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Integrating Plug-in Electric Vehicles into the Grid: Policy Entrepreneurship in California

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Highlights

- The policy process for vehicle-grid integration in California is analyzed, focusing on the developments between 2009 and 2014.
- The empirical data from stakeholder interviews includes representatives from the government, electric utility, and electric vehicle sectors.
- The two largest barriers facing an effective policy solution for VGI are identified.
- The use of Multiple Streams (MS) framework is evaluated for energy policies.

Abstract

The deployment of large numbers of plug-in electric vehicles (PEVs), in order to satisfy zero-emission-vehicle (ZEV) goals in the State of California, brings both potential benefits and costs for the electric grid. Since early 2009, the issue of so-called *vehicle-grid integration* (VGI) has become a center-stage policy discussion among the electricity and transportation sectors. By conducting a policy process analysis, this research addresses the questions of how the policy process for VGI regulations has been formed in California, and what have been the major challenges in policy-making. A series of interviews were conducted between March 2013 and April 2014 including representatives of 18 organizations from the government, electric utility, and PEV sectors. The qualitative data is analyzed under the three dimensions of policy process; *problem, politics, and policy* as suggested by Multiple Streams framework (Kingdon, 1995). The results show that a policy window for VGI regulations was opened for the first time by the political stream, through State Senate Bill 626 in 2009, and later, supported by the Governor's ZEV action plan in 2012. In response, Energy Division Staff at CPUC became a policy entrepreneur, and has adopted an incremental policy-making strategy targeting investor-owned utilities (IOUs). The two largest barriers facing an effective policy solution are identified as; (1) the complexities involved in quantifying economic value from VGI; and (2) the feasibility concerns about adopting VGI enabling technologies on the grid.

Keywords: Plug-in Electric Vehicles; Smart Grid; Vehicle-Grid Integration; Policy Process Analysis; Multiple Streams Framework

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1. INTRODUCTION

Numerous studies have illustrated that plug-in electric vehicles (PEVs) present efficiency and environmental advantages over gasoline vehicles. According to the International Energy Agency (IEA, 2010), if annual PEV sales increase rapidly and reach 50% of new light-duty vehicle (LDV) sales by 2050, such a fleet will result in an approximate 30% reduction of CO_2 emissions from LDVs globally. In another study by Axsen et al. (2011), researchers found if 1 million light-duty PEVs are deployed in California, PEVs will decrease LDV-related greenhouse gas (GHG) emissions by more than 33%. Such environmental benefits, combined with the increasing interest in energy independence, led elected officials to several PEV-related policy actions in California, where the transportation sector contributes the highest fraction of GHG emissions, 37% (ARB, 2014). These PEV-related policy actions included: providing financial incentives for PEV purchases and infrastructure (e.g. Assembly Bill 118, 2007); developing rules for utility companies to support PEV deployment on the grid (Senate Bill 626, 2009); and, eventually, targeting the deployment of 1.5 million ZEVs in the state by 2025 (Executive Order B16-2012).

Most of these policy efforts target the “PEV readiness” of the vehicle market and the grid infrastructure. A classification of major issues associated with PEV readiness is presented in Figure 1. Efforts toward market readiness have dealt with issues such as increasing consumer education, mitigating the high up-front cost of PEV ownership, and advancing PEV inventory. On the other hand, if not managed, large increases in PEV use may require additional electricity generation capacity, and overload distribution transformers, depending on the regional infrastructure. Therefore, efforts toward infrastructure readiness have emphasized deploying PEV chargers strategically, and integrating PEVs into the grid system by load management strategies such as dynamic pricing, demand response, and energy storage.

Since early 2009, energy-related state agencies in California started to look for appropriate technology and policy frameworks for VGI, considering the technical complexities of the highly regulated electricity sector. This study focuses on the policy developments in California related to PEV-grid integration or, in short, vehicle-grid integration (VGI). Focusing on the formation of the policy process between 2009 and 2014, this research addresses the questions of how the policy process has been initiated, who the participants are, and what are the challenges related to policy-making in the area of VGI. California has been chosen as the case study due to the state’s influential role and experience in promoting PEVs, and as the holder of one of the largest LDV markets in the world. The findings provide lessons for other states or regional governments who are considering similar policy actions related to VGI.

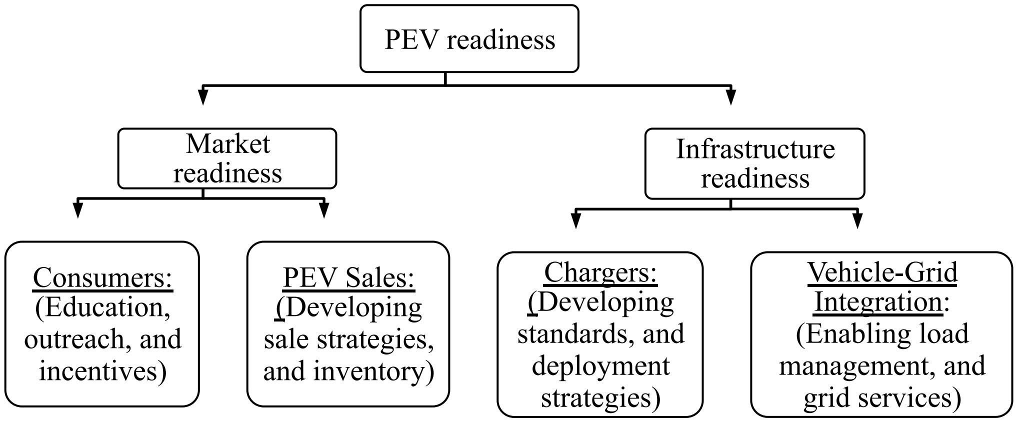

Figure 1. A classification of major topics under the PEV readiness

A theoretical framework, Multiple Streams (Kingdon, 1995) has been used in the analysis of the qualitative data from stakeholder interviews. Parallel to the focus of this study, the framework focuses on the agenda setting and policy formation *stages* rather than implementation and outcomes. It also provides relatively simple language—compared to other policy models/theories—that is accessible to researchers of interdisciplinary backgrounds. The stakeholder interviews were conducted between March 2013 and April 2014 and include representatives of 18 organizations from the government, electricity and PEV sectors. The stakeholders have addressed the questions on why their organizations have been participating in VGI efforts, whether they advocate a particular technology or policy framework, and their experiences with consumer engagement in VGI. Following the MS framework, the qualitative data from the interviews are categorized under so-called *problem, political and policy streams*. These three streams represent three independent processes, which transform a policy alternative into an actual policy.

