A PUBLIC POWER GUIDE TO

Understanding the U.S. Plug-in Electric Vehicle Market

AMERICAN PUBLIC POWER ASSOCIATION™
Powering Strong Communities

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Report written and prepared by NAVIGANT CONSULTING

www.PublicPower.org

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The American Public Power Association is the voice of not-for-profit, community-owned utilities that power 2,000 towns and cities nationwide. We represent public power before the federal government to protect the interests of the more than 49 million people that public power utilities serve, and the 93,000 people they employ. Our association advocates and advises on electricity policy, technology, trends, training, and operations. Our members strengthen their communities by providing superior service, engaging citizens, and instilling pride in community-owned power.

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EXECUTIVE SUMMARY

A new generation of plug-in electric vehicles (PEVs) has emerged over the past decade, thanks to declining battery costs and improved offerings in an ever-expanding number of regions. Battery electric vehicles (BEVs) with ranges greater than 200-miles will likely become price competitive in the near future due to a combination of lower material and manufacturing costs and competition among automotive original equipment manufacturers (OEMs) which are launching these new models in higher volumes for the global market.

Increased PEV adoption offers benefits to stakeholders across the United States, including public power utilities. These vehicles have the potential to be an asset to the grid through vehicle-grid integration (VGI) technologies, such as communications for charging management (V1G) or vehicle-to-grid (V2G) power transfer. Integrating charging through VGI services would enable public power utilities to manage anticipated load growth, while providing net benefits to PEV owners and other utility customers. Higher levels of adoption also offer increased revenue streams for utilities due to heightened demand for electricity. From the customer's perspective, the annual cost to fuel a PEV is typically lower than a traditional gas-powered vehicle. The National Renewable Energy Lab (NREL) completed a study that associated increased PEV adoption with positive total social economic value, caused primarily by the benefits of fuel savings.[1] Finally, since these vehicles do not use fossil fuels, they would reduce overall greenhouse gas (GHG) emissions.

While batteries have traditionally been challenged by price pressure seen through high range battery electric vehicles having high prices, recent advances in both scale of models and range has started to bring down the costs dramatically. With this drop, PEVs could move from a niche choice to a viable option for more customers looking to purchase a vehicle within the next few years. Parts of the United States have already seen high PEV adoption rates, likely due to purchasing incentives and supportive regulations, such as California's zero emission vehicle (ZEV) mandate.

Although an increase in PEV adoption remains likely, challenges to owning this type of vehicle persist. Many customers are unaware of the potential benefits of PEVs, or are uncertain of the feasibility of owning a PEV. One potential way to alleviate this problem is to create partnerships with dealers and other stakeholders to educate customers about the benefits of PEVs, such as cost calculators based on local rates and average area commutes. Another challenge is limited choice. Not all PEV models are available across the country—for example, as of September 2017, the 2017 Hyundai Ioniq is only available in California. Limited model availability may decrease the likelihood a customer will purchase a PEV. Charging availability poses another challenge to adoption. Customers may be concerned about the time it can take to recharge a vehicle or the infrastructure needed to charge a PEV on a regular basis. Public power utilities can diminish this challenge by creating strategic partnerships to provide faster charging options for public use. Furthermore, utilities and others can help inform customers about where charging connectors are offered and when chargers are available.

The expected increase in the number of PEVs on roads in the United States could negatively impact the available supply of power during peak hours by increasing the load in some areas if vehicle charging is unmanaged. Concentrated load growth may cause infrastructure issues, and require unexpected investments in upgrading that infrastructure. Partnerships among stakeholders could help guide utilities, by providing them with insight into market growth, stakeholder engagement, and managing load growth impact. Proactive planning on behalf of public power utilities and local, state, and federal stakeholders

1 NREL, National Economic Value Assessment of Plug-In Electric Vehicles, December 2016. https://www.nrel.gov/docs/fy17osti/66980.pdf

could be beneficial when considering the impacts of increased PEV adoption in the United States.

There are many opportunities for public power utilities to specifically benefit from the adoption of PEVs. Many larger metropolitan and coastal areas that are predicted to adopt PEVs more quickly than other parts of the country are public power communities. Public power utilities that are early to adopt PEV infrastructure and policies could play a key role in setting precedents related to PEVs and utilities' relationships with governing entities. Given the relationship and communication channels with local government, public power utilities may be able to monitor adoption through state and local incentive structures. Furthermore, utilities could promote adoption of PEVs by offering incentives to customers, such as rebates for installing charging infrastructure. Finally, public power utilities may have greater transparency regarding charging behavior of government fleets, allowing the utilities to strategically manage load growth.

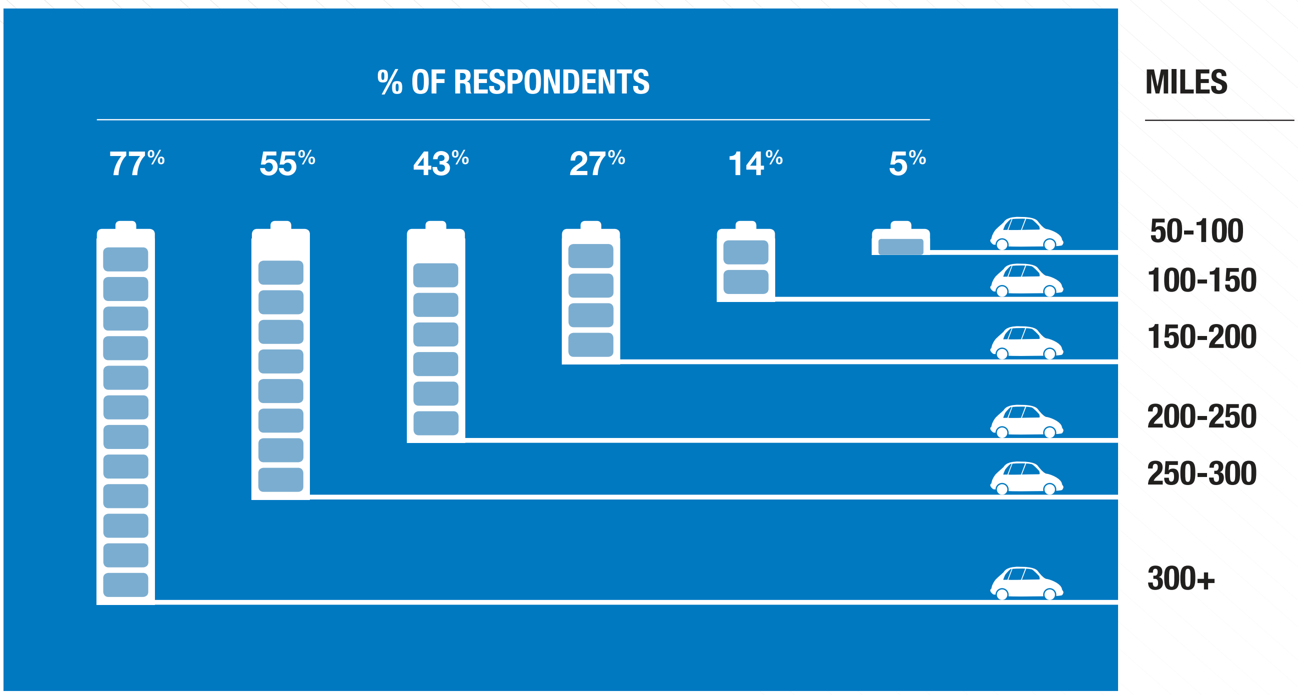
This report examines key PEV-related market factors with the potential to impact public power utilities in the United States. It also provides questions to guide utility PEV strategic planning efforts. The report incorporates Navigant Research market forecasts—on topics including PEV sales, regionality of adoption, and energy consumption—and Navigant analysis summaries on overall market trends and technologies.

PEV MARKET TRENDS AND TECHNOLOGIES

Battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs), collectively known as plug-in electric vehicles (PEVs), are poised to make significant advances in the United States and in global markets. Decreasing battery costs, purchase incentives, and the introduction of long-range vehicles are all factors driving the market for PEV adoption in the United States.[2] These trends combined with international announcements, such as those recently made by several European Union (EU) member countries to ban internal combustion engine (ICE) vehicle sales[3] by the middle of the century, have led large automakers to develop new PEV models.

In Navigant Research's 2016 *Electric Vehicle Geographic Forecasts* report, United States consumer survey respondents indicated that the likelihood they would purchase a BEV increased significantly as vehicle range increased. As Figure 1 shows, over three-quarters of respondents were willing to consider purchasing a BEV if the vehicle offered a 300-mile range, while under half were willing to purchase at the 200-mile range. However, cost was not considered in the survey question. Given that the average new vehicle transaction price in 2016 was just over $34,000, PEV cost reductions will remain key to ensuring higher capacity options are available at the primary market price points consumers are used to seeing when purchasing new vehicles.

Figure 1: MINIMUM RANGE TO CONSIDER BEV PURCHASE, ELECTRIC VEHICLE CONSUMER SURVEY, UNITED STATES: 2016



Source: Navigant Research

[2] Navigant Research, *Market Data: Electric Vehicle Market Forecasts,* 2016.
[3] Kylie MacLellan and Guy Faulconbridge, "Electric cars win? Britain to ban new petrol and diesel cars from 2040," Reuters. https://www.reuters.com/article/us-britain-autos-idUSKBN1AB0U5

Rising battery capacity and reduced battery cost are two drivers of growth in OEM participation in the PEV market, which has led to an increase in available BEV models with ranges of 200 miles or more at lower price points.[4] Some OEMs like Tesla and Chevrolet already have BEVs in production capable of hitting the 200-mile range threshold at starting prices under $40,000. At least fifteen OEMs have announced plans to enter the market with similar range, which is increasing pressure for prices to drop.

Battery Trends

Batteries account for a significant portion of a PEV's cost. According to Chevrolet, the cost of a 2017 battery for the Bolt is $15,734.29,[5] which accounts for 43 percent of the $36,620 base price.[6] As Table 1 shows, battery prices are predicted to decrease year over year, aiding in the expected decline of overall PEV costs. Contracting battery prices coupled with expanding battery capacity creates an environment where increasing PEV ranges at a more reasonable cost is possible.

Lithium-based batteries are the leading battery chemistries used in PEVs. Therefore, the forecast cost of lithium chemistries provides a reasonable understanding of the likely evolution of PEV costs.

With decreasing costs and increasing product options for consumers, more battery manufacturing will be needed to match the demand. It has been projected that light duty BEV Li-ion battery capacity in North America to increase from 4.2 gigawatt-hours (GWh) in 2015 to 18 GWh by 2024.[7] Light duty PHEV Li-ion battery capacity is expected to see a similar increase.[8]

Power Delivery

PEVs rely on wired power delivery to recharge batteries, which requires plugging into electric vehicle supply equipment (EVSE). The types of EVSE on the market vary based on communication capabilities and the time it takes to charge a vehicle. Educating potential customers about the differing capabilities and charging times is a key challenge to PEV adoption. Charging stations can be grouped into four categories (refer to Figure 2) with the following power outputs: Level 1 (1.4 kW maximum), Level 2 (3.3-19.2 kW), direct current (DC) fast charging (50-150 kW), and DC ultrafast charging (up to 400 kW). Alternating

Table 1: LI-ION BATTERY PACK PRICES BY BATTERY APPLICATION, WORLD MARKETS: 2015-2024

Source: Navigant Research

[4] Navigant Research, *Market Data: Electric Vehicle Market Forecasts,* 2016.
[5] John Voelcker, "How much is a replacement Chevy Bolt EV electric-car battery?" Green Car Reports. http://www.greencarreports.com/news/1110881_how-much-is-a-replacement-chevy-bolt-ev-electric-car-battery
[6] Chevrolet, 2017 Bolt EV FWD LT. http://www.chevrolet.com/byo-vc/client/en/US/chevrolet/bolt-ev/2017/bolt-ev/summary
[7] Navigant Research
[8] Ibid.

