Driving the Market for Plug-in Vehicles: Understanding ZEV Mandates

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Key Takeaways

1. Existing research into the supply side regulations for Plug-in electric Vehicles (PEVs) is mostly focused on the California Zero Emission Vehicle (ZEV) mandate, or similar policy in other regions.

2. The mandate has had a positive impact on innovation activity with original equipment manufacturers (OEMs) increasing research and development , forming partnerships, and filing electric vehicle related patents.

3. Research findings indicate an association between increased ZEV sales and presence of a ZEV mandate, though it is difficult to determine causality.

4. The California ZEV mandate appears to have met its goals of accelerating industry investment in ZEV technology, discouraging industry procrastination, establishing initial supply chains, and signaling to the many related companies and governments that they should be engaging sooner and more deeply with the transition to ZEVs.

5. Regions without ZEV mandates may want to consider implementing such a regulation to similarly signal their intent to accelerate the transition to ZEVs.

6. Studies show that a stringent ZEV mandate has the potential to reduce greenhouse gas and criteria emissions from passenger transport.

7. Policymakers need to carefully plan a ZEV mandate and how it interacts with other policies regulations and initiatives, to avoid duplications or conflicting policy mechanisms, reduce disruptions, and help build the larger ZEV ecosystem of investments and actions.

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Background

Plug-in Electric Vehicles (PEVs), which include battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), are more efficient and less polluting than conventional vehicles. PEVs have the potential to reduce urban air pollution and greenhouse gas (GHG) emissions if they are deployed in large numbers and are coupled with clean sources of electricity. To increase PEV market share, a number of market-focused and supply-focused regulatory mechanisms are needed. Market-focused mechanisms include vehicle charging infrastructure, incentives, and consumer education. Examples of supply regulations include fuel economy standards, vehicle emissions standards, and low-carbon fuel standards. This brief focuses on zero emission vehicle (ZEV) mandates.

A ZEV mandate requires automakers to produce and/or sell ZEVs in a given region, subject to fines for non-compliance. California adopted its ZEV mandate in 1990, and has regularly updated the regulation to accommodate changing market conditions, technology readiness, and evolving goals. Several other U.S. states have joined California in adopting the ZEV mandate, and are collectively with California called "ZEV States." A ZEV mandate was also adopted in the Canadian province of Quebec in 2016, via the ZEV Act (MDDELCC, 2016). Further, China has recently implemented its own "new-energy vehicle" (NEV) mandate fashioned after California's ZEV mandate.

This brief summarizes the policies as currently in place in California and China, discusses the available evidence on the potential benefits and drawbacks of a ZEV mandate, and concludes with lessons learned.

Examples of ZEV Mandates or Sales Requirements

California's ZEV Mandate

The ZEV requires automakers to deliver for sale a minimum number of ZEVs each year (the required number is based on the total number of vehicles they sell) or face compliance fines ($5,000 for every ZEV they do not produce). The requirement is actually a credit requirement; when original equipment manufacturers (OEMs) produce a ZEV, they receive credits which they can use to meet their requirement. The regulation includes flexibilities that allow OEMs to produce different kinds of ZEVs, including PHEVs, BEVs, and fuel cell vehicles (FCVs), which earn different credit amounts based on vehicle characteristics. OEMs can bank excess credits to use in later years to meet their growing requirement or sell them to other OEMs. For example, Tesla (which only produces BEVs), can sell all of their credits to other OEMs.

NEV Regulation in China

In September 2017, China's Ministry of Industry and Information Technology finalized their New Energy Vehicle (NEV) Regulation. NEVs include PHEVs, BEVs, and FCVs. The regulation currently sets requirements for the number of NEVs sold in 2019 and 2020, and sets targets for 2021 to 2025. Table 1 outlines the key differences between the China NEV mandate and California ZEV mandate.