The following section (Section 2) provides a critical background on the stakeholders who actively participated in regulatory process for VGI in California. Section 3 describes the methodology of gathering data from VGI stakeholder interviews, as well as the major MS framework concepts used in this research. The MS framework is applied in Section 4 to evaluate three major forces in the policy formation; problem, politics, and policy. Finally, Section 5 includes conclusions of the results under two topics. The first part is related to the conclusions on the use of the MS framework for this particular case. The second part features conclusions and lessons related to policy-making in the area of VGI.

2. REGULATORY ENVIRONMENT IN CALIFORNIA

The regulatory environment related to VGI includes a broad range of stakeholders as it impacts both the transportation and electricity sectors. These stakeholders include participants of the policy process from inside and outside of the government. The participants from inside the government include major energy planning and regulation agencies, the governor's office, and state legislatures who advocate the deployment of PEVs. Participants from outside the government include electric utility companies, automakers, PEV service providers, and research and advocacy groups. The following paragraphs provide a brief background on these stakeholders, particularly government agencies, and their interests in VGI.

In California, the State's electricity grid is largely operated by the California Independent System Operator (CAISO) and the Western Electricity Coordinating Council (WECC). WECC is responsible for the coordination of system operators at the higher, regional level, whereas CAISO's primary responsibilities are balancing electricity generation and consumption by operating wholesale electricity markets and programs, and managing high-level transmission congestion. This organization operates both the energy market and the ancillary services market, which are both relevant to VGI. Along with power generators, customers who can provide demand response and energy storage to the system are identified as *resources* and are compensated as much as they participate in the relevant market programs.

Ancillary grid services in CAISO include frequency regulation and reserve markets. An imbalance between demand and supply can create frequency fluctuations on the grid. The resources that can provide supply or demand based on the automated generation (AGC) signals from CAISO help to stabilize the grid frequency. This service is traditionally done by power stations that can operate fast enough and have the ability to operate their electric machines as both generator and motor. On the other hand, the resources that can generate electricity in a very short amount of time can be used to correct the error between forecast demand and actual supply. If managed, PEVs can be used in both demand response and energy storage resources, where they can provide frequency regulation or reserve services in a more economic way. These aspects of the PEVs made CAISO a very important and active stakeholder in VGI issues. Besides CAISO, there are several other balancing authorities in California, which make up about 20% of the system, including the two largest publicly-owned utilities (POUs) and some agricultural districts (CAISO, 2015).

POUs and investor-owned utilities (IOUs) are other important players in the electricity sector. In California, there are 35 publicly-owned utilities (POUs) operating to provide approximately 25% of the State's electricity (CMUA, 2003). The Los Angeles Department of Water and Power (LADWP) and the Sacramento Municipal Utility District (SMUD) are the largest POUs. On the other hand, the largest IOU is Pacific Gas and Electric (PG&E), which serves a population of approximately 15 million, mostly within Northern California (PG&E, 2015). The other IOUs are San Diego Gas and Electric (SDG&E), and Southern California Edison (SCE). Most of these large-scale utility companies are interested in PEVs, and operate PEV-related electric transportation departments that work on VGI issues. There have been different channels of communication where utility and automaker companies found opportunities to interact with each other. During the stakeholder interviews, these channels of communication were mentioned as CPUC's AFV proceeding workshops, VGI roadmap workshops, PEV Collaborative of California, and Electric Power Research Institute's infrastructure working council.

Figure 2 presents the major stakeholders and organizational interactions in California related to VGI. The participants are categorized into three layers: (1) policy/regulation, (2) whole electricity market/service, and (3) consumption. The policy and regulation layer includes policy-makers in the electricity and transportation sectors. These policy-makers have a complex relationship with the utilities, automakers and consumers. They can influence or impact the regulatory process in different ways. Among the electricity regulators, the California Public Utilities Commission (CPUC) is the primary regulatory agency for the IOUs. CPUC's main responsibly is protecting public interest against the private entities that manage public utilities such as water, electricity, and communication. This agency has the authority to introduce very detailed and narrow regulations on the utilities. These regulations are called CPUC proceedings or "order instituting rulemakings," which may include several phases and decisions. The CPUC proceedings may be related to CPUC's usual responsibilities such as electricity rate adjustments or to addressing the tasks given by legislative authorities. The VGI-related proceedings under alternative fueled vehicle (AFV) program are categorized as quasi-legislative proceedings by CPUC. These policy actions will be discussed in Section 4.3 in detail.

California Air Resources Board (ARB) and California Energy Commission (CEC) are other important actors in both the electricity and transportation sectors. CEC is the state's primary energy planning agency. Besides conducting energy research, CEC provides policy suggestions, regulates siting of power plants, and administers the State's research and development funding on alternative transportation technologies. On the other hand, ARB has a very broad jurisdiction over the organizations whose operations directly impact air quality and GHG. These organizations include automakers and power generators. ARB is currently not an active stakeholder in VGI process as the VGI-related goals initially target utility-level issues.