Figure 2: CHARGING STATION POWER DELIVERY AND CHARGE TIME

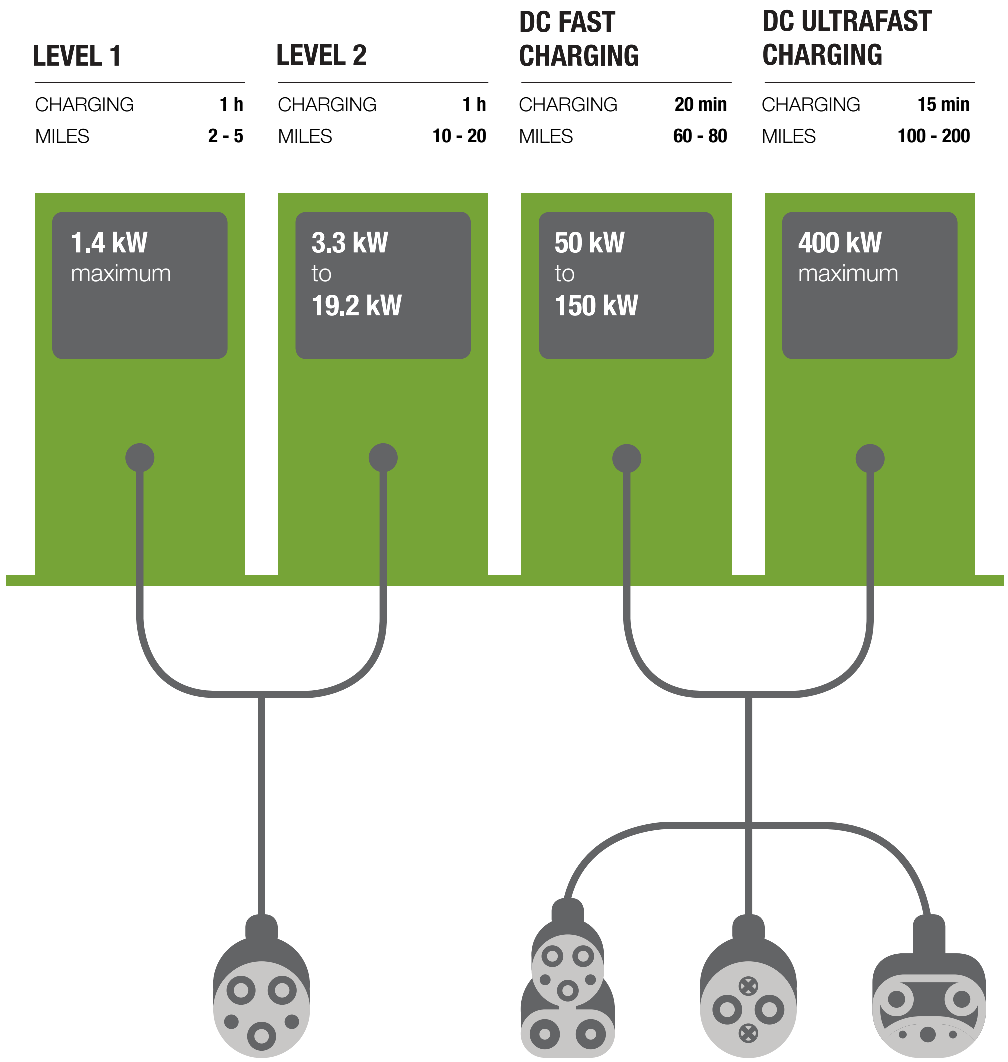


Figure 3: CHARGING STATION PLUG TYPES

J1772

J1772 Combo

CHAdeMO Most ubiquitous in PEVs with DC fast charging capability

Tesla Combo

current (AC) charging (Level 1 and 2) is the most common type of charging infrastructure, but DC charging provides the quickest battery recharge time due to the higher level of power delivery. Tesla's Supercharger network provides DC fast charging for its vehicles at up to 145 kW, and recently announced updates to allow for ultrafast charging up to 350 kW.[9] Ultrafast charging technology is already being deployed—Porsche installed its new 350 kW charger at its headquarters in Berlin, and ChargePoint released an ultrafast 400 kW charging station model early in 2017.[10,11] The amount of power and related infrastructure being installed in a region can help utilities assess the distribution and transmission requirements for power delivery.

[9] Tesla, Supercharger. https://www.tesla.com/supercharger

[10] Jon Fingas, "Porsche installs its first high-speed electric car chargers," Engadget. https://www.engadget.com/2017/07/16/porsche-installs-first-super-fast-ev-chargers/

[11] ChargePoint, ChargePoint Express Plus. https://www.chargepoint.com/products/commercial/express-plus/

Electrify America Charging Network

In April 2017, Volkswagen's Electrify America program began Cycle 1 of its $2 billion electric charging infrastructure investment program. Electrify America's mission is to invest in ZEV infrastructure and education programs across the United States in four investment cycles spanning the next 10 years. The charging network established through this infrastructure is aimed at reducing range anxiety and increasing convenience for PEV drivers. Cycle 1 will invest $200 million in California and $300 million across the rest of the country to install 2,500 non-proprietary EV chargers at over 450 station sites. The sites will be located along high traffic corridors. In California, each location will include 4-10 DC fast/ultrafast chargers capable of delivering power at 150 kW to 350 kW. Sites outside of California will include a mix of Level 2 and DC fast charging stations with power delivery capabilities of 50 kW-150 kW. The American Public Power Association is coordinating with Electrify America to advance PEV adoption and charging infrastructure in public power communities.

Most EVSE and PEVs are equipped with a standard connector based on the Society of Automotive Engineers (SAE) J1772 standard. All major vehicle and charging system manufacturers support this standard, and vehicles with this plug can use Level 1 or Level 2 charging stations. Most PEVs equipped for DC fast charging are using the CHAdeMO[12] connector; however, a growing number are using a competing connector based on the SAE J1772 plug that adds DC connections just below it rather than requiring an all-new outlet on the vehicle, shown in Figure 3. Tesla uses its own DC plug type for its charging stations. DC fast charging equipment has an internal AC-to-DC converter, allowing the unit to deliver DC directly to the PEV at rates higher than the vehicle's onboard inverter can handle, which speeds up battery charging. Additionally, manufacturers may offer the fast charging connector as an option rather than as standard equipment on fast charging-capable vehicles due to the price of including the fast charging capability.[13]

Typically, BEV models include DC fast charging capabilities, whereas most PHEV models do not because of their much smaller batteries. Charging is similar to water flow: fast charging is like a high volume of water flowing quickly into a container. A large capacity container is needed to capture that high flow, which is why the BEVs with larger batteries are better candidates for fast charging than PHEVs with smaller batteries.

Understanding the complexities of power delivery—such as charging times, the variety of charging connectors, levels of charging, and differing vehicle model capabilities—are all factors utilities could consider when assessing PEV adoption and its effects on load growth and infrastructure. Educating prospective PEV owners on these complexities is a key hurdle to PEV adoption.

Operating Cost Comparison

PEVs show benefits in operating cost compared to traditional vehicles. PEVs use a domestically produced fuel—electricity—which typically costs less than gasoline to fully fuel a vehicle. PEVs also have reduced maintenance requirements due to fewer parts and less complexity compared with traditional vehicles. As Table 2 shows, the BEV version of Hyundai's Ioniq has a drive cost of $0.81 for 25 miles compared to the hybrid version's $1.07. The savings are amplified even more when compared to a non-hybrid traditional vehicle such as the Hyundai Sonata, a similar sized sedan with a cost of $2.07 to drive 25 miles. A

[12] CHAdeMO is a DC fast charging standard supported by Mitsubishi, Nissan, Toyota requiring a separate port from the SAE 1772 AC charging port.
[13] US Department of Energy, *Plug-In Electric Vehicle Handbook for Public Charging Station Hosts.* 2012. https://www.afdc.energy.gov/pdfs/51227.pdf

similar trend is seen when comparing estimated annual fuel cost. The BEV Ioniq, hybrid Ioniq, and Sonata have annual fuel costs of $500, $650, and $1,200, respectively.

The initial purchase cost of a PEV like the Ioniq can be reduced when federal and state purchasing incentives (discussed on page 13) are applied to the manufacturer's suggested retail price (MSRP). This reduced price and lower annual fuel cost make the PEV cost-competitive.

Table 2: COST COMPARISON BETWEEN 2017 HYUNDAI SEDANS

	2017 Hyundai		
	Ioniq ELECTRIC	**Ioniq** HYBRID	**Ioniq** GASOLINE
MSRP	**$29,500**	**$23,950**	**$21,600**
Combined MPG(e)	**136**	**55**	**29**
Total Range (Miles)	**124**	**654**	**536**
Annual Fuel Cost*	**$500**	**$650**	**$1,200**
Cost to Drive 25 Miles	**$0.81**	**$1.07**	**$2.03**

** Based on 45% highway, 55% city driving, 15,000 annual miles, national average electricity prices in Aug 2017. Source: U.S. Department of Energy*

PEV Market Forecast

Forecasting markets can be challenging due to the number of factors that can influence them. This is especially true for the dynamic electric transportation market. The electric transportation market fluctuates as OEM participants and models increase, battery producers adjust costs, and regulatory pressures and government incentives change. Furthermore, the implications of factors such as automated vehicles are relatively unknown and may affect the future of the market. Navigant Research developed forecast models that make use of current market information and updates them annually as new information arrives.

The PEV regional sales forecasts model uses high-level macroeconomic factors like GDP, population, vehicle density, and historic sales data to project overall light duty vehicle market growth within a given area. These Navigant Research models show an anticipated increase in PEV sales, especially in certain areas such as the west coast. The energy consumption model uses PEV sales predictions and electricity usage rates to forecast the amount of electricity that will be consumed due to PEVs. Increasing PEV sales leads to load growth, which is why it is important for utilities to monitor the adoption of PEVs in a service area.

PEV SALES

The forecast indicates increasing market growth partly due to growing availability of long-range BEVs and the overall decrease in the price of PEVs from existing models. Markets saw a 37 percent increase in sales of PEVs in 2016. Navigant Research expects 50 percent growth in market sales in 2017 and 2018, largely due to Tesla's Model 3 and other long-range, low cost BEVs coming to the market, as well as larger body types becoming available for PHEVs. By 2021, Navigant Research conservatively projects PEV sales of more than 700,000 units in the United States. If

OEMs continue to produce more 200-mile range BEVs and battery costs continue to decrease, Navigant Research anticipates more than 900,000 vehicle sales by 2021. In the aggressive scenario, a combined 3.5 million PEVs would be on the road in the United States by 2021 versus 3 million in the conservative scenario.[14] While the forecasts take into account the emergence and adoption of new technology, such as automated vehicles (see Automated Driving Impacts on page 12), it is difficult to predict the impact this technology will have on sales.

REGIONALITY OF SALES

PEV sales in the United States are heavily concentrated in the western states that provide supportive PEV incentives such as California, Oregon, and Washington. Georgia was a leader in sales but dropped off dramatically after removal of a state purchase incentive in 2015 (see Regulatory Trends and Incentives). While California leads PEV adoption, because of changes in the zero emission vehicle (ZEV) mandate program (discussed in ZEV Regulations on page 15) Northeastern states are seeing an increase in marketing and deployment of BEVs by automakers, which is expected to lead to an increase in sales throughout the region.[15]

By 2025, the largest BEV populations are expected to be on the coasts of the continental U.S. and in metropolitan regions such as Los Angeles, California; Seattle, Washington; Portland, Oregon; Kahului, Hawaii; and Boulder, Colorado. Of these areas, Los Angeles and Seattle are public power territories, which highlights public power's potential to be involved in early adoption of PEVs and to set the bar for charging infrastructure and power delivery. These areas are expected to have more BEVs which will demand more DC charging infrastructure. In comparison, areas with high PHEV penetration will potentially require more Level 1 and 2 charging.[16]

The middle section of the country, with lower forecast adoption rates, seen in Figure 4, has a higher proportion of truck and SUV/crossover utility vehicle (CUV) purchases than coastal areas. Early PEV models in the market have been primarily sedans, contributing to the lower uptake of PEVs in the middle of the country. With automakers announcing new body styles including CUVs and trucks, the PEV market could expand to the middle of the country as these roll out. The regionality of PEV adoption is a key consideration for utilities. For some, high adoption could be expected in the next few years, while other service areas may have more time to prepare for increased PEV adoption. Uneven adoption rates are expected within a utility's service territory. Nationally in the United States, we are still in the early adoption phase. Early adopters are typically well educated, have high household income, and at ages 33-40 are younger than the average car buyer (mid-50s),[17] but the current buyer demographic will evolve as the market moves to the mainstream. Monitoring neighborhoods with these supportive demographics can help provide insights towards public power companies' potential need to upgrade infrastructure as PEV adoption increases.

