of regions[4,5].

I divide this document into three sections. The first section summarizes the ZEV mandate, as it has been deployed in several jurisdictions in the world. The second section provides evidence in support of a ZEV mandate as an effective policy instrument. The third section briefly considers the suitability of Hong Kong as a jurisdiction for this policy.

Section 1: Overview of the ZEV mandate

A ZEV mandate requires automakers to produce and/or sell ZEVs in a given region, subject to fines for non-compliance. The US State of California first implemented a ZEV mandate in 1990,

[1] Please note that the language and terms of vehicle drivetrains and categories varies widely across sources, regions and policies. Here, we use a simple definition of a ZEV as being a vehicle that can be powered either by hydrogen (HFCV), or that can be plugged in to charge a battery that is fully (BEV) or partially (PHEV) powers a vehicle. Some of the ZEV mandate regulations will distinguish between more specific definitions, including pZEV, tZEV and NEV. However, we use ZEV as the broader definition, including the HFCVs, PHEVs and BEVs noted already.
[2] International Energy Agency (2019). *Global EV Outlook 2019*.
[3] IEA (2017). *New CEM campaign aims for goal of 30% new electric vehicle sales by 2030*. https://www.iea.org/newsroom/news/2017/june/new-cem-campaign-aims-for-goal-of-30-new-electric-vehicle-sales-by-2030.html.
[4] Creutzig, F., P. Jochem, et al. (2015). "Transport: A roadblock to climate change mitigation?" Science 350(6263): 911.
[5] Davis, S. J., N. S. Lewis, et al. (2018). "Net-zero emissions energy systems." Science 360(6396): eaas9793.

and versions have since been implemented in other US States, as well as Canada and China, as summarized below (and in Table 1).

California. In the 1990s, California was the first region to design and implement a ZEV mandate. Most regions that adopt, or consider adopting, ZEV mandates seek to emulate California (such as two Canadian provinces and China). The ZEV mandate is a credit-based system. When an automaker produces a ZEV, they receive credits which can be used to meet their requirements. The mandate requires automakers to earn a minimum number of ZEV credits each year (based on the number of vehicles they sell in the state) or to face compliance fines ($5,000 USD for every ZEV credit they do not accrue). If an excess of credits is accrued, they can be banked for later years or can be sold to other automakers. If a given automaker does not earn enough credits, it can either pay the fines, or purchase excess ZEV credits from other automaker.

China. In September 2017, China's Ministry of Industry and Information Technology finalized their New Energy Vehicle (NEV) Regulation, which in practice is also a ZEV mandate. Like ZEVs, NEVs include PHEVs, BEVs, and HFCVs. The regulation currently sets requirements for the number of NEVs sold in 2019 (10% credit target) and 2020 (12% credit target). While these targets are higher than those of California, the credit award system is also slightly higher with PEVs being able to obtain up to 6 credits per vehicle compared to 4 in California. The NEV regulation contains specific caps and provisions of credits that are related to the NEV technology, vehicle range, and vehicle speed. One difference in China's NEV regulation (compared to California), is that it is coupled to China's vehicle emissions standards policy. Credits generated from NEV can be used to fulfil credit deficits in the fuel economy policy—manufacturers that over-comply with NEV can "double-count" excess credits towards fuel consumption targets.

Quebec, Canada. The province of Quebec passed legislation for its mandate in 2016, which is very similar to the California policy in stringency, timeline, detail and complexity. There are slight differences in what technologies are eligible for credits (or not), and the overall ZEV sales requirements are slightly more lenient in the first two years of introduction (2018 and 2019).

British Columbia, Canada. The province of British Columbia passed legislation for its own ZEV mandate in 2019. Again, many of the design details are similar to the California system. However, the overall time horizon and stringency is noticeably different: British Columbia has the only ZEV mandate with explicit ZEV sales requirements for 2030 (30% ZEV sales) and 2040 (100% ZEV sales). These latter requirements are highly stringent, effectively transitioning into a ban on conventional vehicles in 2040[6].

