



RETAIL ENERGY
PRACTICE BRIEFING SERIES

NEW SOURCES OF UTILITY GROWTH

Electrification Opportunities
and Challenges



RETAIL PRACTICE BRIEFING SERIES

This brief is the third in a series that analyzes potential utility responses to challenges and trends referred to as the “Utility of the Future” (UoF). A new UoF paradigm is emerging as utilities rethink their future business models in response to the expansion of distributed energy resources (DERs), decarbonization goals, declining sales growth, and technological developments. While each of these developments has the potential to disrupt the status quo, they could also provide growth opportunities to utilities and new market entrants. They also raise complex questions concerning how and when to modify, or even completely change, long-standing regulatory practices. Much has already been written on these topics, but, more often than not, each issue is examined in relative isolation. Our briefing series attempts to examine the UoF from an integrated perspective by examining linkages among the financial, technological, strategic, and regulatory dimensions.

This brief provides an alternative paradigm for the U.S. utility industry where electricity sales break out of the often-cited “utility death spiral” through beneficial electrification, particularly in the transportation sector.

INTRODUCTION

The electric power industry is in a period of fundamental transformation. The changing landscape includes increasing concerns about climate change risks, advances in alternatives to traditional fossil-fueled technologies, and enabling customers to become more active managers of their energy consumption. The persistence of these trends is leading some to believe that the traditional utility model is becoming unsustainable.

Concerns about the future of the electric utility are often tied to an observed slowdown in sales growth. The United States Energy Information Administration's (EIA's) 2017 Annual Energy Outlook (AEO) projects that net electricity sales between 2015 and 2040 will grow at an average annual rate of just 0.6%. That rate is significantly below the historical annual average of 1.3% over the previous 25 years. In fact, the EIA's projections could overstate sales growth due to modest assumptions about the growth of distributed solar PV. Since the extension of the solar investment tax credit (ITC), Bloomberg New Energy Finance projects that total non-utility solar PV capacity will be roughly four times greater than the AEO projection.¹

But this prevailing paradigm of anemic utility sales growth could be reversed. Recent increases in electric vehicle (EV) sales and the development of autonomous technology introduce the possibility of electric utilities playing a rapidly increasing role in the future energy system of the country. In this alternative paradigm, electric utilities could replace the roles of fossil fuel companies in providing energy to the heating and transportation sectors. This possibility exists primarily due to the confluence of a greening electricity system – in part due to technological progress of renewable energy technologies and in part due to regulatory action to limit climate change risks – and significant, potentially revolutionary, changes to the transportation and heating sectors.

1. Yozwiak, Maddy, "The Impact of the ITC Extension on U.S. Solar," Bloomberg New Energy Finance, 2015.



THE GREENING OF THE GRID

The U.S. power grid has been “greening” for some time. Electric sector CO₂ emissions have declined by nearly 20% since 2005 and are approaching 1990 levels. Emissions reductions have come primarily from a shift from coal to natural gas and an increasing emphasis on energy efficiency programs and standards, but also from an increasing share of zero-emitting renewable generation resources.

Significant advances in both cost and performance of wind and solar technologies, combined with state level efforts to limit (and ultimately mostly eliminate) greenhouse gas (GHG) emissions from the electric sector will likely lead to a further decarbonization of the electric sector over the coming decades. There is still a lively debate about the pace and the ultimate depth of decarbonization, due to the cost and technical challenges of full decarbonization and the climate risk insurance value of rapid decarbonization.² There are also questions about the relative roles of centralized and decentralized renewable energy generation in this process, how renewable procurements integrate into wholesale markets, and the impact that decarbonization would have on electric utility business models, primarily as a consequence of a significantly increased share of decentralized generation.

Given that the shift from coal- to gas-fired generation has been primarily the result of very low gas prices in the United States, and given that further substantial decreases in the cost of wind and particular solar energy can be expected, it seems likely that the trend toward greening the grid will not be reversed, but rather continue in all but perhaps the most fossil resource-rich states. A greener grid, while not a precondition for electrification, would improve its attractiveness from a CO₂ emissions reductions standpoint³ and give momentum to any efforts by utilities to help accelerate the transition to electric transportation and heating.

POTENTIAL FOR SIGNIFICANT ELECTRIFICATION AND SALES GROWTH

A greening grid alongside rapid technological and other changes in transportation is providing the basis for a counter-narrative to the utility death spiral. It involves additional, perhaps significant, electricity sales growth stemming from the electrification of sectors of the economy that currently rely on the direct use of fossil fuels, most notably transportation, but also space and water heating. Electrifying transportation is commonly identified as one of the more feasible paths towards reaching ambitious 2050 greenhouse gas reduction targets, which tend to focus on at least 80% reductions

2. For a discussion see Jürgen Weiss and Dean Murphy, “Hurry or Wait? Pacing the rollout of renewable energy in the face of climate change risk,” Boston University Sustainable Energy Institute Working Paper, December 2016.