Figure 4:
PROJECTED 100 LARGEST BEV POPULATIONS, UNITED STATES: 2025

Source: Navigant Research

[14] Navigant Research, *Market Data: Electric Vehicle Market Forecasts,* 2016.
[15] Navigant Research, *Electric Vehicle Geographic Forecasts,* 2016.
[16] Ibid.
[17] Ibid.

ENERGY CONSUMPTION

As PEV adoption increases, public power utilities can expect to see electricity consumption increase significantly in the next eight years.

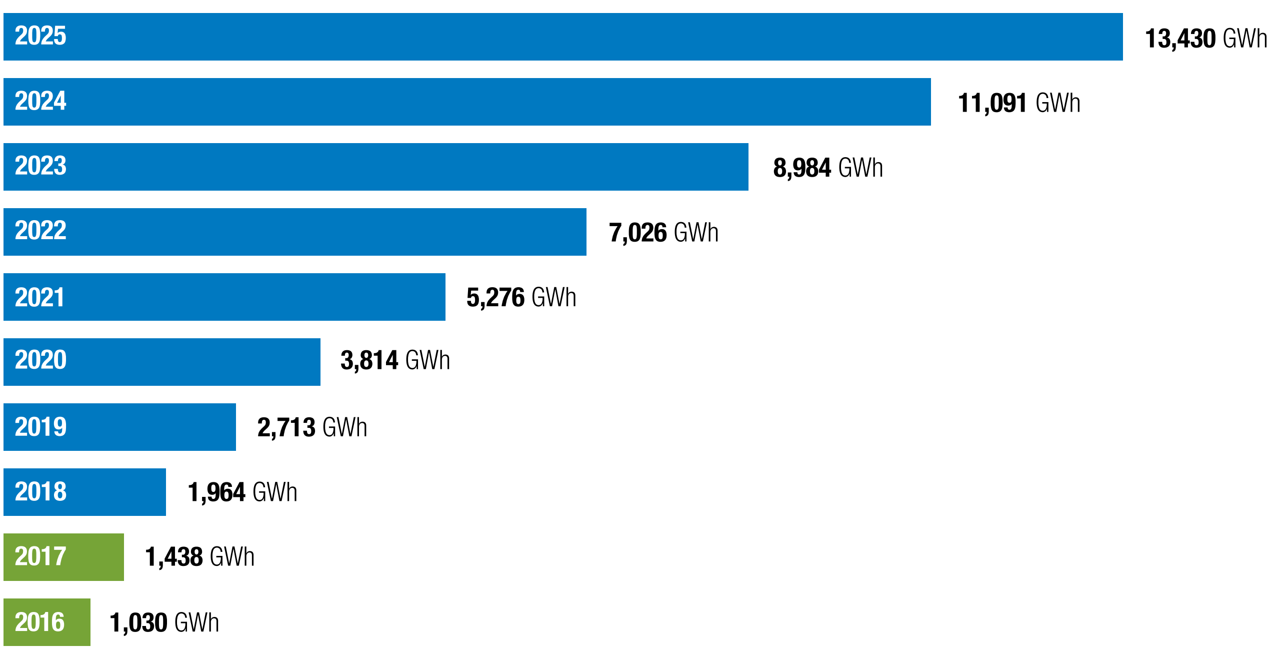
Figure 5 shows Navigant Research's forecast for PEV electricity consumption in the United States. The amount of gigawatt-hours of electricity consumed by electric vehicles in 2018 is expected to be double the amount of consumption of 2016, and 2025 consumption is forecast to be over 13 times the amount consumed in 2016. Such growth could have repercussions for power generation and distribution companies due to the currently uneven nature of these charging loads, unless proactive measures are taken.

In addition to an overall increase in energy consumption, the patterns of consumption may be altered due to varying charging and usage patterns. Individual consumers will likely not be the only segment of the market purchasing PEVs. Key stakeholders including local and state governments are expected to purchase PEV fleets Public power utilities themselves can electrify their fleets to be an example or to test PEVs as a grid asset. Fleets tend to have higher energy requirements due to greater daily usage; these fleets also have different charging needs versus individual buyers. Electrifying a fleet provides an opportunity for public power utilities to advise stakeholders on fleet transition plans and deployment. Engaging government and industry customers in setting fleet charging patterns can help utilities to monitor load and serve as a test case for grid operators in managing predictable charging times. Also, helping local stakeholders makes those key partners aware of what the utility is doing to help make electrified transportation a reality.

Automated Driving Impacts

Automated vehicles are expected to be a key opportunity for PEVs due to electricity offering a much lower cost of operation vs. fossil fuels and electric powertrains requiring less maintenance needs.[18] Automated vehicles will likely be implemented as a shared mobility asset and increase light duty vehicle utilization, thus increasing overall energy consumption. With these vehicles presenting potential new driving and energy usage patterns, new utility strategies for flexible generation and managing distribution could be needed. Public power utilities that monitor their local markets for adoption can provide guidance about how the electrification of this emerging transportation option affects utility operations.

Figure 5: PEV FORECASTED ELECTRICITY CONSUMPTION – UNITED STATES



Source: Navigant Research

[18] Navigant Research, *Market Data: Automated Driving Vehicles,* 2017.

Automated vehicle technology continues to advance in capability. SAE technical standard J3016 defines six levels of driving automation—from no automation (Level 0) to full automation (Level 5). The majority of manufacturers now offer standard or low-cost Level 1 systems across most consumer and commercial vehicle segments, while increasingly capable Level 2 systems are offered on many premium models. Highly automated Level 3 and 4 systems are being tested extensively and governments globally are debating and starting to approve the legislation to allow commercial deployment on public roads. As Level 4 vehicles become more capable and able to handle a greater variety of conditions, they will evolve into fully automated Level 5 vehicles.

Automated vehicles have the potential to bring a range of benefits to society. Long range driving tasks can be made safer, first by introducing increasing levels of assistance to drivers and then by taking over the primary responsibility. Full automation brings many possibilities, including the potential rollout of fleets of vehicles that are available on demand (in high population density areas first). These vehicles could be available at much lower costs per mile than owning a car or using a taxi and would be more convenient than public transport. The rise of automated vehicle technology has the potential to increase the amount of vehicle miles traveled (VMT)—at least initially—therefore creating an unknown factor in energy consumption.

Regulatory Trends and Incentives

Regulatory entities in the United States have begun embracing energy efficiency and smart grid technologies with a goal of making utility systems more stable and efficient. Recent international agreements may play a role in the future regulatory environment for utilities and transportation. Several countries already offer tax incentives for purchasing PEVs, such as the $7,500 tax credit offered in the United States. Also, within the United States, individual states may offer tax credits or other rebates to qualifying customers, which has led to diverse outcomes state to state. Furthermore, automakers in certain states throughout the United States are mandated to sell a certain percentage of vehicles as zero-emission vehicles (ZEVs). These initiatives were developed to help reduce vehicle emissions, and have already led to an increase in PEV adoption. Lastly a new entrant, carbon markets, are emerging to address the challenge of reducing emissions in a different market-based way. The combination of national and local tax incentives, regulatory mandates, and new ways of managing carbon could each help decrease the price of PEVs and make them more price competitive, leading to a change in the direction of the vehicle market.

INTERNATIONAL ACTIONS AND INCENTIVES

In the European Union, a mandatory CO_2 standard was instituted for new passenger vehicles beginning in 2009. The regulation requires each automaker to deploy lower emission vehicles to meet CO_2 emissions targets. New passenger cars in the European Union, on average, should not exceed 130 g CO_2/km in 2015 and 95 g CO_2/km in 2021. While all manufacturers must meet their CO_2 targets across the European Union, the targets do not apply to individual member states. Between 2009 and 2020, it is estimated that these new standards will reduce CO_2 emissions an average of 5 percent per year. They will also likely force new technologies like electric powertrains into the market. Since transportation is typically a top carbon source for developed countries, switching transportation from fossil fuels to electricity can dramatically reduce the carbon intensity at the vehicle tailpipe. However, by electrifying the transportation sector, the carbon challenge will shift to utilities and is a key consideration for them as they create their generation source plans.

In 2017, the United Kingdom announced an end to the sale of gasoline- and diesel-powered cars and vans by 2040, and France announced a proposal for a similar ban of selling gasoline- and diesel-powered cars by 2040. The announcements came soon after Volvo committed to only producing electric and hybrid vehicles from 2019 onward. Both countries are using their respective future bans as a key way to help achieve their carbon reduction pledges.

Outside of the EU, Norway introduced a more ambitious CO_2 emissions standard for new passenger cars in 2012. By 2020, new cars must not exceed 85 g CO_2/km, but the standard does not stipulate penalties for automakers not in compliance.[19] Furthermore, Norway offers PEV purchase incentives in the form of vehicle tax reductions for BEVs through exemptions from the value-added and registration taxes.

In China's 13th five-year plan (which runs 2016-2020), the central government targeted a portion of all vehicle sales to be EVs. To help achieve this goal China incentivized PEV purchases through subsidies and vehicle tax reductions. The incentives are subject to range criteria—only BEVs with a range over 155 miles and PHEVs over 30 miles can

[19] Uwe Tietge, Peter Mock, Nic Lutsey, Alex Campestrini, *Comparison of Leading Electric Vehicle Policy and Deployment in Europe,* ICCT, May 2016. http://www.theicct.org/sites/default/files/publications/ICCT_EVpolicies-Europe-201605.pdf

receive the subsidies. The subsidies are available via the central government through 2020, and their value will decrease 20 percent in both 2017 and 2019. Regarding tax exemptions, PEVs purchased in China are exempt from the acquisition tax and the annual vehicle tax.[20]

UNITED STATES INCENTIVES

Local legislative bodies, such as cities and states, are increasingly taking the lead on national climate issues. Rapid changes in policy by local stakeholders could lead to requests for supporting emissions reduction measures such as helping electrify transportation within the utility territory through supporting charging infrastructure, educational campaigns, or by converting part of a utility's own fleet. Because it may be simpler, OEMs are likely to sell the same vehicles throughout the United States as other states and countries with more stringent regulations, a key consideration for public power utilities to monitor beyond their local markets.

In the United States, a federal tax credit for purchasing a PEV was enacted in 2008. In 2017, the tax credit totaled up to $7,500 per PEV purchase. This incentive is delayed to the consumer due to the need to file federal income taxes to receive the credit rather than the incentive being available at the time of purchase. Adding a bit of complexity, the federal purchase incentive varies based on the size of the vehicle battery, and phases out on an OEM-by-OEM basis once 200,000 credits are claimed for an OEM's PEVs. Tesla appears most likely to be the first OEM to reach the 200,000 threshold due to the debut of its Model 3, which obtained more than 400,000 preorders. Having already sold approximately 100,000 Volts, General Motors may also reach this threshold by the end of 2017 depending on the success of the Chevrolet Bolt.[21] Market players have found a slight workaround for the delayed impact of the tax credit through leases. Automaker-owned leasing companies typically front the customer the value of the credit because they will file for it when they do their corporate taxes. This has led to leasing being popular for many PEVs. Since the credit is OEM-by-OEM, this is an area for utilities to monitor as it is expected the first OEMs to have their tax credit value reduced will lobby for an extension or wholesale alteration of the incentive policy, both of which would have a dramatic impact on the market's sales.

