STATE ROUNDTABLE ON ELECTRIC VEHICLE INFRASTRUCTURE

Proceedings from a convening in San Francisco, California on September 18, 2018

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ATLAS PUBLIC POLICY
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In September 2018, Audi revealed its first all-electric vehicle (EV), a midsize crossover utility vehicle with a manufacturer-estimated range over 200 miles. In conjunction with this launch event, Audi sponsored the State Roundtable on Electric Vehicle Infrastructure in collaboration with Atlas Public Policy and the Alliance for Transportation Electrification. The goal of the roundtable was to raise awareness about emerging issues related to EV charging infrastructure and identify actions necessary to prepare the consumer market for mainstream acceptance of EVs in the context of a changing EV market with faster charging and longer range all-electric vehicles. The Roundtable brought together officials from state utility commissions and energy and/or environmental agencies, electric utilities, non-governmental organizations, and charging service providers. Participants are active in transportation electrification policy and practice and brought their unique perspectives from both their professional positions and respective regions of the United States.

CONVENING SUMMARY

The State Roundtable on Electric Vehicle Infrastructure was held in San Francisco, California on September 18, 2018. There were 33 participants, including two facilitators from Atlas Public Policy. The first session was a plenary that provided background context on the emerging issues with EV charging infrastructure.

The plenary session was followed by two breakout group sessions where case studies specially designed for the Roundtable were evaluated by participants. The case studies asked the participants to step into the shoes of decision makers at an automaker and a charging service provider. The sessions were conducted in a classroom-like setting, with the facilitators leading the groups through the case study challenge and discussion questions. Although the case studies were structured narrowly, the resulting discussion applied broadly and helped participants think through existing challenges and opportunities with EV charging. The two case study topics—DC fast charging and vehicle-grid integration (VGI) —are critical areas for the long-term growth of the EV market. The Roundtable concluded with a summary session where participants heard and discussed perspectives from several state officials on EV charging infrastructure investments and reflected on the takeaways from the day.

FIGURE 1: PARTICIPANTS DISCUSS EMERGING ISSUES DURING THE ROUNDTABLE DISCUSSIONS

Photo Credit: Atlas Public Policy

KEY FINDINGS

Key findings from each session are summarized here and discussed in depth below:

Plenary Session	Significant barriers to EV adoption remain, which participants grouped into three main topics: awareness, access, and affordability and discussed potential solutions to the associated challenges particularly around outreach and education.
	Electricity rate design is a major topic of interest for all parties involved in terms of supporting the electrical grid and controlling costs to EV owners.
DC Fast Charging Session	The business case for DC fast charging remains a significant challenge which could be improved by anchor tenancy (e.g., fleet or ride-hail service).
	Working with a utility to understand the interconnection needs at potential sites early in the siting process can lead to lower cost, faster charging infrastructure deployments.
Vehicle-Grid Integration Session	Grid-to-vehicle (G2V) services are highly valuable to the grid; though, markets for vehicle-to-building (V2B) and vehicle-to-grid (V2G) services have not yet developed.
	A forum is required for automakers, charging providers, utilities, and regulators to debate and harmonize VGI communications and cybersecurity protocols.
Closing Session	Utility Commissions have an important role to play in examining EV-linked electricity demand growth, EV impacts to distribution grids, the challenges and opportunities linked with low-carbon energy and EVs, utility EV rate structures, and utility EV consumer education programs.
	Strategic collaboration between utilities, utility commissions, automakers, and advocacy groups is necessary to optimize and accelerate the EV transition. Specifically, automakers need to increase their engagement and build in-house expertise in the electricity generation and distribution space.

CONVENING PROCEEDINGS

The roundtable event consisted of four major sessions: an opening plenary, breakout groups on the DC fast charging case study and vehicle-grid integration case study, and a closing discussion. The following sections summarize the notable discussion points and findings from each session.

OPENING PLENARY

The opening session featured a panel and group discussion on the emerging issues with EV charging infrastructure. The conversation helped participants understand the depth of EV expertise in the room and also informed later discussions in the breakout groups. Participants grouped significant barriers to EV adoption along with potential solutions into three main topics.

- Awareness
    - The general public does not know about vehicle options and availability, EV charging equipment types and requirements, and the potential for a total cost of ownership benefit of an EV compared to a gasoline vehicle.
    - Utilities are considering investments in EV education and outreach. Utility commissions will be asked to decide if the costs for these types of programs can be recovered.
    - Auto dealerships have an important role to play in EV awareness and access and should play a key role in overcoming some of these adoption barriers. Automakers need to prepare their dealerships so that they are informed and motivated to serve in this role.
- Access
    - The general public doesn't know where EV charging infrastructure is located and where and what EVs are available. Marketing and education efforts, like those funded by charging companies and coalitions, are helping to build excitement and knowledge of EVs and EV charging basics.
    - With a growing EV market, including more and different types of EV models, many new EVs will need DC fast charging (as opposed to slower Level 1 or Level 2 charging).
- Affordability
    - There is a general lack of knowledge about the affordability of EVs when compared to gasoline-powered vehicles on a total cost of ownership basis.
    - Grid-optimized EV charging can improve system utilization and lower costs for all electricity customers, but these conditions will not develop without utilities incenting customers to charge during periods where low-cost generation is readily available.
    - Efforts are underway to determine if battery storage can help improve the business case for public charging stations by reducing demand charges.
    - Utility rate structures will play an important role in how EVs are managed on the grid and how much EV owners pay for charging their vehicles.
        - Convenience, cost, and grid friendliness are important considerations for rate structure design.
        - Harmonized communication protocols are required to transmit price signals and grid conditions between the grid, charging equipment, and EVs.
        - People who have an EV won't want to think about when is best to charge, they just want it to work. There should be a simple way for them to take advantage of the beneficial EV rates.
        - From a utility perspective, pilot programs are one way to try these rates. This offers an opportunity to see if consumers will charge at the times that have attractive rates. Utilities can get a sense of whether price signals drive behaviors.
        - Regulators have an important role to play when reviewing utility EV programs.
        - With technology changing in multiple sectors, managing EV charging may also go beyond the vehicle and charging station and involve technologies that manage other assets at home (e.g., Google Home and Amazon Alexa).

DC FAST CHARGING CASE STUDY

After reading the DC fast charging case study, participants were first asked to step into a role at a third-party EV infrastructure company and decide how they should invest funds on a DC fast charging project along the highway or in an urban setting. The case study contained some business case components, so participants could do a little math to figure out what the hypothetical company could afford. They were also asked to think about the value of partnerships, which were quantified within the case study. There are five possible scenarios for DC fast charging investment that include combinations of station location types, partnerships, and other investments (add-ons), which are summarized in Table 1.