[6] Plötz, P., J. Axsen, et al. (2019). "Designing car bans for sustainable transportation." *Nature Sustainability* 2(7): 534-536.

TABLE 1: Summaries of four ZEV mandates in places (Source: adapted from[7])

	California ZEV Program	**China NEV Regulation**	**Quebec, Canada ZEV mandate**	**British Columbia, Canada ZEV mandate**
Regulated automaker	Sell more than 20,000 vehicles per year	Sell more than 30,000 vehicles per year	Sell more than 4,500	Sell more than 4,500 vehicles per year
ZEV credits[a]	7% in 2019 9.5% in 2020 7-12% by 2025	10% in 2019 12% in 2020 20% by 2025	6.5% in 2019 9.5% in 2020 7-12% by 2025	10% in 2025 30% in 2030 100% in 2040
Penalty for non-compliance	$USD 5000/credit	Penalties within the broader vehicle emissions standard	$CDN 5000/credit	$CDN 5000/credit
Can credits be saved for future years?	Yes	No, with the exception of 2019 to 2020	Yes (but limited to 25% of compliance in a given year)	Yes
Technological specificity	Certain portion of requirement must be pure ZEV (BEV or HFCV)	Any of the three drivetrains can be used for compliance (no maximum)	Same as California	Same as California, escalating requirement for BEVs/HCVSs to be 70% of ZEV sales by 2040
Credits per vehicle sold	Varies by vehicle type: 0.4 to 4 credits (more credits for longer electric driving ranges)	Varies by vehicle type: 1 to 6 credits (more credits for longer electric driving ranges)	Same as California	2020-25: 0.4 to 4 credits (more credits for longer range BEVs and HFCVs 2026 and beyond: 1 credit per ZEV

[a] Automakers must achieve a certain percent of their sales in credits. As credits per ZEV or NEV sold can exceed 1 the number of ZEVs or NEVs actually produced may not equal the percentage credit requirement.

The Europe Union. It is worth noting that while the EU does not have a direct ZEV mandate, it has other supply-focused policies that may in practice require automakers to produce electric vehicles. In 2019, the EU adopted a strict CO_2 performance standard (gCO_2/km) on light-duty vehicles that requires a 37.5% reduction in GHG emissions by 2030 relative to 2021—a target that likely can only be met with adoption of ZEVs. Additionally, there is an additional “incentive mechanism” for ZEV innovation that decreases the emissions requirement for a given automaker that achieves at least 35% ZEV new market share by 2030.

[7] Hardman, S., A. Jenn, et al. (2018). *Driving the Market for Plug-in Vehicles: Understanding ZEV Mandates*. Davis, California, USA, Institute of Transportation Studies, University of California, Davis.

Section 2: Evaluating the ZEV mandate as a policy instrument

The main advantage of a well-designed ZEV mandate is that it sends a clear signal to automakers and other suppliers over the long-term[8]. Most generally, a ZEV mandate can induce a number of compliance strategies among automakers that sell in that region. These strategies could include:

- increasing ZEV availability (more stock, availability and variety of models) in that region;
- lowering the price of ZEVs in that region (and increasing the price of conventional vehicles, via intra-firm cross-price subsidies);
- increasing marketing efforts for ZEVs in that region; and
- investing more in long-term Research & Development to bring down the future cost of ZEVs, and to bring out a broader range of high-quality ZEV models for sale in future years.

A ZEV mandate also:

- creates an environment to support the emergence of new, ZEV-focused automakers;
- can provide automotive dealership with confidence to take the time to train their staff and update their facilities to better sell ZEVs; and
- sends a signal that can encourage other stakeholders to coordinate to support the emergence of ZEVs in that region (including electricity utilities, infrastructure providers, transportation planners, consumer groups, etc.).

Note that existing ZEV mandates are imposed at the automaker level, not directly on automotive dealerships. There are no obligations on dealerships to change their behaviour. That said, automakers may choose to provide incentives to encourage dealerships to more effectively sell ZEV models. Policymakers may also want to enact a complementary program that subsidizes the training of dealership staff in regards to ZEV models, so that they can better inform customers about the availability and benefits of ZEVs.