Public power utilities that promote environmentally-friendly activities, such as renewables integration, may also choose to encourage PEV adoption due to the emissions reduction presented by driving electric. Given the increasing number of renewables in a utility's generation mix and EPA standards for vehicle emissions, driving electric may produce a CO_2 emissions savings of 16 percent by 2020 compared to traditional internal combustion engine vehicles.[22] For environmentally-conscious utilities, PEV adoption may be a tool to continue decreasing emissions.

STATE AND LOCAL INCENTIVES

State-level incentives vary significantly in value, availability, and design. Purchase incentives at state and local levels are typically tied to available funding; therefore, the incentive ends when funds are exhausted. Although these may be more transient than federal incentive programs, state and local purchase incentives have proven particularly effective at driving PEV sales; however, they are another area for utilities to monitor due to the potential of the funding exhausting ahead of expectations.[23] Search a database of local and state laws at http://afdc.energy.gov/laws.

In Georgia, a PEV tax incentive that was enacted in 1998 was eliminated in 2015. The tax credit, which began at $1,500 for those purchasing or leasing alternative fuel vehicles, was increased in 2001 to $5,000 for any ZEV. The credit was successful in bringing PEVs to Georgia, so much so that metro-Atlanta had the highest market share for PEVs in the country in 2014.[24] In 2015, lawmakers ended the tax credit and instead implemented a $200 registration fee for all non-commercial PEVs, causing PEV sales to drop. According to the Atlanta Journal-Constitution (AJC), the state registered 1,426 PEVs in July 2015, the month before the tax credit ended. The following month, it registered 242, a decrease of 83 percent. While some of the decrease was due to pulling ahead demand to capture the tax credit before it expired, the market for PEVs less than $100,000 in Georgia has yet to recover.

Colorado has a PEV purchase incentive structure of $5,000 for purchasing an EV and $2,500 for a lease. Colorado's incentive, similar in structure to that of Georgia's prior to its cancellation, has witnessed much less success. Colorado is a middle of the country market that has strong leanings

20 ICCT, "Evolution of Incentives to Sustain the Transition to a Global Electric Vehicle Fleet," November 2016. http://www.theicct.org/sites/default/files/publications/EV%20Evolving%20Incentives_white-paper_ICCT_nov2016.pdf

21 Navigant Research, *Electric Vehicle Geographic Forecasts,* 2016.

22 Alex Hoffman, *Are electric vehicles environmentally friendly?,* American Public Power Association, Sept 2017. https://www.publicpower.org/blog/are-electric-vehicles-environmentally-friendly

23 Ibid.

24 Andria Simmons, "Georgia Slams Brakes on Electric Cars," The Atlanta Journal-Constitution, April 2015. http://www.govtech.com/state/Georgia-Slams-Brakes-on-Electric-Cars-.html.

CASE STUDY

Los Angeles Department of Water and Power (LADWP) EVSE Incentives

CHALLENGE

LADWP strives to be a leader in PEV adoption and GHG emissions reduction. The utility recognized that a lack of charging infrastructure in their territory may be preventing customers from purchasing PEVs. The utility set a goal of 15% of all new vehicle purchases in Los Angeles to be PEVs by 2021.

RESPONSE

In March 2016, LADWP began a rebate program to encourage the installation of EVSE in commercial and residential areas. The $21.5 million rebate program, "Charge Up L.A.!", will run through June 30, 2018.

Commercial customers may receive $4,000 for installation and equipment costs of EVSE, and are encouraged to install more than one charging station. Residential customers may receive $500 for equipment costs and an additional $250 if a separate time-of-use meter is installed.

RESULTS

By increasing awareness of rebate and charging programs via communications with dealers and customers, LADWP has witnessed heightened interest in the program since its inception. As of July 28, 2017, 183 chargers had been installed in LADWP territory via the residential rebate program. The utility expressed that customers were showing interest in the program, and reported that malls and medical buildings normally install between three to five charging stations. LADWP and the City of Los Angeles plan to bring 145,000 PEVs/PEV equivalents and 10,000 commercial chargers to the city by 2021.

to AWD/4WD, along with trucks and SUV/CUV body styles. As discussed in Regionality of Sales (page 11), these body styles are not yet fully represented in the PEV market. With new models coming and a strong incentive, Colorado will be a market to monitor toward seeing an uptick in PEV adoption rates. It is also possible Colorado will see an increase in PEV sales in 2017 and beyond due to incentive updates that make the tax credit available at the point-of-sale.

Public power utilities may have greater access to adoption information from state and local entities who oversee the utilities. State governments could give public power utilities a better understanding of where customers who use purchasing incentives are located. Examples of potential incentives at state and local levels to consider monitoring include special access to high occupancy vehicle lanes, vehicle rebates or tax credits, preferred parking spaces, or rebates for residential EVSE. In rare cases, incentives by entities other than automakers to dealerships for selling PEVs could also be included.[25] Public power utilities may in turn choose to offer charging station installation incentives, such as the Los Angeles Department of Water and Power's incentive program (see case study).

ZEV REGULATIONS

California is one of a few states to require automakers to sell a pre-defined proportion of their total vehicle sales as ZEVs. Due to these regulatory requirements, California regulators, state officials, and utilities are working together to prepare for the forecast influx of PEVs into the market. In 2012, Governor Brown issued an executive order calling for the state government to accelerate the market for ZEVs. The following year, the ZEV Action Plan was released, aiming to put 1.5 million ZEVs on California roadways by 2025.[26] Since then, several PEV models were introduced into the California market and ZEV adoption has continued to increase faster than the rest of the country.

As part of the ZEV Action Plan, the California Public Utility Commission was tasked with working with utility companies to:[27]

- Inform utilities of charging infrastructure installations
- Develop charging standards that help customers to understand the cost of charging
- Include heightened ZEV adoption into smart grid enhancement planning

25 Navigant Research, *Electric Vehicle Geographic Forecasts,* 2016.
26 State of California, *2013 ZEV Action Plan,* February 2013. https://www.opr.ca.gov/docs/Governor%27s_Office_ZEV_Action_Plan_(02-13).pdf
27 State of California, ZEV Action Plan, October 2016. https://www.gov.ca.gov/docs/2016_ZEV_Action_Plan.pdf

- Pilot programs that minimize PEV impact on the electricity grid (including medium and heavy duty V2G capabilities)
- Revise time-of-use (TOU) rates for PEVs

Pieces of California's model for accelerating ZEV adoption have spread to other parts of the country. New York adopted many of the ZEV Action Plan regulations and committed to getting 800,000 EVs on New York roadways by 2025. New York's EV pledge is part of the Multi-State ZEV Action Plan, including Oregon, Massachusetts, Connecticut, Maryland, and Rhode Island, calling for 3.3 million ZEVs on their collective roadways by 2025.[28]

ZEV programs are constructed as a credit-trading scheme whereby automakers are given credits for each vehicle sold within a state based on vehicle characteristics such as range and refueling speed. Automakers are required to produce a certain number of credits per year based on their sales figures in each state. If an automaker is found to be out of compliance, it can be fined $5,000 per credit needed.

Automakers may transfer credits between states that have adopted California's ZEV regulations under specific circumstances and have in the past focused compliance efforts toward California and Oregon where PEV sales are strong. At the end of 2017, automakers will no longer be able to transfer the ZEV credits that BEVs earn between western and eastern ZEV states. This is an effort to push automakers to expand BEV compliance efforts to eastern states.[29]

CARBON MARKETS

Carbon markets, also referred to as carbon trading or cap and trade programs, are created when carbon emission allowances are traded between companies to decrease GHG emissions in a region by limiting a company's CO_2 emissions. In a typical carbon market, emission limits (or caps) are placed on companies and permits are given to emitters to release a certain amount of CO_2. If a company exceeds its emissions allowance, it must purchase permits from other companies. These programs incentivize reducing emissions and fine companies that exceed their allowances.

Two cap and trade programs exist in the United States: the Western Climate Initiative (WCI) and the Regional Greenhouse Gas Initiative (RGGI). Launched in 2013, California created the first state-level carbon cap and trade program in the United States and has since partnered with Quebec to form the WCI. WCI covers a wide range of sectors that account for roughly 80 percent of its overall emissions. Each year, carbon allowances are auctioned off in California, which are tradable in Quebec, and companies bid on the allowances based on the amount they intend to emit. In 2015, the market incorporated transportation and natural gas fuel sales to end-users, increasing the emissions coverage to 403 metric tons of CO_2 equivalent ($MtCO_2e$), in comparison to the 165 $MtCO_2e$ in 2014. The RGGI caps emissions from electricity generation in nine northeastern states and traded 291 $MtCO_2e$ in 2015. The value of the North American carbon market in 2015 was estimated to be $11.6 billion.[30]

In California, PEVs generate carbon credits. The local investor-owned utilities (IOUs) use the value of the carbon credits generated to promote PEVs, which helps seed the PEV market. While carbon markets may increase fuel costs, they could help encourage PEVs by providing a potential revenue stream through load growth. Increased participation in carbon markets could help to bolster the PEV market, creating more revenue for utilities through energy consumption.

28 For more information on the Multi-State ZEV Task Force, see: https://www.zevstates.us/.
29 State of California, 2016 ZEV Action Plan, October 2016. https://www.gov.ca.gov/docs/2016_ZEV_Action_Plan.pdf
30 Thomson Reuters, *Carbon Market Monitor,* January 2016. https://climateobserver.org/wp-content/uploads/2016/01/Carbon-Market-Review-2016.pdf

CHALLENGES TO ADOPTION

Electric vehicles continue to be developed into sophisticated and advanced transportation options. However, significant adoption challenges exist today. Vehicle pricing, range, model availability, and infrastructure reliability are concerns limiting adoption. When consumers consider a PEV, they are also considering shifting their reliance on the established gas infrastructure to an emerging charging infrastructure. Further, there is an awareness gap among consumers about PEVs, which can lead to slow adoption, low returns on PEV vehicle and infrastructure investments, and shortfalls in GHG reduction and efficiency goals. Overcoming this awareness hurdle is critical for the PEV market to thrive and requires intentional and effective collaboration from market stakeholders.

