# THE ABCs OF EVs

A GUIDE FOR POLICY MAKERS AND CONSUMER ADVOCATES

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# EXECUTIVE SUMMARY

**Once a subject of prophecy, electric vehicles (EVs) have now arrived. While still a small share of car purchases, they are becoming a familiar sight on American roads—and industry analysts predict EV sales will grow at a robust clip in the next decade, as consumers become familiar with the advantages of their technology, and anticipated cost reductions and extended driving ranges turn EVs into appealing alternatives to gasoline-burning cars.**

Why should policymakers and consumer advocates concern themselves with EVs? After all, we don't typically focus on end-use electricity—there aren't regulatory proceedings about refrigerators or coffee-makers. However, EVs are different from other appliances in ways that have profound implications for the electricity system.

An EV in the garage could increase the electricity consumption of an average household by 40%—and millions of them could require costly expansion of electric system delivery and generation capacity. But if EVs and EV infrastructure are managed as distributed energy resources, the rise of transportation electrification can lead to lower—not higher—electric rates for all consumers.

This report is intended to help policymakers forge local and regional strategies designed to capture the potential of EV growth to contribute to system optimization. We identify factors favoring EV market penetration; assess its ramifications for the electric grid and the consumers who depend on it; advance a set of principles to protect the interests of electricity customers; describe proceedings and initiatives underway in a number of jurisdictions; and lay out options for state regulatory action.

We conclude that proactive regulatory efforts to set the direction of state policies are crucial at this nascent stage of EV market development. While regulatory outcomes will reflect differences in law, market structure, supply technologies, load dynamics, social goals and other factors, effective EV policy initiatives will have common elements across jurisdictions. They will:

- Benefit from collaboration among the diverse community of EV stakeholders;
- Maximize consumer and social value by employing smart EV dispatch to optimize system load shapes;
- Adopt optional dynamic and time-based rates to incentivize system-beneficial charging behaviors;
- Promote interoperability, common standards, and open networks for EV infrastructure;
- Ensure that EV policies benefit underserved/disadvantaged communities;
- Subject proposed utility investments to cost-benefit tests, performance standards, and compatibility with comprehensive strategic plans designed to maximize grid value and customer benefit;
- Maintain regulatory oversight of any customer-funded or public investment in EV infrastructure.

To craft viable policies, lawmakers and regulators will first need to consider threshold questions about the scope of state regulatory authority and its applicability to a range of issues related to the pace of EV market penetration and its effects in a jurisdiction. The lengthy list of issues to be examined in an EV evaluation process include:

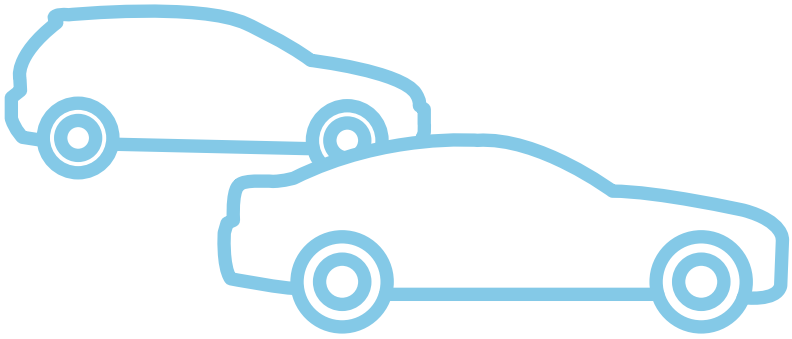
- Implications of EV growth for load shapes, rates and rate designs;
- Available metering, charging, and load management technologies;
- Options for administration, location and support of charging infrastructure;
- Consumer protection rules;
- Consumer education and information;
- Geographic and demographic disparities in EV adoption;
- Allocation and recovery of EV-related costs and investments;
- Value, scale and design of pilot programs;
- Opportunities and obstacles to regional cooperation;
- The roles of public utilities, private vendors, EV owners and other actors.

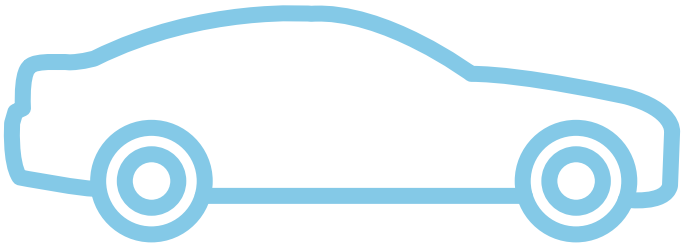
EV issues are complex, and there won't be a one-size-fits-all solution. But if consumer value and system optimization are the central priorities shaping formation of EV policy, public benefit will be the result. This guide is intended to help lay the groundwork for achieving that goal.

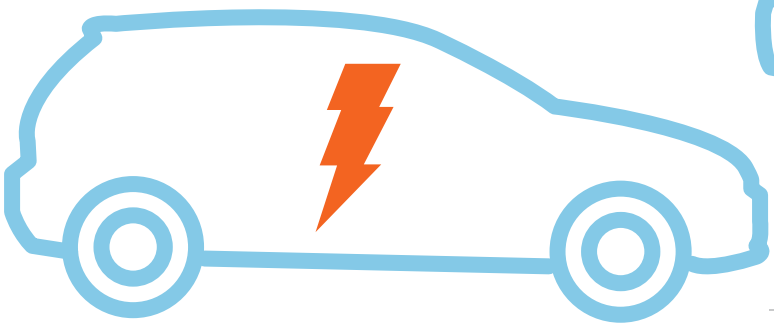
# Electric Vehicles Are Emerging into the Mass Market

Driven by market dynamics, consumer preferences, advances in technology, and public policy, electrification of the global vehicle fleet has begun. While EVs remain a small fraction of the 17.5 million light vehicles sold annually in the U.S. today, EV sales rose by 37% in 2016 and have more than tripled in four years.[1] With 570,187 EVs on the road at the end of 2016, the U.S. ranks third, behind China and Europe, in cumulative sales.[2] Assuming 12,000 electricity powered miles per year and average consumption of 34 kWh to travel 100 miles, EVs are already using more than 2.3 million megawatt-hours of electricity annually, equivalent to the total usage of about 216,000 average households.

With the impending introduction in 2017 of a new generation of EVs with higher range and lower costs, the electrification trend is accelerating and a tipping point toward mass market acceptance may be reached this decade.[3] Market analysts agree that EVs are here to stay, though they offer widely varying forecasts of the pace of adoption. UBS sees EV penetration of the U.S. car market reaching 3% in 2025, a four-fold increase from today but still a fraction of the 22% EV share predicted by Goldman Sachs.[4] Bloomberg predicts EVs will capture 35% of the car market by 2040, with EV unit sales 80 times greater than today.[5] These wide-ranging forecasts reflect different assumptions about EV life-cycle costs, gasoline prices, charging availability, technological advances, environmental policies and consumer behavior. But even at the low end of projections, EV growth will have a substantial positive impact on society. Transportation Electrification (TE) is seen as a key driver of cleaner air, reduced carbon emissions, lower transportation costs, and greater energy independence. This paper focuses primarily on a different goal: How the right set of public policies can use TE to create a more efficient and lower cost electric system.







1 Rising from 52,607 in 2012 to 159,139 in 2016; see http://insideevs.com/monthly-plug-in-sales-scorecard/

2 Data from U.S. Energy Information Administration

3 As used in this paper, EV refers to a car or light truck that plugs in and can drive on electricity only, including Battery Electric Vehicles (BEV) and Plug-in Hybrid Vehicles (PHEV)

4 http://www.goldmansachs.com/our-thinking/technology-driving-innovation/cars-2025/ and http://www.goldmansachs.com/our-thinking/pages/new-energy-landscape-folder/report-the-low-carbon-economy/report.pdf

5 https://about.bnef.com/blog/electric-vehicles-to-be-35-of-global-new-car-sales-by-2040/

# EVs Pose Unique Opportunities and Challenges for the Electricity System

Because anybody can buy an EV, bring it home and plug it in, an electric car may appear to be just like any other electrical appliance. But EVs are different from rolling refrigerators because they store electricity and have controllable demand. With large intermittent loads and manageable charging schedules, EVs are an entirely new form of electrical device, with unprecedented potential for consumer and system benefits.

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The physics of electricity—the need to have supply and demand balanced at every moment for the power grid to function—and the limits of 20th century technology dictated the construction of an inefficient electric system. Generation, transmission and distribution were sized to serve peak electricity demands, leaving tremendous excess capacity most of the time. Advanced technology deployed under careful regulatory policy can use EV loads to optimize tomorrow's electric system. Analyses by the Rocky Mountain Institute show that if the entire U.S. fleet of cars and light trucks were converted to electricity, overall demand for power would go up by about 25%, but could be largely accommodated without additional power plants or grid expansion if EVs were charged at optimal times.[6]

Instead of higher costs for generation and delivery capacity that would otherwise be required to serve EV demand, lower costs will be the result if surplus capacity is the primary resource for EV charging. When new utility revenue from EV charging exceeds incremental costs, average costs per unit of energy

decline, which translates into lower electricity rates for all customers. Using EVs as grid-supporting demand response resources could fill gaps in system load shape and reduce utility costs. And in states with significant variable renewable generation, syncing EV charging peaks with solar and wind output could add a further level of system optimization.

Yet high EV penetration could pose challenges to a system that is unprepared for it. For example, early EV adoption appears to be clustering in certain neighborhoods—those where residents can afford to

6 http://www.rmi.org/Content/Files/RMI_Electric_Vehicles_as_DERs_Final_V2.pdf and http://www.rmi.org/RFGraph-US_projected_electric_vehicle_stocks

buy them, and have a garage or parking space with a power source—which has the potential to strain circuits and necessitate distribution capacity upgrades, the costs of which are generally socialized as ratebase expenditures. In vertically integrated electricity systems, the costs of new generators, if needed to serve EV loads, are also borne across the customer base.

EV policy can enhance grid reliability, advance sustainability, and reduce energy costs for everybody, whether or not they have an EV. But these achievements won't happen automatically and there isn't one clear path for every state.

The right mix of policies and programs—reflecting the market structure, supply mix, load dynamics, social goals and other characteristics in a jurisdiction—can make EVs a substantial source of system benefit, but the wrong one (or none at all) could mean higher costs and cross-subsidies.

EV policies concern many stakeholders operating beyond the usual scope of state regulation. Players on the EV field whose actions and interactions influence EV integration include not just utilities, consumer advocates, and regulatory commissions, but charge station providers, car makers and dealers, transportation service companies, electricity generators, regional grid operators, commercial property and charging site owners, community and civic groups, municipal governments, labor unions, demand response aggregators, and other hardware, software and service providers. All of these stakeholders will want to be heard and will have something to add to EV policy consideration. EV regulatory proceedings would benefit from a process to engage interested stakeholders at the outset—not in an adversarial docket but in a collaborative effort that develops a shared base of information and allows a free exchange of ideas and views. In turn, the regulatory outcome could then benefit from a commonly understood set of policy priorities for EV integration, shared criteria for evaluating the success of those priorities and ultimately, a clearly stated common goal.