Here we review several categories of impacts from a ZEV mandate, which make it a particularly unique policy instrument with long-term transformative potential. Many of these details are summarized by the *UC Davis International EV Policy Council*'s report on ZEV mandates [9].

First, a ZEV mandate increases electric vehicle availability (providing more choice for consumers). Several studies based in North America and Europe demonstrate that there is a limited supply of ZEVs relative to conventional vehicles, including limited model variety and availability in a given jurisdiction[10,11], and limited inventory and knowledge at dealerships [12,13].

---

[8] Melton, N., J. Axsen, et al. (2020). "Which plug-in electric vehicle policies are best? A multi-criteria evaluation framework applied to Canada." *Energy Research & Social Science* 64: 101411.

[9] Hardman, S., A. Jenn, et al. (2018). *Driving the Market for Plug-in Vehicles: Understanding ZEV Mandates*. Davis, California, USA, Institute of Transportation Studies, University of California, Davis.

[10] Axsen, J. and M. Wolinetz (2018). "Reaching 30% plug-in vehicle sales by 2030: Modeling incentive and sales mandate strategies in Canada." Transportation Research Part D: Transport and Environment 65: 596-617.

[11] Wolinetz, M. and J. Axsen (2017). "How policy can build the plug-in electric vehicle market: Insights from the respondent-based preference and constraints (REPAC) model." Technological Forecasting and Social Change 117: 238-250

Regions in the US that are under the jurisdiction of the ZEV mandate have higher ZEV availability than other regions [14]. The logic of the relationship is fairly clear: with a stringent ZEV mandate in place, automakers are incentivized to develop more ZEVs in general in the long term, and to supply and market these vehicles in regions where the policy is in place (compared to a non-regulated region).

Second, a ZEV mandate increases electric vehicle sales. Several studies demonstrate that these ZEV supply constraints can substantially reduce ZEV sales. For example, statistical analysis of 200 metropolitan areas in the US finds that ZEV availability is an important driver of ZEV sales [15]. North American modeling studies show that without increased ZEV supply, ZEV new market share by 2030 is not likely to exceed 5-10% [16]. Modeling of China's ZEV mandate suggests that the policy will drive down battery costs, and increase the market popularity of ZEV models[17]. Another study shows that a small region (similar in population to Hong Kong), cannot effectively "free-ride" off of the innovation effects of a ZEV mandate enacted in other jurisdictions [18], for example, China. Rather, a region-specific ZEV mandate would also be needed to drive ZEV sales in the smaller region.

Third, a ZEV mandate has been shown to successfully drive innovation activities. Several studies find that California's ZEV mandate has positively influenced ZEV-related innovation activities, including increased patent activity [19], the development of vehicle prototypes[20], private companies forming partnerships[21], as well as increased employment and investment in companies in California [22]. Because changes in such activities must be observed over several years, ZEV mandates in China, Quebec and British Columbia are too new to demonstrate these effects. While Hong Kong is a smaller market than California, the adoption of a particularly long-term and stringent ZEV mandate (requiring 100% sales by 2040) can help to inspire other