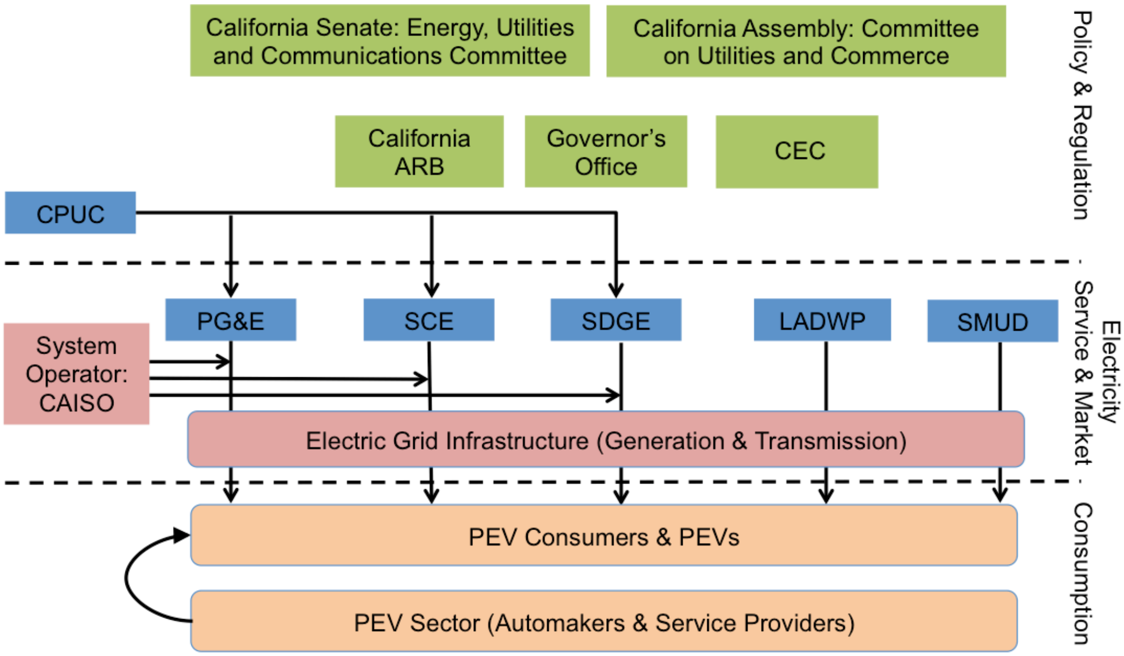

Figure 2. The illustration of the major organizational interactions for VGI in California

3. METHODOLOGY

3.1 Theoretical Framework: Multiple Streams

The Multiple Streams (MS) framework was proposed by American political scientist John Kingdon in 1995 to describe agenda setting and the formation of public policies involving participants from inside and outside the government (Kingdon, 1995). The main premise of this framework is that policy changes may occur when advantageous developments from so-called *problem, political and policy* streams converge into a "policy window." The MS framework suggests that decision makers sometimes fail to define their goals clearly and do not always set satisfactory levels of achievement for these goals. Rather, public policies are typically formed under conditions of ambiguity and semi-random developments (Zahariadis, 2007). Therefore, models of rational decision-making do not accurately describe the reality in public policies (Kingdon, 1995).

Within the MS Framework, the *problem stream* relates to how an issue becomes a concern that motivates policy makers to take action. Several mechanisms that bring problems to the attention of policy makers are presented, including indicators such as data driven reports and expert opinions, focusing events, and feedback channels through which policy makers follow outcomes of a current program (e.g. media). The *political stream* is composed of several elements such as national mood, public opinion, organized political forces, and judicial activities within the government. Lastly, the *policy stream* is conceptualized as a "primeval soup" in which ideas float around, confront one another, and in some cases, merge (Kingdon, 1995). In this stream, some ideas (or policy proposals) float to the top of the policy agenda and others fall to the bottom based on two major criteria; technical feasibility and value acceptability. In this competitive process, Kingdon (1995) discusses the role of policy communities and entrepreneurs. Policy entrepreneurs are the participants who are willing to invest resources in the hope of a future return.

When the problem, political, and policy streams join, they temporarily create advantageous opportunities for policymaking called *policy windows*. When a window opens, policy entrepreneurs sense their opportunity and try to attach their solutions to the problem. This attachment is known as *coupling* in the MS framework. In contrast to problem-solving models—in which people become aware of a problem and consider alternative solutions—the MS framework suggests that solutions *float around in and near government*, searching for problems with which to be coupled, or searching for political events that could increase their likelihood of adoption (Kingdon, 1995, pp172).

The MS framework has been used in several studies related to energy and environment. In addition to the use of the framework, some scientists have tested the theory for their specific cases and provided contributions. For instance, Storch and Winkel (2013) analyzed forestry policy developments in some regions of Germany drawing from the MS framework. The authors found that the concept of coupling in MS fits very well in the case of policy entrepreneurs in Germany who have already prepared solutions and wait for policy windows in order to attach their proposals. Collantes (2006) has adopted the MS framework to conduct an analysis of the origin of the ZEV mandate by ARB between 1990 and 2004. Based on the findings, the author suggests that the problem, political, and policy streams were largely *interdependent*, as opposed to being largely independent as the MS suggested. In the case of the ZEV mandate, elected officials and political appointees have been in close collaboration with state bureaucrats prior to opening a policy window. In another study, Brunner (2008) has adopted MS framework to analyze the policy formation of emissions trading in Germany. The author found that the influence of multi-level governance structures, learning processes, and networks are not sufficiently considered by the theory. This conclusion suggests that the researchers who use the MS framework should consider the additional evaluation of these issues, as they may have an impact on the policy formation and decision-making processes.

3.2 Data Gathering

The on-going policy developments in VGI show that policy-makers have been able to successfully create a channel of communication between utilities and automakers—two fields that were historically largely independent from one another. By conducting stakeholder interviews, the authors aimed to gain a deep understanding of the roles different organizations played in the formation stage of the policy process, and what major barriers exist toward achieving their individual goals. During the semi-structured interviews, stakeholders were asked questions related to four major topics; (1) the motivation of their organizations in participating or advocating VGI; (2) their preferences regarding technology and policy framework; (3) their relations with other stakeholders; (4) and lastly, their visions on consumer engagement. In addition to the use of qualitative data from stakeholders, the analysis is supported by VGI-related official documents published by the government agencies such as the Governor's Office, CPUC, and CAISO.

The PEV-grid stakeholder interviews were conducted between March 2013 and June 2014. The interview participants are representatives of various stakeholder organizations from the public policy, utility, and PEV sectors. The PEV sector consists of representatives from original equipment manufacturers (OEMs), and PEV supply equipment (EVSE) companies. The interview invitations were sent to a sample of 20 organizations that were active participants in the VGI roadmap workshops. As seen in Table-1, the participants included organizations from the five largest utilities in California, five policy makers, and eight companies from the PEV sector. Twelve of the

18 interviews were conducted in-person at the participants' workplaces. The rest of the interviews were conducted by phone. The participants are full-time employees who hold administrative or senior staff positions in a PEV-related department or working group.