	California ZEV Program	China NEV Regulation
Regulated OEMs	OEMs that sell more than 20,000 vehicles per year	OEMs that sell more than 30,000 vehicles per year.
Credits[1]	7% in 2019 9.5% in 2020 7-12% by 2025	10% in 2019 12% in 2020 20% in 2025
Can credits be saved for future years?	Yes, with limitations	No, with the exception of 2019 to 2020
Technological Specificity	Certian portions of requirement must be pure ZEV (BEV or FCV)	Any of the three drivetrains can be used for compliance (no maximum)
Credits per vehicle sold	0.4 to 4	1 to 6

Table 1: Key differences between the California ZEV program and the China NEV Regulation. [1]OEMs 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.

Lessons from Academic Research & Empirical Data

It is difficult to isolate the impacts of a ZEV mandate for several reasons. First, there are only a handful of examples of ZEV regulations globally. Second, its intended impacts are on the private sector (OEM innovation activity), which typically does not make data available for competitive reasons. Third, because ZEV programs are meant to induce long-term effects, a retrospective examination is very challenging. Despite these challenges, a growing body of research has begun to evaluate the various ZEV regulations, including studies that model system dynamics to anticipate the potential long-term effects of a ZEV mandate. This brief draws from these studies to summarize evidence of how a ZEV mandate can stimulate ZEV innovation activity, increase ZEV model availability and sales, and contribute to long-term GHG and criteria emissions abatement goals. It also evaluates the costs of the ZEV mandate and how it interacts with other policies.

Impact on Innovation Activity

Policy can influence industry innovation activity. Measures of industry innovation activity include R&D funding of ZEV technology, filing of ZEV-related patents, making prototypes available, and private companies forming partnerships. Because changes in such activities must be observed over several years, evidence can only really be inferred from California's ZEV mandate (China's and Quebec's are too new). Several researchers have found that California's ZEV mandate has effectively influenced how automakers channel their ZEV technology innovation activities, leading to increased patent activity [18], the development of vehicle prototypes [13], and private companies forming partnerships [5]. Figure 2 shows the number of patents filed by OEMs and the increase in activity after the introduction of the ZEV mandate. In California this activity also lead to positive impacts on the economy, including increased employment and increased investment in companies in the state [2].

Impact on ZEV Availability and Sales

The ZEV mandate encourages OEMs in regulated regions to make more ZEVs available and to market them more heavily. It is difficult to isolate the effect of the ZEV mandate, given that regions also have other ZEV-supportive policies in place (e.g. incentives, deployment of chargers). However, research has found that US states with a ZEV mandate tend to have a greater number of ZEV models available, and higher ZEV sales than other regions [12]. A North American modelling study found that regions with a ZEV mandate could trigger higher long-term ZEV sales compared to non-regulated regions [17].

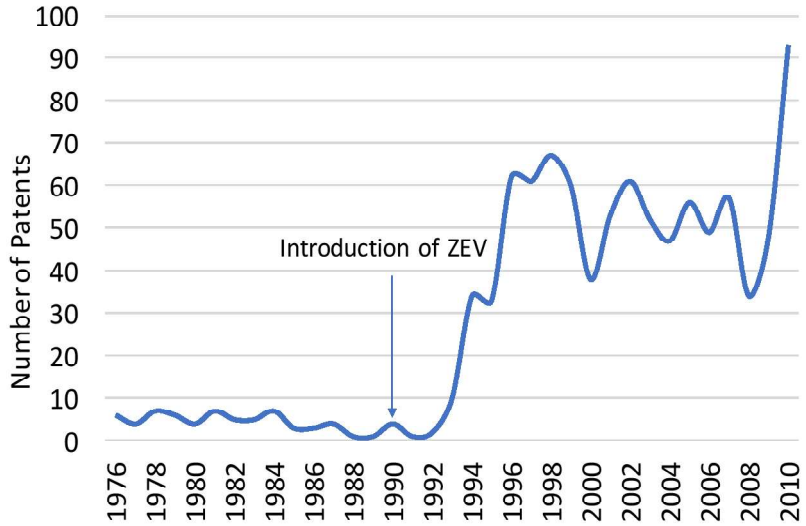

Figure 1: Change in number of patents filed for 'electric vehicles' from 1976 to 2010 [18].

Other modelling studies also show the potential long-term effectiveness of a ZEV mandate on ZEV passenger vehicle sales [8,11]. The presence of a mandate may also increase the likelihood that automakers supply PEVs to that region.