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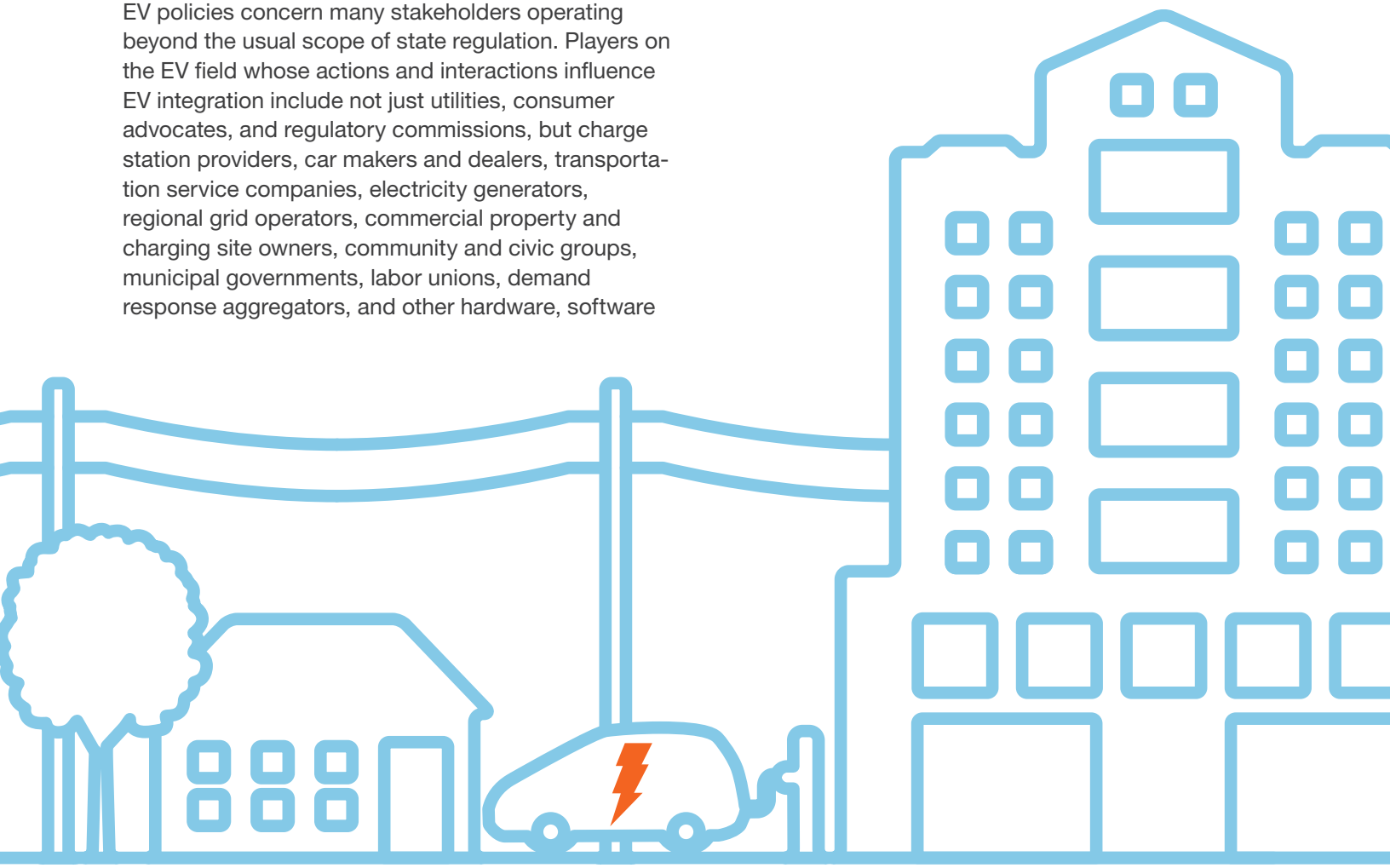

# Effective Public Policy Starts with Customer-Focused Principles

Advancing consumer interests and achieving public benefits are the central goals of sound public utility regulation. Toward those ends, we propose the following core principles to guide public policy discussions:

1. **Optimize charging patterns to improve system load shape, reduce local load pockets, and maximize utilization of renewable generation;**
   *Using a combination of time-based rates, smart charging, financial incentives and other innovative applications, EV loads should be managed in the interest of all electricity customers.*
2. **Ensure any utility customer-funded programs provide demonstrable system benefits;**
   *Cost-benefit analytical frameworks should be developed to project the effects of proposed EV policies and to evaluate ongoing performance of implemented programs. Customer funding of charging infrastructure should include smart dispatch requirements, mechanisms and policies. These can iterate over time as new options become available, but should be part of initial plans.*
3. **Allow EV chargers to be grid-connected efficiently, quickly, and safely;**
   *Administrative process should be minimized and permitting should be expedited so that customers and service providers face minimal impediments and delays.*
4. **Facilitate aggregation of EV demand for dispatch as a Distributed Energy Resource (DER);**
   *The opportunity to participate in Demand Response programs should be made available to all EV chargers, and public policy should make it as seamless as possible to participate.*
5. **Benefit underserved/disadvantaged communities;**
   *A portfolio of EV programs and policies should be designed to benefit all geo-demographic customer segments in a service territory. Efforts to bring EVs to low-income areas could include subsidized EV car-sharing services or EV transit, rather than installation of charging stations in neighborhoods where EVs may be unaffordable or impractical for residents to own.*
6. **Promote interoperability, common standards and open networks;**
   *Any utility investments and subsidies should support deployment of technologies that accommodate all EV makes and models, allow seamless flows of data, and accommodate all EV drivers. Utilities could play an important coordinating role in promoting interoperable, open networks.*
7. **Support competition to accelerate market development, encourage private investment, promote innovation and bring down prices;**
   *Competitors should not be restricted from entering markets for EV-related goods and services. Investments paid for by utility customers require regulatory oversight to protect consumers.*
8. **Deploy utility resources where needed to address public needs;**
   *Where private investment in needed EV infrastructure does not emerge, utility support should be provided to the extent necessary to produce public benefits for its service territory. Putting grid optimization at the center of EV planning is key to reaching this objective.*
9. **Foster coordinated regional planning for systems and infrastructure to accommodate and integrate expanding EV loads;**
   *EV demand is part of complex system dynamics, with potential efficiencies from multi-utility and multi-state coordination.*
10. **Manage EV loads to reduce energy costs.**
    *Increased energy sales to fuel EVs allow utility fixed costs to be spread over a larger number of kilowatt-hours, benefiting all customers when policies and programs are designed to make sure incremental revenue from EV loads exceeds the incremental cost to serve it. EV management can also change load shapes, leading to reductions in peak demand and cost savings from avoided capacity costs.*

How these principles can be realized through innovative policies and programs is the central subject of this paper.

# EV Policy Makers Face Fundamental Regulatory Questions

Each jurisdiction considering EV policy will face a range of questions regarding legal authority, policy framework, and jurisdiction-specific facts. At the outset a commission considering proactive steps must consider threshold questions about its regulatory scope and authority under state law, including:

- **What is the statutory role of public utility regulation in addressing uncertain EV growth?** *Improving reliability and quality of service is at the core of state regulatory responsibility. However, public policy goals and the role of regulators in advancing them vary widely. Some states have explicitly tasked regulators with supporting EVs through policy initiatives and programs. In others, proactive regulatory policies may be authorized by general public interest statutory language.*
- **Does the commission have authority to account for externalities such as environmental effects of energy usage in setting regulatory policy?** *Public utility commissions are generally not charged with environmental regulation, though their oversight of utilities has significant environmental impact. But sustainable energy has become a key goal of many states, often reflected in renewable resource and energy efficiency standards, integrated resource planning, and now in EV support initiatives. Even without explicit environmental goals, if regulatory policies focus on managing EV charging patterns to make the system more efficient, reliable and less costly, the result would include ancillary environmental benefits.*


- **How should EV issues be addressed in long-term planning? Does the commission have authority to include transportation in its scope?** *As technology advances and policies in different energy sectors increasingly overlap and converge toward goals of sustainability and cost reduction, some states are beginning to take an integrated approach to long-term energy planning. EV growth may be a significant new factor, complementary to renewable resource development and delivery system efficiency goals.*
- **Should regulators tackle chicken/egg, cart/horse issues to promote EV expansion?** *"Build it and they will come," is not a traditional basis for regulatory policy, but utilities have always used growth projections for system planning. Any regulatory efforts to stimulate EV markets should be accompanied by policies and programs focused on achieving system benefits.*
- **Does the commission have authority to target regulatory policy at a particular electricity end use such as EVs?** *Regulation has not focused on end uses and generally recovers costs of electricity service through rate designs based largely on energy volumes, demand, time of use, and seasonality; however, the large and intermittent loads of EVs may warrant EV-specific options and incentives for optimized charge management.*

- **Does the commission have authority (and would it be advisable) to require EVs to be on particular rates and/or participate in demand response programs?**
  *Customer choice is generally preferable to regulatory mandates, but incentives for participation by EV owners in programs benefiting all customers might include both carrots and sticks. Optimizing grid value will require policies that impact load shape.*

- **Does the owner/operator of an EV charging station fit the definition of a public utility under current law? Is a charge service provider a reseller or retailer of electricity, or otherwise subject to regulatory jurisdiction?**
  *The nascent EV charge industry asserts that EV charge stations are akin to cell phone charge stations in airports and should not be deemed a regulated provision of electricity. However, statutory language may be interpreted otherwise, or the regulatory category may depend on the pricing mechanisms employed by charge providers. In any case, state regulatory laws were not written with EV charging in mind and will likely need reconsideration to accommodate it. Smart dispatch optimized to reduce peak load and energy prices should be required if utilities build and/or subsidize charging infrastructure.*

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- **Does the commission have jurisdiction and authority to create and enforce standards and consumer protections for non-utility charge station operation?**
  *Competition among EV charge providers may not be sufficient to induce open access and interoperability, or to protect consumers from misleading marketing and price predation. Any public subsidies and utility support for independent charge station operators should be conditioned on their acceptance of regulatory guidelines.*

- **Is installation of EV Supply Equipment (EVSE) subject to permitting, regulation or standards under current law?**
  *Some states have enacted statutory standards requiring licensing of installers by public utility commissions.[7] Others have left EVSE unregulated or under the jurisdiction of local building codes.*

Within its statutory authority and policy objectives, a regulatory commission will face questions about how to make EV policy decisions, including:

- **What factors should be included in a cost-benefit projection for EV-related infrastructure or programs?**
  *Cost-benefit analysis is often used to evaluate utility programs but can raise contentious issues. These may include whether to include social and environmental benefits beyond the traditional scope of commission concern and how to quantify them, as well as projected adoption rates and the time horizon for the analysis.*

- **How should any program or investment costs be allocated among customers and classes?**
  *Cost allocation is a zero-sum game in the short term, and subject to cost of service studies. Whether program costs are allocated across-the-board hinges on the nature and scope of their projected benefits.*

- **What type of evidence is needed for regulators to make EV policy decisions?**
  *Elements of EV policy may be speculative at this early stage but identifying and addressing prospective issues should be a central focus of regulatory inquiry.*

- **How might proposed policies and programs be tested through scalable pilot programs?**
  *Given the uncertainties about EV market evolution, demand for services, and utilization of infrastructure, pilots to gauge the efficacy of different approaches may be warranted (and are underway in several states, as will be discussed later in this paper).*

Another set of questions surrounding EV regulatory policy relates to characteristics specific to the jurisdiction—the local attributes of energy supply, delivery capacity, system loads and other key factors that affect policy options. These include:

7 See charge installer regulations in Illinois for example: http://www.ilga.gov/commission/jcar/admincode/083/08300469sections.html

- **What is the electricity market structure? Vertically integrated? Restructured? How are energy and capacity procured?**
  *In a restructured market (where utilities do not own generating plants and power and energy are procured competitively) the regulated cost of service is generally limited to delivery and customer service. The distinction from a vertically integrated market (where the utility builds, owns and operates power plants as well as the wires system) affects policy considerations. For example, in a vertically integrated system, the embedded costs of power plant investment generally must be recovered in rates even if demand shrinks, and higher demand may precipitate construction of new power plants. In organized wholesale power markets, the output of different generation types is generally reflected in real-time market prices, which would be the basis for smart charging dispatch.*

- **What is the local generation mix, including the marginal generator type during peak periods?**
  *The generation mix and the shape of power output is a key factor in designing EV policies. For example, a state like California, with high solar capacity, may find that the optimal time to charge EVs is generally at mid-day when the sun is shining, whereas a state like Texas, with high wind capacity, may find the optimal charging time is generally overnight. As we will discuss, smart charging can accommodate generation fluctuations in real time for optimized efficiency based on local conditions—including a cloudy day or a windless night.*

- **What is the system load shape and seasonal variation? What are the drivers of demand and supply fluctuations?**
  *The shape of demand is the other side of the always-balanced energy equation. While many systems reach peak annual demand on hot summer days, others may see maximum usage on cold winter nights. Some systems are dominated by commercial/industrial demand and others by residential usage. In all cases, managed EV charging can help fill the gaps and flatten the load shape to make the system more efficient, complementing other demand management programs.*

