PEV Policy Evaluation Rubric:

A Methodology for Evaluating the Impact of State and Local Policies on Plug-in Electric Vehicle Adoption

National Association of State Energy Officials and Cadmus

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Acknowledgements and Disclaimers

Executive Summary

The National Association of State Energy Officials (NASEO), in partnership with Cadmus, has developed a Plug-In Electric Vehicle Policy Evaluation Rubric to evaluate the impact of state and local policies on plug-in electric vehicle (PEV) adoption in states and cities across the United States. Users can use this tool and methodology to evaluate the strengths and weaknesses of all PEV-related policies in a given metro area on a scale of 1-100.

The Rubric provides a unique, evidence-based method to help decision-makers identify and prioritize PEV programs and policies. The Rubric categorizes all PEV policies into 6 policy categories and 14 policy subcategories. Each policy subcategory is assigned a weight, based on its relative strength, to spur PEV adoption relative to other policies. These weightings were assigned after an exhaustive review of peer-reviewed journal articles, publications from Government, non-governmental organizations (NGOs), and the National Academies of Sciences, as well as multiple rounds of expert input from ten external Technical Reviewers from academia, government, and the non-profit sector.

The NASEO-Cadmus team assigned the highest weight to vehicle purchase, followed by PEV deployment targets and policies that incentivize electric vehicle supply equipment (EVSE) installation and reduce EVSE operational costs. While there is some debate in the literature around the relative effectiveness of these policies, it is the project team's conclusion that these four types of policies represent the most effective policies at advancing PEV adoption.

The Rubric and an associated Policy Tool were originally designed for Electrify America to use when considering potential metro areas for Cycle 2 investment under the Zero Emission Vehicle National Investment Plan. While this Rubric was developed for Electrify America, it may also be used by policymakers at the state and local level to evaluate their jurisdiction's current PEV policy environment. It is the authors' hope that this analysis may be used by private and public entities as they consider PEV policy adoption and investment in communities across the United States.

Introduction

This report describes the methodology used to develop the Plug-in Electric Vehicle (PEV)[1] Policy Evaluation Rubric (the "Rubric"), which was designed to evaluate the impact of policies on PEV adoption. The Rubric was created by the National Association of State Energy Officials (NASEO) and The Cadmus Group LLC (Cadmus), in close coordination with Electrify America and an external Technical Advisory Committee, and allows users to evaluate the strength and weakness of all PEV-related policies in a metro area on a scale of 0 to 100. A higher score indicates the policies are stronger in advancing PEV deployment.

The Rubric uses a system of Weights, Ratings, and Evaluation Criteria across six Policy Categories and 14 Policy Sub-Categories to measure the strength of the policy environment accelerating PEV adoption. To develop the Rubric, the NASEO-Cadmus team conducted a deep review of peer-reviewed articles, National Academies of Sciences reports, and other grey literature to understand the number and quality of studies discussing a given policy. This review was supplemented by input from a Technical Advisory Committee (TAC), comprised of PEV policy experts from government, academia, and the NGO community. Ultimately, the literature review and TAC contributions allowed the team to summarize the overall impact of each PEV policy type.

Measuring Policy Impact

A growing body of literature examines the impact of policy on PEV sales. Policymakers rely on this literature to ensure cost-effective use of taxpayer and ratepayer resources and to avoid undesired policy outcomes. Examples of common questions include:

- How large of a vehicle purchase incentive is needed to spur PEV adoption?
- Is a rebate preferable to a tax credit incentive?
- How many additional public charging stations are needed to influence car-buying decisions?
- What type of policy provides the strongest long-term signal to automakers to build PEVs?

Yet, despite the large number of studies that measure policy impacts, studies vary considerably in their level of rigor. Users of the research, therefore, must use caution before implementing findings. The key differentiator between a rigorous and less rigorous study is how well the researchers isolate the cause-and-effect relationship between policy and outcome from other confounding factors that influence the outcome. For PEV sales, confounding factors include: fuel prices, availability of charging equipment, environmental attitudes, socio-demographic characteristics, and prevailing social norms, among other factors (Egbue and Long, 2012; Moons and De Pelsmacker, 2012).

Types of methods used when estimating policy impacts include experimental design (or randomized control trials), quasi-experimental design, regression models, choice experiments, consumer surveys, descriptive statistics, correlations, content analysis, expert opinion, and deductive reasoning. While only experimental and quasi-experimental methods can be used to definitively say a policy has a given impact (i.e., a "causal link"), other techniques still provide useful insights and are accepted alternative practices, especially when rooted in strong theoretical foundations. Given the scope of this project, the NASEO-Cadmus team relied primarily on content analysis, expert opinion, and deductive reasoning, and when possible also considered the experience of the researcher team who conducted the study. For example, a finding in a National Academies of Sciences study was considered more noteworthy than a similar finding in an academic journal paper.

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1   The acronym PEV will be used to refer to plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs) collectively when the distinction between the two is not essential.

Background

Review articles by Hardman et al. (2017a) and Hardman et al. (2017b) provide the most recent assessment of large numbers of papers on policy impact on PEV deployment. Other review papers, such as Coffman et al. (2016), Liao et al. (2017), and Rezvani et al. (2015), summarize literature on both policy and non-policy factors that influence consumer purchase decisions of PEVs. These meta-studies consistently suggest an important role for policy in accelerating PEV adoption.

When looking closer at individual PEV policies, however, studies are somewhat less consistent in their findings and in the strength of evidence used to support the findings. Several factors contribute to this inconsistency. First, past studies measure policy impacts across different geographic regions, timeframes, and data aggregation levels, meaning comparing results across studies requires deep understanding of a given study. Second, geographic spillover effects potentially distort the measured impacts when neighboring jurisdictions have strong policies (see call-out box). Third, the influence of policy may depend on the individual. Langbroek et al. (2016) demonstrate how the impact of policy differs on individuals depending on the readiness of the individual for behavior change. A final challenge to summarizing impacts at the individual policy-level is the threshold effect – policies may only change outcomes when above a certain threshold. For example, Jenn et al. (2013) showed that federal tax credits for hybrid electric vehicles (HEVs) only led to a statistically significant impact on HEV adoption when above $1,000.

> **Geographic Spillovers**
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> Sykes and Axsen (2017) examine the geographic spillover effects from PEV policies in Washington state into Canada. The authors show a negligible-sized effect, which means PEV policies in Washington do not impact Canadian PEV sales. The NASEO-Cadmus team did not find other studies that examine geographic spillovers but acknowledge that spillovers could impact the Rubric's Weights and Ratings if the metro areas are in close proximity to other jurisdictions with strong PEV policies.

Below is the best available evidence to support the selection of the Weights and Ratings in the Policy Evaluation Rubric. In the absence of a "silver bullet" study that examines all PEV-related policies in a single unified study, the sections below piece together available evidence across a range of studies and, where relevant, highlight major uncertainties or disagreements in the literature. The NASEO-Cadmus team draw on studies that use the strongest or most rigorous methods, as described in Section 1.2.

When very little or no evidence is available, the NASEO-Cadmus team rely on input from the external TAC members (see call-out box) or on the theoretical foundation provided in seminal studies, such as NAS (2013; 2015).

> **Technical Advisory Committee (TAC)**
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> The TAC was comprised of ten PEV policy experts from academia, non-profit organizations, and local and state governments. TAC members were selected by the NASEO-Cadmus team based on their professional histories and reputations within the PEV policy sphere (e.g., academics with notable publications related to EV-policy valuation; state and local government representatives with strong PEV policy and program design and implementation experience, etc.).
>
> The TAC met three times over a one-month period via conference call to learn about the project and provide input on the NASEO-Cadmus team's approach. A preliminary draft of the Policy Evaluation Rubric and Methodology and was shared with the TAC, and TAC members were asked to provide feedback.
>
> The NASEO-Cadmus team received both oral and written comments on the team's approach. Significant discussion was given to the impact of marketing and communication policies on PEV adoption, and the appropriate weighting of that Policy Category. While the Committee was not asked to reach a consensus, Committee members were pleased with the Project Team's general approach. In particular, members of the Committee noted that the methodology and proposed Rubric were based on sound research and provided an accurate and comprehensive framework for evaluating policy effectiveness.

Orientation to the Policy Evaluation Rubric

The Policy Evaluation Rubric enables users to evaluate the effectiveness of policies in any metro area to advance PEV deployment. The Rubric is organized into 6 overarching Policy Categories and 14 Policy Sub-Categories. Table 1 maps the Policy Categories on to the Policy Sub-Categories. Detailed information on each Policy Category and Policy Sub-Category is included in Section 3 below. Appendix A includes the complete Rubric.