Table 1. The stakeholders that participated in VGI stakeholder interviews

	STAKEHOLDER ORGANIZATION	DATE
1	CAISO	03.21.13
2	San Diego Gas & Electric (SDGE)	03.25.13
3	Southern California Edison (SCE)	03.25.13
4	Sacramento Municipality Utility District	04.03.13
5	ChargePoint	04.04.13
6	Pacific Gas and Electric (PG&E)	04.05.13
7	Nissan North America	04.08.13
8	AeroVironment	04.10.13
9	Ford	04.12.13
10	Los Angeles Department of Water and Power	04.18.13
11	ECOtality	04.25.13
12	California Public Utilities Commission	11.20.13
13	Electric Auto Association	12.10.13
14	Former Senator Christine Kehoe	12.20.13
15	GM/OnStar Alliance	01.08.14
16	California Energy Commission	04.24.14
17	California Governor's Office	04.30.14
18	BMW North America	06.11.14

The data used in this analysis has limitations in terms of covering a limited number of stakeholders in VGI. For instance, the spectrum of the participants extends to energy researchers, consultants, demand response companies, and some clean technology companies who are interested in developing innovative solutions in the area of VGI. Additionally, more automakers are becoming interested in PEV-grid issues as they have plans to deliver PEVs in the future. These stakeholders are not included in the survey because of the limited time of the researchers. Additionally, the analysis features qualitative data from stakeholders that represent expert opinions. These expert opinions are based on the interviewee's perceptions and limited knowledge. Therefore, the data may not necessarily represent a complete picture about the involvement of the stakeholder organizations in the policy process.

4. DISCUSSION: MULTIPLE STREAMS OF VGI

This section provides an analysis of the qualitative data gathered from stakeholder interviews and VGI-related official documents such as CPUC proceedings, the Governor's ZEV action plan, and VGI roadmap. The stakeholder interview data is categorized into the three-stream format as suggested by the MS. The problem stream addresses the question of which problem(s) are target for stakeholders, and how VGI came into their agenda. The political stream addresses the question of how elected officials were involved in the policy-process, and whether they sensed the public mood and interacted with organized political forces or pressure groups. Finally, policy stream introduces the actors in the policy community, actions by the policy entrepreneur, and addresses how the policy solutions were related to the problems. The analysis is solely based on the qualitative data from stakeholder interviews. This data represents interviewee's private opinions based on their experience within the relevant stakeholder organization.

4.1 Problem stream

The VGI stakeholders, especially policy-makers, highlighted several reasons that motivated them to engage with VGI. These reasons – or from the MS framework's problem-solving perspective, these *problems* – are categorized under three: (1) concerns over limited grid infrastructure, (2) growing need for ancillary grid services, and, lastly, (3) need for improving economics of PEV ownership. Although, different stakeholders prioritized and framed their motivations differently, these three issues have been highlighted frequently in both, stakeholder interviews and government documents such as CPUC whitepapers on AFVs. On the other hand, there have not been any focusing events such as large-scale grid failures related to PEV charging or other types of urgency that suddenly forced stakeholders' attention to this issue.

The first problem is the limited infrastructure to facilitate widespread adoption of PEVs. The impact of the PEV load on the grid infrastructure has been highlighted in two ways; overloading distribution transformers and increasing annual peak demand, (which typically happens in mid-July). Importantly, policy-makers were unanimous that the grid infrastructure is vulnerable to system failures when a large amount of load is added to the system or sudden changes occur in the load patterns. On the other hand, different utilities expressed different opinions about how much the PEV load will affect their systems. This issue appears to be highly dependent on the characteristics of the utilities' individual infrastructure and their generation mix. Specifically, two utilities, SMUD and SDGE, expressed upgrades in the distribution system would be necessary in the case of widespread PEV adoption. The SDGE representative reported that so far they have experienced one transformer failure in a commercial area where several PEVs were being charged at the same time. These PEVs were being operated under a car-sharing program. The SMUD representative mentioned that the residential areas with single-unit households are most likely to be impacted by PEVs if those PEVs are clustered in specific neighborhoods and charged with high-levels of power. This situation seems to be different in highly urban areas. The LADWP representative mentioned that multi-dwelling units in urban areas are less likely to be impacted as they receive power through transformers with larger capacity. PEVs in these areas are also more likely to use shared charging platforms, which can be easier managed by the utility.

According to the most recent PEV load impact analysis provided by the IOUs (CPUC, 2014), the total cumulative PEV ownership in the IOU region is estimated at 97,350 PEVs, an increase of 56,150 PEVs from 2013. For such increase, the total cost for PEV-related infrastructure upgrades in 2014 was reported as $1,771,686. This cost only includes distribution system equipment upgrades such as neighborhood transformers and secondary line conductors and connectors. The CPUC representative mentioned that this amount is not a significant cost considering IOUs' operation budget. Nevertheless, it is very difficult to predict the future impact considering widespread PEV adoption scenarios. Estimating future impacts of the PEV load requires a highly stochastic assessment of future PEV locations, PEV owners' charging behavior, and energy needs. At this early stage of the market, all of the utility representatives agreed that notification of PEV ownership by their customers is highly important for tracking the PEV load that will be added on their distribution system.

The VGI's prospects for grid services were mentioned as the second-most important motivation behind the VGI activities. The CAISO representative mentioned that PEV-based grid services fit perfectly into California's vision of the future grid with, "*a lot of distributed resources and renewables (interview).*" Such potential makes some stakeholders very optimistic about the future of VGI. Especially private entities have a growing interest in being the major service provider for VGI through providing communication or load management services for grid operators. As the representative from ChargePoint, the largest PEV charging network operator, asserted, "*charging car[s] should be free, because the benefit to the grid is higher than the cost of it (interview)."* The interviewee added, "we think that *EV-based demand response is going to be a big business in the future (interview).*" In this regard, the issue of PEV and residential photovoltaics (PVs) integration also earns attention from utility companies. Some utilities mentioned that the electricity generated by residential PVs can create technical difficulties on the distribution system such as voltage sags and so-called *backfeeding* problems (interview). Therefore, consumers can also value managed charging, "*to get the best out of their solar panels (interview*)," if they have PVs on their roof.