TABLE 1: POTENTIAL CASE STUDY DC FAST CHARGING INVESTMENT SCENARIOS

	1	2	3	4	5
Location	Highway	Highway	Urban	Urban	Urban
Partnership	None	Utility	None	Utility	Ride-Hail
Add-on Investment	Siting Analysis	Marketing	Siting Analysis	Marketing	Siting Analysis
Utilization Increase	10%	12%	10%	12%	30%
Profitability*	- -	- -	-	-	+

**Positive profitability is indicated by a "+" and negative profitability are indicated by a "-" or "- -" when station is even less likely to be profitable.*

Participants immediately recognized that the business case for a public DC fast charging station, as presented in the study, is challenging regardless of partnerships and the location of the station. This mirrors current realities where the business case for highway locations in the United States are especially difficult to achieve profitability due to observed lower utilization of those stations. According to the table, an urban station also does not achieve profitability when there is just a utility partnership or no partnership at all. The only scenario with the potential for profitability is an urban station with a ride-hail partner, as this partnership provides a large (30 percent) increase in utilization. Although the scenarios are developed for this specific case study, they led to deeper discussions on fast charging development. Participants spent most of the time discussing the pros and cons of the potential partnerships, as described in the section below.

DISCUSSION ON PARTNERSHIPS

Participants immediately identified the benefits of engaging in partnership under the confines of the case study, but also wanted to stretch beyond the case study boundaries. The main discussion points are summarized below.

NO PARTNERSHIP

- The benefit of no partnership is that the company would maintain full control of the station.
- The downside is that the company would miss out on all the benefits of a partnership, like potentially improving utilization.

- This seemed like the least likely option, as at a minimum, the charging infrastructure company would want to work with the regional utility. Although that engagement may not result in a partnership as specifically described in the case study, the participants were firm in their belief that working with the utility would only help with the deployment of new charging infrastructure.

UTILITY

- Although the utility partnership was described as an either-or option, participants felt that it was critically important to work with a utility on any charging station even in combination with the ride-hail partnership.
- The benefits of partnering with or involving the utility during the station development are clear: they can provide a more efficient deployment, with faster interconnection, and built-in future-proofing.
- Participants felt that utilities would also want to minimize the cost of implementation and choose a site with high utilization – some details they found to be missing in the case study. This implies that there might not be as big a downside to the utility partnership as portrayed in the case study.
- The potential downside of partnering with the utility was giving up some control and short-term profitability (since you would not be partnering with a ride-hail company per the constraints on the case study).

RIDE-HAIL

- The benefit of an anchor tenant is clear. Participants were quick to identify the large bump in utilization from the ride-hail partner with little upfront cost to the charging company.
- Participants saw the ride-hail partner as a certain stream of revenue that could be helpful to the bottom line, especially in the short-term. The arrangement could perhaps provide revenue in the short-term to help fund additional investments in the long-term.
- This partnership was seen as a potential way to build up the brand of the charging infrastructure company; a boost that could help with long-term development.
- The prospect of an anchor tenant outside of ride-hailing, like a medium- or heavy-duty fleet was also discussed as a potentially successful model.
- The downside of the partnership was thought to include the uncertainty in the long-term trend and use of the charging station.

Overarching the discussion on partnerships was the need for rate design to ensure fair and sustainable electricity prices for the charging infrastructure providers and of course for the customer who could absorb those costs. Of particular interest was managing demand charges, which could be done by looking into onsite storage. Additionally, participants saw a role for the public sector with state support, which was not directly addressed in the case study.

VGI CASE STUDY

After reading the case study, participants were first asked to step into the role of an automaker and decide what VGI modes they would support on a future EV offering. In general, participants noted that G2V modes could support demand response services and encourage off-peak charging, are highly valuable to the grid, and that models already exist to encourage vehicle owners to provide these services. They noted that appropriate rate structures are critical to induce consumer G2V participation.

For modes with bi-directional flows—V2B and V2G—participants noted that markets have not developed yet for the services associated with these modes and that supporting these services could be costly to develop for automakers. For these markets to develop, more work is required including determining appropriate compensation for these services, addressing a host of communications and cyber security issues associated with services, educating dealers on how they should market these features, and developing technologies to reduce the impacts that bi-directional flows of electricity could have on vehicle batteries.

Participants also noted that they believe that consumers want to 'set it and forget it' when it comes to their vehicles participating in grid services, and that too much information and required decision making could be debilitating for average car owners. Participants noted that more complicated ancillary services markets could be better suited for medium and heavy-duty vehicles, where there are fewer actors and bigger batteries. Participants also debated several discussion questions in the case study. The questions are listed below and annotated with the ideas discussed by the group.

AS AN AUTOMAKER, WOULD YOU RATHER INCORPORATE VGI DIRECTLY INTO THE VEHICLE OR DEPEND ON CHARGING INFRASTRUCTURE FOR VGI FEATURES?

INCORPORATE INTO VEHICLE

- Potential to serve as an aggregator (and associated revenues)
- More information about customer behavior (and potential revenue)
- Potential to extend and deepen relationships with customers at a time when EVs may mean a reduction in interaction with automakers / dealers after purchase due to less frequent maintenance visits
- Can integrate the features holistically into the user interface (including mobile applications), rather than depending on charging providers or other third parties
- Would make sense in an autonomous future with automaker-owned fleets of ride-hailing cars
- Onboard telematics necessary for other EV services reduce the hardware needs associated with VGI
- All of the above could provide a competitive advantage vs. other automakers

LEAVE IT TO CHARGING SERVICE PROVIDERS

- Fueling has not been a traditional role for automakers, so this would be a departure

- For residential and public charging service providers, smart charging is a core part of their business model and how they differentiate themselves from their competition (in the case of residential charging) and how they achieve profitability (for public charging)
- Charging service providers have or are already developing software to provide authentication, payment processing, and data reporting

ARE UTILITY COMPANIES PREPARED TO SUPPORT VGI (INCLUDING ONE-WAY AND BI-DIRECTIONAL POWER FLOWS)? WHAT BARRIERS REMAIN?