- **What metering technology is in place and planned? What rate options are available or could be introduced with existing meters?**

*Advanced Metering Infrastructure (AMI), otherwise known as "smart meters"—now installed at more than half of U.S. homes, capture near real-time data on energy consumption, demand, voltage and other end-use characteristic and allow two-way communication with the utility through a digital network. Many other meters use Automatic Meter Reading (AMR), which may be able to store interval usage data for occasional one-way transmission to the utility. Even in places with conventional watt-hour meters, time-based rate options and smart charging may be feasible with installation of additional equipment.*

- **What utility systems (software, billing, hardware, etc.) would need modification to accommodate EV solutions, and at what cost and benefit?**
  *A weak link in the chain of innovative options is often legacy utility software and billing systems. Many jurisdictions are looking at what upgrades would be needed to accommodate advanced technology or whether moving to flexible cloud-based solutions would be optimal. Integration of distributed energy resources (DER), including EVs, will be a primary focus for discussions on how distribution utilities could and should evolve.*

# Why Focus on EVs?

If EVs remain a tiny fraction of the car market, there's little reason to consider changes in regulatory policy to accommodate them. But most signs point to a big increase in EV adoption across the country. Stock market investors are particularly bullish on the prospects for Tesla. Although GM sold 125 times more cars in 2016, Tesla has surpassed its market capitalization and become the most valuable U.S. car company—because investors think Tesla will produce more profits in the long run. Rising market penetration of EVs is propelled by a confluence of potent factors including:

### CONSUMER PREFERENCES

EVs are becoming popular because not only are they healthier for the environment and cheaper to operate, but their performance characteristics are superior to Internal Combustion Engine (ICE) vehicles. With immediate torque, quicker acceleration, low maintenance, smoother ride and lower noise levels (not to mention no exhaust fumes), EVs have been the highest ranked cars in recent consumer satisfaction surveys.[8] Charging at home instead of making a trip to the gas station is an unfamiliar consumer convenience—now made even easier by the introduction of plug-free automatic wireless charging—and the potential to power your car from solar panels on the roof of your home is alluring for customers in sunny climes. Early enthusiasm for EVs was powerfully demonstrated when Tesla announced its upcoming Model 3 and 373,000 customers—more than the annual sales of any other American car—put down a deposit, without having seen or driven it and not knowing the final price nor when they might take delivery.

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"Range Anxiety"—the concern that my EV might run out of juice and strand me somewhere I can't plug in, or leave me waiting for many hours while my battery charges—is believed to be a key barrier to broader market acceptance. A 2016 survey conducted for the National Renewable Energy Laboratory (NREL) found that although half of respondents believed EVs are just as good or better than conventional gasoline-powered cars, most people said they would not buy one unless the range on a single charge were at least 300 miles.[9]

However prevalent range anxiety may be, academic research on the issue shows the concern to be largely unfounded for local driving. A 2016 study by MIT and the Santa Fe Institute found that 87% of cars on the road today could complete their daily trips without exceeding the typical 80 mile range of most first-generation EVs.[10] Manufacturers are well aware that range is a barrier for a large segment of car buyers and are quickly adding battery capacity, with high-end Teslas already having crossed the 300-mile threshold and some less expensive cars expected to join them by 2018.[11] But larger capacity batteries are still costly, keeping these EVs out of reach for many potential customers. Cars with more limited range—and lower prices—may succeed in the market when buyers understand that these vehicles will meet their local driving needs. EV road trips are another matter—in a battery-only EV (BEV), they require a network of fast-charging stations. Until fast charge stations are ubiquitous on highways, BEVs will be primarily urban/suburban vehicles.

For many drivers the ideal car may be a plug-in hybrid vehicle (PHEV). PHEVs operate on electricity for a limited range—about 10 to 55 miles, depending on model—before switching to an auxiliary gasoline

8 See Consumer Reports: http://www.consumerreports.org/cars/the-most-satisfying-cars-for-commuting/ Tesla's Model S received the highest performance rating ever given for a car by Consumer Reports. But Tesla's reliability rankings recently have been below average.

9 http://www.afdc.energy.gov/uploads/publication/consumer_views_pev_benchmark.pdf

10 http://www.santafe.edu/news/item/new-model-electric-vehicles-could-meet-driving-needs-across-diverse-us-cities/, http://news.mit.edu/2016/electric-vehicles-make-dent-climate-change-0815

11 http://en.yibada.com/articles/152860/20160819/volkswagen-announce-300-mile-electric-car-paris-motor-show.htm

engine when the battery runs down.[12] They are not zero-emission vehicles (ZEV) but General Motors estimates that 90% of the miles driven in PHEV Chevy Volts are powered by electricity only, although its electric range is just 53 miles. At the current cost of batteries, it's cheaper to have an extra engine in a car than a huge battery pack, and the Volt sells for about $4,000 less than the battery-only Bolt. As battery costs drop, the differential may disappear, but PHEVs have the advantage of eliminating range anxiety, which is why Goldman Sachs forecasts that 80% of EVs on the road a decade from now will be PHEVs, not BEVs.

## AUTOMOBILE INDUSTRY INVESTMENT

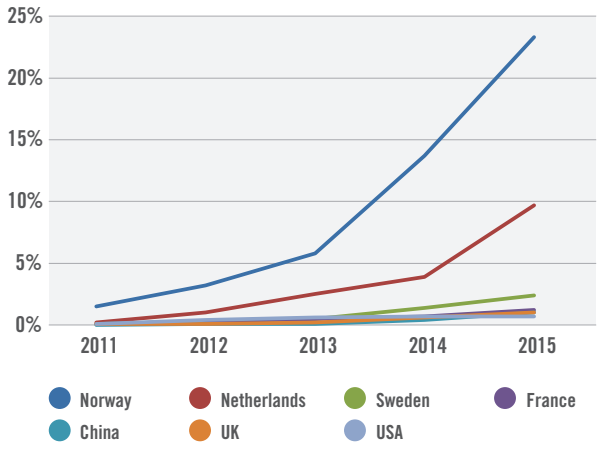
Car companies across the globe are making huge investments in EV development and manufacturing. More than two dozen plug-in vehicles are available in the 2017 U.S. market, including pure electric cars such as the Nissan Leaf, Chevy Bolt and the Tesla models, as well as PHEVs such as the Chevy Volt and the Ford Fusion Energi. Federal loan guarantees and grants supporting EV research and development in the U.S. are subject to potential curtailment, but intensifying global competition will continue to drive EV innovation. Manufacturers recently adding to the stream of new EV model announcements include BMW, Audi, Subaru, Fiat Chrysler, GM, Honda, Hyundai, Jaguar, Kia, Mercedes, Nissan, Renault, Tesla, Toyota, Volkswagen, Volvo, and a raft of Chinese companies led by BYD, the world's largest volume EV manufacturer. Seven countries reported EV market share exceeding 1% in 2015: Norway, the Netherlands, Sweden, Denmark, France, China and the United Kingdom. Norway led by a wide margin, with EVs totaling 23% of new car sales (increasing to 30% in the first half of 2016 and more than 50% in early 2017).[13] In pollution-plagued China, which has every incentive to electrify its fleet, government subsidies may soon bring the cost of an EV below $8,000, and Chinese EV sales have surpassed the U.S.[14]

## FEDERAL AND STATE POLICIES

Crucial to initial EV sales have been federal tax credits of up to $7,500 per vehicle, plus a range of state incentives and policies.[15] Colorado has the highest state tax credit of up to $5,160, bringing the available financial incentives to as much as $12,660.[16] The importance of tax credits in stimulating demand was demonstrated in Georgia—which had been home to the second highest number of EVs—where elimination of the $5,000 state credit, and its replacement with a $200 annual fee, resulted in an 80% drop in EV registrations.[17] Federal tax credits are embedded in the tax code and subject to Congressional oversight.[18] Under current law, federal credits begin to phase out when EV sales volume for a manufacturer reaches 200,000 vehicles, so in any case EVs will

12 Some PHEVS, such as the Toyota Prius, plug-in operate on a system that uses both motors simultaneously, with the ICE kicking in for acceleration and higher speeds. Technologies vary, and the latest Volt has two electric motors as well as the gasoline engine.

**Figure 1: International EV Market Penetration**




Source: International Energy Association's 'Global EV Outlook' for 2016

13 https://www.iea.org/publications/freepublications/publication/Global_EV_Outlook_2016.pdf; and http://www.greencarreports.com/news/1109339_half-of-norways-new-car-sales-are-now-hybrids-or-electrics

14 http://www.autoblog.com/2016/11/06/cheap-electric-vehicles-china-carlos-ghosn/

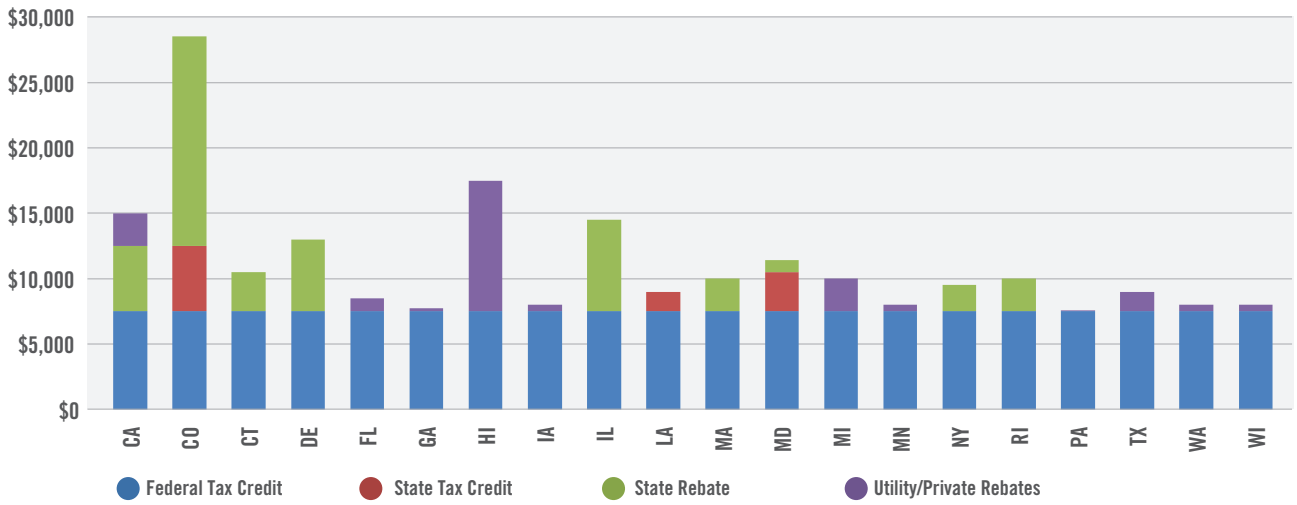
15 The U.S. Department of Energy maintains a database of all state and federal EV-related laws and incentives: http://www.afdc.energy.gov/laws/. Also the National Conference of State Legislatures maintains a state-by-state listing of policies and programs: http://www.ncsl.org/research/energy/state-electric-vehicle-incentives-state-chart.aspx#il

16 State rebate is assignable to the car dealer, allowing a reduction in cost at point of sale regardless of buyer's tax status. 11 states have state tax credits, tax waivers or rebates.

17 See http://www.myajc.com/news/state-regional-govt-politics/here-why-electric-car-sales-are-plummeting-georgia/INGjfnDMALGkv2iUzwwXlO/

18 The EV federal tax credit varies based on the size of the battery. For a small capacity PHEV like a Prius, the credit is $2500 and reaches $7500 for an all-electric vehicle or longer range PHEV like the Chevrolet Volt. The tax credit is provided to the buyer of the car or to the leasing agent, which allows people who do not owe enough in taxes to take advantage of the credit to derive its benefit.