---

[12] Matthews, L., J. Lynes, et al. (2017). "Do we have a car for you? Encouraging the uptake of electric vehicles at point of sale." Energy Policy 100: 79-88.
[13] Zarazua de Rubens, G., L. Noel, et al. (2018). "Dismissive and deceptive car dealerships create barriers to electric vehicle adoption at the point of sale." Nature Energy 3(6): 501-507.
[14] Lutsey, N., S. Searle, et al. (2015). Assessment of Leading Electric Vehicle Promotion Activities in United States Cities. . San Francisco, CA, The International Council on Clean Transportation.
[15] Slowik, S. and N. Lutsey (2018). The Continued Transition to Electric Vehicles in U.S. Cities. San Francisco, USA, The International Council on Clean Transportation (ICCT).
[16] Axsen, J. and M. Wolinetz (2018). "Reaching 30% plug-in vehicle sales by 2030: Modeling incentive and sales mandate strategies in Canada." *Transportation Research Part D: Transport and Environment* 65: 596-617.
[17] Zhao, F., Chen, K., Hao, H., Wang, S. & Liu, Z. (2019). Technology development for electric vehicles under new energy vehicle credit regulation in China: scenarios through 2030. *Clean Technologies and Environmental Policy* 21, 275-289, doi:10.1007/s10098-018-1635-y.
[18] Sykes, M. and J. Axsen (2017). "No free ride to zero-emissions: Simulating a region's need to implement its own zero-emissions vehicle (ZEV) mandate to achieve 2050 GHG targets." *Energy Policy* 110: 447-460.
[19] Vergis, S. and V. Mehta (2010). Technology innovation and policy: a case study of the California ZEV mandate. *Paving the Road to Sustainable Transport: Governance and innovation in low-carbon vehicles*. T. F. Group.
[20] Melton, N., J. Axsen, et al. (2016). "Moving beyond alternative fuel hype to decarbonize transportation." *Nature Energy* 1(3): 1-10.
[21] Dyerson, R. and A. Pilkington (2005). "Gales of creative destruction and the opportunistic incumbent: The case of electric vehicles in California." *Technology Analysis and Strategic Management* 17(4): 391-408.
[22] Burke, A., K. S. Kurani, et al. (2000). *Study of the Secondary Benefits of the ZEV Mandate,* UCD-ITS-RR-00-07 University of California, Davis, Institute of Transportation Studies.

regions to adopt a similar policy, further sending a signal for long-term investment in ZEV research and development.

Fourth, a ZEV mandate can play a strong role in environmental goals (air quality and GHG emissions). Several modeling studies have demonstrated the importance of this policy in achieving long-term GHG reductions in the US [23,24,25]. Similarly, published research in Canada confirms the importance of this goal of 30% ZEV sales by 2030, and more ambitious goals by 2040 as part of a trajectory to meet 80% GHG reduction targets by 2050[26]. A ZEV mandate could be a particularly important driver of emissions reduction in the light-duty vehicle sector [27], especially in regions where the carbon intensity of electricity generation is planned to decrease in future years [28]. Widespread ZEV uptake has also been found to reduce air pollution in urban areas (NOx, VOCs, CO and $PM_{2.5}$), even when powered by thermal electric power plants – though air quality benefits would be even stronger with future changes to cleaner sources of electricity and more efficient power plants[29].

Fifth, a ZEV mandate can be designed to be relatively cost-effective. Generally, economists will recommend environmental pricing as the most "efficient" type of policy for air pollution or GHG mitigation, as it is technology-neutral and can send a long-term price signal. However, in the real world, the stringent carbon pricing needed for ambitious environmental goals is not likely to be politically acceptable in most regions [30]. One modeling study shows that the (social welfare) efficiency of a ZEV mandate depends on the details of policy design, and that such a policy can be more efficient if it sends a strong and clear signal to more quickly reduce adoption costs for electric vehicles [31].

Finally, a ZEV mandate can be a powerful complement to other ZEV policies. For example, a ZEV purchase incentive program can be used to help automakers comply with a ZEV mandate, especially in the initial years of the mandate[32]. A ZEV mandate can also induce confidence