- Time-of-use and dynamic residential pricing is still being debated in many parts of the country
- Requires some sort of advanced metering (smart metering, sub metering, or vehicle-based technology), which is not yet installed ubiquitously
- Standards still needed to be created or harmonized. IEEE has identified 14 different interfaces with different functionalities amongst EVs, communication systems, and charging stations. It is not yet clear that the standards are sufficient for managing VGI. A forum to debate and finalize these standards and an interoperability testbed is needed. Participants debated who should host such a forum and testbed (i.e., industry and government), although no consensus was reached.
- Utilities still need to think about the negative impacts of using EVs for grid services, such as new late night 'timer' peaks, voltage fluctuations, etc.
- The financial costs and benefits associated with VGI are just beginning to be studied. More granularity is needed to questions including: Can VGI help defer distribution grid upgrade costs associated with responding to the new electricity demand from EVs? How should customers be compensated for VGI? Are there financial costs and benefits for the transmission grid?
- Utilities have significant work to do to help their customers through these decisions, and consumer education will be a critical need moving forward.
- These evolving questions will be in front of utility commissions in the years to come as utilities try to justify new investments and tariff structures.

HOW DO YOU EVALUATE THE TRADEOFFS BETWEEN CONSUMER BENEFITS AND BATTERY DEGRADATION FOR BI-DIRECTIONAL FLOWS? UNDER WHAT CONDITIONS WOULD YOU RECOMMEND CHANGING OEM WARRANTY POLICIES TO ALLOW THIS?

- Batteries are extremely costly, so premature reductions in capacity with repeated cycling or deep discharges associated with V2B and V2G could lead to a bad consumer experience with automakers.
- New research shows that there are ways to reduce the impacts to battery life through careful use of EV batteries, but the state of the science needs to advance.
- In a future with ubiquitous charging, battery sizes may be smaller, which could limit the potential for individual EVs to meaningfully participate in these markets.

- The economic trade-offs using of stationary storage vs. vehicle batteries for grid services needs to be evaluated more
    - On the other hand, there are times where marginal electrons on the grid are highly valued, (e.g., daily ramps in California during sunsets, or emergency situations like the polar vortex), so EV owners could stand to reduce their electric bills or even have net profits by allowing their vehicles to backfeed the grid.
- There are other times, like in a power outage, where an EV owner may want to use their vehicle to power their home.

WHAT CYBER SECURITY ISSUES DOES VGI RAISE? WHAT RESPONSIBILITIES EXIST AMONG DIFFERENT ACTORS (FEDERAL GOVERNMENT, UTILITIES, CAR COMPANIES, ETC.)?

- In general, charging infrastructure, and therefore, VGI features, are vulnerable to both cyber and physical threats. Also in general, charging infrastructure is unmanned and sometimes located in remote areas, even as it is connected to back-end systems where customer data is saved and processed. Charging service providers have required cybersecurity protections in the equipment they are purchasing from manufacturers, but more work is required to ensure those protections are robust enough, especially when bi-directional communication, which is required for V2B and V2G, is enabled.
- Federal government role: standard setting, R&D, threat reporting
- Utilities: Recognize threat, harden grid control to allow safe interaction between vehicles and grid, threat monitoring
- Car companies and charging service providers: Threat recognition, hardware and software design, threat monitoring

AS AN AUTOMAKER, HOW WOULD YOU MARKET THE VARIOUS VGI MODES TO POTENTIAL EV OWNERS?

G2V

- Even bigger delta between gasoline costs and electricity costs for taking advantage of super off-peak. Market specific difference in cost (i.e., ~$1000/year)
- Potential electric bill rebates or other benefits for participating in demand-response.
- Charging when the grid is ‘clean’ could offer value to ‘green’ EV customers.

V2B

- Emergency power for your home in case of grid failure (e.g., severe weather). Exportable power for recreation, etc.
- For fleet owners, demand charge reductions.

V2G

- Same as G2V, get paid for letting your car support the electric grid while you aren’t using it.

CLOSING SESSION

During the afternoon panel discussion, utility commissioners from three states shared their diverse perspectives on vehicle electrification, including updates on each state's approach to electrification. Speakers noted the challenges commissions are facing in attempting to set the ground rules for electrification infrastructure and shared their views on what it will take to accelerate the EV transition.

Commissioners noted that political will, in the form of a state legislative mandate or state executive branch leadership, is an important basis for utility commissions to engage on transportation electrification. Commissioners discussed tools that state governments have implemented or are considering implementing, including, among others, goals for EV adoption, carbon pricing, transportation system carbon emissions reduction targets, state agency purchases of EVs, EV and charging incentives, low-income EV programs, outreach and education programs, and a variety of pilot programs.

Given the potentially very large impact that EVs could have to electrical grids in the very near future, utility commissions are also examining their role in the EV transition. Commissioners noted current or future decision-making processes around EV-linked electricity demand growth, the impacts to distribution grids, the challenges and opportunities linked with low-carbon energy and EVs, utility rate structures, and utility consumer education programs. In some cases, commissioners noted that they have initiated proceedings focused specifically on optimizing the EV transition, given the wide range of linked questions utilities and regulators are grappling with in this space.

Some specific challenges and questions commissioners mentioned include:

- What is the appropriate ownership and rate recovery models for utility charging investments?
- Given that market participants involved in EV decision-making are generally new to utility proceedings, how should commissions design stakeholder engagement processes?
- Can the EV transition be harnessed to lower costs for EV and non-EV owners alike?
- Are the traditional programs and tariffs adopted by commissions in many states, such as mandatory energy efficiency targets, decoupling mechanisms, and others suitable for this transition to EVs since EV charging will lead inevitably to increased load for utilities?
- What electrification opportunities exist in the medium and heavy-duty vehicle market?

During the roundtable discussion that followed the commissioners' remarks, participants engaged in a debate on the role of utilities and automakers in EV consumer education and outreach. Participants noted the unfamiliarity that consumers have with EVs, even in states like California that have the relatively high levels of EV adoption and noted that marketing and education will be critical to change this. Some participants stated that utilities are uniquely situated to leverage their relationships and frequent communications with their customers to increase EV education and marketing. Some participants noted that utilities have begun asking for the ability to spend funds on these types of programs, and that programs are now being designed and implemented where they have been approved. Other participants challenged that notion, saying that most utilities do not have experiencing marketing and have small marketing budgets; in addition, others are not yet well-versed in EVs to have a conversation with their customers about them. They noted that industry-funded coalitions can help overcome these barriers.

The role of automakers and dealers was also discussed. Some participants noted that it is not financially advantageous for dealerships to sell EVs, that dealer education efforts need to increase their ability to sell

EVs, and that marketing efforts by automakers about EVs needs to increase as well. One participant noted: "nobody sells cars like a car company."

The discussion concluded with participants around the room agreeing that collaboration between utilities, automakers, and advocacy groups will be important to optimize and accelerate the EV transition. Participants also noted that for the first time, utilities had a role to play in the nation's transportation future. They encouraged automakers to engage in utility commission proceedings on EVs, to invest in additional utility partnerships, and build their own in-house utility expertise. They also noted the first-time nature of the roundtable and stated that more collaborative forums like it would be needed in the future to examine specific issues in the EV space.