**Figure 2: Combined Maximum State and Federal Tax Credits and Rebates towards EV/EVSE Purchase Price**




Source: U.S. Department of Energy's database of State EV Incentives

have to compete without federal subsidies to achieve high market penetration.[19]

Combined Average Fuel Economy (CAFÉ) standards for cars and small trucks are slated to rise about 5% per year, reaching 54.5 mpg in 2025 under current federal policies. Even assuming continued advances in ICE vehicle efficiency, EV market share would have to reach 11% — 900,000 cars and trucks produced for the U.S. market in 2020—to meet the standards, according to a study by the World Energy Council.[20] While CAFE standards are subject to changes in federal policy, EV support at the state level remains high. California— where half of EVs in the U.S. are currently sold—and many other states can be expected to continue their policies favoring zero-emission vehicles (ZEV), regardless of federal policy.

California—where half of EVs in the U.S. are currently sold—and many other states can be expected to continue their policies favoring zero-emission vehicles (ZEV), regardless of federal policy.

Ten states require carmakers to offer ZEVs, and eight states comprising 27% of the U.S. auto market signed an agreement to put 3.3 million ZEVs on their roads by 2025 and to coordinate actions to build a robust EV market.[21] Tesla intends to produce 100,000 Model 3s in its first year, rising to an extremely ambitious 500,000 annual vehicles by the end of 2018. But GM has scaled back first year production of the Chevy Bolt to about 30,000 units. More than two dozen EV models are on the market but many are not yet available outside California and very little marketing has been done by car companies.[22]

ZEVs also include vehicles powered by fuel cells which convert hydrogen into electricity (FCVs) and emit only plain water as a byproduct. Toyota, Honda and Hyundai already have a small number of FCVs on the road in California. With a full tank of compressed hydrogen an FCV is capable of a range equal to a conventional gasoline powered car. However, fuel cell vehicles are a long way from widespread adoption due to high costs, relatively low performance, and lack of readily available fuel. EVs start with a big advantage because their basic fueling infrastruc-

19 For state-by-state incentives details see http://www.plugincars.com/federal-and-local-incentives-plug-hybrids-and-electric-cars.html

20 http://www.worldenergy.org/news-and-media/news/growth-in-electric-vehicles-sales-central-to-closing-emissions-gap/

21 https://www.oregon.gov/ODOT/HWY/OIPP/docs/Multi-State_ZEV_ActionPlan.pdf

22 http://www.ucsusa.org/clean-vehicles/electric-vehicles/ev-availability#.WFrIuvkrKUm

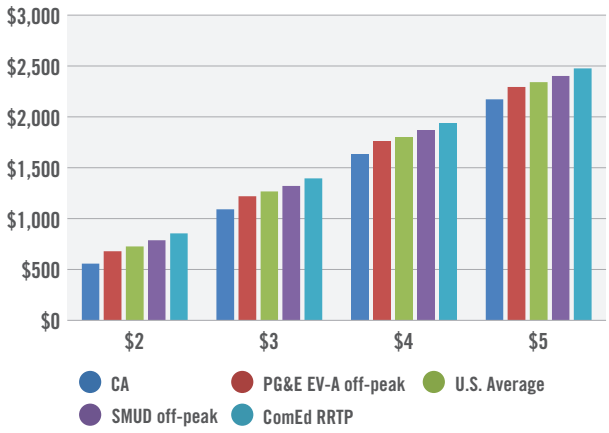
EVs cost less to operate than ICE vehicles, a comparative advantage that will grow as battery and motor technology continues to improve, and EV charging is optimized to reduce electricity outlays.

ture—the electricity grid—already exists.

### VEHICLE ECONOMICS

While EVs are becoming a familiar sight on American roads, there remain significant barriers to mass market acceptance, most prominent of which is today's relatively high purchase price—a gap that is beginning to shrink. EVs cost less to operate than ICE vehicles, a comparative advantage that will grow as battery and motor technology continue to improve, and EV charging is optimized to reduce electricity outlays. Today's EV fuel costs are already substantially lower than comparable ICE vehicles. For example, the 2017 Chevy Bolt has a 60 kWh battery with an EPA-estimated range of 238 miles.[23] At the average residential electric rate of 12.63 cents/kWh, it will cost $7.38 to "fill the tank," compared to $23.80 for gasoline to drive a 25-mpg ICE car the same distance (at $2.50/gallon). Using the national average of 11,244 miles driven per year, that equates to annual fuel costs of $1,125 for the gasoline-powered car and $350 for the EV—a difference of $775, which rises with increased driving. At 18,000 miles, the yearly EV fuel cost advantage reaches $1,450, enough to finance about $8,000 of the additional cost to purchase the Bolt, which at $30,000 after the federal tax credit remains a relatively expensive car for its size. Fuel savings can be higher in locations with off-peak electric rate discounts, but are offset by $200-300 in higher annual costs for EV insurance. For some drivers, EVs are already an economical choice.

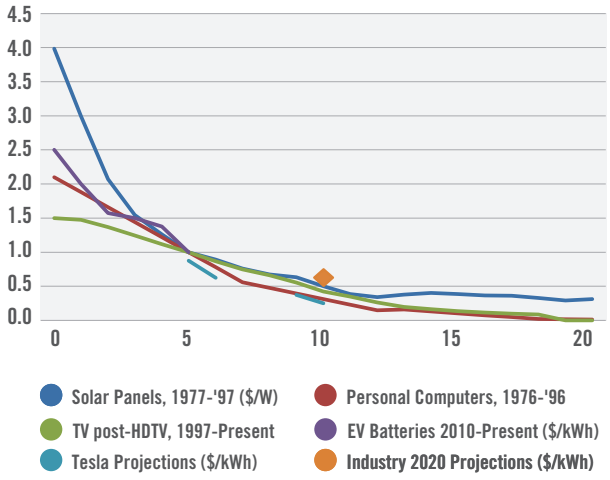
**Figure 3: Annual Fuel Savings of Chevy Bolt vs. 25 MPG ICEV at Varying Gasoline Prices**




Source: CUB calculations, based on rates available on utility websites

23 A reported Bolt road test found the actual range to be higher than 238 miles, however under normal driving conditions and using heat or AC, the anticipated range would be shorter. http://gmauthority.com/blog/2016/10/2017-chevrolet-bolt-ev-goes-240-miles-with-range-to-spare/

**Figure 4: Unit Price Reductions after Major Product Introduction Indexed to Year 5**




Sources:
PV Panels: Bloomberg New Energy Finance
PCs: 'Price and Quality of Desktop and Mobile Personal Computers', American Economic Review
TVs: Consumer Price Index, BLS
Batteries: 'Here's How Electric Cars Will Cause the Next Oil Crisis', BNEF; Cars 2025, Vol. 2, Goldman Sachs Equity Research

EVs also have non-fuel cost advantages over conventional cars. With few moving parts in the motor, simple transmissions, and no oil changes or engine tune-ups, EVs are anticipated to have far lower maintenance costs than ICE vehicles. And electric motors can be expected to last far longer than combustion engines.[24] Chevy's recommended maintenance schedule for the Bolt includes only tire rotation and new brake fluid every five years.[25]

In some locations, the life cycle outlays to own and operate an EV is dropping close to the average cost of similar ICE vehicles, but the differential must disappear for EVs to have maximum appeal. This now appears feasible. Battery costs—which can make up as much as half the cost of an EV—have fallen 50% in recent years and are anticipated to continue their decline. With manufacturing capacity expected to triple, Goldman Sachs forecasts another 62% drop in battery costs by around 2020, as well as technology improvements to cut their weight in half.[26] As EV manufacturing costs drop with higher production, battery technology continues to improve, and innovative rate designs and smart technologies bring down charging expenditures, the cost of owning and operating an EV is projected to become lower than a comparable ICE vehicle. A McKinsey report for Bloomberg New Energy Finance concludes that this inflection point will be reached by the mid-2020s.[27]

24 The useful lifetime of EV batteries is not yet known. While expensive to replace, they are warrantied for 80,000 to 100,000 miles by most manufacturers. EV batteries also have "second life" value for potential home use and grid support when no longer suitable for powering vehicles; however, these applications are not addressed in this paper.

25 Close to zero maintenance makes car dealers reluctant to push EV sales because servicing vehicles is a core part of their business model. Car dealers' lack of enthusiasm may be one reason why most maintain little EV inventory and manufacturers are not widely advertising EV models: https://chargedevs.com/newswire/data-shows-what-we-all-knew-the-auto-industry-isnt-advertising-its-evs/

26 http://pg.jrj.com.cn/acc/Res/CN_RES/INVEST/2015/8/5/2c24a0d8-eda6-4e79-93fb-4c49139f6614.pdf

27 https://www.bbhub.io/bnef/sites/4/2016/10/BNEF_McKinsey_The-Future-of-Mobility_11-10-16.pdf

# The EV Market Is Rapidly Evolving

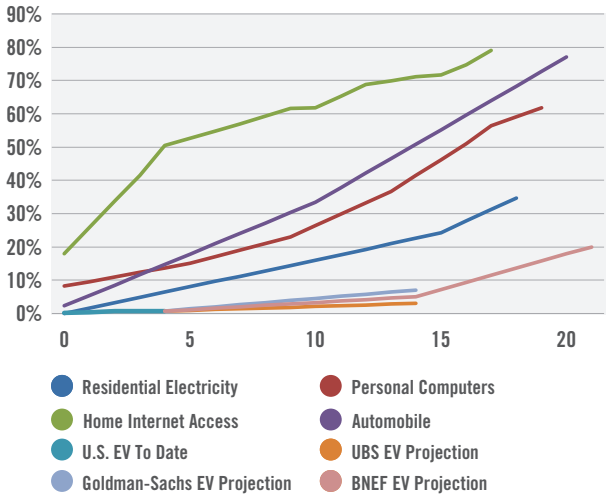
Early adopters in the residential market are beginning to acquire EVs, but broader acceptance will be accelerated by commercial fleets, shared vehicle services, and taxis and livery services, which can take advantage of the scale economies of centrally housed and charged vehicles. As EV range increases and charging time shrinks, drivers for mobility providers like Uber and Lyft may find it economical to use EVs because fuel and other EV operating savings increase with miles driven.

Heavy-duty trucks and buses are also prime candidates for electrification. Like other fleet applications, they can benefit from economies of scale through centralized housing and charging. Their enormous energy consumption and miles driven provide unique opportunities for fuel cost reductions, and their conventional diesel engines are heavy polluters. Giant trucks need giant batteries and a network of fast charging stations on interstate highways, but major truck manufacturers including Mack, Daimler, and Chinese company BYD are investing in electric truck development. The "California Sustainable Freight Action Plan" calls for 100,000 low or zero emission trucks, trains, and other heavy duty vehicles to be in service by 2030.[28]

Local bus transit electrification is feasible now and being piloted around the world. Many manufacturers are developing E-buses, with the most advanced model to date introduced by Proterra in 2016. It claims a range of 200-350 miles on a charge (depending on driving, load, and other conditions), enough for any local route. And it can be fast charged with high voltage in as little as 10 minutes, though most charging would be expected to take place over several overnight hours. They presently cost about twice as much as a typical diesel bus, but battery-electric buses have the same quiet, high performance and low maintenance characteristics of electric cars, and their higher costs can be offset more quickly through greater fuel savings. With more than 70,000 intra-city buses on the road and a replacement rate of about 8% per year, the introduction of cost-effective battery-electric bus transit could rapidly transform the industry. Electric buses can also be used to develop and demonstrate smart (and fast) charging systems and prepare for mass aggregation of smaller EV loads.

To be sure, there are factors that may inhibit EV growth. In addition to the uncertainty of national policies to reduce carbon emissions, these include persistently low gasoline prices, the relatively high cost to purchase EVs (which might not decline as quickly as forecast), the lack of public charging opportunities in many areas, and concerns about degraded battery performance over time. These issues may slow the pace of EV market penetration but, as technology and markets evolve, they are unlikely to stop it.