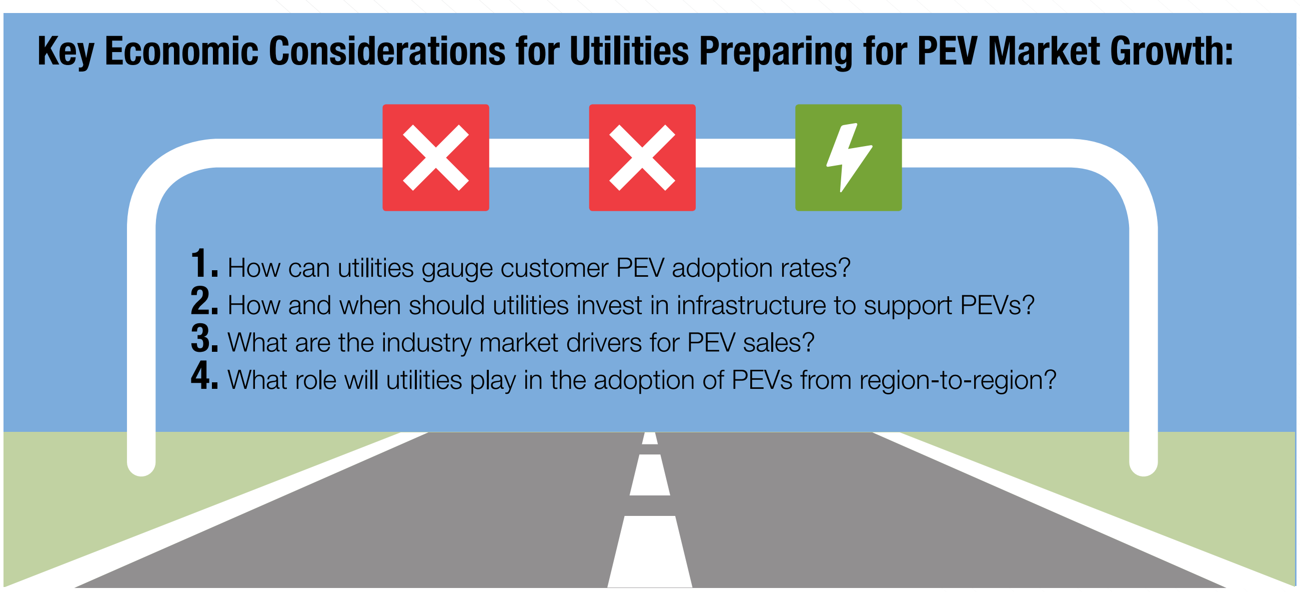
Necessary stakeholders in increasing adoption include:

- **OEMs:** Produce consumer-desired PEV body styles that are long-range, cost-effective, and readily available
- **Dealerships:** Provide consistent, accurate information to customers, thereby increasing the public knowledge of PEVs
- **Utilities/Charging Hosts:** Enable convenient access to charging systems at an affordable price; increase education and awareness of charging networks
- **Consumers:** Purchase PEVs that fit transportation needs
- **Industry Associations:** Create spaces to share experiences and disseminate information on electric transportation trends

Knowledge and Awareness

Public power utilities are in a unique position to educate customers and dealers. While the market is growing, PEVs are not yet a prevalent transportation source. The primary challenge in raising consumer knowledge is the awareness of what PEVs are and can offer to customers and dealers. As sales of PEVs grow and potential customers gain increased exposure, awareness is expected to increase. More PEVs on the streets and highways will reduce the out-of-sight, out-of-mind mentality for potential consumers and help dampen range anxiety. Increased visibility can encourage potential consumers to envision PEVs as an option for their primary transportation. Positive word-of-mouth testimonials can have a large influence on a customer's purchase.

Identifying ways to track changes in knowledge and awareness is one pillar of a successful PEV strategy. The most common way is via surveys that can gauge consumer

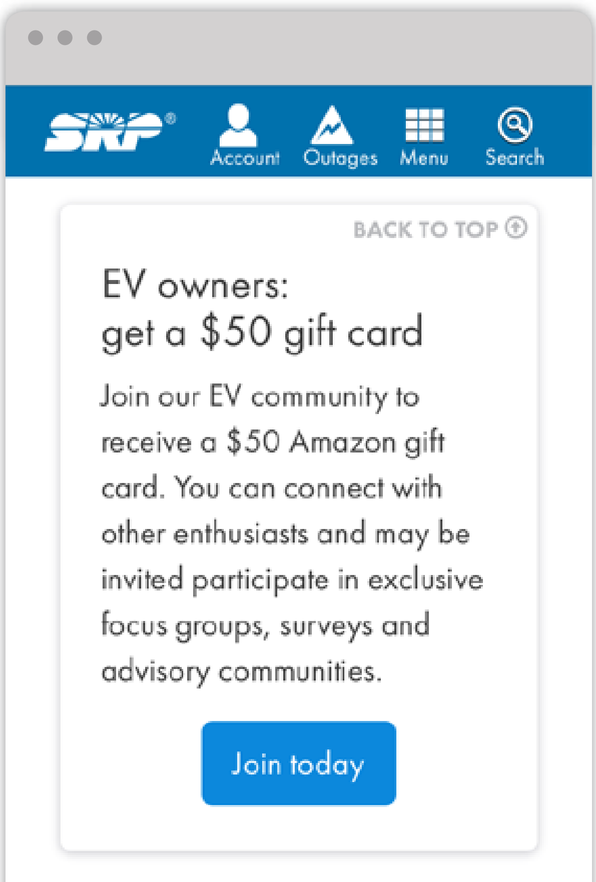


knowledge and track the increase in knowledge over time. Another key influential factor is dealership education. Dealers commit an increased amount of time on PEV consumer education about the differences between a PEV and a traditional vehicle to complete a sale. Automotive salespeople are typically compensated with a per vehicle sold incentive, therefore salespeople aim to spend the least time possible accomplishing a sale as a way to maximize their income. Vehicles that require more time to sell consequently get less focus. Popularly selling vehicles are more likely to lead to quicker sales transactions, and it is common for a salesperson to hop from one dealer to another following the hottest vehicle in a market. The high turnover is an added challenge for many dealerships in keeping salespeople educated about the full array of vehicles offered.

OEMs carry out extensive training with dealerships to try and address this knowledge gap. However, since dealers are independently owned and operated, OEMs are limited in their ability to directly influence dealers. One potential way to address the education gap could be documents that bring together information from multiple PEV market stakeholders. For example, OEMs and public power utilities could collaboratively develop documents that explain the process and ease of charging along with basic vehicle information and details.

As model availability and PEV demand increases, market awareness is expected to grow among both dealership personnel and consumers. To expedite awareness, stakeholders in the PEV market can help PEVs gain visibility through traditional word of mouth discussions, advertising, educational websites and online tools, and social media platforms such as The Salt River Project shown in Figure 6. Finally, as model availability and PEV demand increases, natural market awareness is expected to grow among both dealership personnel and consumers.

Figure 6: SALT RIVER PROJECT EV WEBSITE



Source: Salt River Project Website

Charging and Infrastructure Availability

In choosing to make the leap to PEVs, customers may have concerns about charging infrastructure availability. As seen in Figure 7, potential PEV customers listed vehicle charging infrastructure, price, and range as the highest concerns in PEV ownership.

Regarding cost, with the increase in PEV demand and continual technology advancements, the cost of PEVs has decreased and is expected to continue decreasing over the next few years. This will help address the vehicle price premium.

Range, or the distance traveled before needing to recharge, remains a significant concern for PEV adopters. Higher capacity batteries, which provide longer range, will likely reduce customer concerns for charging availability for unplanned and spontaneous trips. Furthermore, regularly spaced charging infrastructure (like mentioned in the Electrify America box on page 9), in addition to increasing the volume of infrastructure, will allow drivers to plan trips with less anxiety.

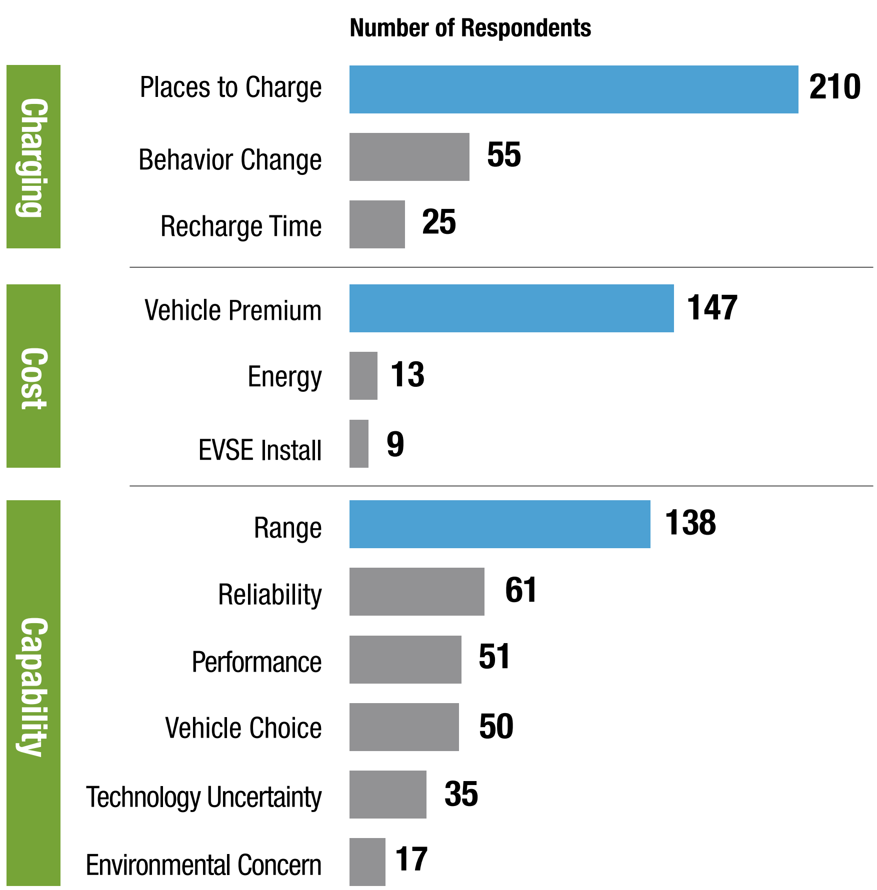
As the PEV market grows, public charging will also need to grow. Smaller capacity vehicles in particular will rely on the public charging infrastructure. Utilities and other stakeholders can confront this concern by communicating when and where a reliable charging infrastructure exists.

All PEV market stakeholders have a role in addressing the ability of the infrastructure to meet charging needs.

Technology advances such as smartphone applications and in-car infotainment systems can communicate to a driver where a charging station exists and when a station is available. Because of solutions like these, range anxiety is expected to decrease with the increase in PEV adoption.

Similarly, the time required to charge a PEV will decrease as technology advances, but the power demand of those

Figure 7: PRIMARY DRAWBACKS TO PEV OWNERSHIP, ELECTRIC VEHICLE CONSUMER SURVEY, UNITED STATES: 2016



Source: Navigant Research

chargers will climb. As discussed in Power Delivery (page 7), AC or DC considerations have various implications on electricity demand. EVSE infrastructure and local grid investments will need to account for various charging power considerations or risk having peak charging times lead to unforeseen challenges.

Another consideration for building charging infrastructure is the differences in charging across types of PEVs. PHEVs require significantly less power and need less charging time than BEVs due to their smaller battery packs. They also have a backup power source via the onboard engine when the battery is depleted. Therefore, PHEV drivers may utilize charging where available. BEV drivers are assumed to have interest in charging options outside their homes, most notably at the workplace, to extend their daily mileage capabilities or simply to reduce range anxiety. Further, some urban living situations like apartments, condos, or other multi-unit dwellings may not allow for installation of chargers leading drivers who live in those places to rely exclusively on non-home charging. Since BEVs do not have a backup power source for when the battery is depleted, public charging is more important for them than for PHEVs. PHEV drivers can choose the most convenient and/or the lowest cost power source.

Each utility has a specific role to play in preparing for consumer adoption through direct or indirect support for accessible and affordable charging infrastructure. Examples of direct support may include items like directly purchasing or incentivizing PEV chargers. Indirect support for charging infrastructure may include actions such as an active role in educational programs, promotion of increased model availability, and preparing for the increase in electricity load demand. Finally, as the market develops, utilities may want to incorporate revenue opportunities from PEV charging through V2G programs, discussed later in Strategic Load Management.

CASE STUDY

Seattle City Light

CHALLENGE

Seattle City Light aims to be carbon neutral by 2050, which will require change in the transportation sector. To encourage adoption of PEVs, the utility believes they should promote access to charging in their service area to reduce charging infrastructure availability issues. Additionally, multi-unit dwellings may not have the ability to install residential charging units, creating more need for public charging infrastructure.

RESPONSE

In 2017-2018, the public power utility plans to install 20 DC fast charging stations at 10-15 sites in its service territory which will be owned and operated by the utility. These stations will charge most of a vehicle's battery in less than thirty minutes. The per session fee for charging will be designed to recover fixed and energy costs. The goal of this initiative is to increase access to charging, especially in areas with multi-family units with less access to residential charging options. Between 2017 and 2019, the utility plans to deploy a residential charging pilot that will offer in-home charging at manageable costs. Furthermore, in 2017 the city of Seattle issued a request for information regarding electrifying its fleet. Seattle joined San Francisco, Los Angeles, and Portland in this request.

RESULTS

Seattle City Light will continue to increase adoption of PEVs in its service territory through other state incentives and by continuing to increase access to charging. For a utility looking to deploy a charging infrastructure program, Seattle City Light recommends implementing a use case that is appropriate for a service area and considering professional assistance when choosing charging station sites.