APPENDIX A: ROUNDTABLE AGENDA

8:30 am	*Continental Breakfast*
9:00 am	Welcome and Introductions *Stephanie Seki, Atlas Public Policy* *Phil Jones, Alliance for Transportation Electrification*
9:30 am	Plenary Session/Panel Discussion: Emerging issues with EV charging infrastructure and vehicle-grid integration *Moderator: Phil Jones, Alliance for Transportation Electrification* *Spencer Reeder, Audi of America* *Sophie Shulman, Electrify America* *Terence Sobolewski, National Grid* Within the next five years, most major automakers will introduce long-range all-electric vehicles and today's charging infrastructure may not be up to the challenge. This session will lay out some of the challenges and opportunities with passenger electric vehicles and charging, including the importance of fast charging, the role of the electric utility, and vehicle-grid integration.
10:30 am	Breakout Group: Fast Charging Challenges and Opportunities *Facilitators: Stephanie Seki and Tarak Shah, Atlas Public Policy* This case study will ask participants to think of themselves as a Planning Manager at the third-party electric vehicle infrastructure company. As the Planning Manager, participants will be asked to make an informed decision on how best to invest in DC Fast Charging for a hypothetical metro area in the United States. Details on costs, utilization, user fees, and other profits will be provided. The breakout group will conclude with a 10-minute report out.
12:00 pm	*Lunch*
1:00 pm	Breakout Group: Electric Vehicle-Grid Integration *Facilitators: Stephanie Seki and Tarak Shah, Atlas Public Policy* This case study will ask participants to think of themselves as a Product Managers at a car company. As the Product Manager, participants have been asked to make a decision on what level of vehicle-grid integration the company will support with a new mid-market electric vehicle. Details on the costs, technology assessment, and potential benefits will be provided. The breakout group will conclude with a 10-minute report out.
2:30 pm	*Break*

2:45 pm	**Workshop Summary and State Perspectives** *Moderator: Phil Jones, Exec-Director, Alliance for Transportation Electrification* *Commissioner Dan Lipschultz, Minnesota PUC* *Commissioner Norm Saari, Michigan PSC* *Commissioner Ann Rendahl, Washington UTC* We'll end the day with an interactive discussion on diverse state perspectives, lessons learned from the breakout groups, and possible next steps in advancing policies for EV infrastructure, and thoughts from the organizers, Atlas Public Policy and the Alliance. Brad Stertz and Spencer Reeder of Audi will conclude the Roundtable event by offering their thoughts and perspectives given Audi's unveiling here and future product development.
3:30 pm	**Adjourn and travel back to the hotel via Audi shuttle**
6:00 pm	**Optional dinner**

APPENDIX B: MEETING PARTICIPANTS

First Name	Last Name	Organization
Tom	Ashley	Greenlots
Michael	Backstrom	Southern California Edison
Janine	Benner	Oregon Department of Energy
Matt	Coldwell	California Energy Commission
Angie	Dykema	Nevada Energy Office
Stephanie	Greene	Pacific Gas & Electric
Brett	Hauser	Greenlots
Roland	Hwang	Natural Resources Defense Council
Robert	Jackson	Michigan Energy Office
Phil	Jones	Alliance for Transportation Electrification
James	Lester	Colorado Public Utility Commission
Dan	Lipschultz	Minnesota Public Utilities Commission
Steve	Lommele	National Renewable Energy Laboratory
Kyla	Maki	Montana Department of Environmental Quality
Christopher	Michelbacher	Audi of America
Patty	Monahan	Energy Foundation
Spencer	Reeder	Audi of America
Ann	Rendahl	Washington Utilities and Transportation Commission
Lang	Reynolds	Duke Energy
Norm	Saari	Michigan Public Service Commission
Anna	Schneider	VW Group of America
Stephanie	Seki	Atlas Public Policy
Tarak	Shah	Atlas Public Policy
Sophie	Shulman	Electrify America
Ryan	Silvey	Missouri Public Service Commission
Carrie	Sisto	California Public Utilities Commission
Amanda	Smith	Minnesota Pollution Control Agency
Brad	Stertz	Audi of America
Terence	Sobolewski	National Grid

First Name	Last Name	Organization
Jim	Varian	Florida Public Service Commission
Mark	Vasconi	Washington Utilities and Transportation Commission
Sam	Watson	North Carolina Utilities Commission
Lincoln	Wood	Southern Company

APPENDIX C: BREAKOUT GROUP CASE STUDIES

Breakout group case studies were created by Atlas Public Policy on two topics: *Fast Charging Challenges and Opportunities* and *Electric Vehicle-Grid Integration*.

DC FAST CHARGING INVESTMENT

CASE STUDY FOR THE STATE ROUNDTABLE ON ELECTRIC VEHICLE INFRASTRUCTURE

INTRODUCTION

A third-party electric vehicle (EV) infrastructure company, Charge&Go, that provides and owns charging infrastructure just received $720,000 in funding for new DC fast charging (DCFC) infrastructure in the Metro City region. As a Regional Planning Manager for Charge&Go, you must decide what types of locations to serve.

CHARGING LANDSCAPE

The U.S. EV market continues to grow each year with national sales of EVs – both plug-in hybrid electric and battery electric – totaling 874,000 EVs through June 2018. Most EV charging currently happens at home, but the pattern of charging may shift soon due to EV adoption by drivers without dedicated charging infrastructure (e.g., apartment building residents), longer range EVs that benefit from higher power charging, and the use of EVs for ride-hailing. When EVs are parked for extended periods of time, such as at home, at a workplace, or during a shopping trip at a retailer, Level 1 (110 V) or Level 2 (240 V) charging is often sufficient. Providing these charging services is easier for the grid to accommodate and is cheaper to deploy and use. DCFC is best for EV drivers who do not have reliable access to home charging, are on longer road trips, or who need access to quick charging during the day, like EV drivers on ride-hailing platforms.

The current fast charging landscape is still emerging and not yet ready to satisfy the anticipated increasing number of long range all-electric vehicles. Most fast charging sites today are single units, which can lead to a frustrated driver if the equipment is being used or is otherwise unavailable. Additionally, fast charging is supported by three different plug types, making it more challenging to deploy charging for all EVs.[1] Developing and promoting interoperability of charging infrastructure will increase the availability of charging for all EV drivers. Finally, current DC fast charging stations typically operate at 50 kilowatts, but new EV models will raise consumers' expectations for the charging experience since they will have larger batteries and accommodate power levels of 150 kilowatts and up to 350 kilowatts in the not too distant future.