Table 1. Policy Categories and Corresponding Policy Sub-Categories in the Rubric

Policy Category	Policy Sub-Categories
Sending Long-Term Signal to Market	PEV Deployment Targets
	Transportation Climate Policy
Reducing PEV Operational Costs	Non-Financial Incentives
	Residential PEV Electricity Rates and Programs
	PEV Fees
	Other Operational Costs
Improving Economic Viability of EVSE	EVSE Installation
	EVSE Operations
Improving PEV and EVSE Planning	PEV and EVSE Planning
	PEV-Ready Building Codes and Zoning Ordinances
	Streamlined EVSE Permitting
Increasing Awareness and Education	Marketing and Communication
	Fleets
Reducing Upfront Costs	Vehicle Purchase Incentives

As shown, some Policy Sub-Categories address PEV demand (e.g., vehicle purchase incentives), while others address PEV supply (e.g., PEV Deployment Targets). Figure 1 illustrates a portion of the Rubric and identifies important features.

Major features of the Rubric include:

- **Policy Categories** are broad type of policies that address a specific PEV market barrier.
- **Policy Sub-Categories** are specific policy types within the broad Policy Category.
- **Weights** reflect the relative importance of each Policy Sub-Category relative to other Policy Sub-Categories. The higher the weight, the greater the evidence of a strong policy impact in driving PEV sales. Across Policy Sub-Categories, Weights vary between 1 and 30. Weights sum to 100.
- **Ratings** reflect how well or strongly a policy is implemented in a jurisdiction. The four levels of Ratings are Strong (100%), Moderate (50%), Weak (10%), and none (0%), with the percentages representing the quantified use of the rating within the Rubric.
- **Evaluation Criteria** are specific criteria that allow the user of the Rubric to identify which Rating to assign to a given policy (or bundle or policies).

Using the Rubric is straightforward. For a given metro area, the user collects information about all PEV policies at the local, state, and utility level. Next, using the Evaluation Criteria as a guide (Figure 1), as well as the user's knowledge of the presence and strength of a given policy, the user identifies the best fitting Rating. The score for that Policy Sub-Category is calculated by multiplying the assigned Rating and Weight. Using Figure 1 as an example, if a metro area has a Moderate Rating for PEV Deployment Targets, the score for that Policy Sub-Category would be 10 points (50 percent rating times the 20-point Weight). After scoring each of the 14 Policy Sub-Categories, all 14 scores are summed. The maximum total score is 100. .

Several similar PEV scorecards and rating systems have emerged in recent years and deserve mention. Melton et al. (2017) developed a "ZEV Policy Handbook for Canada" which evaluates ZEV policy options across five qualitative criteria: (1) effectiveness of the policy to impact ZEV market share, (2) cost effectiveness, (3) public support, and (4) policy
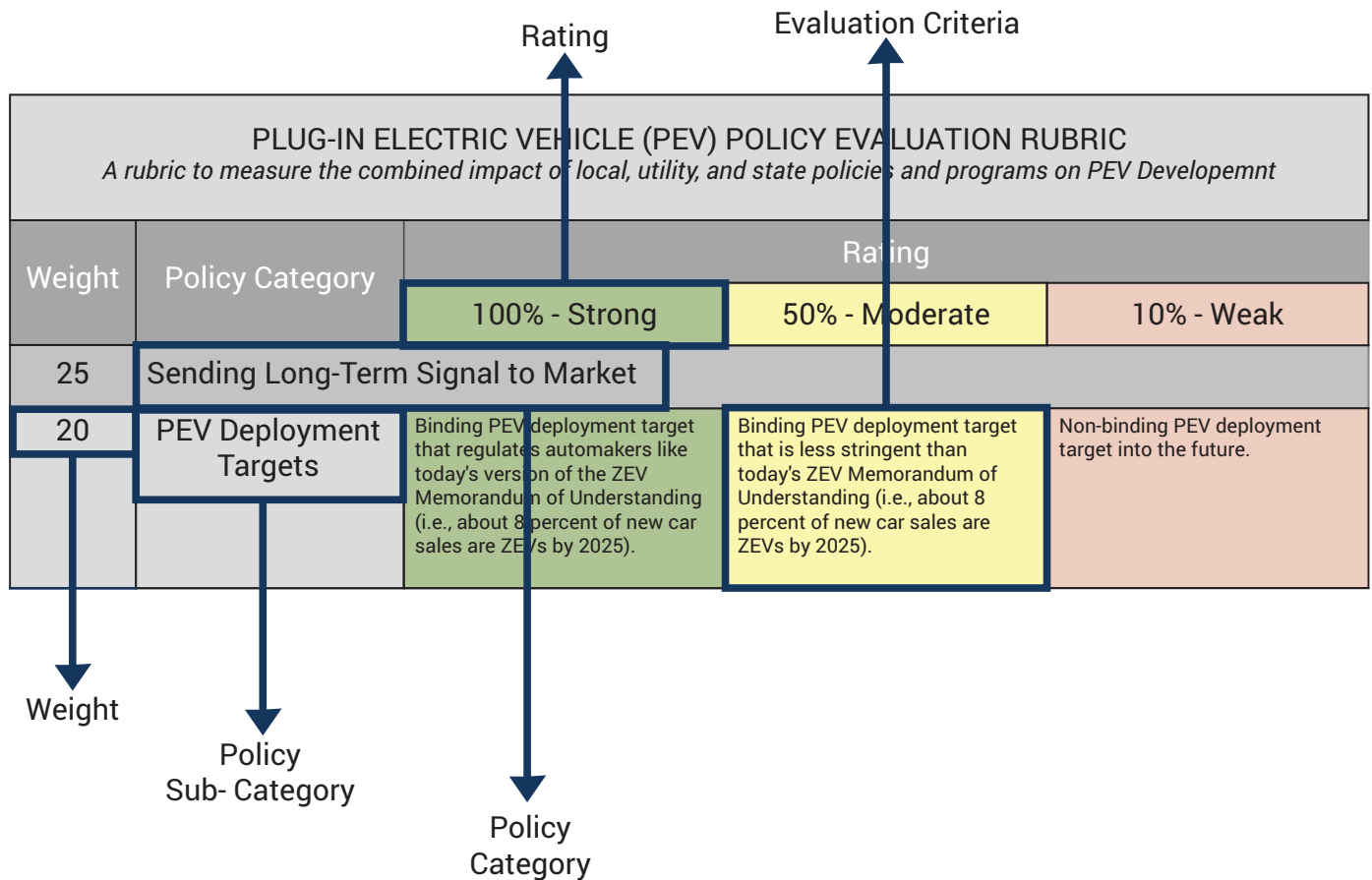
Figure 1. Illustration of Policy Evaluation Rubric and associated definitions.

simplicity; and (5) transformational signal. As with the Policy Evaluation Rubric, the ZEV Policy Handbook allows the user to rank the relative strength and weakness of the bundle of PEV policies in a jurisdiction. ACEEE (2017) developed an energy efficiency scorecard for utilities across 18 metrics, including vehicle electrification. Clark-Sutton et al. (2016) developed a PEV readiness rating system across 13 policy categories, assigning point values for the strength of implementation of the programs. The authors use their PEV readiness rating system to rank 36 major U.S. cities. Cattaneo (2018) compares the average PEV market share in states with and without nine categories of PEV policies, allowing the author to rank the policies on their ability to impact PEV sales.

The Policy Evaluation Rubric differs from other PEV scoring systems in several important ways. First, the number of studies reviewed and summarized in the development of the Rubric far exceed the number in other scoring systems. Second, the Rubric uses both Weights and Ratings to differentiate each Policy Sub-Category. This ensures the Rubric captures not only the relative strength of each Policy Sub-Category (via the Weights), but also the strength of implementation of a given Policy Sub-Category (via the Ratings). Finally, unlike other PEV scoring systems, evaluation criteria in the Rubric were validated by the external committee of experts.

The following section corresponds to the six Policy Categories. Within each Policy Categories are sub-sections corresponding to the Policy Sub-Categories. Each sub-section includes a snapshot of the Rubric for that Policy Sub-Category, a description of the evidence from the literature about the policy impact on PEV deployment, and a defense of the Weight and Rating used in the Rubric.

Establishing Weights and Ratings

This section summarizes evidence from the literature and input from the TAC on the Weights and Ratings in the Policy Rubric. Sub-sections below follow the structure of the Rubric and are broken into Policy Category and respective Policy Sub-Category.

1. Sending Long-Term Signal to Market

Policies in the "Sending a Long-term Signal to Market" section provide a publicly visible, long-term commitment to deploy PEVs—or complementary climate commitments with PEV components—in the form of mandates and targets. Such mandates and targets provide a strong signal to automakers, utilities, investors, and consumers, providing the certainty necessary to attract investment and grow the PEV market. This Policy Category is comprised of two Sub-Categories: (1) PEV Deployment Targets and (2) Transportation Climate Policy.

1.1 PEV Deployment Targets

Weight	Policy Category	Rating		
		100% - Strong	50% - Moderate	10% - Weak
20	PEV Deployment Targets	Binding PEV deployment target that regulates automakers like today's version of the ZEV Memorandum of Understanding (i.e., about 8 percent of new car sales are ZEVs by 2025).	Binding PEV deployment target that is less stringent than today's ZEV Memorandum of Understanding (i.e., about 8 percent of new car sales are ZEVs by 2025).	Non-binding PEV deployment target into the future.