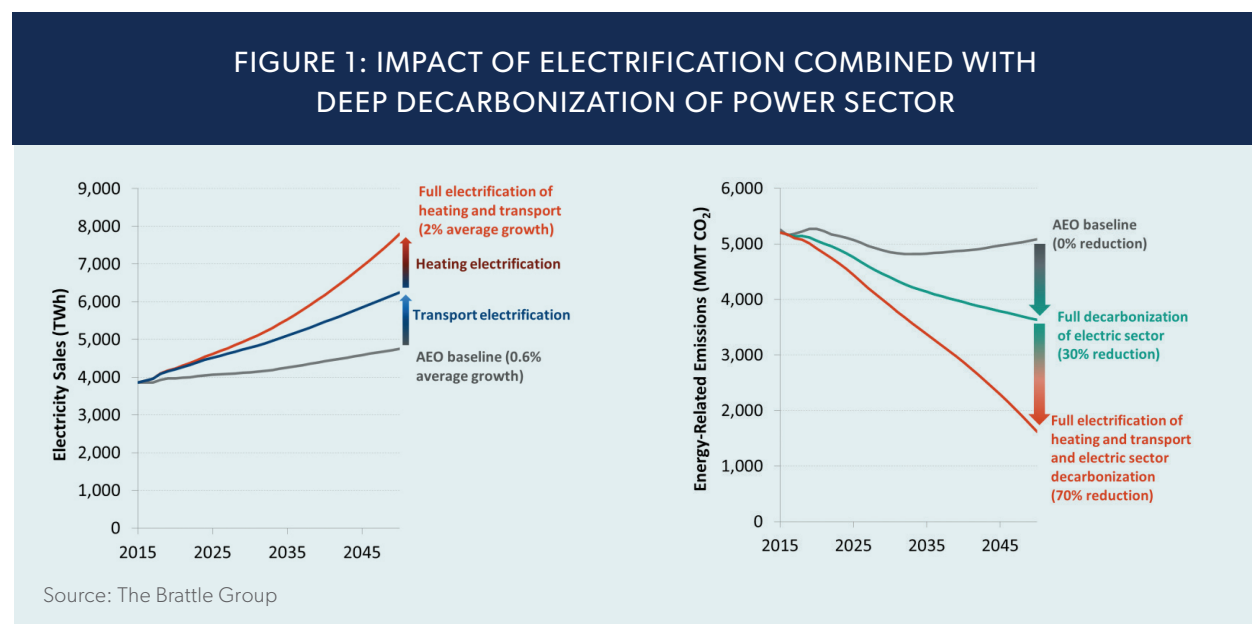
3. Because EVs tend to be more efficient than gasoline-powered vehicles, electrification of transportation would tend to reduce CO₂ emissions in most parts of the U.S. even without a further substantial “greening of the grid.” However, long-term economy-wide decarbonization goals would likely not be achievable without moving further in this direction.

of *economy-wide* greenhouse gas emissions, but may also occur as a consequence of a confluence of changing consumer attitudes and innovations related to EVs, autonomous driving, and transportation-related business models (Uber, Lyft, Zipcar, etc.).

According to our modeling, fully electrified heating and transportation (light and heavy duty vehicles, rail, etc.) could add up to 3,000 TWh to U.S. electricity demand by 2050, nearly doubling 2015 electric load.⁴

This would correspond to an annual growth rate of 2% per year on average, more than three times the current projections of annual growth rates of less than 0.6% per year (or less). Also, if by 2050 the sources of electricity were 100% emissions-free, fully electrifying heating and transportation would lead to economy-wide emissions reductions of over 70% relative to 2015, a significant contribution to meeting long-term emissions reduction goals set by many states and cities. Electrification thus constitutes an attractive vision for utilities and society.

Figure 1 provides a summary of Brattle’s modeling of the technical potential for full electrification of heating and transport, coupled with deep decarbonization efforts in electric power generation.



4. For further discussion of the assumptions behind this analysis, see Brattle’s recent whitepaper “Electrification: Emerging Opportunities for Utility Growth.” http://files.brattle.com/files/7376_electrification_whitepaper_final_single_pages.pdf