[1] American, European, and some Asian automakers support the SAE 1772 Combo standard, Nissan and Mitsubishi support the Japanese CHAdeMO standard, and Tesla has a proprietary connector.

DC FAST CHARGING FOR METRO AREAS

Metro City, a medium sized metro area, has a population of 600,000 people and a burgeoning market for EVs. Currently, there are over 200 Level 2 ports and 30 DCFC ports in the area. The state has recently approved a tax credit for EV purchases that is expected to increase the number of EVs in the state, especially in Metro City. Charge&Go has identified Metro City as an attractive market and was able to secure funding from a private investor to spend $720,000 on public, fast charging at 150 kilowatts. The investor does not expect an immediate profit and is gaining a stake in the company to have a say in decisions and influence over the strategy to achieve long-term profitability.

Charge&Go has a simple fee structure that is based on the energy used at the stations you own and operate. For the Metro City project, Charge&Go will own and operate all the DCFC in which you are investing.

As the Regional Planning Manager, you are working with other charging infrastructure investors and interested parties to leverage existing efforts and develop partnerships that could generate new sources of revenue for the company. Entities looking to invest in DCFC in Metro City include the local investor-owned utility and ride-hail service providers. The utility has their EV program, including $45 million for DCFC investment in "make-ready" installations,[2] approved by the state's public utility commission less than six months ago. Additional revenue could come from partnerships and revenue sharing opportunities that capture value for the charging service.

THE CHALLENGE

As the Regional Planning Manager, you must decide how to invest the $720,000 and make the case to your higher ups. As part of a private company, your decision must reflect the company goal of achieving profitability over the 10-year anticipated life of the equipment with the expectation that future projects will earn a return more quickly. Your company has decided that the stations should be publicly accessible, include at least three dual-port charging stations per site (6 ports total); you also have the option to site a station near the highway entrance or within the metro area.

How will you, as the Regional Planning Manager, invest the money and what partnerships will you pursue? You can choose either a highway or urban location for the charging infrastructure, the total cost to Charge&Go must be under $720,000, and you can only enter into one partnership, if any.

Charge&Go's investment funds can be spent on infrastructure (charging equipment and installation) or could be used for complementary programs, such as marketing and outreach or a siting analysis. Investing in one of these complementary programs is expected to boost your charging equipment's utilization by 10 to 12 percent over the baseline.

Partnering with a ride-hail service company to provide exclusive use of the charging stations at urban locations is expected to improve utilization by 20 percent over the baseline. The ride-hailing company will not partner for highway-based stations. The exclusive use of the charging station would limit Charge&Go's customer base and is an important consideration for the long-term growth of a charging network.

[2] For the purposes of this case study, "make-ready" indicates that the utility will cover the electrical infrastructure that supports the EV charging, short of the equipment.

Charge&Go could also partner with the regional utility. The utility is offering to cover the costs for electrical grid upgrades, grid interconnection, host site identification, screening, design, and property transactions at a total value of $64,500. However, if Charge&Go partners with a utility, you will lose your ability to choose the location for the station. Charge&Go would then forego the potential benefit of a 10 percent increase in utilization from the company's siting analysis.

See Appendix A for the cost, use, and revenue assumptions. The project financial performance and discounted cashflow is presented in Appendix B.[3] See Appendix C to understand how increasing utilization can improve the project's profitability.

DISCUSSION QUESTIONS

- What are the challenges to achieving near-term profitability for this investment in charging infrastructure?
- Should the company choose to participate in a ride-hailing service or utility partnership? What are the trade-offs with choosing one partnership over another?
- With limited funds, how should the company prioritize marketing & outreach and the siting analysis? What do they potentially sacrifice by not investing in these programs?
- Given that the investor is looking for long-term profitability in its investment, does one partnership provide better long-term prospects than another? What about no partnership?
- What are some ways not mentioned here that could lower the installation or operating costs of the charging stations? What about ways to improve charging station utilization?
- How would the decision change if you were to account for the uncertainty in the estimates? Which numbers would you want to be sure of to support your decision?

[3] Profit and cashflow were estimated using the EV Charging Financial Analysis Tool developed by Atlas Public Policy.

APPENDIX A: COST, USE, & REVENUE ASSUMPTIONS

TABLE 1: EQUIPMENT AND INSTALLATION COSTS

	Highway & Urban
Electric utility upgrades and grid interconnection (per site)	$30,000
Host site identification, screening, design and property transaction costs (per site)	$34,500
Construction and equipment installation (per port)	$25,000
Charging Equipment (per port)	$80,000
Total, one port per site	$169,500
Total, six ports per site	$694,500

TABLE 2: OPERATING COSTS

	Highway & Urban
Energy Costs ($/kWh)	$0.10
Demand Costs ($/kW/month)	$5.00
Fixed Costs ($/month)	$50.00
Operating Expenses ($/month)	$6,650

TABLE 3: CHARGING USE & REVENUE

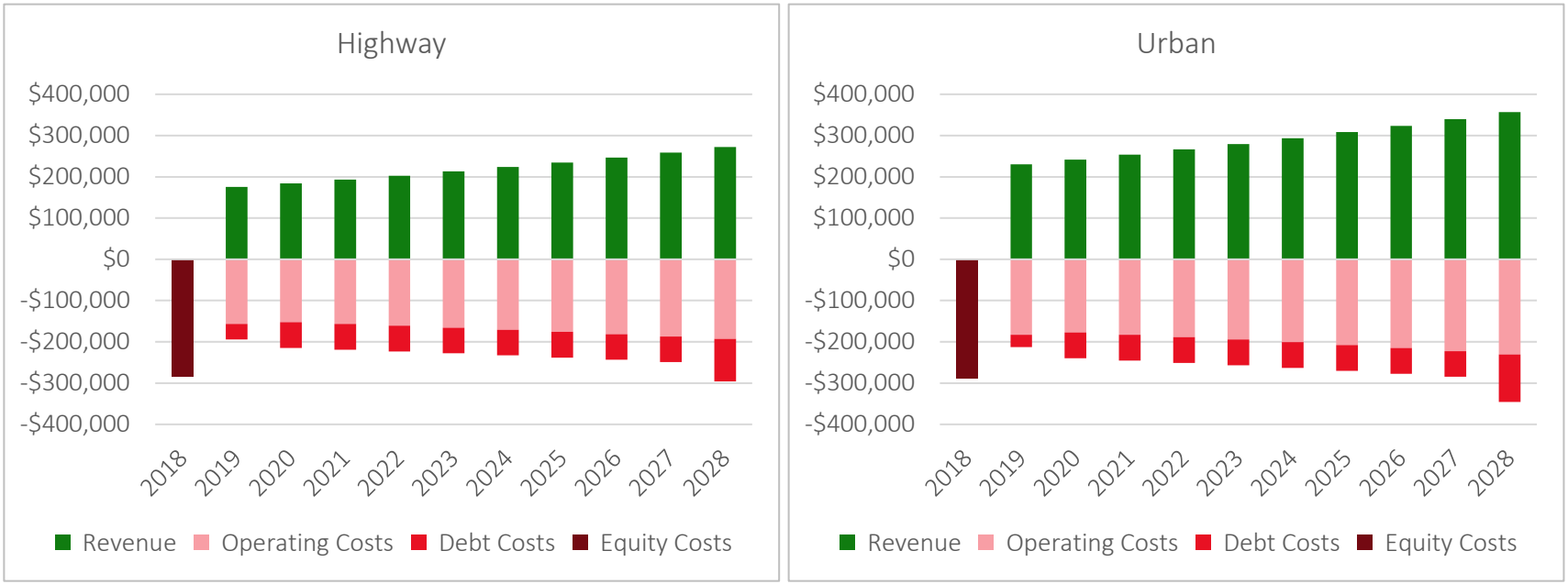
	Highway	Urban
Expected Utilization per Port (charging sessions per day)	5	7
Average Use per Charging Session (kWh)	30	
Max Power Draw per Port (kW/session)	125	
Use Fee ($/kWh)	$0.50	