Summary: PEV Deployment Targets are publicly-stated targets related to the total number or fraction of new vehicle sales in a future year, such as California's zero emission vehicle (ZEV) program (also known as the "ZEV Mandate"). Despite widespread agreement about the importance of targets, relatively little empirical evidence links targets with increased PEV sales. This lack of clear evidence is due to several factors. First, PEV targets regulate automakers rather than individual consumers. Internal strategies of automakers are proprietary and visible only through secondary indicators – such as patents, vehicle sales, or press releases (e.g., Wesseling et al., 2015). Additionally, for the ZEV Mandate, elements of the mandate like the "Travel Provision[2]" and banking of ZEV credits further mask the policy impacts. Due to these factors, the NASEO-Cadmus team, in coordination with TAC members, assigned a Weight of 20 out of 100 to this Sub-Category.

Description of Evidence: PEV deployment targets have received relatively little attention in the literature when compared to other policies, like vehicle purchase incentives. Four studies below discuss the most important binding deployment target – the ZEV Mandate. Each study suggests a relatively important role for the ZEV Mandate in PEV adoption. The first two studies are based on expert opinion and therefore fall relatively low on the hierarchy of evidence described in Section 1.2.

Greene et al.'s (2014) is anecdotal but is based on solid sources in the auto-industry. The authors state:

> "Until 2018, the Travel Provision of the ZEV Mandate allowed automakers to meet the mandate requirements of a given state by selling vehicles in other ZEV Mandate states. This meant researchers have difficulty attributing PEV sales to the ZEV Mandate versus other factors."

Lutsey et al. (2015) are experts in the field of PEV policy impacts and have multiple papers on the topic. After studying cities with strong PEV sales, the authors state:

> "Adoption of the California ZEV program is the most direct policy change any state can take to ensure increased electric vehicle deployment" (p. 9).

Cattaneo (2018) use a state-level statistical analysis comparing PEV sales in states with and without certain PEV policies. The author finds the PEV market share is roughly twice as high in states with the ZEV mandate than those without it. When the State of California is removed from the analysis, the ZEV Mandate becomes the strongest predictor of PEV market share of any of the policies (with California it is the second strongest). The study does not control for confounding factors (like differences in consumer preferences or income between states), which may play a role in the findings.

Finally, Wesseling et al. (2015) use automaker patent and sales data to examine how automakers innovate to respond to the ZEV Mandate. Based on content analysis and correlation analyses, the authors conclude that the ZEV Mandate is an important technology-forcing policy. Its weakness is that the study does not provide a comparison of the strength of the ZEV Mandate to other PEV policies like purchase incentives or parking incentives.

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2   Until 2018, the Travel Provision of the ZEV Mandate allowed automakers to meet the mandate requirements of a given state by selling vehicles in other ZEV Mandate states. This meant researchers have difficulty attributing PEV sales to the ZEV Mandate versus other factors.

The NASEO-Cadmus team did not identify studies that evaluate the impact of non-binding deployment targets.

1.2 Transportation Climate Policy

Weight	Policy Category	Rating		
		100% - Strong	50% - Moderate	10% - Weak
5	Transportation Climate Policy	Long-term (i.e., 10 years or more), binding transportation policy that incentivizes PEVs and/or EVSE operators through direct investment and/or performance-based system, such as a low carbon fuel standard, feedbate system, and/or GHG vehicle emissions standard. generates revenue for PEV owners and/or EVSE operators, such as a low carbon fuel policy and reduces carbon intensity by 10-15% over 10 years.	Binding transportation policy that incentivizes PEVs and/or EVSE operators through direct investment and/or performance-based system, such as a low carbon fuel standard, feedbate system, and/or GHG vehicle emissions standard.	Other less stringent (i.e., non-binding), comparable transportation policies.

<u>Summary:</u> Transportation Climate Policies are those that shift consumers toward lower emission products through market-based, technology-neutral approaches, such as clean fuel standards, feebates, vehicle emission standards, and other similar policies. As discussed below, the magnitude of the impact of these policies on PEV sales is relatively small, resulting in a Weight of 5 of 100. Policies that are binding and/or policies that are longer in duration receive a higher Rating.

<u>Description of Evidence:</u> Because regulators enact Transportation Climate Policies primarily to support climate goals, not PEV sales, relatively few studies demonstrate a link to PEV sales. Yet, some evidence does exist. In its Final Determination on the Appropriateness of the Model Year 2022-2025 Light-Duty Vehicle Greenhouse Gas Emissions Standards under the Midterm Evaluation, EPA (2017) estimates that 2 to 4 percent of new vehicle sales will need to be PEVs for automakers to meet EPA's vehicle emission standards. This result comes from an EPA cost accounting tool that attempts to mimic the decisions of automakers under increased fuel economy standards. The tool has been vetted by experts and represents the state-of-the art system for such an analysis.

Additionally, statements like this from the Union of Concerned Scientists (UCS 2018) provide anecdotal evidence about this Policy Sub-Category:

> *"The Low Carbon Fuel Standard is critical to advancing electric vehicles (EVs) in California. The policy, which supports clean transportation fuels, generated $92 million to support transportation electrification in 2016. This money has been used for a variety of initiatives that help make EVs more affordable for drivers, transit agencies, and private businesses. The impact of the LCFS in accelerating deployment of EVs and reducing carbon emissions will grow over time as the electric vehicle market matures and as more electricity is generated from renewable resources." (p. 1).*

The NASEO-Cadmus team did not find other studies specific to this Policy Sub-Category.

2. Reducing PEV Operational Costs
Operational costs are part of the accepted costs of vehicle ownership, but tend to be less influential in vehicle purchase decisions than upfront costs or certain non-monetary costs like the cost of sitting in congested traffic. This Policy Category includes policies that improve operational costs associated with vehicle operation or travel, either through financial or non-financial incentives. The four Policy Sub-Categories are: (1) Non-Financial Incentives, (2) Residential PEV Electricity Rates and Programs, (3) PEV Fee, and (4) Other Operational Costs.

2.1 Non-Financial Incentives

Weight	Policy Category	Rating		
		100% - Strong	50% - Moderate	10% - Weak
4	Non-Financial Incentives	Jurisdiction has aggressively implemented non-financial incentives for PEVs where possible, such as: 1. HOV lanes: unlimited access to HOV lanes. 2. Tolls: Fee waivers on tolls. 3. Parking: Free or preferred parking. 4. Ferry: Free ferry rides for PEVs. 5. Airports: Programs that incentivize PEV drop-off and pick-ups. Programs are well-advertised through the city's website and there is no cap on the number of participants. through the city's website and there is no cap on the number of participants.	Jurisdiction has some combinations of non-financial incentives for PEVs, such as: 1. HOV lanes: unlimited access to HOV lanes. 2. Tolls: Fee waivers on tolls. 3. Parking: Free or preferred parking. 4. Ferry: Free ferry rides for PEVs. 5. Airports: Programs that incentivize PEV drop-off and pick-ups.	Jurisdiction is using at least one non-financial incentives for PEVs, such as: 1. HOV lanes: unlimited access to HOV lanes. 2. Tolls: Fee waivers on tolls. 3. Parking: Free or preferred parking. 4. Ferry: Free ferry rides for PEVs. 5. Airports: Programs that incentivize PEV drop-off and pick-ups.

Summary: Non-financial incentives include high occupancy vehicle (HOV) lane access, privileges at airports, and discounted tolls, parking, and ferries. The NASEO-Cadmus team gave a fairly low weight to the Policy Sub-Category (4 out of 100), which reflects the large range of findings in the literature, from no impact to strong impact. To receive the full score, jurisdictions must have multiple non-financial policies.

Description of Evidence: At a theoretical level, any reduction in the cost of travel provided for PEVs relative to internal combustion engine vehicles (ICEVs) acts as an incentive towards PEVs. However, the various papers that quantify this impact demonstrate a wide range of findings, from extremely large to negligible. For example, Tal and Nicholas (2014) conducted a post-purchase survey of 3,659 PEV buyers in California and found that HOV lane access was the number one reason car buyers chose a PEV for 34 percent to 57 percent of respondents, depending on the vehicle model purchased. On the other hand, Vergis and Chen (2015) examined PEV sales data across the U.S. in a "stepwise" regression and found that including the variable "HOV lane access" did not improve the fit of the model. Another study (Cattaneo, 2018) finds that free HOV lane access to PEVs is one of four policy types that are statistically significant predictors of PEV market share in the United States

For parking, many studies in Europe show that free parking is a statistically significant predictor of PEV adoption (e.g., Bjerkan et al., 2016; Aasness and Odeck, 2015). The choice model by Lieven (2015) finds that free parking is attractive for some consumers, though financial incentives and freeway charging stations are more effective in promoting PEV sales. However, the 2016 review article by Liao et al. (2017) concluded that no evidence exists in the literature regarding free parking or its impact on PEV adoption. Other research suggests that context matters when examining policies addressing operational costs. Langbroek et al. (2016) find that the value of reducing operational costs depends on the environment of the traveler. For example, the authors find that travelers in congested areas can gain much from being allowed to make use of restricted bus lane (similar to HOV lanes). Similarly, travelers in areas with severe parking problems or high parking tariffs can gain much from the allowance to park for free or to park at designated parking places.