Finally, the need to improve the economics of PEV ownership is mentioned as another challenge where VGI can provide solutions. This need became more significant after the Governor's Brown ZEV initiative in 2012. Based on the IOU estimates, Figure 3 represents the existing cumulative PEV adoptions between 2012 and 2014, and IOU estimations up to 2022 (CPUC, 2014). Achieving PEV deployment goals requires very high consumer adoption rates. Although, this aspect of VGI was not discussed by the majority of the stakeholders, policy-makers envision VGI as an innovative way to improve the economics of PEV ownership. For instance, participant from Governor's Office stated that "*if we can figure that out and understand what the benefits are, and tie them back to the consumer, this will also help to drive PEV adoption -- it creates another value stream to incentivize EV ownership (interview).*" In this regard, policy-makers envision that monetary returns from VGI can overcome barriers related to the high upfront cost of PEV ownership, even at the stages of market launch. In contrast to the previously mentioned issues, which are long-term target areas, the vision to create additional value for consumers falls under near-term target areas.

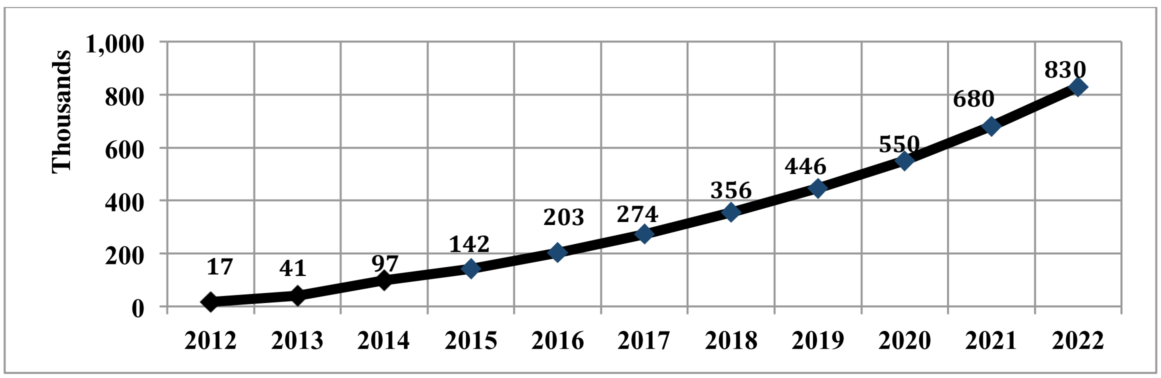

Figure 3. Actual (2012-2014) and estimated numbers of PEVs in the IOU regions of California (data is gathered from CPUC (2014).

4.2 Political stream

In the MS framework, the political stream entails involvement of politicians, and some important developments related to changes in public mood, pressure group campaigns, ideological distributions in congress, and administration. In the case of VGI, the impact of public mood and partisan politics was very low, and has not been an important factor that shaped the policy process. On the other hand, legislative actions have played a very important role. The policy window for VGI regulations was opened largely by two major legislative actions, i.e. Senate Bill 626 and Governor Brown's ZEV initiative. These legislations did not include any technical solutions. They rather set the agenda on VGI for energy-related regulatory agencies in California. Specifically, SB626 gave CPUC the authority to implement regulations on enabling PEV load management systems and PEV-based grid services. The following analysis describes the limited but critical involvement of political actors in VGI.

The first utility-oriented PEV policy initiatives in the legislation began in the State Senate with Senate Bill 626 (Kehoe, 2009). The bill was introduced by former San Diego Senator Christine Kehoe to the senate in February 2009, and was supported by the majority of both the senate and assembly members (supported 85% in senate and 77% in assembly). SB626 directed CPUC to adopt policies *to develop infrastructure sufficient to overcome any barriers to the widespread deployment PEVs* (Kehoe, 2009). In stakeholder interviews, Kehoe described her general interest in PEVs and the electricity sector as being members of various energy and environment-related committees in the senate. She stated that she wanted to, "*keep pushing electric cars,*" and, she thinks, "*it is a great idea for California (interview)."* According to Kehoe, SB626 was not controversial enough to receive coverage by national and local media. She also did not face any serious opposition from other elected officials. She claims:

> *"I don't remember a single conversation with another senator who told me they will vote 'no'…[in] some cases, some politicians think climate change is not a serious threat, others say that if it is a serious threat, the market should come up with solutions…But we didn't have any formal opposition on this bill. Utilities didn't say, 'We cannot manage this bill'* (interview)*."*

In detail, SB626 directed CPUC to adopt rules and perform some important assessments to address several issues such as: (1) the electrical infrastructure upgrades necessary for widespread use of PEVs, (2) the impact of PEVs on grid stability and the integration of renewable energy resources, and (3) the impact of widespread use of PEVs on achieving the State's GHG emission reduction goals and renewables portfolio standard program. This bill is supported by CPUC, some PEV advocate groups, and also some major PEV manufacturers such as Nissan, Toyota, and Tesla. In response to SB626, CPUC reactivated its Alternative Fuel Vehicle (AFV) proceedings, which were originally founded to support ARB's zero emission vehicle (ZEV) mandate policy in the early 1990s. CPUC's policy actions to address SB626 will be discussed in the following section.

In March 2012, there was another development in the political stream that supported the policy window opened by SB626. California Governor, Jerry Brown, introduced the goal to deploy 1.5million ZEVs as an executive order (Executive Order B16-2012). This legislation set several milestones toward the deployment of 1.5 million ZEVs in California by the year 2025 (GOV, 2012a). These milestones in the executive order include the order that "electric vehicle charging will be integrated into the electricity grid." Following the executive order, specialists in the Governor's Office prepared an action plan that required CEC, CPUC, and CAISO's collaboration to develop a VGI roadmap plan for California (GOV, 2012b). These state agencies formed a policy community called *VGI working group* (interview). The VGI working group organized three stakeholder workshops between October 2012 and October 2013. Collaborating with these workshops, CAISO released a VGI roadmap in December 2013. This roadmap suggested policy-makers focus on developing solutions under three inter-dependent tracks; (1) determining VGI value, (2) developing enabling policy, and (3) supporting enabling technology (CAISO, 2013). From SB626 to the VGI roadmap, Table-2 presents a summary of the VGI related policy and market developments in California between 2009 and 2013. Although, the term of *VGI* has not been used in government papers until 2013, the CPUC's AFV regulations from 2010 and 2011 were the first policy actions to address VGI.