APPENDIX B: FINANCIAL PERFORMANCE AND CASHFLOW

TABLE 4: FINANCIAL PERFORMANCE SUMMARY

	Highway	Urban
Capital Cost (six ports per site)	$694,500	$694,500
Expected Utilization per Port (charging sessions per day)	5	7
Net Present Value, 10 years	-$380,000	-$156,000

FIGURE 1: DISCOUNTED CASHFLOWS FOR HIGHWAY AND URBAN LOCATIONS



APPENDIX C: PARTNERSHIP OPPORTUNITIES & UTILIZATION SENSITIVITY

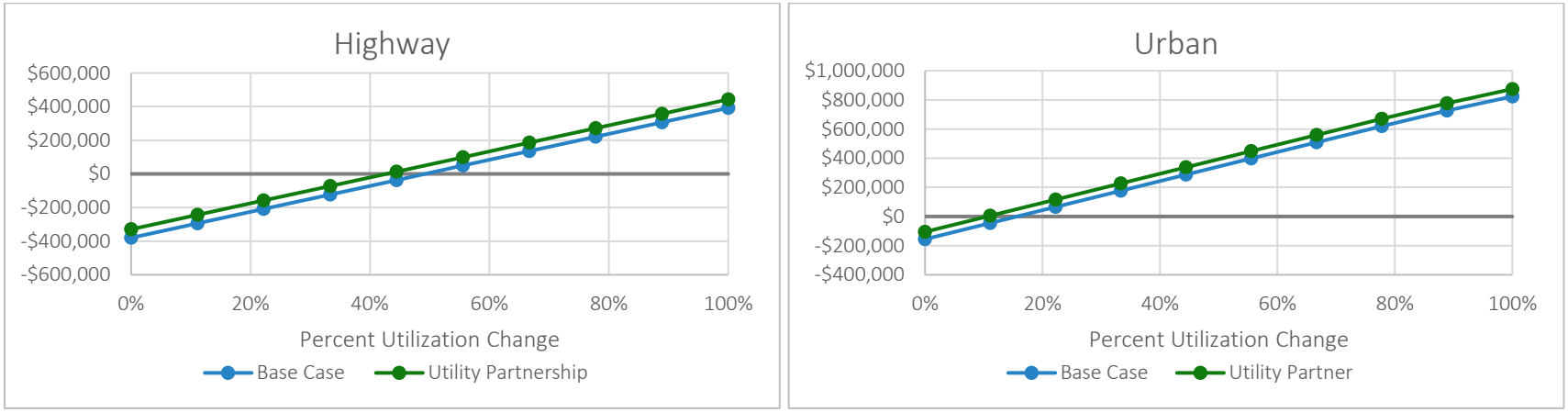
TABLE 5: OTHER POTENTIAL INVESTMENTS WITH UTILIZATION BENEFITS FOR ALL STATIONS

Item	Cost per Site	Utilization Improvement
Marketing & Outreach	$50,000	12%
Siting Analysis (does not apply if partnered with the utility)	$25,000	10%

TABLE 6: POTENTIAL PARTNERSHIPS WITH BENEFITS

Partnership	Highway	Urban
Ride-Hail/Carshare Users	No partnership available	20% increase in utilization
Utility Partnership	$64,500 (local grid upgrades, grid interconnection, host site identification, screening, design, and property transactions)	

FIGURE 2: NET PRESENT VALUE OF STATION INVESTMENTS WITH CHANGING UTILIZATION



Percent change in utilization is measured from the initial value of 5 and 7 charging sessions per port per day for a highway and urban station, respectively. Zero percent represents the initial value in the figures. NPV improves with more utilization.

This case study was created by Atlas Public Policy. Atlas is a Washington, DC-based policy tech firm that works with federal and state agencies, private companies, and the advocacy community to develop strategies to advance clean energy technologies. Atlas has extensive experience in research and analysis on plug-in electric vehicles and related charging infrastructure. Atlas is a nationally-known resource on good practices on the role of government and the private sector in advancing the electric vehicle market. More information is available at www.atlaspolicy.com.

ELECTRIC VEHICLE-GRID INTEGRATION

CASE STUDY FOR THE STATE ROUNDTABLE ON ELECTRIC VEHICLE INFRASTRUCTURE

THE PERSPECTIVE

You work at an automaker as the Product Manager for a forthcoming electric vehicle (EV) offering and are making a decision on what level of vehicle-grid integration (VGI) you plan to support in a new mid-market EV. Your CEO has asked for a briefing on the features you intend to integrate.

EV CHARGING MODES AND GRID SERVICES

EVs have the potential to become one of the largest flexible loads on the grid in the near future, creating new strategic challenges and opportunities for the automakers that design and market them. You are considering supporting one, two, or all three of the following VGI modes, including:

- Grid-to-Vehicle (G2V): Allows the grid to remotely control EV charging by turning power flow up, down, or off to correspond with the needs of the grid. Because G2V only requires a one-way flow of power, G2V is low cost to incorporate from an automaker perspective. G2V is also known as managed charging, smart charging, or V1G.
- Vehicle-to-Building (V2B): Allows a building (including homes and business) to draw electricity from an EV to provide back-up power, demand charge management, or emergency services. V2B requires bi-directional flows of power and is high cost to incorporate from an automaker perspective.
- Vehicle-to-Grid (V2G): Allows the sending of power back to the grid from an EV using available battery capacity. V2G requires bi-directional flows of power and is high cost to incorporate from an automaker perspective.