**Figure 5: Market Penetration of Major Technologies over Time**




Sources:
Electrification: Historical Statistics of the United States, Colonial Times to 1970, US Census Bureau
PCs, Internet: Current Population Study Appendix Table A: Computer and Internet Use, 1984-2009
Automobiles: State Motor Vehicle Registrations, 1900-1995, US DOT
EVs: Global EV Outlook 2016, IEA; The Low Carbon Economy, Goldman Sachs Equity Research, 2015; 'Electric Vehicles to be 35% of Global New Car Sales by 2040', BNEF, 2016

28 http://www.dot.ca.gov/casustainablefreight/

In this early stage it is not known whether EVs have potential for explosive growth similar to personal computers in 1984, the Internet in 1995, cellphones in 2000 or HDTV in 2005. All of these quickly became ubiquitous, supplanting earlier technologies seemingly overnight. EV market penetration may not follow those trajectories, not just because of their higher initial cost but due to a unique barrier to ubiquity: half of American households do not have a place to park a car with an electrical outlet nearby.[29] And those who do, and want a faster Level 2 charge, will have to equip their parking space with higher voltage electrical equipment (at a cost of about $800-$1,000), making an EV purchase a longer term commitment. EVs are similar in this way to rooftop solar panels, which currently are uneconomic for a significant segment of consumers and have an extended payback period. Like distributed photovoltaics, EVs have potential to produce system benefits without dominating the market, and as a result will prompt changes in utility systems and public policy. But already, EVs are sparking improvements in another key area: battery-charging technology.

## Charging Technology Continues to Advance

A typical EV today uses about 30 kWh to travel 100 miles. To get that amount of electricity out of a 120 volt standard wall socket capable of handling 16 amps of current (a high Level 1 charge rate) takes about 15 hours.[30] A Level 1 charge can deliver a maximum of about six miles of travel per hour of charge and many chargers deliver about half that amount. Quicker charges require installation of "Electric Vehicle Supply Equipment" (EVSE), to connect to higher voltage and amperage. Level 2 EVSE uses a 240 V circuit (like an electric oven or clothes drier) and cuts charging time by as much as 75%, depending on the capacity of the circuit and charger. Tesla advertises that its level 2 connector adds 58 miles of range per hour when the car is equipped with optional dual chargers. GM says that the Chevy Bolt will charge from fully depleted to its 238 mile range in about 9 hours using its optional level 2 charger, a delivery of about 26 miles of travel per charging hour.[31] [Note: The charger itself is actually in the car, not in the EVSE. The EVSE just delivers electricity to the charger, which converts AC to DC and sends current to the battery.] The next step up in charging speed is the DC Fast Charger (DCFC), also known as Level 3 or DC Quick Charger (DCQC). Converting alternating current into direct current at 440-480 volts or above, DC Fast Chargers bypass the onboard charger in the vehicle and feed current directly into the battery through a separate connector (which few cars today have as standard equipment and many do not offer as an option). Operating at 30-150 kW, DCFC can deliver up to 250 miles of

29 As reported in a survey by the National Renewable Energy Laboratory: http://www.afdc.energy.gov/uploads/publication/consumer_views_pev_benchmark.pdf

30 The last 20% of a charge takes longer, as the charging rate slows as the battery gets closer to full charge.

31 An option anticipated to cost about $750

### COMING SOON TO URBAN AMERICA: THE SELF-DRIVING CAR

Autonomous vehicles (AVs)—aka "self-driving cars"—are not yet embryonic as a commercial force, but remaining technological obstacles may soon be overcome, as a host of leading tech companies including Apple, Intel, and Google, as well as car manufacturers are racing to solve them. The social and political barriers to AVs are another matter, and it will take time before people are comfortable with the idea of driverless cars on the road. But Tesla has announced that all its cars will soon be AV-capable, Uber has begun operating an AV pilot in Pittsburgh, and General Motors is road testing AVs in its home state of Michigan. Eventually the 100-year-old paradigm of car ownership may be upended because when a car doesn't need the driver, the driver no longer needs a car. This entails a social shift that may seem far-fetched in a culture steeped in car ownership, however "Mobility as a Service" (MaaS) may come to dominate urban transportation markets—and because of cost advantages and fleet scale economies, autonomous vehicles are almost certain to be electric.

range in an hour, though existing stations are not yet capable of that speed and most cars today can't accept such a powerful charge. The Bolt's owner's manual says it can add 90 miles of range in 30 minutes on DCFC, about the same as a Nissan Leaf.

Tesla has installed more than 5,300 of what it calls DCFC "superchargers" at an expanding proprietary network of about 800 stations (about half of which are in the U.S.). The company claims eventually it will be able to deliver a full charge in five to ten minutes (though its current vehicles could not accommodate it).

Improvement in battery technology is the focus of an unending stream of announcements. For example, Samsung says it has developed a battery capable of adding 300 miles of range in 20 minutes—but it will not be in production until 2021.[32] And the co-inventor of the lithium-ion battery that powers most EVs has come up with a solid state battery that holds three times the energy, lasts far longer and can be charged much more quickly. It may be many years from commercialization but is being scaled up for further testing and development.[33]

Volkswagen's Porsche division has demonstrated a fast charger operating on 800 volts, and the technology to fill a battery with electricity almost as quickly as a gas pump can fill the tank is technologically feasible.[34] Such high voltage/high amperage DCFC will certainly be expensive to maintain, as it requires delivery cables to be cooled. Oak Ridge National Laboratory is testing wireless fast-charge equipment that could use electrified roadways and eliminate the need for highway charge stations altogether.[35] But it is not known if or when a path will be found from technical feasibility to mass deployment of ultra-fast charging, and many potential EV drivers simply await greater access to convenient public charging stations.

32 http://electronics360.globalspec.com/article/7983/samsung-develops-electric-car-battery-allowing-a-300-mile-range-on-a-20-minute-charge
33 https://www.sciencedaily.com/releases/2017/02/170228131144.htm
34 https://chargedevs.com/newswire/porsches-new-fast-charger-could-work-with-other-brands-including-tesla/
35 See: https://www.ornl.gov/news/ornl-surges-forward-20-kilowatt-wireless-charging-vehicles and http://thesai.org/Downloads/Volume6No6/Paper_34-Dynamic_wireless_charging_of_electric_vehicles.pdf

### ELECTRICITY 101

Electricity is the lifeblood of modern life, but even physicists don't know quite how to describe it. It has elements of waves, charged particles and magnetic fields, but electricity remains a mysterious force. We do know that when an electric charge moves through a wire it can be harnessed to create energy that can be used to do work, like running a motor or lighting a bulb. Or it can be stored in a battery for later use.

The power of electricity is quantified through the simplified equation of Volts x Amps = Watts. One way to think about these terms is to imagine electricity as if it were water flowing through a hose.

Voltage is equivalent to the size of the hose. Wattage is the pressure in the hose. Amperage is the amount flowing through it. Finally, Watt-hours measure the volume that pours out when you open the faucet.*

For example, at 120 Volts, it takes less than 1 Amp of current (.8333) to power a 100 Watt lightbulb, which in ten hours will consume 1,000 watt-hours of electricity (or one kilowatt-hour (kWh)).

*Please note that this metaphor is not perfectly accurate but close enough for a general understanding.

## Away-from-Home Charging Opportunities Are Expanding

The average U.S. daily round trip commute of 30 miles could be fully fueled by connection to a standard 120 V wall socket during the work day, and many employers are beginning to provide on-site charging as a benefit to employees. Some jurisdictions are deciding that social benefits of EVs warrant public support of employer-provided charging stations, and theorize that people will be more likely to acquire EVs when they see their coworkers doing so—and getting preferred parking and charging as perks of employment.

Level 1 and Level 2 charge stations are becoming commonplace at parking garages, retail stores,


motels, shopping malls and other public locations. These privately financed public charge stations are often provided at little or no cost to the user, a promotional model that may have limited application and does not accommodate the fast charging needed for long trips.

Until 2017, Tesla provided Level 3 fast charging to its customers for free on its expanding DCFC network along several interstate highway routes and in high traffic areas. Under a revamped policy, owners of current Tesla models will pay for charging after the first 400 kWh (about 1000 miles) annually. The impending Model 3 may not be eligible for any free charging. Tesla's charging structure and fees will vary from state to state, not just due to electricity price variation, but because some states prohibit volumetric fees for non-utility charge providers and allow fees to be assessed only by length of charging session. Meanwhile, as part of a strategy to make its technology the global standard for fast chargers, Tesla has said it will open up its proprietary system to other manufacturers if fair compensation can be worked out, though none have yet taken up the offer. Nissan is also building out a fast charging network and—for now—offering its use for free to Leaf buyers. But Nissan cars cannot plug into the Tesla network, and vice-versa. This lack of interoperability is a challenge to EV expansion.

## Interoperability Is Essential to a Seamless Network

Today there are three incompatible fast-charge plug standards in use by EV manufacturers. Each claims to have technological and customer advantages over the others. While this poses no problem for an EV owner plugging into a home charger, on the road a common technology is essential for consumers to be able to get a quick-charge when and where they need it. Otherwise each station would need to be equipped with costly multiple connectors and equipment. One standard may come to dominate the market eventually, as occurred with other new technologies such as video cassettes more than 30 years ago. Such a sorting out process, however, could take many years and be very costly, posing an obstacle to EV growth if not addressed through collaboration among vehicle manufacturers.

A greater barrier lies in the multiple networks for customer transactions, which do not provide a simple and seamless experience for the customer. Making it easy for a driver to charge at any station anywhere in the country is perhaps the most daunting challenge facing the EV charging industry. Interoperability from the customer's point of view—where a driver can plug into any charger and get service from any provider, much like they can use their cell phone on any network—should be a key objective of EV-supportive public policy. State utility commissions as well as regional and national regulatory and advocacy organizations, such as the National Association of Regulatory Utility Commissioners (NARUC) and the National Association of State Consumer Advocates (NASUCA), can play roles in pushing the industry toward interoperability.

Interoperability from the customer's point of view—where a driver can plug into any charger and get service from any provider, much like they can use their cell phone on any network—should be an objective of EV-supportive public policy.

# System Benefits Require Smarts

While it is not true that EVs pose an immediate threat to reliability—most Level 1 chargers draw less current than a hair dryer, or about 10-12 amps—high EV penetrations could pose problems if many people charge simultaneously, especially at high Level 2 current flows, which could reach 60 amps or more. Congestion could occur on a weekday evening in an EV-intensive area if people arrive home from work and plug in to charge simultaneously. If it happens to be a hot day when air-conditioners are also being turned up at the same time, the distribution circuit—and perhaps the local substation—could become overloaded. Meanwhile, at off-peak times and periods of high local solar and wind generation output, the electric system has extensive underutilized distribution and generation capacity that could be used to charge EVs at little incremental cost. The keys to both avoiding the potential problems posed by EV loads and to maximizing their system benefits lie in the application of smart rate design and smart charging, as we discuss in the next section.

The keys to both avoiding the potential problems posed by EV loads and to maximizing their system benefits lie in the application of smart rate design and smart charging.

## Smart Rate Design Is Fundamental to Sound Policy

The structure of electricity rates has a big effect on how much of it is consumed and when consumption occurs. Raising the cost of a kWh will cause people to use less of it. Raising prices at certain times and lowering them at other times will move some usage from the higher priced to the lower priced periods. The amount by which consumers will use less when the price goes up—the elasticity of demand—is relatively low for an essential commodity like electricity, which has some usage that can't be controlled. We can't turn the refrigerator off, no matter the price. But some of us would do the laundry on nights or weekends if the price were discounted, and would turn up the temperature on the AC unit during high priced periods, especially if it were done automatically. If the overnight electricity price were cheap enough we might even take advantage of thermal storage technology such as an air-conditioning unit that makes ice at night to store cold for use during the day (or electric radiators that store heat). And we would certainly want to charge an EV when electricity rates were cheapest, as long as the car is ready to go when we are.

There are at least as many rate designs as there are utilities, but all are intended to provide opportunity for recovery of an amount of annual revenue determined by regulators to be sufficient for long-term reliable service (including an adequate return on investment), while fairly spreading the costs among customers.[36] In rate design theory, fairness is closely aligned with the aim of "assigning costs to cost causers," a principle subject to the overarching public interest standard that utility rates must be "just and reasonable."[37] Ratemaking has always been subject to an array of social goals, including economic development, universal service, support for renewables, load building, load shedding, and load shaping. These sometimes conflicting objectives make rate design proceedings adversarial, as the allocation of the revenue requirement appears at the outset to be a zero-sum game: when somebody's bills go down, somebody else's must go up. While this may be true in the short term, over time rate

36 Many jurisdictions allow "performance-based" or "alternative" rate plans that may boost or shrink utility earnings based on performance relative to certain standards, but these generally do not factor into cost allocation and rate design and are not discussed here.