Model Availability

Model availability of PEVs varies across the United States. This has been driven by areas that have a sales requirement, like ZEV states and locations with an incentive structure to support PEV sales. The locations with favorable support systems have the most models available, as shown in Figure 8.

Initial product launches focused primarily on smaller sedan body style offerings, due to their aerodynamic body helping achieve a set range with a smaller battery size, which helped reduce PEV cost premiums as well. This sedan focus for initial PEV options has introduced adoption limitations, since presently around 50 percent of United States vehicle sales are composed of truck, SUV, and CUV body styles. The market is now catching up, with Tesla, Hyundai, Audi, Kia, Mercedes, BMW, and Volkswagen announcing new SUV and CUV models that will be available as early as 2018.

Public power utilities can join local, state, and federal government in playing a central role in supporting PEV market growth and helping create an environment that encourages adoption; this will, in turn, encourage OEMs to make more models available to more areas.

Figure 8: MODEL AVAILABILITY BY STATE: 2015

Source: IHS Automotive.

GRID LOAD MANAGEMENT AND UTILITY RATE PROGRAMS

Heightened PEV adoption rates could require new strategies for energy distribution and grid load management. The prospect of more customers plugging in their vehicles throughout the day could lead to an uneven increase in load growth and a need for public power utilities to better understand when customers will charge. Infrastructure upgrades may be an option to manage increased grid loads, but factors such as adoption rates, charging patterns, and the type and size of existing infrastructure all affect the need of a utility to upgrade.

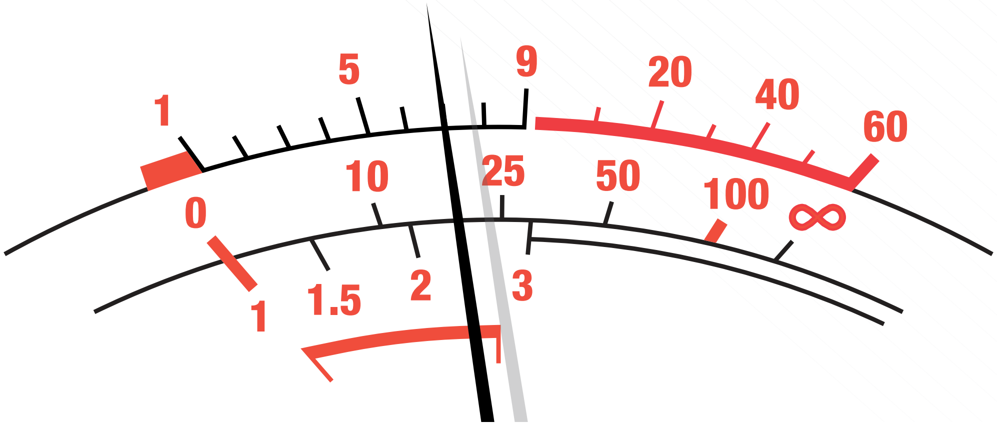
Increased grid load from PEVs could be used to the advantage of power delivery companies. Demand-side management techniques, such as programs that provide rebates and charging-focused rate structures, could offer pathways to helping drivers consider their charging behavior. Such demand-side management programs could manage the expected increased load from PEVs and offer the potential to provide marginally cheaper and cleaner energy by maximizing renewable power consumption. Rebates encourage customers to alter charging habits by providing monetary rewards for charging during certain times of day, so as to avoid peak times. PEV-specific rate structures have the potential to disaggregate the PEV load from the household load, though these rate structures increase the cost to consumers since they typically require a separate meter installation. Program and rate options that provide more value for consumers and align consumer benefit with grid benefit are more likely to be successful. Utilities plan far in advance and any market disruption, like high PEV adoption, can affect rates, incentives, and generation. Planning now for the projected load growth may determine how successful a utility is in the future.

When and Where Do Customers Charge?

As discussed in Regionality of Sales, PEV adoption rates differ from region to region throughout the United States and may show uneven growth even within utility service areas. For example, if a service area spans across state lines, different purchasing incentives could be a factor in growth rates, as well as state regulations and availability of charging infrastructure.

Understanding Uneven Load Growth

- ARE YOU AWARE OF UNEVEN LOAD GROWTH PATTERNS IN YOUR SERVICE AREA?
- ARE YOU TRACKING WHERE THE POTENTIAL LOAD GROWTH WILL BE LOCATED?



Renewables Integration

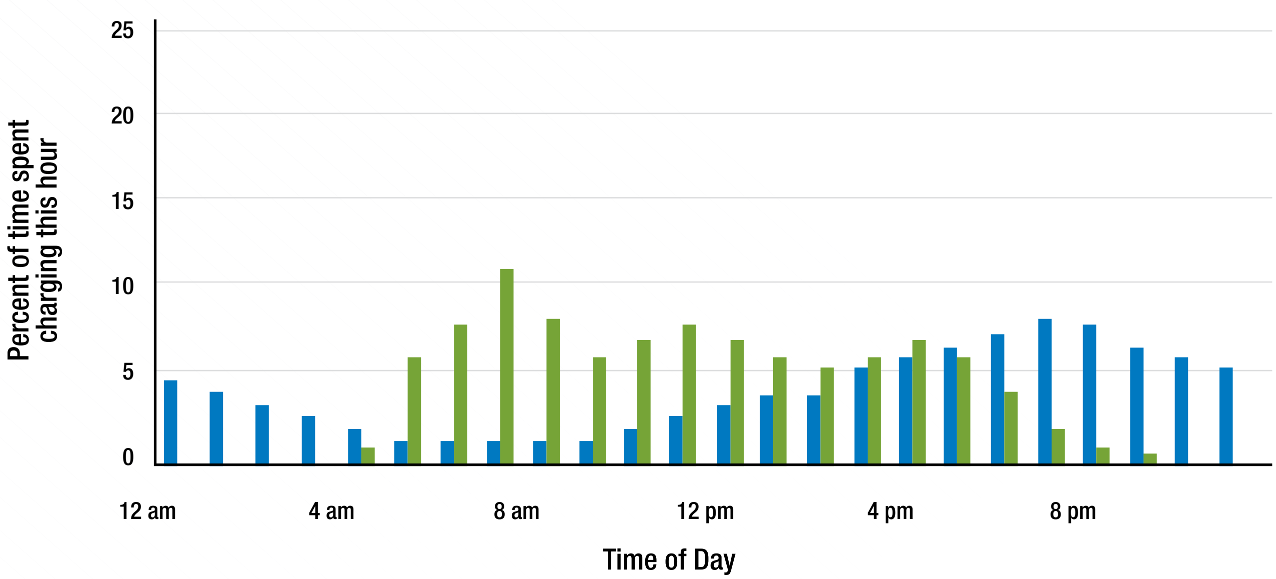
In recent years, energy generation via renewable sources has seen growth worldwide due to decreasing prices, favorable policies, and technology improvements. Utilities can use solar and wind energy in concert with PEVs as a controllable load resource. Workplace charging infrastructure offers potential to be engaged as a tunable load for solar energy, which is available during typical workday hours. Wind energy could be paired with PEV fleets in the evenings, when wind energy is more commonly available. Most fleets would likely not be in use during evening hours and most PEVs driven to work are parked all day, providing opportunities to use renewables and PEVs as a combined system to improve load management options for utilities.

The time of day when customers charge their vehicles could be problematic for utility companies, but incentivizing charging at certain times of the day allows for more efficient load management. As shown in Figure 9, vehicles are forecast to be charged using residential chargers (blue bars) primarily during peak demand periods, such as in the early evenings after work when drivers arrive home. Workplace charging (green bars), if implemented, would incur charging during the daytime hours when a PEV is parked near the owner's workplace. However, if a workplace has solar PV, the local charging could provide a predictable load to help absorb some or all of the local solar production. To avoid PEV charging raising rates for all due to the amplification of peak power consumption periods, utilities may want to consider options for customers to shift charging from being coincident with peak period to off-peak periods.

Strategic Load Management

Understanding where and when PEVs are likely to be charged allows for strategic management of anticipated load growth across service areas. Customer and utility awareness of the charging infrastructure may also be a key factor in load management. Level 1 charging will likely not require management due to the low power delivery rates, but this level is not expected to be the primary means for charging a PEV. However, Level 1 charging could be

Figure 9: UNCONTROLLED, AGGREGATE EV CHARGING LOAD PROFILE



Source: Rocky Mountain Institute

an option for workplace charging to help reduce cost of installation and minimize spikes during daytime high-power use periods. Level 2, DC fast charging, and DC ultrafast charging will require more management from a grid load perspective and are anticipated to be used more by PEV owners.[31] Several rate structures and technologies could be employed to manage anticipated increased grid load, which are discussed in the following sections.

For utilities, TOU, dynamic pricing, DR charging, and the incorporation of VGI or V2G technologies could offer management techniques to address the load growth presented by increasing rates of PEV adoption. Service areas vary in what technique would be most supported or responsive, so understanding where and when customers will be charging are important considerations when aiming to influence charging behavior.

VGI AND V2G TECHNOLOGY

Vehicle-grid integration (VGI) technologies, which have been in development since before the Volt and LEAF were first sold in the United States, are designed to use PEVs as a grid asset. The term VGI refers to a suite of hardware and software technologies that enable PEVs to participate in grid services. PEVs can provide services to the grid by changing the rate at which they consume power, known as vehicle-to-grid communications for charge management (V1G), or by providing power back to the grid, known as vehicle-to-grid power transfer (V2G). Not all charging infrastructure and PEVs are equipped with the necessary technology to participate in grid services, and those that are vary in their capabilities.[32]

VGI benefits utilities by enabling the reduction in the amount of energy needed at peak times by instructing the charging infrastructure and/or vehicle to either reduce charge rates, begin after a delay, or cease charging based on demand. Some PEVs (but not all) can even discharge power back into the grid during peak demand to lower the cost and rate of power delivery, then begin to charge again when demand is lower. This more advanced approach requires additional hardware and adds some communication complexity. While there are promising opportunities for VGI used in conjunction with storage and renewables, no program has yet been implemented past the pilot program stage within the United States. Examples of VGI and V2G programs tested in the United States include the University of Delaware's Grid on Wheels, Pacific Gas and Electric (PG&E) and BMW's iCharge Forward program, and the United States Department of Defense V2G demonstrations on several military bases across the country.[33]

VGI and V2G Implications

- ARE YOU AWARE OF UNEVEN GROWTH PATTERNS IN YOUR SERVICE AREA?
- ARE YOU TRACKING WHERE THE POTENTIAL GROWTH WILL BE LOCATED?

CASE STUDY

University of Delaware & Grid on Wheels-V2G Pilot

CHALLENGE

Increased PEV adoption often brings up questions regarding load growth and whether PEVs could be an asset for the grid. The University of Delaware began addressing these questions in the early 2000s by pioneering work with bidirectional inverters to allow vehicles to provide power back to the grid.

RESPONSE

The Grid on Wheels project began in 2012 to test whether the technology created by the University of Delaware could feasibly be used on vehicles to become a grid asset. Nineteen BMW Mini E's and one Honda Accord PHEV were installed with the bidirectional inverter onboard the vehicles.

RESULTS

Results have shown that the vehicles earned, on average, around $5 per day from ancillary services market participation. The findings and technology from the Grid on Wheels project were used in other V2G demonstrations in Europe, and is being used in a pilot program at the University of California San Diego.

31 Navigant Research, *Market Data: Electric Vehicle Charging Equipment,* 2017.
32 Navigant Research. *Vehicle Grid Integration,* 2015.
33 Ibid.

DYNAMIC PRICING

The concept of dynamic pricing—changing the value of a product based on time and demand—exists in many aspects of society including airline tickets, road tolls, and sporting event tickets. In regards to electricity, dynamic pricing uses the real-time cost of generation to vary electricity prices. Under a dynamic pricing model, electricity prices could change hourly or even more frequently depending on the use of technologies such as smart meters.