Each of these three modes supports different types of grid services, as identified by an expert panel recently convened by the U.S. Department of Energy and summarized in Table 1 of Appendix A.

POTENTIAL VALUE PROPOSITION TO THE CUSTOMER

EV buyers have the potential to reap benefits from their vehicle's batteries by allowing the device to serve as an energy storage appliance for the electrical grid and/or their home. To date, the most common VGI programs feature utilities offering special electricity rates for residential EV owners and charging providers in exchange for basic G2V functionality. These rates can lower the cost of charging at home by 50 to 90 percent in exchange for charging at preferred times (see Figure 1 and Figure 2, Appendix A) for examples of these rate structures). Automakers can use this benefit as a marketing tool to potential EV owners.

Given the small size of each individual EV storage resource, multiple EVs will need to be aggregated and managed centrally as a single grid resource to realize the full value of VGI. Car owners, automakers,

charging providers, third-party providers, and electric utilities could each serve as an aggregator as they attempt to capture the value associated with EV-linked grid services (i.e., compensation for bidding into power markets). EV owners would receive cash or other incentives (like free public charging) for participating in an aggregator's program. Once these benefits are more clear, automakers could market them to potential EV owners as part of a package of lower total lifecycle costs, especially in comparison to vehicles that still use internal combustion engines.

CHALLENGES WITH VGI

Challenges exist which are unique to automakers considering supporting VGI. They include:

- Unclear Value Proposition: Given the immature market for EV-enabled grid services, automakers are just beginning to invest in the software needed for consumers to participate in VGI. While most EV software supports Time-of-Use rates, more dynamic forms of pricing (e.g., real-time pricing) and ancillary services (e.g., frequency regulation) are not yet supported because there are few mechanisms to compensate car owners for these services. More work is needed to determine which rate structures and payments support EV adoption.
- Battery Degradation: Because bi-directional charging (required for V2B and V2G) may degrade vehicle battery life, no automaker currently extends vehicle warranties to batteries where bi-directional charging is enabled. While deep discharge of batteries in repeated V2B and V2G cycling will harm battery life, some experts believe that proper battery management in these applications can reduce wear to an acceptable level. More technical and economic work is necessary to validate this view.
- Range Anxiety: Because EVs are primarily used for transportation, some customers may be concerned about VGI reducing their ability to make it to their final destination with adequate charge. Opt-out / VGI override are important features that automakers must consider. See Figure 3, Appendix A for a current example of how EV owners can program their vehicle to charge during off peak rates and, if desired, override this feature.
- Communications/Interoperability: While most EVs are equipped with on-board telematics, no single industry standard for VGI messaging protocols and network communications protocols has been agreed upon, which will be critical if vehicles and utility grids are to interact.
- Cyber Security: Communications links between connected EVs or chargers and battery control software and hardware are expected to be an attractive point of entry for cyber-attacks.
- Cost: Developing the hardware and software necessary to support VGI is time consuming (because industry has yet to agree on a standard) and costly (involving new devices and millions of lines of code).

LESSONS FROM PILOTS AND SIMULATIONS

- In 2015 and 2016, BMW's iChargeForward pilot utilized about 100 EVs and a stationary battery bank made of recycled EV batteries to provide demand response services to Pacific Gas & Electric. Combined, the batteries responded to over 200 demand response events, totaling 19.5 MWh.

- A National Renewable Energy Laboratory analysis looked at different levels of managed EV loads in a 2030 scenario with 3 million EVs in California. It found savings between $210-$660 million annually in generation system costs.
- A 2015 SAE Technical Paper found that EVs could provide between $623 and $1,014 per vehicle in annual revenue when connected in V2G mode.
- UPS is partnering with the Department of Energy to develop bi-directional wireless charging for its electric delivery trucks so that trucks can operate in V2B or V2G mode in the event of a power outage.
- In August 2018, Honda announced a partnership with eMotorwerks (a DR provider) to offer California EV drivers $350 in annual benefits for participating in a program that uses pricing signals from the grid to determine optimal charging periods within customer preferences.

THE CHALLENGE

As the Product Manager, you must decide which features you will support in your forthcoming vehicle. You are attempting to minimize costs and difficulty associated with incorporating VGI features, while maximizing customer benefits. First, as individuals, on a scale of 1-5 (5 being highest) rate each grid service in terms of the potential value to EV owners and the potential to improve grid resilience services on Worksheet 1. Second, as small groups, choose which VGI mode(s) you would recommend to your CEO for your new EV, and identify three reasons why for each mode. Discuss the following questions to help you make your decision.

DISCUSSION QUESTIONS

- As an automaker, would you rather incorporate VGI directly into the vehicle or depend on charging infrastructure for VGI features?
- Are electric utilities prepared to support VGI (including one-way – G2V? bi-directional flows - V2B and V2G)? What barriers remain?
- How do you evaluate the tradeoffs between consumer benefits and battery degradation for bi-directional flows? Under what conditions would you recommend changing OEM warranty policies to allow this?
- What cyber security issues does VGI raise? What responsibilities exist among different actors (federal government, utilities, car companies, etc.)?
- As an automaker, how would you market the various VGI modes to potential EV owners?
- What are the competing motivations between players in the VGI space (utilities, regulators, automakers, charging providers, vehicle owners, etc.)? How would you attempt to bridge these gaps in order to speed VGI deployment?