Table-2. VGI related policy and market developments

Policy and Market Developments	**Organization**	**Date**
California Senate Bill 626 is introduced	CA Senate	October, 2009
Alternative Fuel Vehicle Proceedings on VGI started	CPUC	August, 2010
First wave PEVs arrived: Chevy Volt and Nissan Leaf sales began	GM and Nissan	December, 2010
Governor Brown's ZEV initiative is announced	Governor's Office	March, 2012
ZEV Action Plan is released	Governor's Office	September, 2012
VGI Roadmap workshops started	Vehicle-Grid Working Group	October, 2012
Vehicle-Grid Integration Roadmap is released	CAISO	December, 2013

4.3 Policy stream

The policy stream represents the stage where elected officials leave problem-solving in the hands of specialists. In this stage, career bureaucrats and specialists have a highly influential role and they often work as a community, called the *policy community* in MS. Here, alternatives are being developed, and solutions are being presented to the decision-makers by the so-called *policy entrepreneurs*.

In CPUC, regulations are usually proposed by specific divisions based on their areas of expertise, then presented to a CPUC commissioner who leads the commission on that particular topic. In the case of VGI, the Energy Division Staff at CPUC has been the policy entrepreneur by preparing the CPUC's policy proposals on VGI. During this process, CPUC collaborated with other state agencies such as CEC and CAISO. In this analysis, this collaborative group of bureaucrats is represented as a policy community specializing in VGI.

The major developments and issues discussed in Section 4 are summarized in the following figure (Figure 4). This analytical representation provides a basic scheme, solely based on the concepts from MS framework. On the other hand, it does not represent possible complex relationships between problem, politics, and policy streams. In Figure-4, the policy solution, R.09-08-009, refers to the first rulemaking in the area of VGI, which is introduced by CPUC in August 2010. This rulemaking described major issues that needs to be addressed by CPUC but did not release the final regulations (decision D11-07-029) until July 2011. The content of D11-07-029 will be discussed in the following paragraphs.

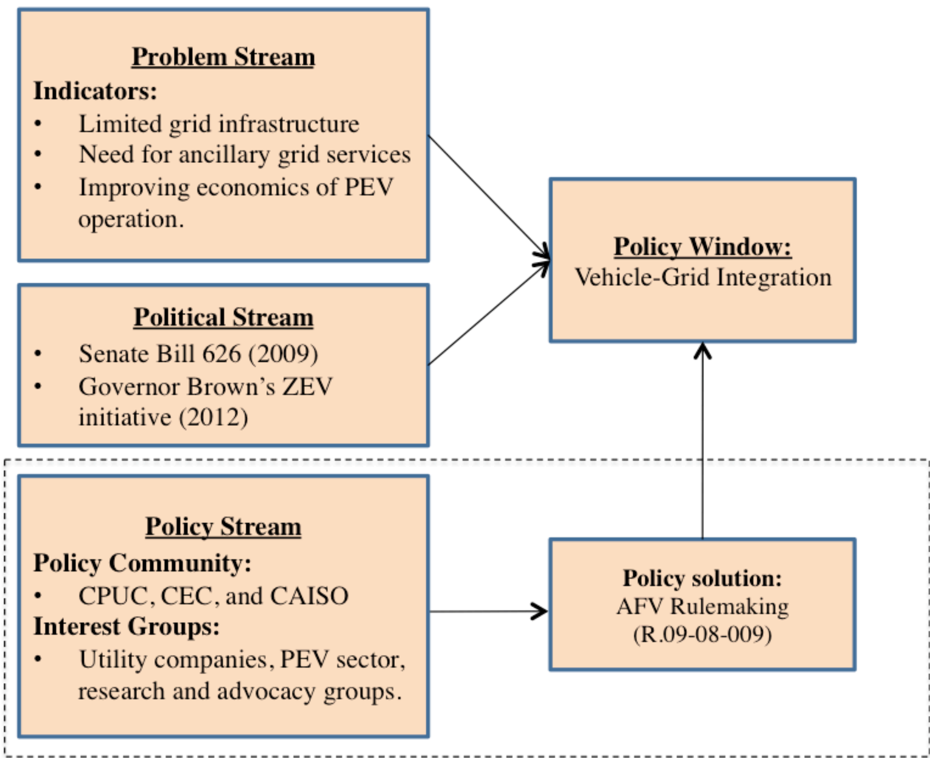

Figure 4. Conceptual representation of MS framework applied to VGI.

When it was introduced in 2009, SB626 provided a framework for how CPUC should develop PEV-related utility regulations. CPUC has been directed to collaborate with CEC, ARB, air quality management districts, utility and OEMs *to evaluate and implement policies to promote the development of equipment and infrastructure for the use of low-emission vehicles* (SB626, 2009). According to the MS, policy entrepreneurs sense when a policy window will be opened and start developing their ideas prior to the windows of opportunities. Consistent with this premise, the issue of VGI had been on the CPUC's agenda prior to arrival of SB626. The Commission started a proceeding on this topic about two months before the governor signed SB626 in October 2009.

In response to SB626, CPUC initiated the first rulemaking on VGI in August 2010, which resulted in VGI regulations (decision D11-07-029). The content of this decision was prepared by the Energy Division Staff of CPUC collaborating through six stakeholder workshops organized between September 2010 and February 2011. Besides the IOUs, there were some organizations that actively participated in the rulemaking discussions. These organizations included SMUD, GM, EVSP Coalition, and some environmental research and advocacy groups such as Natural Resources Defense Council, Green Power Institute, Environmental Coalition, and Clean Energy. Through this decision, regulators introduced specific rules as well as some general expectations of CPUC from the IOUs regarding several important VGI issues. The content of D.11-07-029 introduced PEV rate design principles and enforced research on the growing PEV load, tracking infrastructure upgrade costs associated with PEVs, and developing innovative PEV metering and load management strategies. Table 3 presents the content of D.11-07-029 as it relates to VGI. In the following paragraphs, the major target areas of these policy actions and their effectiveness on addressing the problems will be evaluated.