CASE STUDY

Sacramento Municipal Utility District (SMUD)

CHALLENGE

SMUD is focused on increasing market adoption of PEVs in its territory and has incorporated transportation electrification load into its demand forecast since 2012.

RESPONSE

SMUD incentivizes PEV adoption by offering customers a $599 incentive to pay for charging for approximately two years, or a free Level 2 charger. To incentivize and monitor usage, SMUD implemented residential time of day rates with peak ($0.15/kWh), summer super peak ($0.32/kWh), and off-peak specifications ($0.09/kWh). In terms of awareness, the utility developed new outreach and education activities, and deployed six public DC fasting chargers. Additionally, the utility is piloting workplace and multi-family incentive programs.

RESULTS

PEV adoption in its territory continues to increase. SMUD's TOU rates and incentive programs will continue, and allow greater transparency to the utility regarding PEV adoption and charging usage patterns. The utility plans to expand its fleet to include more PEVs over the next five years.

Utilities should use caution when evaluating dynamic pricing mechanisms due to customer sensitivities and relatively inelastic demand. Currently, market implementations of dynamic pricing are limited due to factors such as a need for advanced metering infrastructure, a lack of customer education and demand, and a need for regulatory approval. However, technology and distributed energy resources have steadily increased the interest in dynamic pricing as a viable rate structure option for helping with PEV adoption. One example is San Diego Gas & Electric (SDG&E), which received approval in 2016 from the California Public Utilities Commission (CPUC) for a dynamic pricing program within a larger VGI program.[34] SDG&E will release hourly rates a day in advance on their website, as well as a database of recent hourly prices. Charging customers may reference the hourly rates when deciding when to charge.[35]

For utilities, TOU, dynamic pricing, DR charging, and the incorporation of VGI or V2G technologies could offer management techniques to address the load growth presented by increasing rates of PEV adoption. Service areas vary in what technique would be most supported or responsive, so understanding where and when customers will be charging are important considerations when aiming to influence charging behavior.

Residential TOU Rates

TOU rates are a form of dynamic pricing that has seen higher implementation across the country. TOU rates offer different prices for power consumed during different times of the day. The price acts as a signal to customers and aims to influence their charging behavior by showing a benefit for charging at times that alleviate potential strain on the grid. To take advantage of cheaper rates, many PEVs and charging infrastructure are equipped with on-vehicle or remotely connected timers that allow vehicles to schedule charging for off-peak periods. However, a PEV owner could manually take advantage of cheaper rates by plugging in their vehicle during typical off-peak times. Overcoming the manual aspect is a key benefit of automated systems, which are expected to improve consumer acceptance. TOU rates differ from standard dynamic pricing in that TOU offers more predictability to customers, but that is offset for utilities by not necessarily covering the real-time cost of generation.

A couple of example TOU rate designs include:

- **NV Energy:** TOU rates with wide differentials between on and off-peak usage—$0.41/kWh for on-peak and $0.06 /kWh for off-peak power.[36]

[34] Navigant Research, *Dynamic Pricing,* 2016.
[35] Rocky Mountain Institute, *Electric Vehicles as Distributed Energy Resources,* June 2016.
[36] Ibid.

- **Portland General Electric:** TOU rates for on-peak ($0.13/kWh), mid-peak ($0.08/kWh), and off-peak ($0.04/kWh) time periods. TOU pricing periods differ seasonally, but rates remain the same.[37]

One concern for public power utilities is the increase in power demand when vehicles begin charging. PEV interfaces allow consumers to take advantage of TOU rates by programming when to start vehicle charging. If PEVs are set to begin charging when off-peak rates begin, utilities may experience a sharp increase, or ramping-up, of demand. Acting independently, customer charging requirements may lead to load management concerns from utilities, but using aggregation networks can minimize these negative impacts. For example, EVSE networks could administer and dictate charging times of vehicles using their network, or control an EVSE on an individual basis.

DEMAND RESPONSE

Demand response (DR) charging is a specific variant of VGI around making the PEV load partially dispatchable. Charging demand could be controlled through an aggregator, which controls a group of PEVs and their charging needs. The aggregator could be an automaker, or some other market participant, using additional equipment for the vehicle or charger in use. If a grid operator signaled to an aggregator that demand was high, the aggregator could reduce the rate at which PEVs are charged, while still ensuring that vehicles are charged by a pre-set time. eMotorWerks is one such aggregator in California, with plans to control the charging load of 1,000 smart PEV chargers and deliver DR for Southern California Edison, SDG&E, and PG&E. Utilizing systems that control charging in coordination with DR signals present the opportunity of further developing EVSE, specifically DC fast charging. Other value streams include using second-life batteries as storage at charging locations, peak shaving for reducing demand charges, and ancillary service markets like frequency regulation.

FAST CHARGING AND DEMAND CHARGES

Many electric utilities impose fees for power demand as part of their commercial rate structure. The demand charge is related to the peak power used during a monthly billing cycle. If a customer surpasses the allotted amount of power in a billing cycle, demand charges are added to their bill. A demand charge is typically assessed for the highest average power over any 15-minute interval during the monthly billing cycle. Some utilities impose a demand charge for every kilowatt of usage, while others only impose a demand charge when a customer surpasses a certain power threshold.[40]

DC fast charging site hosts can incur demand charges if charging is not carefully managed, as it requires a higher power delivery rate than Levels 1 and 2. During the early adopter period for a new DC fast charging station, the station is used only intermittently. This leads to a challenge with demand charges as a couple of back to back charge sessions can trigger a higher demand charge, but without a steady flow of customers the revenue generated by charging is not enough to cover the demand charge unless the station operator charges a high enough per charge price as to potentially drive off customers. When planning for integration of DC fast charging, it is important to consider the expected peak demand of a site, the utility rate structure, expectations on ramp to high utilization, and how the demand charge would impact the success or failure of the station. No one solution exists for DC fast charging for site hosts, since options—such as installing storage to offset high power demands—add costs and do not completely alleviate the issue.[41]

Effects on Transmission and Distribution

Heightened PEV adoption and the implied grid load increase has the potential to affect electric transmission and distribution networks. Factors such as age of infrastructure, use of smart technology, and climate could all be considered when assessing the potential impact of PEV adoption on electricity delivery infrastructure. Upgrading infrastructure is one method for mitigating these potential impacts; however, infrastructure upgrades may not be necessary for all service areas. A 2014 study by the University of Vermont found that lower temperatures present in most Northern climates allow for higher PEV adoption, whereas certain levels of PEV adoption in higher

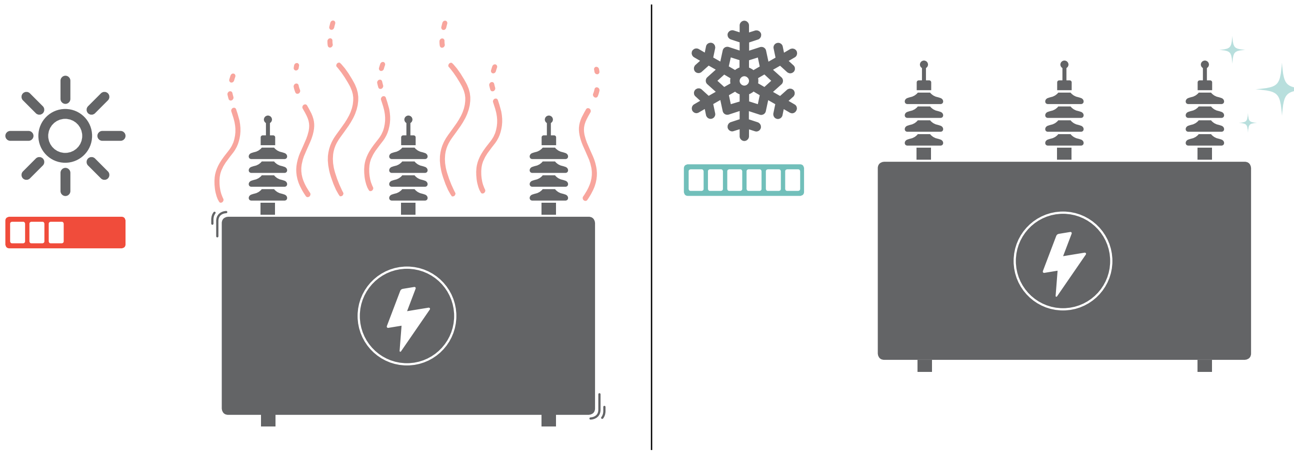
[37] Portland General Electric, "Time of Use Pricing," https://www.portlandgeneral.com/residential/power-choices/time-of-use/time-of-use-pricing.

[38] NREL, *Aligning PEV Charging Times with Electricity Supply and Demand,* June 2017. https://www.nrel.gov/docs/fy17osti/68623.pdf

[39] Rocky Mountain Institute, *Electric Vehicles as Distributed Energy Resources,* June 2016.

[40] Idaho National Laboratory, *What is the Impact of Utility Demand Charges on a DCFC Host?* June 2015. https://avt.inl.gov/sites/default/files/pdf/EVProj/EffectOfDemandChargesOnDCFCHosts.pdf

[41] ECOtality North America, Lessons Learned –The EV Project DC Fast Charge -Demand Charge Reduction Prepared for the US Department of Energy, May 2012. https://avt.inl.gov/sites/default/files/pdf/EVProj/DCFastCharge-DemandChargeReductionV1.0.pdf



temperature climates could cause significant damage to the networks.[42] With lower outside temperatures, transformers can tolerate higher loads for longer time periods than when external temperatures are higher which make transformers more likely to overhear. For many public power utilities, the concerns of the potential impacts on transmission and distribution networks are far enough in the future to allow them time to prepare. Understanding local adoption rates of PEVs and mapping out potential weak points for additional monitoring could be precursors to upgrading utility infrastructure.

“Lower temperatures present in most Northern climates allow for more PEV adoption than higher temperature climates”

— University of Vermont , 2014 study

[42] University of Vermont, “Understanding and Managing the Impacts of Electric Vehicles on Electric Power Distribution Systems,” http://www.uvm.edu/~transctr/research/trc_reports/UVM-TRC-14-010.pdf

IMPLICATIONS FOR PUBLIC POWER UTILITIES

Utilities play a pivotal role in the future of transportation electrification. Increasing battery capacity, decreasing battery costs, and purchase incentives are likely to lead to heightened PEV adoption in the United States. This growth may cause an increased grid load for a utility to manage, and monitoring the market to plan for when new load management strategies might be needed. Distributed energy resources combined with technical innovations provide an exciting future for electrification management in the PEV market. Challenges to adoption, such as awareness, access to charging, recharging times, range anxiety, and model availability, will likely continue to diminish over the next five years.

These issues have implications for utilities and stakeholders, but with proactive planning each issue can be managed. Partnerships with other PEV market stakeholders will be key. For example, the New York Power Authority (NYPA) partnered with the Municipal Electric Utilities Association in 2016 to promote electric vehicles to customers in their service territory.[43] This utility partnership combined forces to build PEV awareness across the state of New York. Additionally, in 2017, New York municipalities, with NYPA's assistance, applied to receive rebates through the state to install charging stations.[44] Utility partnerships can lead to new opportunities to push forward PEV market progress. Partnerships with OEMs and dealers could allow a utility to gain a better understanding of what models are available in certain regions and where people are purchasing the vehicles. For example, in 2014 Austin Energy connected with Town North Nissan and Nissan North America to install DC charging stations near two major highways in Austin Energy's service territory.[45] Partnerships could provide more opportunities to educate customers on available rate structures, and gain data for the utility that could make it easier to anticipate load growth. Errors in anticipating this load growth could have implications for infrastructure investments, but other partnerships with charging networks could be another way of understanding where load growth can be expected.

The following section details pivotal questions utilities could consider when reviewing the implications of an advancing PEV market. Through addressing these questions, a utility will likely be more prepared for the anticipated growth in PEV adoption and better understand the key stakeholders, issues, and internal capabilities of their organization.