[23] Greene, D. L., S. Park, et al. (2014). "Analyzing the transition to electric drive vehicles in the U.S." *Futures* 58: 34-52.
[24] Greene, D. L., S. Park, et al. (2014). "Public policy and the transition to electric drive vehicles in the U.S.: The role of the zero emission vehicles mandates." *Energy Strategy Reviews* 5: 66-77.
[25] Greenblatt, J. B. (2015). "Modeling California policy impacts on greenhouse gas emissions." *Energy Policy* 78: 158-172.
[26] Sykes, M. and J. Axsen (2017). "No free ride to zero-emissions: Simulating a region's need to implement its own zero-emissions vehicle (ZEV) mandate to achieve 2050 GHG targets." *Energy Policy* 110: 447-460.
[27] Lepitzki, J. and J. Axsen (2018). "The role of a low carbon fuel standard in achieving long-term GHG reduction targets." *Energy Policy* 119: 423-440.
[28] Kamiya, G., J. Axsen, et al. (2019). "Modeling the GHG emissions intensity of plug-in electric vehicles using short-term and long-term perspectives." *Transportation Research Part D: Transport and Environment* 69: 209-223.
[29] Li, N., J.-P. Chen, et al. (2016). "Potential impacts of electric vehicles on air quality in Taiwan." Science of The Total Environment 566-567: 919-928.
[30] Rhodes, E., J. Axsen, et al. (2017). "Exploring Citizen Support for Different Types of Climate Policy." *Ecological Economics* 137: 56-69.
[31] Fox, J., J. Axsen, et al. (2017). "Picking Winners: Modelling the Costs of Technology-specific Climate Policy in the U.S. Passenger Vehicle Sector." *Ecological Economics* 137: 133-147.
[32] Axsen, J. and M. Wolinetz (2018). "Reaching 30% plug-in vehicle sales by 2030: Modeling incentive and sales mandate strategies in Canada." *Transportation Research Part D: Transport and Environment* 65: 596-617.

among other stakeholders to take supportive action, such as deploying further charging infrastructure[33].

Section 3: The case of Hong Kong

ZEVs currently make up about 2.2% of new light-duty vehicle sales in Hong Kong. We note that Hong Kong has a population of about 7.5 million people, and does not have local vehicle manufacturing. These features make Hong Kong quite similar to several of the jurisdictions that already have a ZEV mandate. In terms of population, California is larger (almost 40 million), Quebec, Canada is similar in size (8.5 million), and British Columbia, Canada is even smaller (5 million). Further, like Hong Kong, these regions do not have significant vehicle manufacturing. In short, it seems that the absence of local vehicle manufacturing may be an advantage, politically, for the implementation of a ZEV mandate.

Drawing from the above review, we see the following advantages for a ZEV mandate enacted in Hong Kong:

- A transition to ZEVs should help Hong Kong to meet environmental goals in the long term (GHG mitigation and air quality improvement).
- Strong policy is needed to support ZEV uptake (beyond 5-10% new market share of light-duty vehicles).
- Research shows that a ZEV mandate can achieve much more ambitious ZEV market share numbers (30% by 2030 and beyond), while leading to increased ZEV availability for consumers.
- Compared to other policies, a policy mix lead by a ZEV mandate strategy can be more credible in sending a transformative signal to industry and other stakeholders.
- Research suggests that regulations like a ZEV mandate are much more acceptable to citizens than strong carbon or environmental pricing.
- Hong Kong does not have local vehicle manufacturing, meaning that automaker opposition should be less strong than regions that are dominated by automakers.
- Research shows that smaller regions (like Hong Kong) are likely to need a ZEV mandate in order for global automakers to focus marketing and sales efforts in that region.

[33] Melton, N., J. Axsen, et al. (2020). "Which plug-in electric vehicle policies are best? A multi-criteria evaluation framework applied to Canada." *Energy Research & Social Science* 64: 101411.

CV for JONN AXSEN, Ph.D. (Updated July 2, 2020)

School of Resource and Environmental Management
Simon Fraser University
8888 University Drive,
Burnaby, B.C. V5A 1S6

778-239-1169
jaxsen@sfu.ca
Office: TASC 1 8411

EDUCATION

Ph.D., Transportation Technology and Policy, University of California, Davis, 2010. Dissertation: Interpersonal influence within car buyers' social networks: Observing consumer assessment of plug-in hybrid electric vehicles (PHEVs) and the spread of pro-societal values. Advisor: Dr. Kenneth S. Kurani, Dr. Thomas Turrentine and Prof. Daniel Sperling.

Master of Resource Management, Simon Fraser University, Vancouver, Canada, 2006. Thesis: Combining stated and revealed choice research to inform energy system simulation models: The case of hybrid-electric vehicles. Advisor: Prof. Mark Jaccard and Prof. Dean Mountain.

Bachelor of Business Administration, First class honors, Simon Fraser University, Vancouver, Canada, 2004.