Table 3. Content of the VGI regulations under alternative-fueled vehicle proceedings by CPUC

Decision D.11-07-029 Content	Major Goals
Utility Notifications	Developing utility notification systems related to the location of new PEV purchases (mostly through automakers and dealerships).
Load Research and Cost Tracking	Tracking growing PEV load on the grid, and infrastructure maintenance and upgrade costs associated with this PEV charging.
PEV Metering	Identifying PEV metering options, and developing a sub metering protocol for metering PEV load through non-utility devices.
DR and Load Management	Developing innovative load management strategies, and demonstrating new technologies in small-scale projects.
PEV Rate Design principles	Introducing special rates for different PEV metering configurations to keep PEV operation competitive to the conventional LDVs.
Utility Cost Recovery	Sharing PEV-related utility cost of infrastructure upgrades to all rate payers
Consumer Education & Outreach	Educating consumers on cost effective PEV charging, and potential uses of PEV battery in grid services.

One of the major goals that VGI regulation targeted is enforcing VGI-related research and demonstrations to the IOUs. Each technology option for VGI may bring several risks to the utility-level grid operations. For instance, using a separate electricity meter for PEVs through the PEV supply equipment risks liability issues regarding customer billing.

Enabling PEV-grid communication risks data security, and lastly, bidirectional power flow brings technical difficulties on the distribution system. Most importantly, failures in the management of these technologies may damage consumer satisfaction on both PEV ownership and the utility service. Therefore, most of the stakeholders agree that introducing such a new technology to the grid system can be difficult, especially if the stakeholders do not know what the actual economic value from that technology will be. In this regard, utilities may not be willing to directly engage with VGI. This concern has been mentioned by the CPUC representative through the following statement;

> *"*[In VGI] *their* [the utilities'] *first reaction is going to be skeptical, because their first reaction is going to be, 'Reliability is our number-one concern. We are willing to do new things, but we will not risk our grid reliability. What you are saying has some potential risks over reliability. We are nervous about that, we first need to do a lot of testing' (interview)."*

A similar opinion is expressed by the CEC representative, "*utilities are not known for innovation. They are known for consistency and lack of change... because they need to deal with the consequences (interview)."* To overcome this problem, CPUC introduced several regulations that enforce IOUs to conduct VGI research and development activities such as providing an annual research report on the PEV load in their territories and conducting demonstration and pilot projects on DSM and PEV metering. These research and development activities help CPUC to circumvent information asymmetry between utilities and policy makers so that policy makers can understand how the growing PEV load on the grid impacts the distribution system, can consider potential solutions for each utility region, and can ascertain the potential economic value from PEV-based grid services. The results and reports from VGI demonstration and pilot projects by the IOUs create a feedback channel for CPUC to continue their incremental policy-making with a better understanding of the technical feasibility and economic value of VGI.

Additionally, VGI regulation targeted to provide financial protection and educational support for PEV consumers. D.11-07-029 enforced utilities to provide consumer education and outreach about PEV charging. The same regulation also provided financial protection to PEV buyers from high electricity rates and the cost of upgrading distribution infrastructure due to PEV load. The cost of infrastructure upgrades by the utility will be accepted as a shared cost to all ratepayers until the end of 2016.

Overall, CPUC's regulations emphasized research, and created an environment where stakeholders try new solutions through demonstration and pilot projects. However, the rules brought by D.11-07-029 did not effectively address all of the SB626 objectives. For instance, the key concerns, such as how a growing PEV load on the grid should be managed and what kind of technologies should be used, are not addressed completely.

Considering the early phase of the PEV market and smart grid applications, the agency adopted an incremental policy-making strategy on VGI. Several issues are being carried over into the upcoming AFV proceedings.

During the regulatory process, the agency has faced two major barriers in policy-making; (1) the complexities involved in quantifying economic value from VGI; and (2) the feasibility concerns about adopting VGI enabling technologies on the grid. Feasibility concerns exist because adopting a new metering or communication technology in the grid system requires high reliability standards. On the other hand, these enabling technologies including PEV metering, PEV-grid communications, and bidirectional PEV chargers are still being evaluated by the automakers and electricity industry.

Secondly, the difficulties to quantify economic value from VGI are mentioned by several policy-makers. The economic assessment of a particular VGI solution requires high amounts of data from a regional grid system and deals with uncertainties related to future conditions of the PEV and electricity markets and PEV consumer behavior. Due to these complexities, stakeholders, especially policy-makers, are having difficulty understanding the economic value of VGI. Consequently, investing resources for policy-making becomes difficult. For instance, the interviewee from CPUC stated, "*we have to do a lot more research on that (to determine economic value)… I don't know how we can create policies in this space without understanding what the value is* (interview)." Additionally, the participant from the Governor's Office highlighted the importance of quantifying the value of VGI for different stakeholders including consumers: "*if you talk to stakeholders, some folks are interested what the value is…If I am an EV buyer, what do I get out of it as a customer? This question can be understood in 2-3 years (interview)*."

5. CONCLUSIONS

5.1 Conclusions on the use of MS

The framework provided a systematic approach on investigating the policy process for VGI in California. It has been observed that the three streams of policy formation exist in this state-level energy policy issue. Additionally, the framework's emphasis on agenda setting and policy formation can provide important insights for other government organizations that are interested in initiating similar policies. However, there were also some disadvantages of using the MS framework. Some premises of the framework did not fit within the case study, as some aspects of the policy-making have not been captured in the model.

Most importantly, MS framework's description of the "coupling" process did not accurately capture the policy-making in VGI. MS assumes that solutions *float around in and near government*, searching for problems to which to be coupled (Kingdon, 1995, pp172). Such generalization in decision-making may suit sudden policy changes but may not be applied to cases in which policies target long-term energy planning issues. In these cases, the solutions may not be instantaneously available because of the technical complexities or unknown market conditions. Regarding VGI regulations, CPUC specialists did not give a prompt response when the policy window was opened by SB626 in October 2009. The first set of decisions was introduced in July 2011, after the agency's involvement with stakeholder workshops to understand the technical and economic complexities from different perspectives. As observed in the case of VGI, the incremental aspect of policy-making in energy and environmental issues may be very significant.