37 Complicating things a bit further is the fact that in some jurisdictions electricity rates are decoupled—rising slightly to make up for shrinking sales volumes due to utility energy efficiency efforts or adjusting to account for weather and other variables. Some states use "formula rate" adjustments to assure achievement of an immediate return on new technology investment and/or to pass through operational savings to customers. Such annual changes are based on the view that "regulatory lag" between rate cases increases risk and diminishes utility incentives to make investments. Others point out that regulatory lag tends to discipline utility costs.

design can have a big effect on overall utility cost levels as well as economic, social and environmental impacts. No matter how and where you set them, rates send signals as to how electricity is to be valued, which influence the behavior of all actors in the chain of supply and demand, including electricity users, producers, distributors and markets.

An optimal rate design can be win-win-win-win: making EVs more economical, making the system more efficient, improving reliability, curtailing emissions and reducing average unit costs of electricity—while better aligning the interests of the utility and its customers.

An optimal rate design can be win-win-win-win: making EVs more economical, making the system more efficient, improving reliability, curtailing emissions and reducing average unit costs of electricity—while better aligning the interests of the utility and its customers. But the right rate design can be quite different from place to place because it must take into account a long list of variables including market structure, load characteristics, meter technology, generation mix, economic drivers, distributed resources, climate factors and social goals. For example, a largely rural winter-peaking state like Maine, with relatively high industrial load and electricity sourced primarily from hydro, gas and wind may design rates quite differently from a state like Arizona, with a small industrial sector, high air-conditioning use, heated swimming pools, and substantial solar energy development.

Rate designs usually include a combination of monthly fixed fees and volumetric charges. Commercial and industrial rates often have a three-part rate with a demand charge based on maximum usage. Rates of a vertically integrated utility—one that owns and operates power plants as well as the distribution system—are generally "bundled" to recover all costs of service in one set of charges for delivery and supply (often with an adjustment to account for the fluctuating costs of fuel and purchased power). In about half of states, restructuring of the industry is reflected in "unbundled" rates, which separate charges for the monopoly utility system from competitive power procurement. A restructured state like Illinois, with smart meters in place, has a different set of rate options from its vertically integrated neighbors in Indiana and Wisconsin. And each state has its own set of laws and regulatory rules.

Rate design is a way to allocate a known or projected amount of costs among customers, not a determinant of the revenue or earnings of a utility. Elements of typical traditional rate designs and their implications for EV charging include:

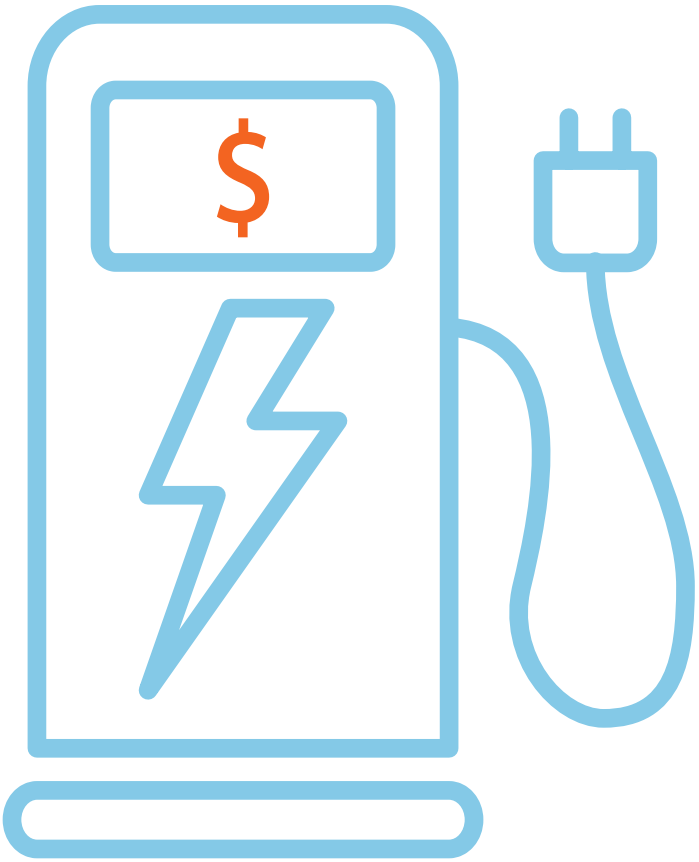
- **Fixed Monthly Basic Customer Charge:** Fixed fees are generally set to recover the costs associated with a customer's service that do not vary with usage, such as the connection, the meter, billing and other customer-based costs. These costs are not different if there is an EV in the garage.
- **Fixed Monthly Distribution Charge:** Because the costs of electric system infrastructure—the poles, wires, transformers and other equipment needed to provide service—do not vary significantly with usage, utilities often would prefer to recover most of these costs through fixed monthly charges rather than volumetric usage rates. Higher monthly fixed charges mean lower per-kWh rates, thus benefiting relatively high volume customers such as EV owners but raising the bills of low volume customers. High fixed charges combined with low volumetric charges also reduces the customer savings from energy efficiency measures and leaves a smaller portion of costs available for time-based rate treatment. For these reasons, consumer and environmental advocates typically advocate for lower fixed charges.
- **Volumetric Distribution Charge:** The portion of delivery services not recovered through fixed charges is collected in each kWh consumed. Most of today's residential rate designs assign an average amount of cost to each unit of energy, without variation by usage volume, time of use, or season. This flat rate provides no opportunity to influence EV charging patterns.
- **Inclining Block Charges (aka Inverted Block Rates):** In an effort to incent energy conservation, some rate designs increase the costs per unit of

energy as a customer's monthly volume increases.[38] This increases the costs of higher volume customers and provides a big disincentive to EV ownership because the cost of charging is inflated regardless of when it occurs.

Optimizing EV charging patterns requires sending price signals to customers indicating when—from the point of view of the electricity system—are the best times to charge. Measuring when usage occurs in addition to how many kWh of electricity are used in a month entails meters that record and retain usage data in each hour or smart meters that communicate consumption levels and other data to the utility in near-real time. Time-based rate options include:

- **Time of Use (TOU) rates:** By charging higher prices in peak periods and lower prices off-peak, rates influence customer usage patterns. The efficacy of a TOU rate structure depends on the pattern and magnitude of its price variation. A market-based rate schedule that approximates differentials between average wholesale prices at different times is not as effective at influencing usage patterns as rates with larger and more uniform price variations. So TOU rates can be calculated using a predetermined Peak to Off-Peak Price (POPP) ratio. For example, off-peak, shoulder peak, and peak rates could be set at easily understood ratios such as 1-2-4 or 1-3-6.
- **Renewable Output Rates:** Variable output of renewable generation can have a dramatic effect on the resource mix, and price signals can optimize use of this zero-incremental cost energy. For example, electric rates could be reduced during peak periods of wind or solar output, and/or EV charging could be managed to coincide with it. However, the difference in impact on local wires systems between distributed rooftop solar and central station solar generators complicates these considerations and requires smart charging technology.
- **Real-Time Pricing (RTP):** In restructured states, where rates for commodity energy are unbundled from delivery services, RTP programs can tie retail energy rates directly to wholesale market price, changing each hour. To date, the only state that offers optional residential RTP is Illinois. While it exposes customers to potential price spikes, experience over eight years in Illinois has shown so far that most customers would see lower bills under RTP.[39] Because off-peak competitive energy prices often are very low—occasionally dropping to zero or below in some wholesale markets—RTP can substantially reduce EV charging costs, particularly when combined with TOU distribution rates and price-responsive smart charging equipment.
- **Demand Based Rates (DBR):** Demand Based Rates collect a portion of delivery costs according to how much electricity is used by a customer at one time, rather than by monthly energy volume or in fixed monthly fees. Generally, DBR rewards customers with flatter load shapes at the expense of customers with steep peaks and valleys of usage. Demand rates are a common component of

38 Declining block rates, under which prices decrease with higher usage, are still employed in some jurisdictions to support large industrial facilities but have largely disappeared from smaller customer rate design.




39 See: https://hourlypricing.comed.com/ and https://www.powersmartpricing.org/

commercial and industrial rates and more than 15 utilities offer some form of optional DBR to residential customers. Their effect on EV costs depends on how the demand charge is calculated. For example, if it uses a simple "ratchet" based on maximum usage in any hour of the month, an EV owner could see high demand charges, particularly if they charged the car while using other appliances and lighting. However, if the DBR was calculated only on demand during peak periods, such as daytime afternoons, a more powerful signal would be sent to charge EVs at night or on weekends, as off-peak charging would incur no demand charges.

High demand charges present a big challenge to cost recovery for the "peaky" load shapes of public fast-charge stations, which may require special rate designs to be commercially viable.

One rate structure is usually applied to all usage on a customer's meter. However, a different set of rates can be used for EV charging through a separate meter or a sensor attached to the EVSE. Disaggregation software with the capability of dividing a household's overall electricity usage into its end use components can also allow vehicle charging costs to be calculated under distinct rates. Separately calculating EV charging costs can be a boon to adoption by customers who fear having all their household usage priced under time of use rates. But it raises the question of whether such a carve-out is appropriate. Under a pilot program of utility PEPCO in Maryland, EV owners could choose to have their EV usage metered and charged separately or to have whole-house TOU rates. Most chose separate EV rates, and in both cases TOU rates had a significant effect on charging behavior.[40]

EVs offer the perfect type of load shape for dynamic pricing, so that kind of rate design should be utilized. Time-based rate options are clearly effective at motivating EV owners to charge their vehicles when they will not burden the utility system. But to further capture the system benefits of EVs' load flexibility requires an additional technology: smart charging.

## Smart Charging Turns Aggregated EV Loads into Valuable DER

Unmanaged charging whenever the owner plugs in the vehicle can be called "dumb charging." But at

40 http://www.utilitydive.com/news/how-pepco-is-finding-ways-to-shift-demand-through-maryland-ev-pilot-program/434156/

### EVs, DER AND THE RISE OF THE "PROSUMER"

The rise of electrified transportation coincides with the emergence of distributed energy resources (DER) as key elements of tomorrow's energy mix. Wind and solar are becoming leading supply technologies while demand response and energy storage are beginning to help balance loads and improve efficiency. Smart grid deployment is creating a more resilient and decentralized electricity system, allowing a growing number of electricity customers of all sizes to become "prosumers"—not just consumers of electricity but compensated participants in DER markets. Some states are considering fundamental and unprecedented changes to the utility concept itself, moving from the traditional hub-and-spoke model with the utility at the center—acquiring, selling, and distributing power and energy to its customers—to a network platform over which the utility facilitates energy resource transactions. EVs could become pivotal distributed energy resources under this evolving utility paradigm, with managed charging to optimize system load shape and the potential to discharge stored energy back to the grid in times of peak demand.* Integrating all these innovations and trends to maximize system efficiency and reliability will be a key mission of the utility of the future.

*Note: Such "V2G" (Vehicle to Grid) transactions are not imminent—constrained by both the deleterious effect on batteries of additional cycling and the lack of a viable V2G business model—however, the systems to make it work are being developed.

relatively low concentrations of EVs using standard 120 V wall sockets for Level 1 charging, it poses few problems, as the draw of an EV on a slow charge is no more than a toaster or hair dryer. However, high neighborhood concentrations of Level 2 chargers could change system dynamics and increase capacity needs, particularly if many vehicles are charging simultaneously.

A smart charger communicates with the utility or central controller and adjusts charging based on real-time circumstances, creating a flexible and manageable distributed resource that can improve the system load shape while saving money for the customer. Controlling variables could include overall demand on the system, local grid conditions, real-time output of renewable generation, marginal plant carbon emissions, and variable electricity prices under the customer's rate plan. Smart chargers could allow aggregated charging demand to be used as regulation service to address momentary fluctuations in voltage and power flows, making chargers into grid-support resources for system operators. By filling in the valleys of system load shape, smart charging can allow high EV penetration while minimizing the need for expanded generation or distribution capacity. Smart charging allows curtailment during critical peak periods, protecting reliable service. As in other direct load control programs, the value of smart charging can be monetized for participants as a demand response resource. And car owners can retain the ability to get a charge whenever they need it or to specify the time by which they need to have a full charge.