RESEARCH EXPERIENCE

- Adoption of pro-environmental technology
- Electric mobility and alternative fuel vehicles
- Consumer attitudes, values, lifestyle and social influence
- Citizen acceptance of energy and policy
- Energy system simulation modeling
- Climate policy design and impacts

RESEARCH SKILLS

- Behavioral research methods: consumer surveys and interviews; social network analysis and observation.
- Simulation modeling: energy-economy models, discrete choice models, and integration across models.
- Quantitative analysis: continuous and categorical statistics; linear and logistic regression; factor and cluster analysis.
- Qualitative analysis: narrative and content analysis.
- Policy analysis: quantitative and qualitative tradeoffs.

ACADEMIC POSITIONS

Associate Editor, *Energy Research & Social Science*, January 2019-present.
Associate Professor, Simon Fraser University, 2016-present.
Visiting Senior Research Fellow, University of Sussex, July-December 2017.
Assistant Professor, Simon Fraser University, 2011-2016.
Post-Doctoral Research, UC Davis, 2010-2011.
Doctoral Research, UC Davis, 2007-2010.
Master's Research, Simon Fraser University, 2004-2006.

SELECTED PEER-REVIEWED PUBLICATIONS

Notes:

- Has published a total of 59 peer-reviewed journal articles, 22 as first author. 10 of these articles have been cited over 100 times.
- Has also published 4 book chapters, and 29 reports for industry, government and stakeholders
- H-index = 32 (32 publications cited at least 32 times).
- Note that author order proceeds from author with largest contribution to author with least.
- Has given over 100 presentations at international conferences on energy, transportation and climate change.

Selected Recent Journal Articles

2020

- **Axsen, J**., P. Plotz and M. Wolinetz (Accept with Minor Revisions). Crafting strong, integrative policy mixes to meet deep CO_2 targets for road transport, accepted by *Nature Climate Change*.
- Long, Z., **J. Axsen**, and S. Kitt (Accept with Minor Revisions). Public support for supply-focused climate policy in the transport sector: Vehicle emissions, low carbon fuel, and zero-emissions vehicle standards in Canada and California, accepted by *Transportation Research Part A: Policy and Practice.*
- Bhardwaj, C., **J. Axsen**, F. Kern & D. McCollum (2020). Why have multiple climate policies for light-duty vehicles? Policy mix rationales, interactions and research gaps, *Transport Research Part A: Policy and Practice,* 135, 309-326.
- Melton, N., **J. Axsen**, B. Moawad, (2020). Which plug-in electric vehicle policies are best? A multi-criteria evaluation framework applied to Canada, *Energy Research & Social Science*, 64, 101411.
- Hammond, W., **J. Axsen**, and E. Kjeang (2020). How to slash greenhouse gas emissions in the freight sector: Policy insights from a technology-adoption model of Canada, *Energy Policy,* 137, 111093.
- Miele, A., **J. Axsen**, M. Wolinetz, E. Maine and Z. Long (2020). The role of charging and refuelling infrastructure in supporting zero-emission vehicle sales, accepted by *Transportation Research Part D: Transport and Environment*, 81, 102275.

2019

- Plotz, Patrick, **J. Axsen,** S. Funke and T. Gnann (2019). Designing car bans for sustainable transportation, *Nature Sustainability,* 2, 534-536.
- Long, Z., **J. Axsen**, & C. Kormos, (2019). Consumers continue to be confused about electric vehicles: Comparing awareness among Canadian new car buyers in 2013 and 2017, *Environmental Research Letters*, 14, 11.
- Long, Z., **J. Axsen**, I. Miller, & C. Kormos. (2019). Electric vehicles and automotive brand: How has Tesla shaped consumer perceptions? *Transportation Research Part A: Policy and Practice*, 129, 185-204.
- Lajevari, M., **J. Axsen**, and C. Crawford (2019). Comparing alternative heavy-duty drivetrains based on GHG emissions, ownership and abatement costs: Simulations of freight routes in British Columbia, *Transportation Research Part D: Transport and Environment,* 76, 19-55.
- **Axsen, J.,** and B. Sovacool (2019). The roles of users in shared, electric and automated mobility transitions, *Transportation Research Part D: Transport and Environment*, 71, 1-21.
- Kamiya, G., **J. Axsen**, and C. Crawford (2019). Short-term and long-term perspectives on plug-in electric vehicle GHG intensity, *Transportation Research Part D: Transport and Environment,* 69, 209-223. [2016 JCR = **3.4**,]
- Long, Z, **J. Axsen**, C. Kormos, and S. Goldberg (2019), Latent-demand for zero-emissions vehicles in Canada (Part 1): Insights from a design space exercise, *Transportation Research Part D: Transport and Environment*, 67, 51-66.