As suggested by Gormley (1986), dynamics of the policy process may be different based on the so-called *issue areas*. The regulatory politics may vary systematically based on two main characteristics of an issue: public salience (or public attention) and the technical complexity. Following this premise, the MS framework can be expanded in a way that the narrative includes two cases of policy formation where the policy solution is ready, or not ready. As the MS framework only assumes instantaneous availability of the solutions, it does not provide a space for discussions of technical or market challenges on addressing a problem where a final solution is not ready. Such technical challenges can be related to several issues such as; (1) information asymmetry between the stakeholders, (2) technology constraints, or (3) past regulations that create limitations and need to be changed. Future steps of this study will investigate these aspects of the policy process to provide potential contributions regarding policy-making in energy-related sectors.

5.2 Policy-Making in the Area of VGI

Concerns over the limited grid infrastructure, growing needs for ancillary grid services, and improving the economics of PEV ownership led elected officials to take policy actions in the area of VGI. A policy window was opened for the first time through SB626 in 2009, and later, supported by the Governor's ZEV action plan in 2012. These developments brought VGI into the agenda of a policy community that works on electricity and transportation-related energy planning issues. Empirical findings show that the Energy Division Staff in CPUC has been a policy entrepreneur among the participants of the policy process by introducing VGI-related regulations for the IOUs.

Considering technical barriers, the agency initiated an incremental policy-making strategy, in which policies aim to address the three major problems previously mentioned in 5.1. CPUC's VGI regulations emphasized research, created an environment where stakeholders can discuss and try new solutions, and identified major issues that stakeholders should consider in the long-term. However, the rules brought by D.11-07-029 did not effectively address all of the SB626 objectives. Several important issues have been carried over into the upcoming AFV proceedings. The empirical evidence suggests that two largest barriers facing an effective policy solution have been (1) the complexities involved in quantifying economic value from VGI; and (2) the feasibility concerns about adopting VGI enabling technologies on the grid.

The findings from this analysis may have implications in policy-making. First, the results show that policy-makers should focus on developing methodologies to quantify economic value from VGI solutions, perhaps, *before* investing resources into demonstration and pilot projects. Such methodologies should consider regional characteristics of the grid operations, and uncertainties in the LDV and electricity markets. Each utility's region should be evaluated individually, considering unique characteristics of infrastructure, grid operations, and consumer profiles. Later on, policy-makers can integrate these individual assessments to evaluate VGI from a bottom-up approach to see the State-level impacts.

Secondly, stakeholders are currently in the phase of evaluating feasibility of various load management technologies from different perspectives such as data privacy, billing liability, and impacts on battery life. These evaluations are mostly being done through demonstration projects managed by the utility companies. However, the existing model where utilities propose and manage these demonstration projects may not be an effective solution. As mentioned by several stakeholders, utilities currently do not have any significant incentive to develop innovative and cost-effective solutions for VGI. On the other hand, utilities, being risk-averse organizations, may diminish the potential benefits in their VGI assessments. This situation may result in the inefficient use of funding resources and, even, block the progress toward innovative strategies toward VGI. Alternatively, these VGI-related assessments can be performed by the third party research organizations closely collaborating with the utilities on issues such as data gathering, hardware installations and communicating with PEV consumers when necessary.

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REFERENCES

Axsen, J., Kurani, K. S., McCarthy, R., & Yang, C. (2011). "Plug-in hybrid vehicle GHG impacts in California: Integrating consumer-informed recharge profiles with an electricity-dispatch model," *Energy Policy*, vol. 39(3), pp. 1617-1629.

Baumhefner, M., Mui, S., & Huang, R. (2011, May). "The importance of model utility policies for vehicle electrification," Paper presented at Electric Vehicle Symposium 26, Los Angeles, CA.

Brunner, S. (2008). "Understanding policy change: Multiple streams and emissions trading in Germany," *Global Environmental Change*, vol. 18(3), pp. 501-507.

CPUC (2009). Cal. Pub. Util. Code § R09-08-009. California Public Utilities Commission.

CPUC (2011). Cal. Pub. Util. Code § D11-07-029 (2011). California Public Utilities Commission.

CPUC (2013). Cal. Pub. Util. Code § R13-11-007 (2013). California Public Utilities Commission.

CPUC (2014). "Load research report compliance filing of San Diego Gas & Electric Company (u 902-m)," by the California Public Utilities Commission.

CARB (2014). "California greenhouse gas emission inventory: 2000-2012," by the California Air Resources Board.

CAISO (2013). "California vehicle-grid integration (VGI) roadmap: Enabling vehicle-based grid services," by the California Independent System Operator. Retrieved from http://www.caiso.com/Documents/Vehicle-GridIntegrationRoadmap.pdf

CAISO (2015, Jan). California Independent System Operator: Company Profile. Retrieved from http://www.caiso.com/about/Pages/OurBusiness/Default.aspx

Collantes, G. O. (2006). *The California Zero-Emission Vehicle Mandate: A Study of the Policy Process, 1990-2004.* Doctoral dissertation. University of California, Davis, CA.

Gormley, W. (1986). "Regulatory issue networks in a federal system," *Polity*, vol. 18(4), pp. 595-620.

GOV (2012). Executive Order B16-2012. California Office of Governor. Retrieved from http://gov.ca.gov/news.php?id=17472

GOV (2013). “Zero-Emission Vehicle Action Plan,” by the California Office of Governor. Retrieved from http://opr.ca.gov/docs/Governor%27s_Office_ZEV_Action_Plan_%2802-13%29.pdf

Kingdon, J. W. (1995). *Agendas, Alternatives and Public Policies* (2nd edition). New York, NY: Longman.

Kehoe (2009). An act to add Section 740.2 to the Public Utilities Code, relating to electrical infrastructure, Senate Bill 626. California State Senate.

PG&E (2014). Pacific Gas and Electric: Company Profile. Retrieved from http://www.pge.com/en/about/company/profile/index.page?

CMUA (2003). Publicly owned electric utilities: What makes as different? [Pamphlet]. California Municipal Utilities Association.

Storch, S., & Winkel, G. (2013). “Coupling climate change and forest policy: A multiple streams analysis of two German case studies,” *Forest Policy and Economics*, vol. 36, pp. 14-26.

IEA (2011). “Technology roadmap: Electric and plug-in hybrid electric vehicles,” by the International Energy Agency, Paris, France.

Zahariadis, N. (2007). “The multiple streams framework: Structure, limitations, prospects,” in Sabatier, P. A. (2007). *Theories of the Policy Process* (2nd ed.). Boulder, CO: Westview.