A smart charger communicates with the utility or central controller and adjusts charging based on real-time circumstances, creating a flexible and manageable distributed resource that can improve the system load shape while saving money for the customer.

Smart charging aggregation programs are beginning to be designed and piloted. How they will be organized and operated at scale is not yet known; there are many potential service providers and business models. As distribution system operators responsible for maintaining reliable service, utilities may be well-equipped for dispatch of EV charging as a demand response resource under direct load control and as curtailment service bid into wholesale markets. However, aggregation and other smart charging services eventually could be provided by other entities with established customer relationships. These could include retail energy providers, independent charging providers, sellers of charging equipment, curtailment service providers, and vehicle manufacturers. BMW has a smart charging pilot underway in northern California in which its EV owners are paid for responding to charging signals provided by the utility during peak periods. In some cases, BMW supplies "second use" batteries for on-site backup charging service where they can be used instead of real-time generation when advantageous.[41] The company reports 94% success in meeting its load shifting goals.

Incentives for EV owners and charge providers to acquire and use smart chargers may be the most effective application of public investments to support healthy EV growth. Combined with time-based electric rates designed to save customers money when they optimize charging patterns, smart charging is crucial to capturing the potential system benefits of electric vehicles. Another crucial element is utility involvement, and regulators have myriad options in developing regulatory policy.

41 https://chargedevs.com/newswire/next-phase-of-bmws-chargeforward-program-pays-drivers-to-use-smart-charging/

# Regulators Have Many Options for EV Support

EV adoption is supported by a range of state policies including purchase rebates, charging infrastructure investment, tax abatement, electric rate options, parking preferences and road privileges. The options for regulatory policies to address EV-related issues range from doing nothing beyond responding to reliability-related issues if and when they arise, to stimulating EV market growth by publicly funding construction of a charge station network—with a long list of choices in between. Options along the continuum of utility involvement in EV support include:

### CONSUMER EDUCATION

Utility provides customers with material to educate and inform them about EV options such as:

- General information on EVs, including:
  - Charging options and other considerations for prospective buyers
  - Available rate options and demand response programs
  - Shadow billing to compare projected costs of charging under different rate plans
- Public charge station location database
- Nearest immediately available public charge location
- Available incentives

A media plan to educate consumers about EVs could involve pushing information to customers using print, broadcast, apps and online media, perhaps including outreach through community organizations and institutions. The extent of such efforts would depend on whether the public goal is to accelerate EV growth or just to accommodate it.

### CUSTOMER SUPPORT

Utility provides assistance to facilitate EV ownership such as:

- Expedited permitting and interconnection for home and workplace EVSE coordination with local authorities who regulate connections, license charge station installers or issue permits
- Aggregation of EV demand and implementation of smart charging programs
- Rebates for smart chargers at homes and workplaces

Costs/benefit analysis could be used to set rebate amounts and other program budgets.

### CHARGE STATION SUPPORT

Utility offers assistance, services and incentives to charge station developers/owners/operators:

- Identification of optimal charge station locations based on existing electricity infrastructure or other characteristics
- Incentives for locating charge stations in where they will maximize system benefits
- Identification of optimal vehicle fleet siting locations based on existing infrastructure and other considerations such as local distributed generation output
- Incentives for optimized EV fleet siting in light of system benefits.

### INFRASTRUCTURE FOR NON-UTILITY CHARGE STATIONS

Joint participation in equipping charge station sites:

- Utility provides “make ready” infrastructure such as high voltage service drop and trenching:
  - upon application of a site owner, or
  - at locations selected in a planning process
- Independent charge vendors install and operate charge stations under contract with site owners
- Competitive bidding process could use reverse auctions for lowest required subsidy to install stations at commission-approved sites
- Utility provides assistance but has no stake or responsibility for outcomes
- Subsidies could vary with:
  - preferred locations
  - charge speeds
  - number of connections
  - other factors such as pricing options

- Subsidies for charge stations might be contingent on:
  - ~ open access and interoperability
  - ~ supply at EV-charge tariffed prices
  - ~ restrictions on retail pricing, terms and conditions
- Could include deployment of energy storage coupled with time-variant rates and smart charging

### SUBSIDIES FOR NON-UTILITY CHARGE STATION DEVELOPMENT

Utility functions as conduit for charge station support with regulatory commission-approved customer funding through ratebase or expenditures.

- Rebates to employers who install interoperable workplace charging sites
  - ~ Rebates could vary depending on factors such as charge levels deployed and utilization frequency
  - ~ Contingent on participation in direct load control and/or TOU rates, smart charging programs
- Rebates to individuals for home or business EVSE, contingent on certain requirements, such as:
  - ~ Smart chargers
  - ~ Professional installation
  - ~ Participation in charge management programs
- Rebates to landlords and/or tenants for installation of EVSE in multi-unit buildings (with similar requirements)
- Incentives to serve underserved/disadvantaged communities, including:
  - ~ Subsidized EV car-sharing service or other mechanisms to introduce EVs in low-income neighborhoods where conditions are not conducive to EV acquisition
  - ~ Targeted subsidies for charge stations
  - ~ Added rebates, other incentives for individuals
  - ~ Special incentives for school buses, public transit

### UTILITY CHARGE STATION DEVELOPMENT

Utility builds or funds a charge station network in its service territory.

- Regulatory commission approves a deployment plan after docketed proceeding considering:
  - ~ public need and social goals
  - ~ projected costs/benefits
  - ~ optimal locations
  - ~ competitive effects
- Charge network optimized for system benefits:
  - ~ Employ smart charging, energy storage, other technology
  - ~ Regulated rates and consumer protection rules
  - ~ Pilot programs to test assumptions and projections
- Incentives to promote development, minimize costs, maximize usage/performance
- Utility owned or leased sites—possible public-private partnership with site owners
- Rate-based EV supply equipment and infrastructure investment; regulated cost recovery of expenses net of revenues

While "future-proofing" charge station policies is challenging, given uncertainties about how the EV market will evolve, flexible, scalable approaches that can respond to advancing technologies and changing markets will be keys to successful charge network projects.

## Jurisdictions Are Beginning to Authorize Customer-Funded Charge Stations

Many states are beginning to consider or implement supportive policies for EV charging infrastructure, including Washington, Nevada, Oregon, Massachusetts, Michigan, Connecticut, Maryland, Rhode Island, Vermont and Missouri. They are coming to different conclusions about the appropriate role of utilities at this stage of EV development. California—home to more than half of today's U.S. EV fleet—is furthest down the road to testing different models of direct utility participation under regulatory oversight. It passed legislation in 2015 requiring utilities to include electrification of transportation in integrated resource plans and giving the green light to customer funding of infrastructure support—if approved by state regulators as cost-effective.[42] That law precipitated a series of proposals to the California Public Utilities Commission (CPUC) for EV charge

42 SB 350: https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB350; for summary see: http://www.energy.ca.gov/sb350/

network development. The initial proposals were scaled back after opposition from consumer advocates concerned about the costs and from charge station companies who see utility charging investment as anti-competitive and likely to stifle innovation. The CPUC has now approved three utility pilot programs intended to test the charging market and different models of utility participation in serving it:

- San Diego Gas & Electric was authorized to invest $45 million in 3,500 utility-owned and operated charge stations over three years—up to ten each at 350 businesses and multi-unit residential sites.[43] Half of the stations will be installed in multi-unit dwelling complexes and 10% will be in disadvantaged communities. The pilot will also test response to a variable rate plan to encourage charging at off-peak times and when renewables like solar energy are at maximum output, and it will include optional demand response programs for Level 2 chargers. When fully in place, the charge program will add about $2.75 per year to the bill of a typical household. The utility's original proposal was for 5,500 stations at 550 sites at a cost of $103 million.

- In a $22 million pilot of Southern California Edison, the company's customers will subsidize up to 1,500 charging stations but they will be owned and operated by third parties, not the utility.[44] This is known as the "make-ready" approach, in which the utility furnishes, installs and owns all infrastructure installed at a site except the charge stations. Ratepayer-funded rebates also cover a portion of the site-owner's costs to purchase EVSE from pre-qualified vendors, with whom the utility coordinates installation. Under this turnkey approach, site-owners are responsible only for ongoing costs of repairs, maintenance, and electricity. Rebates to site-owners are 25% of a set standard cost for chargers at workplaces and fleet sites, 50% at multi-unit dwellings, and 100% for charge stations installed in disadvantaged communities. In the pilot, program costs will be expensed, not rate-based, so the utility will not profit on the investment. If successful, a rollout of up to 30,000 stations at an investment of $333 million could follow—adding about one dollar per month to residential electric bills.


- The most ambitious utility proposal was by PG&E, originally put forward at $654 million for 25,000 Level 2 charge stations, but scaled back in a "settlement agreement" with some (but not all) parties to be proportional to the approved SDG&E program—7,500 utility-owned Level 2 charging stations and 100 DCFC stations, at a cost of $160 million. In response to concerns that this is still too large for a pilot program and is still utility-dominated, the CPUC order provides for 2,625 utility-owned charging stations—35% of the total—to be located in multi-unit dwellings and disadvantaged communities.[45] PG&E will provide "make-ready" infrastructure for up to 7,500 charging ports at other sites including workplaces, with a total program cost of $130 million over three years. Energy purchased at charging stations would be priced at time-variant rates intended to ensure "charging is not cost-prohibitive." The proposal to include 100 utility-owned DC fast chargers in the pilot was rejected. As in the other California pilots, a stakeholder Program Advisory Council will oversee program execution.

43 Decision at: http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M158/K055/158055671.PDF
44 Tariff sheets: https://www.sce.com/NR/sc3/tm2/pdf/ce361.pdf
45 http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M171/K219/171219240.PDF

Oregon passed a law in 2016 allowing rate-base treatment of a utility's "transportation electrification program" and laying out six criteria for approval. The Public Utility Commission must consider whether the proposed investment and/or expenditures:

- Are within the service territory of the electric company;
- Are prudent as determined by the commission;
- Are reasonably expected to be used and useful as determined by the commission;
- Are reasonably expected to enable the electric company to support the electrical system;
- Are reasonably expected to improve the electric company's electrical system efficiency and operational flexibility, including the ability of the electric company to integrate variable generating resources; and
- Are reasonably expected to stimulate innovation, competition and customer choice in electric vehicle charging and related infrastructure and services.

These criteria outline a pre-approval decisional framework starting with traditional regulatory principles and adding goals of renewable integration and support of competition. While few possible outcomes are excluded by this list of considerations, the final clause indicates that the Oregon legislature supports development of a competitive charging market intended to be utility-supported but not dominated.

State regulators in Massachusetts had already encouraged utilities to propose EV-supportive investment as part of grid modernization plans when the law was changed to explicitly allow public utilities to own and operate charging stations, provided regulators find that it is in the public interest and does not "hinder the development of the competitive electrical vehicle charging market."[46] In an initial test of this standard, the state's largest utilities have proposed charging infrastructure plans now pending before regulators. The 2017 law also prohibits public charging providers from requiring drivers to pay membership or subscription fees, but they are allowed to charge preferential prices conditional on such membership. Regulators are given authority to adopt interoperability standards for billing and payment of charging fees, and state building and electrical codes are allowed to include EV-capability requirements.

Other states have taken different approaches. For example, Washington law allows regulators to approve an "incentive rate of return" for utility provision or subsidization of EV charging infrastructure up to a maximum overall rate impact of .25%.[47] On the other hand, some states have decided not to subsidize EV charging at this time. Kansas City Power and Light pursued its own charge station pilot without regulatory preapproval from either state in which it operates. When neither Kansas nor Missouri regulators would allow any portion of its costs for 1,000 installed charge stations (with 2,000 ports) to be recovered through general rates, the cost and risk were absorbed by the utility, which has initiated the service at no cost to users.[48] The Missouri PSC decided to take a deeper look at EV policies in a separate proceeding, in which the commission staff report concluded that under existing law, all firms that sell electricity or charging service to the public are subject to state regulatory jurisdiction.[49] The Kansas City experiment in unsubsidized utility-provided charge stations may provide an initial test of the effect of infrastructure investment on EV adoption. If relatively more people there decide to buy EVs, the "build it and they will come" theory may be vindicated.