Impact on Emissions

Studies indicate that ZEV adoption could be an important component of achieving deep 2050 GHG reduction targets—where such vehicles would have to make up 90% or more of passenger vehicles by 2050 [7,19,23]. Several modelling studies find that a ZEV mandate could play an important role in achieving long-term (2050) GHG reduction targets in the passenger vehicles sectors [9,17]. Research also shows that increasing sales of PEVs reduces criteria emissions [3,4,22].

Policy Interactions

It is important to note how a ZEV mandate may interact with other ZEV-supportive policies. On a positive side, policies that offer consumers financial incentives to buy ZEVs, or that support PEV charger deployment can help OEMs to comply with ZEV mandate targets. However, some interactions can have perverse impacts in the short run (the next 5-10 years). As one U.S.-specific example, under the current vehicle GHG emissions and fuel economy standard (or CAFE) requirements, emissions of conventional vehicles could increase if OEMs sell more PEVs (in the 2019-2025 time frame of the policy), because the standard is based on fleetwide average emissions [9,10].

The Costs of a ZEV Mandate

Different types of policies impose costs—or impacts—to social welfare. Some analyses suggest that a ZEV mandate is costlier than a technology-neutral policy, such as a carbon tax [6]. However a strong carbon tax is not politically acceptable in many regions [15,16]. A ZEV mandate can induce higher ZEV sales than a financial purchase incentives-only policy, with much lower government expenditure [1].

Other Research Findings

Wesseling [20,21] followed OEMs' political strategies on the California ZEV mandate between 1990 and 2013. Initially, the researcher found, OEMs were mostly against the regulation and lobbied for reductions. Over time, however, perhaps due to advancements made in technology, OEMs' stance shifted to being more accepting of the program, though they did lobby for adjustments. Other researchers have also suggested that OEMs and oil companies lobbied for reductions in the mandate [5,14].

Summary

Evidence of the impact of supply-side regulations is currently limited. It can be drawn from retrospective studies of the California ZEV mandate and modeling of the potential long-term effects of a ZEV mandate in California and other regions. The California program appears to have met its goals of fostering technology innovation and development; in the early days of the mandate this was seen in increased R&D activity, increased patent filings, and OEMs forming partnerships. This activity eventually lead to BEVs and PHEVs being commercial products and today there are 46 PEVs for sale in the United States (as of mid-2018). Modeling research suggests that a stringent and well-designed mandate can substantially contribute to GHG and criteria emissions reductions, though policymakers will need to take care to avoid negative interactions with other regulations. Although a ZEV mandate regulation does appear to have higher social welfare costs than a carbon tax, it may be more politically acceptable in most regions, and more likely sends a clear transformative signal to industry.

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Further Reading

This policy brief is part of a series of briefs. Each brief concentrates on a specific aspect of PEVs.

The following briefs are available:

1. Lessons from the California ZEV Program
2. Understanding Financial Purchase Incentives
3. Understanding Reoccurring Incentives
4. Increasing Consumer Awareness and Knowledge
5. Developing Charging Infrastructure for Consumers

Briefs are available at: *https://phev.ucdavis.edu/international-ev-policy-council-policy-briefs/*

Selected References

[1] Axsen, J., Wolinetz, M., 2018. Reaching 30% plug-in vehicle sales by 2030: Modeling incentive and sales mandate strategies in Canada.

[2] Burke, A.F., Kurani, K.S., Kenney, E.J., 2000. Study of the Secondary Benefits of the ZEV Mandate.

[3] Cunningham, J., 2010. Achieving an 80 % GHG Reduction by 2050 in California ' s Passenger Vehicle Fleet : Implications for the ZEV Regulation.

[4] Dixon, L., Porche, I., Kulick, J., 2002. Driving Emissions to Zero: Are the benefits of California's Zero Emission Vehicle Program Worth the Costs? RAND.