2.2 Residental PEV Electricity Rates and Programs

Weight	Policy Category	Rating		
		100% - Strong	50% - Moderate	10% - Weak
4	Residential PEV Electricity Rates and Programs	Policy/program(s) satisfies all of the following: 1. PEV-specific charging rates or favorable time of use (TOU) rates and/or incentives for PEV charging. 2. Program is easy to find and navigate on the website. 3. Widespread eligibility of program (offered by all utilities serving the metro region to all residential customers). 4. Free Smart Meter upgrade program in support of EV-charging and TOU efforts.	Policy/program(s) satisfies 1 of 2 of the following: 1. PEV-specific charging rates or TOU rates that do not meet all the criteria for a rating of Strong. 2. Jurisdiction has Smart Meter program focused on PEVs.	Other PEV-specific rates that do not meet requirements of "Moderate" rating.

Summary: This Policy Sub-Category encompasses utility-led programs that reduce the cost of residential charging. The Policy Sub-Category is given a weight of 4 of 100, reflecting the relatively small financial incentive of residential rates compared to other incentives and the fact consumers value operational savings differently than upfront savings.

Description of Evidence: Operational cost is a key variable explored in several papers using choice experiments, in which survey respondents are given a list of vehicle attributes and costs and told to choose the vehicle that best suits their preferences. Operational cost negatively affects the decision to purchase a given vehicle (Lioa et al., 2015). Also, individuals with higher incomes place lower importance on fuel cost (Helveston et al., 2015; Valeri & Danielis, 2015). Operational costs are typically defined in these choice experiments as cost per distance traveled or in terms of fuel efficiency and cost per gallon price (Musti & Kockelman, 2011). However, any type of operational savings factors into the total operational cost of a vehicle. For example, Kara et al. (2015) show that a smart meter can reduce a BEV household's electric bill by approximately 25 percent per month.

In the paper mentioned above, Vergis and Chen (2015) use historical state PEV sales data in a regression model and find electricity rates negatively predict BEV market share, but not PHEV market share. In their analysis, electricity rates are measured in cents per kWh and the coefficient is -0.012. This means an increase of one cent per kWh in electricity rates reduces the market share of BEVs by 0.012 percent, all else equal. The magnitude of this estimate is much lower than other variables in their model. For example, the authors find that every charger added per 1,000 people is correlated with an increase in BEV market share of 2.3 percent.

A further consideration is that a dollar of operational savings is not valued the same as a dollar or upfront savings. NAS (2015) find that the calculations needed to estimate the payback of PEVs relative to a gasoline equivalent vehicle are "complex enough to be overwhelming for a typical mainstream consumer…" (p. 65). Together, the evidence in the literature clearly shows an impact of electricity rates on PEV sales, but for various reasons discussed, the impact is relatively small.

2.3 PEV Fee

Weight	Policy Category	Rating		
		100% - Strong	50% - Moderate	10% - Weak
1	PEV Fee	No existing PEV Road Usage Fee (i.e., government revenue traditionally supplied by gas tax). Note: category is unique in that it provides points for the absence of a policy.	PEV Road Usage Fee that is lower than $150 per year.	PEV Road Usage Fee that is roughly equivalent to the annual gas tax paid by gasoline vehicle drivers (i.e., roughly $150 per year).

Summary: Annual fees placed on PEV drivers to recover lost revenue from gasoline or diesel tax. The NASEO-Cadmus team assigned a Weight of 1 out of 100 for this Policy Category because the fee is relatively small compared to other vehicle costs.

Description of Evidence: Ten states now use PEV fees ranging from $50 to $300 per year to recover lost revenue from fuel taxes. Overall, these fees account for a minor fraction of total vehicle cost. For example, using Argonne National Laboratory's AFLEET Tool, a generic PEV passenger car has a lifetime cost of around $85,000[3] (Argonne, 2017). This means that an annual $150 fee over 12 years of ownership has a net present value of $1,368, or 2 percent of the total cost of the vehicle. Since consumers undervalue future fuel savings by half or more relative to what would otherwise be expected (NAS, 2013), the PEV fees amount to a very small disincentive for PEV purchases.

The NASEO-Cadmus team found minimal evidence that PEV fees impact PEV sales. Hoen and Koetse (2014) conduct a stated preference choice experiment and show a statistically-significant finding that respondents are willing to pay higher vehicle costs to avoid paying a PEV fee[4]. Additionally, some papers demonstrate that even small changes in the relative costs of alternative fuel vehicles can impact vehicle demand. In their study of historical hybrid electric vehicle sales in the U.S., Gallagher and Muehlegger (2011) show that a $100 increase in annual fuel costs is associated with a 13 percent decrease in hybrid vehicles sales. Of course, whether consumers would value a PEV fee cost in the same way they value the equivalent fuel cost is not part of the study. Cattaneo (2018) include PEV fees in their state-level statistical analysis of PEV policies. In models with and without California, the author does not find a statistically significant result.

Weight	Policy Category	Rating		
		100% - Strong	50% - Moderate	10% - Weak
1	Other Operational Costs	Policy/program(s) satisfies 2 of 4 of the following: 1. Registration tax exemption. 2. Emissions testing exemption. 3. License tax reduction. 4. Other operational cost saving.	Policy/program(s) satisfies 1 of 4 of the following: 1. Registration tax exemption. 2. Emissions testing exemption. 3. License tax reduction. 4. Other operational cost saving.	Other operational cost program that does not meet requirements of "Moderate" rating.

Summary: This Policy Sub-Category includes all other operational cost savings provided to PEV owners not captured in other categories. This Policy Category is given a weight of 1 out of 100 because the relatively small total cost associated with the category.

Description of Evidence: As with the PEV fee category, no study reviewed by the NASEO-Cadmus team specifically examines other operational costs/savings such as registration tax exemptions, emissions testing exemption, and license tax reduction. Despite the lack of empirical evidence, a deductive argument for including this category is that higher costs nearly always imply lower demand for products. Furthermore, since these incentives are typically realized at the time of vehicle purchase or shortly thereafter, their impact may be greater than other types of operational savings, like fuel and maintenance savings.

3.   Improving Economic Viability of Charging
Improving Economic Viability of Charging includes policies that facilitate the adoption of electric vehicle supply equipment (EVSE), either through direct incentives for EVSE installation or by helping the business case of EVSE. This Policy Category is comprised of two Sub-Categories: (1) EVSE Installation, and (2) EVSE Operation.

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3   This value is the net present value using a real discount rate of 1.42 percent.
4   Survey respondents were in the Netherlands, which has road taxes (MRB) that differ by fuel type and vehicle weight. In addition, some vehicles are exempt from MRB, depending on the amount of CO2 they emit per kilometer. In the choice experiment, PEVs were exempt from road taxes while internal combustion engine vehicles were not.

Weight	Policy Category	Rating		
		100% - Strong	50% - Moderate	10% - Weak
10	EVSE Installation	Policy/program(s) satisfies 1 or more of the following: 1. Provides more than $5,000 financial incentive per public, workplace, or multi-unit dwelling L2 charging station installation. 2. Provides more than $10,000 financial incentive per DCFC installation. 3. Provides more than $1,000 financial incentive for single-family dwelling L2 charging station installation. 4. Enables residents in multi-family dwelling to install L1 or L2 charging stations in public areas. Policy/program(s) satisfies all of the following: 4. Program is easy to find on the website or through other media. 5. Program has a long-term funding stream.	Policy/program(s) satisfies 1 or more of the following: 1. Provides more than $1,000 financial incentive per public, workplace, or multi-unit dwelling L2 charging station installation. 2. Provides more than $5,000 financial incentive per DCFC installation. 3. Provides more than $500 financial incentive for single-family dwelling L2 charging station installation. Policy/program(s) satisfies all of the following: 4. Program is easy to find on the website or through other media. 5. Program has a long-term funding stream.	Policy/program(s) satisfies 1 of the following: 1. Provides more than $1,000 financial incentive per public, workplace, or multi-unit dwelling L2 charging station installation. 2. Provides more than $5,000 financial incentive per DCFC installation. 3. Provides more than $500 financial incentive for single-family dwelling L2 charging station installation.

3.1 EVSE Installation

Summary: This Sub-Category includes programs or policies that reduce the cost of or facilitate installation of public or private EVSE. The NASEO-Cadmus team gave this Policy Sub-Category a total weight of 10 of 100 because most studies reviewed clearly show that greater EVSE availability is associated with greater PEV deployment. However, studies differ widely on their estimated effect size.

Description of Evidence: Drivers experience mild or strong range anxiety depending on the vehicle range, charging routines, and drivers' driving patterns (Frank et al. 2011; Lim et al., 2014). EVSE availability helps alleviate those anxieties. Egbue and Long (2012) find in their study of technology enthusiasts that 17 percent identify lack of charging infrastructure as their biggest concern with PEVs. Similarly, the Colorado Energy Office (2012) conducted an online survey of 285 residents about barriers to PEV adoption in the state. The survey respondents noted that a key barrier was the cost burden on financing EVSE installation.