Utility Role in Load Management

With the onset of intermittent renewables generation, specifically with solar and wind, public power utilities are dealing with increasingly complex load management. Load growth associated with PEV adoption may need to be incorporated into a utility's existing load management planning due to its potential implications for load and generation planning, customer interactions, infrastructure improvements and maintenance, and rate design. The following questions can help in identifying challenges and opportunities within your organization.

43 http://www.publicpower.org/Media/daily/ArticleDetail.cfm?ItemNumber=6439
44 http://www.publicpower.org/ /periodical/article/nypa-help-municipalities-speed-installation-ev-charging-stations
45 http://www.publicpower.org/Media/daily/ArticleDetail.cfm?ItemNumber=41316

CUSTOMERS

- Are customers aware of PEV-focused rates?
- What feedback are you receiving from your customers regarding PEVs? Feedback can come from community meetings, surveys, and phone calls.
- How frequently are you updating these customer feedback loops?
- Do you know where PEV growth is expected within your area?

INFRASTRUCTURE

- When and where are customers charging?
- What data do you have in regards to customer charging?
- What level of renewables integration is possible with your current resources?
- What level of investment do you plan to put toward PEV infrastructure? Are you an early adopter?
- Are you anticipating infrastructure technology advancements? How will you incorporate these advancements?

PRICING AND RATE STRUCTURES

- What price signals will you send to customers who are charging? When will those price signals change? What are metrics that will determine the impact of those changes?
- How might your rate structure impact workplace charging? Fast charging?
- How are you communicating your payment structure to customers?
- What incentives are you or other stakeholders offering PEV consumers?
- What programs are best for your PEV customers? Is there a difference between residential and commercial?

"There are a lot of different things you can do to encourage and embrace the EV market. You can focus on the cars, you can focus on different applications of the vehicles or you can focus on access to electricity, the charging."

—Brendan O'Donnell, Manager, Strategy, Planning & Analytics, Seattle City Light

Utility Role in Building PEV Awareness

Public power utilities have a key role in building PEV awareness among their customer base, including individuals, businesses, and governments. For publicly owned utilities, this is important since a delay in adoption could result in a delay in revenue and return on investment. The following questions can help utilities address PEV adoption-related implications regarding customers, dealers, OEMs, and other stakeholders.

UTILITIES' POTENTIAL CONSIDERATIONS IN ADDRESSING CHALLENGES TO PEV ADOPTION

- What percentage of your customers are current or potential PEV owners?
- What is the current model availability in your territory?
- In what ways does your utility support and/or hinder PEV awareness and knowledge?
- In what ways might your utility support education for consumers and dealers?
- What leverage can you exercise toward incentivizing automakers to bring PEVs to your service territory?

UTILITIES' POTENTIAL CONSIDERATIONS IN ADDRESSING CHALLENGES IN CHARGING

- To what degree should your utility be involved in public charging?
- How many chargers and which type should your utility support in the marketplace?
- What actions might your utility take to help drive PEV adoption within your service territory? Should incentives be considered and if so in what form?
- What could future partnerships look like that would help your utility manage demand?
- What role will your utility take in EVSE ownership, services, and charging?

To better understand their customer base, publicly owned utilities can engage in communication and tracking of key metrics. Developing meaningful partnerships with OEMs and dealers at a national and local level may aid in model availability in the territory, which will also be helpful in forecasting and discussing types of EVSE strategies. Additionally, tracking the announcement of new PEV models will assist in increasing utility preparedness.

Regarding public charging, public power utilities should consider resources such as grants, partnership co-funding, and government goals to meet customer desire for PEVs in their territory. Decisions like investing in charging infrastructure will likely be driven by model availability, lifetime and reliability of chargers, compatibility with customers and utility constraints, and appropriate rates for all or specific charging levels. Consider how best to communicate the program details such as managing infrastructure costs, ensuring access, how the effort is being paid for, and how the infrastructure impacts the territory as a whole. Smaller utilities, discussed in the "What about smaller utilities?" call-out box below, may need to prioritize and focus on their most pressing concerns in their territory in order to have the greatest impact. Partnering with other organizations to outsource and access available external resources is another way smaller utilities could address their needs and goals.

Public power utilities must consider a number of factors when developing a plan for local transportation electrification, including partnerships, available resources, and timeline. Strategy and vision are an important factor in reaching customers and for having achievable methods for increasing awareness. Market modeling and forecasting tools are helpful in creating a strategy that ties program goals to local market realities.

Utility Role in Strategic Partnerships

Since partnerships will be key for most utilities, below are some questions that can help with the process of thinking through who might make the best partners:

OEMS

- Have you identified key partnership opportunities to pursue with OEMs?
- What models are OEMs offering in your service area?
- What charging connectors do those OEMs use?

OTHER STAKEHOLDERS

- What are the regulatory barriers to PEV adoption in your area?
- Are you working with a public utilities commission, city council, or other third-party hosts to overcome the identified barriers?
- Where are chargers located in your area, who manages them, and where are they needed?
- Are you coordinating with charging networks?

OTHER CONSIDERATIONS

- What marketing strategies are you using to bring PEV awareness to your service area?
- What economic, management, or operational involvement do you have in charging infrastructure?
- Have you considered the impacts of PEV accessibility to middle- and low-income communities?
- What metrics are you regularly monitoring in regards to PEV load management?
- What forecasting tools are you using to anticipate PEV load growth?

WHAT ABOUT SMALLER UTILITIES?

Not all of these efforts require large investments of resources and many can be achieved through partnerships with other key stakeholders.

For example, tracking the market progress can be done through local customer surveys, or by partnering with larger organizations such as state associations, non-governmental groups that are focused on EVs and/or environment, or joint action agencies. Other options could include partnering with other nearby utilities, RTO, ISO, or a similar regional power authority.

Conducting research, planning, and engagement efforts as part of a larger group can help create regional support and idea sharing among electric transportation subject matter experts.

Big budgets and resources will not necessarily lead to success but strong active partnerships across key local influencers and stakeholders is a proven solution to moving a market forward.

Suggested Strategies for Success

Public power utilities can take specific steps to increase customer and dealer PEV awareness. The following outlines three plans for gathering and increasing PEV market knowledge.

1. CREATE A MONITORING PLAN

This plan maintains a history of customer responses to PEVs over time. Such a plan may include identifying and tracking key metrics like:

(1) early adopter demographic areas,
(2) PEV adoption rates,
(3) charging networks active in the area, and
(4) top selling dealers for PEVs.

Ensure incentive structures feed key metrics and adapt infrastructure plans appropriately in response.

2. DEVELOP A CUSTOMER FEEDBACK PLAN

This plan involves proactively seeking out customer input and may include developing a survey to be distributed to a sample of service territory customers on a periodic basis to:

(1) gauge their interest in PEVs,
(2) prioritize their PEV fears or concerns,
(3) receive feedback on communication and incentive strategies, and
(4) gain recommendations for effective awareness programs and addressing dealer education concerns.

3. CREATE AN EDUCATION PLAN

A strategic customer education plan might include developing an interactive webpage using already available information sources to give your customers a resource about key PEV information. Other options could include in-person events or webinars for dealerships to educate them on the changing PEV market and local information including, but not limited to:

(1) model availability and vehicle characteristics,
(2) incentives and other financial benefits,
(3) infrastructure plans,
(4) connections with local PEV advocacy groups,
(5) partner dealers who've met basic PEV awareness and outreach standards, and
(6) basic charging information with utility specific context.

These three plans outline steps that public power utilities can take to increase awareness about PEVs and charging infrastructure. The scope of the plan will depend on the goals and priorities of the utility, but even resource constrained publicly owned utilities can benefit from monitoring and other low-cost tools to stay informed on trends that may affect operations.

CASE STUDY

Portland General Electric (PGE)

CHALLENGE

PGE aims to increase customer PEV adoption, while efficiently integrating PEVs to be an asset for the grid. The utility wants to provide a reliable and accessible charging network.

RESPONSE

In 2010, PGE installed the first public DC fast charging station in the United States, and in December 2016, PGE filed plans to help continue growing adoption in its territory. To provide information on the benefits of PEVs, the utility will conduct an outreach and education campaign for customers. PGE plans to conduct community charging infrastructure and residential smart charging pilots, offering increased charging availability and incentivize purchasing demand response charging equipment. PGE also offers a TOU rate for customers, detailed in Residential TOU Rates on page 27.

RESULTS

PGE is a leader in providing public fast charging and plans to install six additional DC fast charging sites and six electric bus charging stations. The results from ongoing pilot programs will help the utility to better understand when and where customers charge their vehicles. In addition, the utility's TOU rates will likely aid in customer adoption of PEVs.

Conclusion

Public power utilities have several opportunities to advance the PEV market, including strategic partnerships, proactively engaging customers, developing strong forecasting tools, and optimizing present and future PEV load demand. By engaging in the PEV market and addressing the questions stated above, utilities can make informed decisions about PEV adoption and how it affects the electric system. Managing these new challenges will potentially require new approaches to actively tracking metrics, customer feedback, load management, rate design, and technology advancements, but also bring a new load opportunity for utilities.

CASE STUDY

Braintree Electric Light Department

CHALLENGE

Braintree Electric Light Department in Massachusetts aims to increase PEV adoption in its service area.

RESPONSE

The utility saw customer awareness as a key challenge to adoption, and acted to minimize this challenge across its service territory. Braintree promoted PEV adoption through semi-regular workshops that encouraged customers to electrify. The utility has installed public charging stations and leases PEVs for its municipal fleet at $150/month from local auto dealers. Additionally, Braintree offers an $8 per month incentive to PEV owners for charging at off-peak hours, roughly the equivalent of 175 miles of charging, and a $250 rebate for installing a Level 2 charger.

RESULTS

Braintree has increased PEV awareness and adoption in its service area, in addition to leading by example with its electrified fleet. More than 300 residents have engaged with the program and 32 residential PEVs were acquired in 2017. A 2017 customer survey indicated increased satisfaction with the utility due to its EV and community solar initiatives. The utility hosted an event to celebrate the heightened PEV adoption in the community, furthering outreach and education efforts to customers.

APPENDIX A:
UTILITY ADOPTION ROADMAP

Utilities may present different commitment levels to implementing PEV infrastructure depending on where their local markets are on the PEV adoption curve. Figure 10 is a high-level roadmap for utilities at three stages of implementing PEV infrastructure. First adopters are classified as utilities that have already begun integrating PEV infrastructure into their portfolios and currently offer at least one PEV-related program. Mid-level adopters have researched the impacts of the PEV market but have not implemented full-scale programs. Incoming adopters are new to the market and have not yet invested in PEV infrastructure. These categories are intended to encompass major integration milestones. As this roadmap is reviewed, a utility may find value or insight from multiple adoption level categories.

Figure 10: UTILITY PEV INFRASTRUCTURE ADOPTION ROADMAP

	Metrics and Tools	Customer Feedback	Load Management and Rate Structure Design	Technology
Incoming Adopters (Designing)	Identify relevant metrics Develop and build forecasting tools	Identify and establish communication channels Build community relationships to enhance customer outreach	Monitor PEV and EVSE trends Assess current infrastructure capabilities	Assess current technology trends and resource planning Create tracking plan to periodically update internal teams on new market updates and technology releases
Mid-Level Adopters (Implementing)	Review current metrics, tools, and assumptions Compare metrics to industry standards	Optimize communication channels to ensure best practices Test program ideas with consumer panel(s)	Implement PEV-specific rate structures to optimize load management and revenue Upgrade infrastructure as needed	Develop pilot programs to assess impacts of new technologies
First Adopters (Maturing)	Recalibrate strategy tools to reflect market changes Identify secondary market growth opportunities and prioritize	Review results from changes made based on customer feedback and educate customers on these improvements Diversify community engagement through partnerships with other PEV stakeholders	Assess rate structure program performance Adjust strategy for optimal pricing	Implement successful technologies on a large scale Routinely research and update technology as needed

Source: Navigant

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