[5] Dyerson, R., Pilkington, A., 2005. Gales of creative destruction and the opportunistic incumbent : The case of electric vehicles in California Gales of Creative Destruction and the Opportunistic Incumbent : The Case of Electric Vehicles in California 7325. doi:10.1080/09537320500357160

[6] Fox, J., Axsen, J., Jaccard, M., 2017. Picking Winners: Modelling the Costs of Technology-specific Climate Policy in the U.S. Passenger Vehicle Sector. Ecol. Econ. 137, 133–147. doi:10.1016/j.ecolecon.2017.03.00

[7] Greenblatt, J.B., 2015. Modeling California policy impacts on greenhouse gas emissions. Energy Policy 78, 158–172. doi:10.1016/j.enpol.2014.12.024

[8] Greene, D.L., Park, S., Liu, C., 2014. Analyzing the transition to electric drive vehicles in the U.S. Futures 58, 34–52. doi:10.1016/j.futures.2013.07.003

[9] Jenn, A., Azevedo, I.M.L., Michalek, J.J., 2017. A Tale of Two Policies: Interactions of U.S. Federal and State Policies for Promoting Alternative Fuel Vehicles' Increase in Greenhouse Gas Emissions. Transp. Res. Board 2017 Annu. Meet.

[10] Jenn, A., Azevedo, M.L., Michalek, J.J., 2016. Alternative Fuel Vehicle Adoption Increases Fleet Gasoline Consumption and Greenhouse Gas Emissions under United States Corporate Average Fuel Economy Policy and Greenhouse Gas Emissions Standards. doi:10.1021/acs.est.5b02842

[11] Lepitzki, J., Axsen, J., 2018. The role of a low carbon fuel standard in achieving long-term GHG reduction targets. Energy Policy 119, 423–440. doi:10.1016/j.enpol.2018.03.067

[12] Lutsey, N., Searle, S., Chambliss, S., Bandivadekar, A., 2015. Assessment of leading electric vehicle promotion activities in United States cities. International Council on Clean Transportation.

[13] Melton, N., Axsen, J., Sperling, D., 2016. Moving beyond alternative fuel hype to decarbonize transportation. Nature. doi:10.1038/NENERGY.2016.13

[14] Raux, C., 2004. The use of transferable permits in transport policy 9, 185–197. doi:10.1016/j.trd.2004.01.001

[15] Rhodes, E., Axsen, J., Jaccard, M., 2017. Exploring Citizen Support for Different Types of Climate Policy. Ecol. Econ. 137, 56–69. doi:10.1016/j.ecolecon.2017.02.027

[16] Sperling, D., Eggert, A., 2014. California ' s climate and energy policy for transportation. Energy Strateg. Rev. 5, 88–94. doi:10.1016/j.esr.2014.10.001

[17] Sykes, M., Axsen, J., 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 target. Energy Policy.

[18] Vergis, S., Mehta, V., 2010. Technology Innovation and Policy: A case study of the California ZEV Mandate. Stock. Enviornment Inst. 1–35.

[19] Wei, M., Nelson, J.H., Greenblatt, J.B., Mileva, A., Johnston, J., Ting, M., Yang, C., Jones, C., McMahon, J.E., Kammen, D.M., 2013. Deep carbon reductions in California require electrification and integration across economic sectors. Environ. Res. Lett. 8. doi:10.1088/1748-9326/8/1/014038

[20] Wesseling, J.H., Farla, J.C.M., Hekkert, M.P., 2015. Environmental Innovation and Societal Transitions Exploring car manufacturers ' responses to technology-forcing regulation : The case of California ' s ZEV mandate. Environ. Innov. Soc. Transitions 16, 87–105. doi:10.1016/j.eist.2015.03.001

[21] Wesseling, J.H., Farla, J.C.M., Sperling, D., Hekkert, M.P., 2014. Car manufacturers ' changing political strategies on the ZEV mandate 33, 196–209. doi:10.1016/j.trd.2014.06.006

[22] Witt, M., Bomberg, M., Lipman, T., Williams, B., 2012. Plug-In Electric Vehicles in California for 2020 , and Policy Outlook 155–162. doi:10.3141/2287-19

[23] Yang, C., Yeh, S., Zakerinia, S., Ramea, K., McCollum, D., 2015. Achieving California's 80% greenhouse gas reduction target in 2050: Technology, policy and scenario analysis using CA-TIMES energy economic systems model. Energy Policy 77, 118–130. doi:10.1016/j.enpol.2014.12.006