Several studies show that PEV adoption and public EVSE are strongly correlated. For example, Sierzchula et al. (2014) examine the relationship between several policy and non-policy variables with 30 national electric vehicle market shares for the year 2012. The authors estimate that an additional charger per 100,000 residents is correlated with a 13 percent increase in market share. At smaller units of geography, the strong link between charging availability and PEV still holds. Javid and Nejat (2017) conducted a regression analysis at the county-level in 58 California counties and found a statistically significant correlation between public charging and PEV adoption. In a regional- and municipal-level analysis of PEVs in Norway, Mersky et al. (2016) found that PEV charging availability is the strongest predictor of PEV uptake. Narassimhan and Johnson (2014) conduct a regression analysis that suggests that public charging infrastructure availability has a significant link to both PHEV and BEV purchases. Hardman et al. (2018) conduct a review of literature on EVSE siting and find that the most important location of EVSE is at home, followed by workplace, followed by public charging. Lin and Greene (2012) come to similar conclusions.

Only a few studies suggest that the existence of public charging is not an important predictor of PEV sales. Carley et al. (2013) and Bailey et al. (2015) use stated preference surveys about EVSE availability to show weak or no significant

correlations between recalling public EVSE and the willingness to buy a PEV. More important for the participants than public EVSE was the possibility of installing charging equipment at home. These studies also showed that awareness of EVSEs is low at the time the surveys were taken, which was 2011 and 2013 respectively. Cherchi (2017) examine charging infrastructure availability and parking policies and find that non-residential EVSE infrastructure availability has an impact, but residential infrastructure does not.

3.2 EVSE Operation

Weight	Policy Category	Rating		
		100% - Strong	50% - Moderate	10% - Weak
10	EVSE Operation	Policy/program(s) satisfies all of the following: 1. Utility commission encourages competition in the EVSE market. 2. Utility commission provides active support for utilities in PEV programs. 3. Government or utility enables a return on investment for DCFC stations.	Policy/program(s) satisfies 1 of the following: 1. Utility commission encourages competition in the EVSE market. 2. Utility commission provides active support for utilities in PEV programs. 3. Government or utility enables a return on investment for DCFC stations.	Other utility regulatory or government action that is weaker than "Moderate" rating.

Summary: This Policy Sub-Category includes government- or utility-led policies and programs that improve the economic business case of public EVSE stations. As with the category above, this Policy Sub-Category was given a weight of 10 out of 100 to reflect the importance of EVSE in PEV purchase decisions. Since no literature separates the relative importance of EVSE installation versus operation costs, the weight given by the NASEO-Cadmus team is 10 of 100.

Description of Evidence: Only limited evidence was found by the NASEO-Cadmus team on the role of utility commissions in PEV adoption. Santini et al. (2015) demonstrate that the most successful of the 14 metro areas reviewed in preliminary investigations each had significant levels of state and utility support and PEV growth was limited when a utility program was not also supported by state- and/or city-level policies and/or incentives (e.g., Duke Power in South Carolina, North Carolina and Indiana).

Among various types of EVSE, DC fast chargers (DCFCs) are among the most difficult type to economically justify. Fitzgerald and Nedler (2017) show that in some states like California, Ohio, and Colorado, the cost to operate a DCFC per mile of vehicle travel is approximately twice the cost of gasoline. In addition to a much higher upfront cost than Level 2 chargers, demand charges substantially increase costs of DCFC operation in some part of the country. For example, in Denver demand charges may make up approximately 80 percent of the electrical bill incurred by these stations (Svitak, et al.,2017). At the same time, consumers are willing to pay thousands of dollars to reduce amount of time for charging (Hirdue et al., 2011). When viewed together, the above evidence strongly suggests that policies that reduce the operational costs of EVSE (in particular DCFCs) are critical to the deployment of public EVSE and (using evidence cited above in Section 3.3.1), therefore to the deployment of PEVs

4. Improving PEV and EVSE Planning

This Policy Category encompasses activities that address long-term planning considerations at the municipal, utility, or community level. This Policy Category is comprised of three Sub-Categories: (1) PEV and EVSE Planning, (2) PEV-Ready Building Codes and Zoning Ordinances, and (3) Streamlined EVSE Permitting.

4.1 PEV and EVSE Planning

Weight	Policy Category	Rating		
		100% - Strong	50% - Moderate	10% - Weak
2	PEV and EVSE Planning	Strong and ambitious PEV readiness plans created at multiple jurisdictional levels (e.g. city and state), and local jurisdictions that have PEV readiness plans in place cover the majority of the metro area by population. Active Clean Cities Coalitions, dealers, nonprofit coalitions, car clubs, advocacy groups.	Strong and ambitious PEV readiness plans are in place, either at the state or the regional level. Somewhat active Clean Cities Coalitions, dealers, nonprofit coalitions, car clubs, advocacy groups.	PEV readiness planning has occurred, but plans are not strong or not ambitious. Limited activity of Clean Cities Coalitions, dealers, nonprofit coalitions, car clubs, advocacy groups.

Summary: Policies, programs, and organizations that support PEV and EVSE readiness and planning on the local level, such as PEV Readiness Plans, or PEV-promotion among Clean Cities Coalitions, non-profit coalitions, auto dealers, PEV car clubs, and other advocacy groups with the support of local or state-level policies. This Policy Category received a weight of 2 out of 100 due to support from the TAC.

Description of Evidence: The adoption of new technology involves collaboration with dozens of actors, such as environmental and clean air agencies, utility commissions, utilities, departments of energy, transportation agencies, licensing and inspection agencies, general services agencies, workforce training organizations, local businesses, automakers, and their suppliers. An "on-the-ground" organization often helps facilitate this collaboration.

A few research papers examine how PEV and EVSE planning activities impact PEV sales. In their statistical state-level analysis of the PEV policies, Vergis and Chen (2015) used the variable "Community Readiness Funding" levels awarded in 2011 by the U.S. Department of Energy to capture community readiness plans. The authors used a stepwise regression and determined that this variable did not improve the fit of the model (and therefore was excluded from the model). Cahill et al. (2014) highlight the importance of dealer inclusion in PEV planning and advocacy.

The lack of evidence in peer-reviewed papers around the impact of PEV for the category should be expected. PEV and EVSE planning activities are diverse across jurisdictions and are not easily quantified.

The NASEO-Cadmus team discussed the category with the external TAC members, who thought the category was somewhat important and belonged in the Rubric.

4.2 PEV-Ready Building Codes and Zoning Ordinances

Weight	Policy Category	Rating		
		100% - Strong	50% - Moderate	10% - Weak
2	PEV-Ready Building Codes and Zoning Ordinances	Building code(s) or ordinance(s) specifically aimed at PEV charging or EVSE installation, such as: 1. A dedicated electrical circuit with sufficient capacity for each charging spot. 2. Installation of the conduit and wire required to run electricity to PEV charging spots. 3. Electrical panels labeled PEV Ready and positioned near where people will park.	PEV-ready building codes exist but not strongly implemented.	Other PEV-ready building codes and/or zoning ordinances that do not meet requirements of Moderate policy.

Summary: This Sub-Category includes local codes and ordinances written to support deployment of PEV infrastructure. This category is weighted 2 out of 100 based on the deductive argument that cheaper and faster installation of EVSE implies greater potential to promote PEV growth, but has limited support from the literature.

Description of Evidence: PEV-ready building codes and zoning ordinances prepare buildings and neighborhoods for PEV market growth and reduce costs of installation of EVSE in the future. The study by NAS (2013) concludes that one of the four key barriers to widespread adoption of PEVs is the permitting and construction of new electrical systems in neighborhoods and buildings. The authors also discuss how policies around building codes and zoning lack attention in the literature (NAS, 2013).

The NASEO-Cadmus team did not find empirical evidence showing a policy impact. Instead, the following deductive argument along with validation from the TAC members provides a reasonable foundation for the assigned weight. In existing buildings, adding wiring to deliver electricity to a parking stall represents over half of the cost of installing an electric vehicle charger. Therefore, installing the necessary infrastructure components at the time of building construction prevents the need for post-hoc trenching and repaving or increasing the electric capacity.

4.3 Streamlined EVSE Permitting

Weight	Policy Category	Rating		
		100% - Strong	50% - Moderate	10% - Weak
1	Streamlined EVSE Permitting	Municipal or state program(s) that specifically aims to streamline permitting for DCFCs, L2 chargers, or other PEV infrastructure.	Municipal or state program(s) that specifically aims to streamline permitting for DCFCs, L2 chargers, or other PEV infrastructure.	Other EVSE permitting rules that do not meet requirements of Moderate.