APPENDIX A

TABLE 1: DEFINITIONS OF POTENTIAL EV PROVIDED GRID SERVICES (AND MODES SUPPORTED)

Grid Service	Definition	Mode
Demand Response	Reducing EV charging use at times of high system prices or unstable conditions	G2V
Valley Filling	Encouraging EV charging when system demand is low (off-peak) to reduce peak demand	G2V
Negative Demand Response	Encouraging EV charging (and other non-essential loads) during negative pricing periods to avoid curtailment	G2V
Coordinated Charging	Synchronizing EV charging to avoid timer peaks (i.e., TOU rate load spikes)	G2V
Demand Charge Reduction	Using EV batteries to reduce building demand charges	V2B
Emergency Back-up	Using EV batteries to power a building during outages	V2B
Capacity Firming	Using EV batteries to smooth the output associated with variable power generation	V2G
Voltage Control	Using EV batteries to help maintain voltage at a building on the grid	V2G
Frequency Regulation	Ramping EV batteries up or down over milliseconds to maintain grid frequency	G2V, V2G
Reserves	Using EV batteries to supplement reserve capacity requirements	G2V

FIGURE 1: POTENTIAL UTILITY RATE STRUCTURES

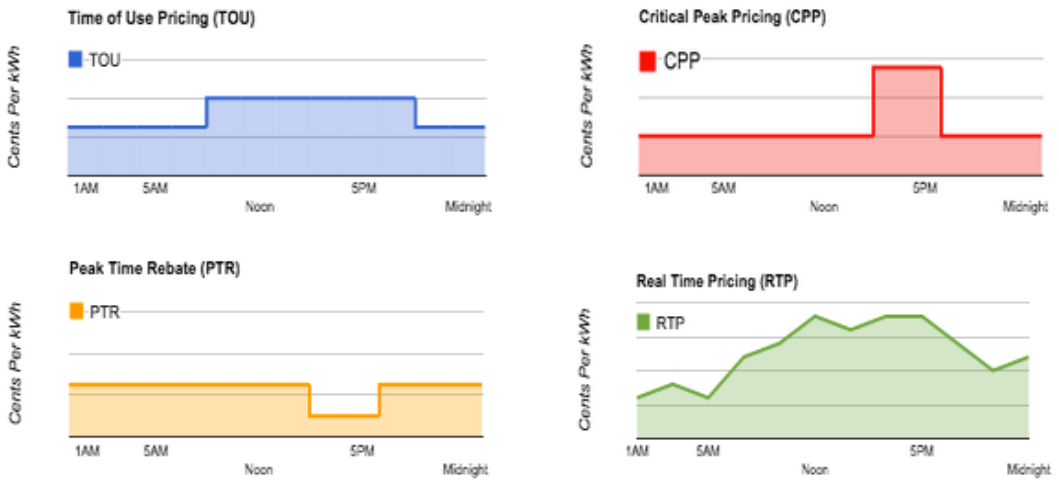
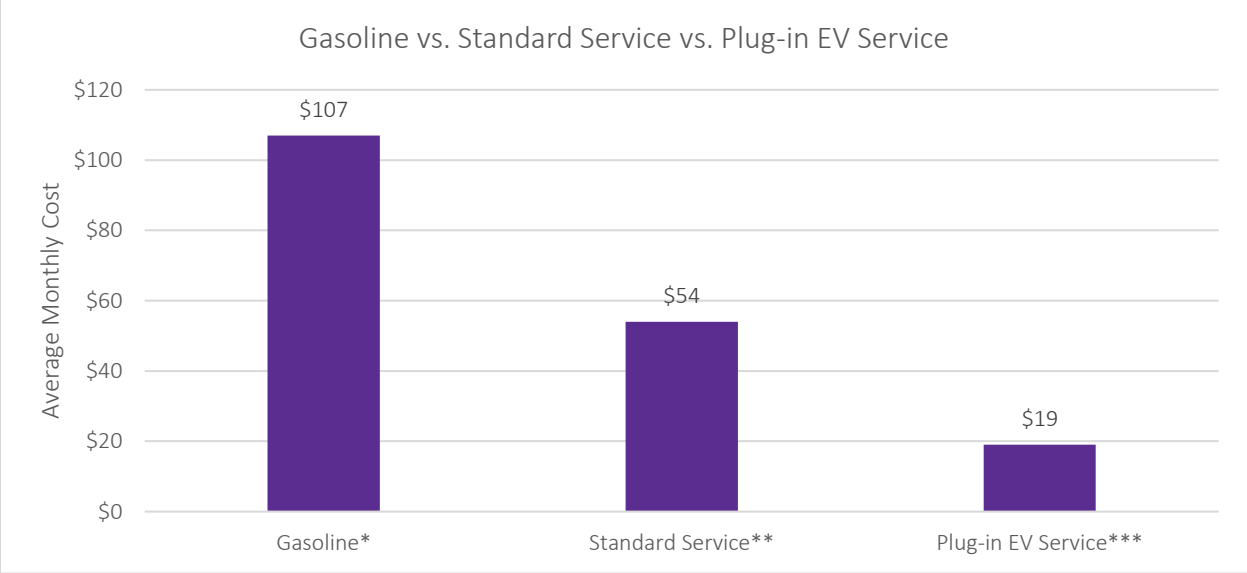


FIGURE 2: GEORGIA POWER EV CHARGING



*Notes: *Gasoline estimate based on a ratio of 1 kWh = 3.4 miles, 24.7 MPG, and a cost of $2.50 per gallon.*
***Georgia Power's Residential Standard Service features progressively increasing rates in three tiers of monthly electricity use (between 0-650 kWh, 650-1000 kWh, and above 1000 kWh). EIA form 861 data indicates that average monthly residential consumption in Georgia is 1138 kWh in 2016. For the purposes of this calculation, it is assumed that marginal electricity use to power an EV will be at Georgia Power's 1000 kWh and above electricity rate.*
****All charging under the Plug-in EV service is assumed to occur at the Super Off Peak Rate, which occurs between 11p and 7a each day of the year in Georgia Power's service territory.*
***, *** Non-energy charges occur at the same percentages and rates for both Residential Standard Service and Plug-in EV Service and are based on Georgia Public Service Commission approved rates as of September 2018*

FIGURE 3: FORD SYNC 3.0 SCHEDULED CHARGING INTERFACE – USER MANUAL (AVAILABLE ON FORD FUSION ENERGI)

"In the Charge Settings menu, you can monitor your vehicle's current battery charge status and schedule times to charge your vehicle, which allows you to take advantage of times when utility rates are lower (Value Charge). To access the Charge Settings menu, press the Settings icon in the feature bar at the bottom of the touchscreen. Then press the Charge Settings icon.

You can also set up My Go Times for cabin conditioning temperatures and charging times—so your vehicle is ready to drive when you are ready to go. The Cabin Conditioning feature lets you set the cabin temperature when you set your GO Time—in order to use energy from your home or charging station instead of your vehicle battery."

WORKSHEET 1: POTENTIAL VALUES FOR EV-LINKED GRID SERVICES

Rank each grid service on a scale of 1 to 5. (1 is lowest value and 5 is highest value)

Grid Service	Potential Value to EV Owners	Potential to Improve Grid Resilience
Demand Response		
Valley Filling		
Negative Demand Response		
Coordinated Charging		
Demand Charge Reduction		
Emergency Back-up		
Capacity Firming		
Voltage Control		
Frequency Regulation		
Reserves		

ATLAS PUBLIC POLICY

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