- Kormos, C., **J. Axsen**, Z. Long, and S. Goldberg (2019), Latent-demand for zero-emissions vehicles in Canada (Part 2): Insights from a latent-class choice model, *Transportation Research Part D: Transport and Environment*, 67, 685-702.

2018

- Wolinetz, M., **J. Axsen,** J. Peters, and C. Crawford (2018), Simulating the value of vehicle-grid integration using a behaviourally-realistic model, *Nature Energy*, 3, 132-139. [2016 JCR = **46.8**]
- **Axsen, J**, and M. Wolinetz (2018). Reaching 30% plug-in vehicle sales by 2030: Modeling incentive and sales mandate strategies in Canada, *Transportation Research Part D: Transport and Environment*, 65, 596-617. [2016 JCR = **3.4**]
- Lepitzki, J., and **J. Axsen** (2018). The role of a low carbon fuel standard in achieving long-term GHG reduction targets, *Energy Policy*, 119, 423-440. [2016 JCR = **4.0**]
- **Axsen, J,** J. Cairns, S. Goldberg and N. Dusyk (2018). What drives the Pioneers? Applying lifestyle theory to early electric vehicle buyers in Canada, *Energy Research & Social Science*, 44, 17-30. [2016 JCR = **3.8**]
- Hardman, S, A. Jenn, G. Tal, **J. Axsen**, G. Beard, N. Daina, E. Figenbaum, N. Jakobsson, P. Jochem, N. Kinnear, P. Plotz, J. Pontes, N. Refa, F. Sprei, T. Turrentine and B. Witkamp (2018), A review of consumer preferences of and interactions with electric vehicle charging infrastructure, *Transportation Research Part D: Transport and Environment*, 62, 508-523. [2016 JCR = **3.4**]
- Lajevari, M., **J. Axsen**, and C. Crawford (2018). Examining the role of natural gas and advanced vehicle technologies in mitigating CO2 emissions of heavy-duty trucks: Modeling prototypical British Columbia routes with road grades, *Transportation Research Part D: Transport and Environment*, 62, 186-211. [2016 JCR = **3.4**]

2017

- Fox, J., **J. Axsen** and M. Jaccard (2017). Picking winners: Assessing the costs of technology-specific climate policy for U.S. passenger vehicles, *Ecological Economics*, 137, 133-147. [2016 JCR = **3.9**]
- Rhodes, K., **J. Axsen**, and M. Jaccard (2017). Exploring citizen support for different types of climate policy, *Ecological Economics*, 137, 56-69. [2016 JCR = **3.9**]
- Wolinetz, M., and **J. Axsen** (2017). How policy can build the plug-in electric vehicle market: Insights from the respondent-based preference and constraints (REPAC) model, *Technological Forecasting and Social Change*, 117, 238-250. [2016 JCR = **3.1**]
- Sykes, M., and **J. Axsen** (2017). No free ride to zero-emissions: Simulating a region's need to implement its own zero-emissions vehicle (ZEV) mandate to achieve 2050 GHG targets, *Energy Policy*, 110, 447-460. [2016 JCR = **4.0**]
- Melton, N., **J. Axsen**, and S. Goldberg (2017), Evaluating plug-in electric vehicle policies in the context of long-term greenhouse gas reduction goals: Comparing 10 Canadian Provinces using the "PEV Policy Report Card", *Energy Policy*, 107, 281-293.