Summary: This Sub-Category includes local policies, programs, and statutes that reduce the time and cost barriers of EVSE permitting. While the process for obtaining permits for charging – particularly commercial DC fast chargers – can be complicated and time consuming, there is relatively little evidence showing that streamlined permitting processes actually leads to greater PEV adoption. Because of this, the project team has assigned this category a weight of 1 out of 100.

Description of Evidence: Streamlined EVSE permitting is mentioned as an important strategy in most community-level PEV readiness plans. However, the NASEO-Cadmus team found very limited evidence this streamlining has an impact on PEV sales. In one study, NAS (2015) gave a prescriptive recommendation but did not provide empirical evidence for their recommendation:

> *"…state permitting processes have been ill-suited for the simple installation of some PEV charging infrastructure. As a result, unnecessary permit burdens and costs have been introduced into the installation process. Because most charging will occur at home, PEV deployment could be seriously impeded if the buyers must bear high permit and installation costs and experience delay in the activation of their home chargers. Accordingly, clarity, predictability, and speed are needed in the permitting and approval process for installation of home and public charging stations. Local governments should streamline permitting and adopt building codes that require new construction to be capable of supporting future charging installations." (p. 5).*

In another study, CEO (2015) surveyed 285 residents of Colorado and demonstrated that key permitting challenges include: price variability of electrical permits (administered by local building departments); and the lengthy permitting process which lacks standardization across metro areas.

Lacking other evidence, the NASEO-Cadmus team and TAC members included this Sub-Category using the deductive argument that a streamlined permitting process facilitates a lower cost of EVSE installation and/or greater numbers of EVSE installed, which will improve PEV adoption.

5.   Increasing Awareness and Education
This Policy Category includes a variety of different supporting programs such as PEV and EVSE planning programs, marketing and communication initiatives, community support programs, and other relevant policies or programs not captured in the categories above. This Policy Category has two Sub-Categories: (1) Marketing and Communication and (2) Fleets.

5.1 Marketing and Communication

Weight	Policy Category	Rating		
		100% - Strong	50% - Moderate	10% - Weak
9	Marketing and Communication	Policy/Program(s) satisfies all of the following: 1. Large-sized promotional campaign, such as education, social media, outreach, or workplace charging programs. 2. Long-term commitment to continue this promotional campaign. 3. Public Utility Commission allows utilities to spend money on education and communication material.	Policy/Program(s) satisfies 1 of 3 of the following: 1. Large-sized promotional campaign, such as education, social media, outreach, or workplace charging programs. 2. Long-term commitment to continue this promotional campaign. 3. Public Utility Commission allows utilities to spend money on education and communication material.	Limited program or project related to promoting PEV or EVSE deployment.

Summary: This Sub-Category includes policies that increase the level of public awareness of PEVs. A weight of 9 out of 100 was given to this Policy Category because of the strong evidence from the literature showing that consumers are ill-informed about the technical and economic aspects of PEVs. Despite recommendations from the TAC to increase the weight higher than 9 out of 100, the NASEO-Cadmus team felt the evidence showing a link between marketing programs and PEV adoption was relatively weak and so kept the weight at 9.

Description of Evidence: Past research notes that the car-buying public is deficient in their awareness about PEV technology and their understanding about the incentives for PEVs. For example, NAS (2015) state:

> *"A significant body of research demonstrates that having the right technology (with a compelling value proposition) is still insufficient to achieve success in the market. That technology must be complemented with a planned strategy to create market awareness and to overcome customer fear, uncertainty, and doubt about the technology" (pp. 9-10).*

In general, awareness of PEVs is low among the car-buying public, but differs by location. Kurani and Caperello (2016) conducted a survey of 5,654 new car buying households across the U.S. and find that the fraction of respondents in a given state who had reported seeing PEVs on the road ranged between 25 percent for Delaware to 72 percent for Oregon. Other research shows that even after driving a PHEV for several weeks, drivers may be confused about how the vehicle operates and/or when it needs to be plugged in (Kurani et al., 2014).

The car-buying public is also uninformed about PEV incentives. The same NAS study (NAS, 2015) states:

> *"The many state and local incentives that differ in monetary value, restrictions, and calculation methods make it challenging to educate consumers on the incentives that are available to them and emphasize the need for a clear, up-to-date source of information for consumers…" (pp. 9-10).*

Krause et al., (2013) used a survey to understand the general population's awareness of PEV incentives. They find that awareness of HOV lane access for PEVs is low, with only 2.8 percent of 2,302 respondents being aware. However, the authors also find that if consumers are aware of HOV lane access, 48 percent are more likely to consider purchasing a PEV.

Despite the various research that notes knowledge gaps among the public, little research found by the NASEO-Cadmus team links marketing programs to increased PEV adoption. Some studies show that proper dissemination of information increases consumer awareness of and knowledge about a policy or program, and can have a more permanent impact on consumer behavior than incentive programs alone (Iyer and Kashhyap, 2007). Lutsey et al. (2015) estimate a best-fit statistical regression model and find that including variables such as "PEV information provided on a city or utility website" or "outreach and educational activities available" improves the fit of the model, although the variables are not statistically significant. A survey of 19,460 users of California's Clean Vehicle Rebate Project (CVRP) rebate conducted by CSE (2017) suggests early adopters of PEVs were easily able to find information they needed. For example, 73 percent said that "finding dependable information during the time you were researching PEVs" was easy or very easy. Also, 44 percent said that a ride

and drive was very to extremely important in their PEV purchase decision. While evidence showing a linkage between PEV awareness programs and PEV adoption is somewhat limited, the above studies, combined with strong recommendations from the TAC, led the NASEO-Cadmus team to give this Policy Sub-Category a weight of 9.

5.2 Fleets

Weight	Policy Category	Rating		
		100% - Strong	50% - Moderate	10% - Weak
1	Fleets	Binding policy that requires the jurisdiction's government and/or commercial fleets to increase PEV deployment in at least 20 percent of fleet in ten years or less.	Binding policy that requires the jurisdiction's government and/or commercial fleets to increase PEV deployment in at least 10 percent of fleet in ten years or less.	Non-binding policy on PEV deployment requiring the jurisdiction's large government and commercial fleets to increase PEV deployment in at least 10 percent of fleet.

Summary: This Policy Sub-Category includes policies that encourage public or private fleets to electrify. The NASEO-Cadmus team gave this Sub-Category a total weight of 1 of 100. While there is a proven relationship between increased visibility of a technology and reduced uncertainty about the costs of that technology, no evidence specifically demonstrates this relationship for fleet vehicles. Furthermore, state and local government fleets are typically so small as to be relatively unnoticeable by the public, yielding the relatively small weight for this Policy Sub-Category.

Description of Evidence: The NASEO-Cadmus team found no empirical evidence in the literature that demonstrates a link between fleet-related PEV policies and market uptake of PEVs. However, several deductive arguments for the inclusion of this Policy Sub-Category in the Rubric can be made. Past research establishes a strong connection between increases in visibility of a product and demand for that product. When applied to new vehicles, Pettifor et al. (2017, p. 248) characterize this as the "Neighborhood Effect" – i.e., the reduction in perceived "technological and social uncertainties" that occurs when information is "gained from observing vehicles being demonstrated by others in close physical proximity." This uncertainty is a major barrier to PEV adoption, so it logically follows that a reduction in this barrier will lead to greater PEV market uptake. Research also notes the benefits of increased awareness and potential positive word-of-mouth from simply having more PEVs on the road (Zhang et al., 2011; Axsen and Kurani, 2012). The neighborhood effect was also noted as important or extremely important in 43 percent of responses to California's CVRP customer survey (total number of responses was 19,000) (CSE, 2017).

A qualitative assessment from the NAS (2015) report on PEV barriers states:

> "Although the total number of vehicles in government fleets is small compared with the total number of vehicles in the overall market, converting some portion of the fleets to PEVs is important… The large number of people working at all levels of government, particularly in the federal government, could play a role in information diffusion and the education of friends and neighbors" (p. 82).

One study by Cattaneo (2018) examines the impact of state-level PEV policies on PEV market share. The findings suggest that fleet requirements for PEV sales are not a statistically significant predictor of PEV market share, although the market share is higher in states with the policies.

To date, government policies focus on increasing PEVs in government fleets. However, moving forward, there are discussions of regulation of private fleets such as Lyft and Uber (Ohnsman, A., 2018). These regulations, as currently proposed, would require additional PEVs on the road, further raising awareness among the community. Furthermore, private fleets are much larger than government fleets (Lyft and Uber have 200,000 drivers in California alone), meaning the impact of their electrification would not solely be valuable from a visibility standpoint, but on a scale to have a significant impact on PEV sales in total.

6. Reducing Upfront Costs

This Policy Category encompasses any policy that reduces the upfront cost of PEVs, through rebates, tax incentives, or other methods. Policies that address this upfront cost, therefore, play an important role in accelerating PEV adoption. This Policy Category has a single Policy Sub-Category: Vehicle Purchase Incentives.