## Funding of Charge Stations by Utility Customers Must Maximize Grid Value

Proposals are emerging across the country for utilities to build out or subsidize public EV charging networks. These proposals are responsive to a growing constituency of EV owners (and potential owners), and are aligned with the natural utility incentive to make new investments, increase revenues, and offer new

46 https://malegislature.gov/Laws/SessionLaws/Acts/2016/Chapter448

47 Text of statute at: http://lawfilesext.leg.wa.gov/biennium/2015-16/Pdf/Bills/Session%20Laws/House/1853-S.SL.pdf

48 http://estar.kcc.ks.gov/estar/ViewFile.aspx/20160913110134.pdf?Id=4b0556f3-425d-4469-8eb1-a105109511ec

49 See MPSC Staff Report: https://www.efis.psc.mo.gov/mpsc/commoncomponents/view_itemno_details.asp?caseno=EW-2016-0123&attach_id=2017002326

services. In some jurisdictions, statutory directives to accelerate EV market penetration and develop distributed energy resources invite such utility investment. In others, public need for rate-based utility investment in charge stations is premised on a set of implicit assertions:

- Use of charging stations will be sufficient to justify their installation.
- Without utility support they won't be built—or at least not soon and not in optimal locations.
- Any net ratepayer costs will be exceeded by system and social benefits.

Because of widely differing circumstances and conditions, jurisdictions are coming to dissimilar conclusions about these assertions and what they mean for regulatory policy.

In formulating policy, lawmakers and regulators must consider whether advantages of using utilities to build out public charging infrastructure outweigh concerns that utility-owned charging facilities would shut out competitors and stifle innovation. In addition to being service and price-regulated and accountable to regulators, utilities generally have access to low-cost capital, ability to integrate EVs as DER, call center capability, established customer relationships, and other incumbent and legacy advantages. However, construction and operation of EV facilities may not be within the core competency of utilities and they may lack the incentives and entrepreneurial culture of unregulated firms. Costs and risks of utility investment may be borne by non-participants, and customers may be at greater risk of stranded costs in the event of underperforming or obsolete facilities. These difficult issues raise fundamental questions of whether public charging networks—particularly DCFC—have "natural monopoly" characteristics, and whether the need for accountability through the regulatory process necessitates a leading utility role.

In formulating policy, lawmakers and regulators must consider whether advantages of using utilities to build out public charging infrastructure outweigh concerns that utility-owned charging facilities would shut out competitors and stifle innovation.

# EV Infrastructure Investment Highlights Many New Regulatory Issues

Involvement of public utilities in charge station development raises myriad regulatory questions beyond competitive market effects, including risk and cost sharing between site owners and utility customers, how siting decisions are made, what (if any) technology requirements are specified, physical and cyber security, amounts, allocations, terms and conditions of any subsidies, and public charging policies (and how to enforce rules). Each jurisdiction grappling with these issues may come to different conclusions in context of their particular laws, circumstances, and regulatory goals.

If utility funding or construction of charging infrastructure is found appropriate, one option to pay for it is by simply adding the costs to rate base. Treating these investments as capital expenditures much like wires, poles, and other equipment allows longer term amortization, and a return on investment adds incentive for the utility. Alternatively, support for charging infrastructure can be recovered as operating expenses, or a combination of methods could be used for different types of support, as is being tested in the California pilots.

Utility-owned charge stations are under the purview of state regulators, which can approve tariffs and

## TAXES AND EVs

Higher efficiency vehicles—whether ICE or EV—will make gas taxes a shrinking and outdated source of funds for road maintenance, which could be replaced by taxes based on vehicle miles traveled (VMT), which is a more fair and reliable method.* But ten states have imposed fees on EVs and hybrids to make up for lost gas tax revenue, and six more are considering it. Several are now testing VMT taxes.

*http://www.sierraclub.org/compass/2017/02/flurry-state-bills-introduced-likely-backed-oil-industry-penalize-electric-car

Regulators should consider whether subsidies for independent charge stations should be contingent on acceptance of model rate structures and price constraints.

enforce consumer protection rules. Depending on state law, independent third parties may be subject to far less, if any, jurisdiction. In an effectively competitive public charging market, competition would constrain prices and protect consumers, but the very fact that subsidies are needed to induce market entry shows that a robust market does not exist. When shopping for gasoline, there are usually multiple choices of where to fill up, but when a driver with a low battery pulls up to a remote public charge station, she may be facing a situational monopoly, with no choice but to pay whatever fees are assessed.

Charge providers in the initial stage of the industry have introduced a number of business models, including closed networks and monthly fee requirements, which may not be appropriate for publicly subsidized facilities. Regulators should consider whether subsidies for independent charge stations should be contingent on acceptance of model rate structures and price constraints.

# Regional Approaches May Be Most Effective and Efficient

A 10% penetration of the car market—25 million EVs on American roads—would pose challenges to electric system operators. For example, imagine a super-fast charging station at a highway exit with 20 cars plugged in. The combined maximum load could be more than 2,000 kW (2 MW), or enough juice to supply the average demand of 1,000 homes. Put several of those at an interchange and it's the equivalent of adding the electric load of a large industrial facility—but with huge peaks and valleys of usage. To serve driver needs, highway charging stations may need far more capacity than would be used on an average day in order to serve high demand on a holiday weekend. Complicating the issues surrounding utility investment is the fact that DCFC charge stations may primarily serve non-local drivers who are just passing through a utility service territory.

A multi-state approach may be an effective way to share the costs and benefits of highway fast charge infrastructure and to provide a seamless network and uniform customer experience. Such a coordinated regional approach has been agreed to by Nevada, Utah and Colorado, with the goal of allowing BEVs to drive "from the Rockies to the Pacific."[50] How the network will be developed and paid for has not been announced but the principle is in place: drivers will derive maximum benefit and the EV market will be advanced if states jointly develop regional charge networks.

The Midwest lacks a coordinated multi-state effort but several environmental groups have formed "Charge Up Midwest" to initiate a regional approach to EV infrastructure development. In the Northeast, seven public, private and coop utility systems formed the Regional Electric Vehicle Initiative to advance regional EV planning efforts.[51] Several interstate highways in the area have been designated "alternative fuels corridors" by the Department of Transportation and targeted for charge station development by the Northeast Electric Vehicle Network, a consortium of 11 states and the District of Columbia.[52] Similar designations cover 48 highways over 25,000 miles in 35 states, sketching out the map of a national charging infrastructure plan.

## Federal Support Would Accelerate Network Development

A robust DCFC network open to all makes and models and easy for the customer to use may be a prerequisite for mass EV adoption. However, at an estimated cost of $100,000 or more for each level 3 charge station unit, and higher for the next generation of super-fast chargers, a national network would be very expensive to deploy. UBS estimates Tesla's cost to expand its highway network to provide charging access spaced similarly to gas stations would require more than 30,000 chargers and investment of $8 billion.[53] An ample interstate network would often have enormous idle capacity, only needed during peak driving periods.

A sustainable business model for EV charging based on user fees has not yet emerged and may not be feasible. Without a viable privately funded business model, public or ratepayer-backed utility investments would be needed to build out DCFC infrastructure.

As in development of the interstate highway system itself, evolving transportation needs may call for federal funding, if state-fragmented regulation and private markets prove unable to deliver a seamless national network. Charging infrastructure is currently

50 https://www.colorado.gov/governor/news/governors-colorado-utah-and-nevada-announce-joint-action-build-regional-electric-vehicle
51 http://www.revi.net/
52 http://www.transportationandclimate.org/content/northeast-electric-vehicle-network
53 https://neo.ubs.com/shared/d1N4RjMdUf/

eligible for up to $4.5 billion in federal loan guarantees for energy innovation.[54] If the economic and social benefits of transportation electrification justify further public support for charging infrastructure, a program similar to the one that accelerated smart grid deployment through federal "stimulus" funding may be a good investment for America.

54 https://www.whitehouse.gov/the-press-office/2016/07/21/fact-sheet-obama-administration-announces-federal-and-private-sector

# Concluding Recommendations

The electrification of transportation presents a rare opportunity to achieve gains for all stakeholders affected by electricity regulatory policy. The right set of policies can help achieve the traditional regulatory goals—safe, reliable, and affordable service—while advancing new goals of sustainability, efficiency, and customer choice.

Transportation electrification is in its infancy but is poised for rapid growth that should make it a focus of regulatory attention in coming years. This paper has laid out a set of recommendations for EV policy:

- Foster stakeholder communication and consensus-building—in a collaborative process convened by state regulators—to analyze key issues, and recommend regulatory options;
- Optimize system load shape by aggregating EV loads for use as a distributed energy resource;
- Adopt dynamic and time-variant rates to reduce EV operating costs and capture system benefits;
- Support cost effective utility programs to address public needs identified in strategic plans and supported by cost-benefit analyses;
- Promote customer interests through interoperability and seamless networks;
- Benefit disadvantaged and underserved communities; and
- Protect consumers while promoting innovation and market development.

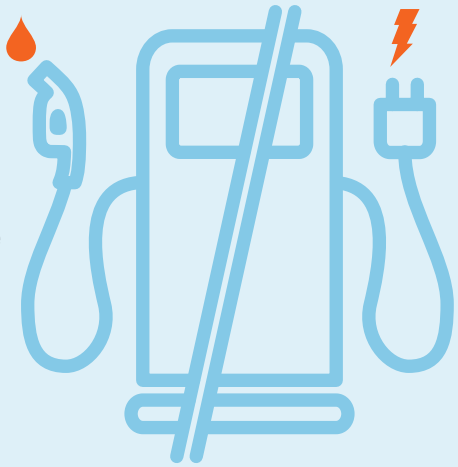
Each state will be challenged to maximize the net benefits of EVs, based on its own laws, electric system characteristics, technology, market structure, regulatory framework, and social/environmental objectives. While the policy outcomes may be different, managing EV demand to create a more efficient, reliable, and less costly electric system is a universal goal. Achieving it will require an integrated approach using a common toolbox, which includes:

- Deployment of smart charging technology;
- Development of new rate designs;
- Support for infrastructure investment;
- Consumer education; and
- Regional cooperation and planning.

Nobody knows how long it will take for EVs to become a major factor in electric system dynamics, but the wheels are beginning to roll downhill and are unlikely to stop. Keeping up with this evolving market and ensuring it delivers system benefits will require proactive regulatory policies informed by input from a wide group of affected stakeholders. For utility regulators and consumer advocates, now would be a good time to start.

## THE PUMP VS. THE CHARGING STATION

Collateral effects of transportation electrification may begin to be felt in the next decade. As in other technology displacements, there will be casualties, which could eventually include part of the petroleum industry—though not soon, as global demand for oil is anticipated to rise through at least 2030.* But today's ubiquitous gas stations may become fewer and farther between, and perhaps they will change their product offerings. Shell has become the first oil company to announce it will test installation of EV charging equipment alongside their gas pumps.**



*See World Energy Council 2016 global report: http://www.worldenergy.org/wp-content/uploads/2016/10/World-Energy-Scenarios-2016_Full-Report.pdf

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## ABOUT THE CITIZENS UTILITY BOARD

The Citizens Utility Board (CUB) has been called the "gold standard" of consumer groups by the St. Louis Post-Dispatch. Since 1984, the non-profit consumer watchdog has saved consumers in Illinois more than $20 billion by advocating for investments in energy efficiency technologies and cleaner sources of power, while also policing against unwarranted utility rate hikes.

## ABOUT THE LEAD AUTHOR

Martin R. Cohen is a long-time energy issues leader. For 15 years he led the Citizens Utility Board (CUB), a group created by the Illinois legislature to represent the interests of residential customers in regulatory matters. After serving in state government from 2005 to 2007, including briefly as Chairman of the Illinois Commerce Commission, Mr. Cohen began consulting to consumer advocates, environmental groups, and public utilities on energy and consumer protection issues. He facilitated the Illinois Statewide Smart Grid Collaborative, and his consulting work has included expert testimony in regulatory cases and research and writing on energy policy.

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