6.1 Vehicle Purchase Incentives

Weight	Policy Category	Rating		
		100% - Strong	50% - Moderate	10% - Weak
30	Vehicle Purchase Incentive	NOTE: *Policies that reduce the upfront vehicle cost are evaluated on a continuous scale using the equation below. Update cells in light grey cells to calculate total policy value (shown in dark grey cell).*		

Total Points=(0.3/((1+ e^((−0.0006 ⊠ (Incentive −2000)))))) * (Type) * (Comms) * (Long)

TOTAL POINTS	27.50	
INCENTIVE	$6,000	Incentive level: Total dollar value of all upfront incentives of a given type ($).
TYPE	10	Type of Incentive: ☐ 10 for a rebate at the time of vehicle purchase; ☐ 7 for a rebate after purchase; ☐ 5 for a tax credit after purchase.
COMMS	2	Communications and marketing of incentive: ☐ 2 for a well-advertised incentivized; ☐ 1 for a poorly advertised incentive.
LONG	5	Longevity of funding: ☐ 5 for funding provided through secure, long-term (i.e., 10 years or greater) mechanism that is resistant to legal challenges and shifts in governance (e.g., secure cap-and-trade revenues); ☐ 2 for funding provided through semi-secure mechanism with some uncertainty due to legal challenges or shifts in governance; ☐ 1 for funding provided year-to-year based on legislative oversight.

Summary: This Policy Sub-Category includes vehicle purchase grants, rebates, and tax credits; sales tax exemptions; registration fee waivers; and licensing fee waivers. The NASEO-Cadmus team gives this category a weight of 30 out of 100 due to the evidence that clearly indicates the importance of vehicle purchase incentives in encouraging customer adoption. The weighting is higher than the PEV Deployment Targets category (20) because the academic evidence is clearer and because of the historical examples of the boom-and-bust of PEV sales associated with these incentives. Additionally, the literature shows a clear rank order of most preferable to least preferable incentives, including (1) incentives at the time of purchase (e.g., dealer discounts, tax waivers, registration fees), (2) incentives offered immediately after purchase (e.g., rebates), and (3) incentives offered weeks or months later (e.g., tax credits). These preferences have been reflected in the equation in the Rubric.

Description of Evidence: Stated preference studies clearly demonstrate the importance of vehicle price in consumers' purchase decisions (Carley et al., 2013; Graham-Rowe et al., 2012; Lebeau et al., 2012). The upfront cost is the main consideration of new car buyers (NAS, 2013), even though it accounts for a minority fraction of the total cost of ownership[5].

Numerous academic studies indicate vehicle purchase incentives play an important role in encouraging customer adoption of PEVs. For example, Hardman et al. (2017a) reviewed 35 studies that examine the impact of purchase incentives on PEV adoption and consistently found a positive impact of the incentive on PEV sales. Lutsey et al. (2015) conclude that incentives that reduce the cost of ownership of PEVs are important to improve the consumer-value proposition and that financial incentives should be around or above 15 percent of the PEV purchase price available at the initial point of vehicle sale. However, this analysis also found that the impact of these incentives is moderated by other variables. For example, with limited charging infrastructure and limited PEV model availability, even large incentives have only minor impacts on PEV adoption.

Several studies also highlight how the policy impact differs depending on the delivery method of the incentive. As

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5   For ICEVs, Argonne's (2017) AFLEET tool estimates that a generic passenger sedan has a total cost of ownership of around $80,000 (when including time-discounted depreciation, fuel, maintenance, insurance, and license and registration). Thus, an

background, some metro areas allow car buyers to individually submit rebate applications. In these cases, the rebate is received as a paper check or a direct deposit with a delivery time ranging from a few days to several weeks after application approval. Other jurisdictions, such as those in Texas, require the vehicle dealer to file the rebate application. In these cases, the dealer receives the rebate on behalf of the purchaser and subtracts the rebate amount from the sale price of the vehicle or from the monthly payments. Still other states allow the purchaser to choose whether they receive the rebate individually or request the rebate through the dealer.

Across studies, the authors find that vehicle purchase incentives are most effective when applied at the time of the purchase, not after a purchase (Gallagher and Muehlegger, 2011; Sierzchula et al., 2014; Hardman et al., 2017a). Coplon-Newfield and Devine's (2015) analysis suggests that tax credits are less effective than immediate rebates because tax credits must be claimed by the purchaser at a later date and depend on the purchasers' tax liability. Of the incentives provided at the time of vehicle purchase (as opposed to weeks or month after the purchase), rebates are least preferable because they still require a customer to have the financial ability to pay the full upfront cost of the vehicle. Other incentives offered at the time of purchase – such as negotiated vehicle costs, VAT tax exemption, and grants – allow cost reductions without the customer first paying the full cost.

The estimated size of the impact varies across studies and across incentive types. Jin et al. (2014) find that every 10 percent increase in the total benefit offered is related to a 1.8 percent increase in PEV sales. Jenn et al. (2013) find that the tax credit passed in the Energy Policy Act of 2005 increased hybrid electric vehicle sales by 4.5 percent per $1,000. Similarly, Narassimhan and Johnson (2014) find that a $1,000 increase in BEV tax credits leads to a 4.1 percent increase in BEV purchases, while a $1,000 increase in rebates leads to a 9.4 percent increase in purchases. Gallagher and Muehlegger (2011) conduct a state-level regression analysis examining the impact of both sales tax waivers at the time of vehicle purchase and tax credits provided after vehicle purchase. The authors show the tax waivers at the time of vehicle purchase are valued by consumers more than three times higher than those after-purchase. Research also demonstrates a threshold effect for PEV purchase incentives.

As with other public policies, a vehicle purchase incentive will be more effective the longer it provides a given level of incentive. Several policy and industry analyses from the renewable energy sector note that incentives subject to inconsistent funding streams cause markets to spike and crash (Barradale, 2010; Luthi and Prassler, 2011). This boom-or-bust behavior was observed in the PEV market, in newly-subsidized markets like the State of New York and in markets with incentives removed, like the State of Georgia (Washington Post, 2017).

Finally, a limited number of studies examine the magnitude of purchase incentives compared to other policy categories. These studies provide the strongest basis for the weighting of 30 used in the Policy Evaluation Rubric. Vergis and Chen (2015) conducted a regression analysis of incentives for PHEVs and BEVs at the state-level. The authors show that the existence of a purchase incentive is correlated with an increase in PHEV sales of 14 percent. Further, other EV-focused policies are correlated with only a 1 percent increase in PEV sales. The authors conclude that incentives may support PHEVs more preferentially than BEVs. Other studies such as Lutsey et al. (2015) and EIA (2015) also provide suggestive evidence that the overall monetized value of vehicle purchase incentives is the highest dollar value of any incentive (financial or non-financial). However, unlike Vergis and Chen (2015), these two studies do not control for other factors such as socio-demographics. These studies, combined with support from the TAC, led the NASEO-Cadmus team to give this Policy Sub-Category a weighting of 30.

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average upfront cost for an ICEV of $20,000 is approximately one quarter of the total cost.

Conclusion

The Policy Evaluation Rubric allows the user to evaluate the strengths and weaknesses of all PEV-related policies in a given metro area on a scale of 1-100. The policy categories and subcategories were developed after a deep literature review, and were further refined and assigned appropriate weightings based on the literature and significant input from the TAC. As noted above, the NASEO-Cadmus team assigned the highest weight to vehicle purchase, followed by PEV deployment targets and policies that incentivize EVSE installation and reduce EVSE operational costs.

The Rubric provides a unique, evidence-based method to help decision-makers identify and prioritize PEV programs and policies, and can be used to evaluate the impact of state and local policies on PEV adoption. It is the authors' intent for this analysis to be used by private and public entities as they consider PEV policy adoption and investment in communities across the United States.

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PLUG-IN ELECTRIC VEHICLE (PEV) POLICY EVALUATION RUBRIC				
A rubric to measure the combined impact of local, utility, and state policies and programs on PEV Developemnt				

Weight	Policy Category	Rating		
		100% - Strong	50% - Moderate	10% - Weak
25	**Sending Long-Term Signal to Market**			
20	PEV Deployment Targets	Binding PEV deployment target that regulates automakers like today's version of the ZEV Memorandum of Understanding (i.e., about 8 percent of new car sales are ZEVs by 2025).	Binding PEV deployment target that is less stringent than today's ZEV Memorandum of Understanding (i.e., about 8 percent of new car sales are ZEVs by 2025).	Non-binding PEV deployment target into the future.
5	Transportation Climate Policy	Long-term (i.e., 10 years or more), binding transportation policy that incentivizes PEVs and/or EVSE operators through direct investment and/or performance-based system, such as a low carbon fuel standard, feedbate system, and/or GHG vehicle emissions standard. Generates revenue for PEV owners and/or EVSE operators, such as a low carbon fuel policy and reduces carbon intensity by 10-15% over 10 years.	Binding transportation policy that incentivizes PEVs and/or EVSE operators through direct investment and/or performance-based system, such as a low carbon fuel standard, feedbate system, and/or GHG vehicle emissions standard.	Other less stringent (i.e., non-binding), comparable transportation policies.

10	Reducing PEV Operational Costs			
Weight	**Policy Category**	**Rating**		
		100% - Strong	**50% - Moderate**	**10% - Weak**
4	Non-Financial Incentives	Jurisdiction has aggressively implemented non-financial incentives for PEVs where possible, such as: 1. HOV lanes: unlimited access to HOV lanes. 2. Tolls: Fee waivers on tolls. 3. Parking: Free or preferred parking. 4. Ferry: Free ferry rides for PEVs. 5. Airports: Programs that incentivize PEV drop-off and pick-ups. Programs are well-advertised through the city's website and there is no cap on the number of participants. through the city's website and there is no cap on the number of participants.	Jurisdiction has some combinations of non-financial incentives for PEVs, such as: 1. HOV lanes: unlimited access to HOV lanes. 2. Tolls: Fee waivers on tolls. 3. Parking: Free or preferred parking. 4. Ferry: Free ferry rides for PEVs. 5. Airports: Programs that incentivize PEV drop-off and pick-ups.	Jurisdiction is using at least one non-financial incentives for PEVs, such as: 1. HOV lanes: unlimited access to HOV lanes. 2. Tolls: Fee waivers on tolls. 3. Parking: Free or preferred parking. 4. Ferry: Free ferry rides for PEVs. 5. Airports: Programs that incentivize PEV drop-off and pick-ups.
4	Residential PEV Electricity Rates and Programs	Policy/program(s) satisfies all of the following: 1. PEV-specific charging rates or favorable time of use (TOU) rates and/or incentives for PEV charging. 2. Program is easy to find and navigate on the website. 3. Widespread eligibility of program (offered by all utilities serving the metro region to all residential customers). 4. Free Smart Meter upgrade program in support of EV-charging and TOU efforts.	Policy/program(s) satisfies 1 of 2 of the following: 1. PEV-specific charging rates or TOU rates that do not meet all the criteria for a rating of Strong. 2. Jurisdiction has Smart Meter program focused on PEVs.	Other PEV-specific rates that do not meet requirements of "Moderate" rating.
1	PEV Fee	No existing PEV Road Usage Fee (i.e., government revenue traditionally supplied by gas tax). Note: category is unique in that it provides points for the absence of a policy.	PEV Road Usage Fee that is lower than $150 per year.	PEV Road Usage Fee that is roughly equivalent to the annual gas tax paid by gasoline vehicle drivers (i.e., roughly $150 per year).
1	Other Operational Costs	Policy/program(s) satisfies 2 of 4 of the following: 1. Registration tax exemption. 2. Emissions testing exemption. 3. License tax reduction. 4. Other operational cost saving.	Policy/program(s) satisfies 1 of 4 of the following: 1. Registration tax exemption. 2. Emissions testing exemption. 3. License tax reduction. 4. Other operational cost saving.	Other operational cost program that does not meet requirements of "Moderate" rating.

20	Improving Economic Viability of Charging			
Weight	Policy Category	Rating		
		100% - Strong	50% - Moderate	10% - Weak
10	EVSE Installation	Policy/program(s) satisfies 1 or more of the following: 1. Provides more than $5,000 financial incentive per public, workplace, or multi-unit dwelling L2 charging station installation. 2. Provides more than $10,000 financial incentive per DCFC installation. 3. Provides more than $1,000 financial incentive for single-family dwelling L2 charging station installation. 4. Enables residents in multi-family dwelling to install L1 or L2 charging stations in public areas. Policy/program(s) satisfies all of the following: 4. Program is easy to find on the website or through other media. 5. Program has a long-term funding stream.	Policy/program(s) satisfies 1 or more of the following: 1. Provides more than $1,000 financial incentive per public, workplace, or multi-unit dwelling L2 charging station installation. 2. Provides more than $5,000 financial incentive per DCFC installation. 3. Provides more than $500 financial incentive for single-family dwelling L2 charging station installation. Policy/program(s) satisfies all of the following: 4. Program is easy to find on the website or through other media. 5. Program has a long-term funding stream.	Policy/program(s) satisfies 1 of the following: 1. Provides more than $1,000 financial incentive per public, workplace, or multi-unit dwelling L2 charging station installation. 2. Provides more than $5,000 financial incentive per DCFC installation. 3. Provides more than $500 financial incentive for single-family dwelling L2 charging station installation.
10	EVSE Operation	Policy/program(s) satisfies all of the following: 1. Utility commission encourages competition in the EVSE market. 2. Utility commission provides active support for utilities in PEV programs. 3. Government or utility enables a return on investment for DCFC stations.	Policy/program(s) satisfies 1 of the following: 1. Utility commission encourages competition in the EVSE market. 2. Utility commission provides active support for utilities in PEV programs. 3. Government or utility enables a return on investment for DCFC stations.	Other utility regulatory or government action that is weaker than "Moderate" rating.

5	Improving PEV and EVSE Planning			
Weight	**Policy Category**	**Rating**		
		100% - Strong	**50% - Moderate**	**10% - Weak**
2	PEV and EVSE Planning	Strong and ambitious PEV readiness plans created at multiple jurisdictional levels (e.g. city and state), and local jurisdictions that have PEV readiness plans in place cover the majority of the metro area by population. Active Clean Cities Coalitions, dealers, nonprofit coalitions, car clubs, advocacy groups.	Strong and ambitious PEV readiness plans are in place, either at the state or the regional level. Somewhat active Clean Cities Coalitions, dealers, nonprofit coalitions, car clubs, advocacy groups.	PEV readiness planning has occurred, but plans are not strong or not ambitious. Limited activity of Clean Cities Coalitions, dealers, nonprofit coalitions, car clubs, advocacy groups.
2	PEV-Ready Building Codes and Zoning Ordinances	Building code(s) or ordinance(s) specifically aimed at PEV charging or EVSE installation, such as: 1. A dedicated electrical circuit with sufficient capacity for each charging spot. 2. Installation of the conduit and wire required to run electricity to PEV charging spots. 3. Electrical panels labeled PEV Ready and positioned near where people will park.	PEV-ready building codes exist but not strongly implemented.	Other PEV-ready building codes and/or zoning ordinances that do not meet requirements of Moderate policy.
1	Streamlined EVSE Permitting	Municipal or state program(s) that specifically aims to streamline permitting for DCFCs, L2 chargers, or other PEV infrastructure.	Municipal or state program(s) that specifically aims to streamline permitting for DCFCs, L2 chargers, or other PEV infrastructure.	Other EVSE permitting rules that do not meet requirements of Moderate.

10	Increasing Awareness and Education			
Weight	Policy Category	Rating		
		100% - Strong	50% - Moderate	10% - Weak
9	Marketing and Communication	Policy/Program(s) satisfies all of the following: 1. Large-sized promotional campaign, such as education, social media, outreach, or workplace charging programs. 2. Long-term commitment to continue this promotional campaign. 3. Public Utility Commission allows utilities to spend money on education and communication material.	Policy/Program(s) satisfies 1 of 3 of the following: 1. Large-sized promotional campaign, such as education, social media, outreach, or workplace charging programs. 2. Long-term commitment to continue this promotional campaign. 3. Public Utility Commission allows utilities to spend money on education and communication material.	Limited program or project related to promoting PEV or EVSE deployment.
1	Fleets	Binding policy that requires the jurisdiction's government and/or commercial fleets to increase PEV deployment in at least 20 percent of fleet in ten years or less.	Binding policy that requires the jurisdiction's government and/or commercial fleets to increase PEV deployment in at least 10 percent of fleet in ten years or less.	Non-binding policy on PEV deployment requiring the jurisdiction's large government and commercial fleets to increase PEV deployment in at least 10 percent of fleet.
30	Reducing Upfront Costs			
30	Vehicle Purchase Incentive			

NOTE: *Policies that reduce the upfront vehicle cost are evaluated on a continuous scale using the equation below. Update cells in light grey cells to calculate total policy value (shown in dark grey cell).*

$$\text{Total Points} = (0.3/((1 + e^{((-0.0006 \times (Incentive - 2000)))})) * (Type) * (Comms) * (Long)$$

TOTAL POINTS	27.50
INCENTIVE	$6,000
TYPE	10
COMMS	2
LONG	5
STEEPNESS OF CURVE	-0.0006
X-VALUE OF SIGMOID'S	2000

Incentive level: Total dollar value of all upfront incentives of a given type ($).

Type of Incentive:
☐ 10 for a rebate at the time of vehicle purchase;
☐ 7 for a rebate after purchase;
☐ 5 for a tax credit after purchase.

Communications and marketing of incentive:
☐ 2 for a well-advertised incentivized;
☐ 1 for a poorly advertised incentive.

Longevity of funding:
☐ 5 for funding provided through secure, long-term (i.e., 10 years or greater) mechanism that is resistant to legal challenges and shifts in governance (e.g., secure cap-and-trade revenues);
☐ 2 for funding provided through semi-secure mechanism with some uncertainty due to legal challenges or shifts in governance;
☐ 1 for funding provided year-to-year based on legislative oversight.

Equation term that determines steepness of curve
Equation term that determines midpoint of curve