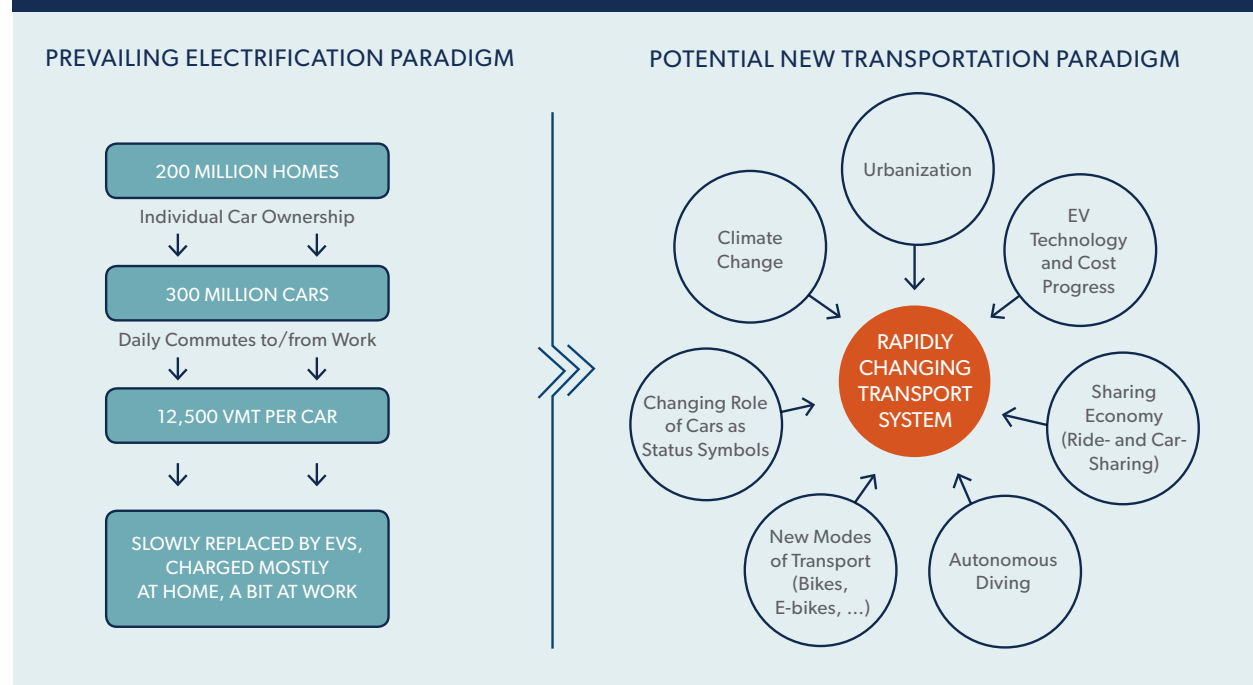


THE ACCELERATING EFFECT OF VEHICLE AUTOMATION AND SHARING

As utility planners grapple with the implications of transportation electrification, several standard assumptions are often made. The trajectory of light-duty EV adoption is assumed to be fairly gradual. Additionally, EV charging is commonly assumed based on a vision of transportation largely identical to the current system with individual car ownership, stable daily driving patterns, gradual charging that occurs at home overnight, and a slow and geographically dispersed increase in EV adoption. This evolution and the resulting charging patterns are relatively inexpensive and lead to only modest and somewhat predictable changes to the shape of overall electricity demand.

However, advancements in autonomous vehicle technology and the growth of ride and vehicle sharing are creating the possibility of a more radical transformation of transportation, particularly in urban areas, that would require an equally radical re-thinking of our assumptions about the future impact of transportation electrification on the power system. The potential speed at which this transformation could occur is often underappreciated. Figure 2 illustrates many of the factors that could contribute to this alternative transportation paradigm.

FIGURE 2: THE EMERGING POSSIBILITY OF AN ALTERNATIVE TRANSPORTATION PARADIGM



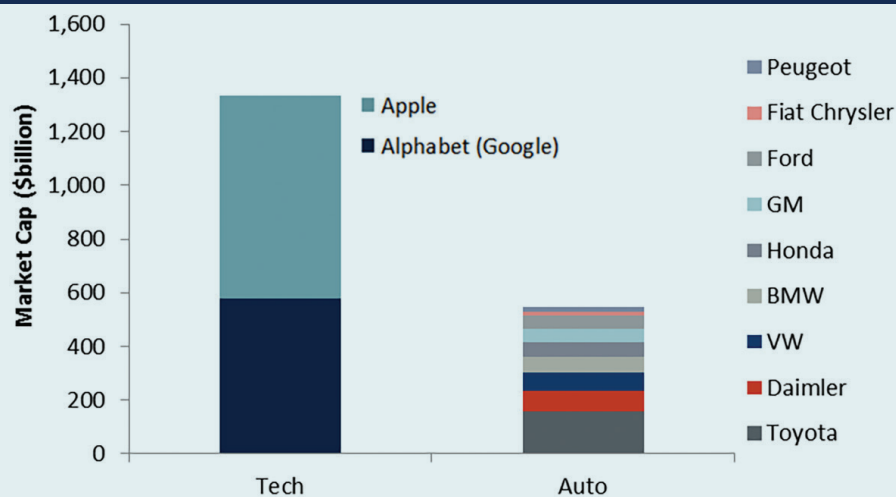
There are at least three reasons to believe that the emergence of shared autonomous vehicles could accelerate the adoption of EVs:

1. Automation and sharing could increase the customer-friendliness of EVs by overcoming “range anxiety” concerns and reducing barriers to adoption, such as uncertain maintenance costs or new technology risk aversion.
2. Automation and sharing could improve the economics of transportation electrification by increasing vehicle utilization and thus capitalizing on the fuel cost advantage that EVs hold over internal combustion engine vehicles.
3. Automation and sharing could bring down charging costs by reducing the total number of charging stations that are needed and/or by optimizing charging patterns relative to electricity costs.

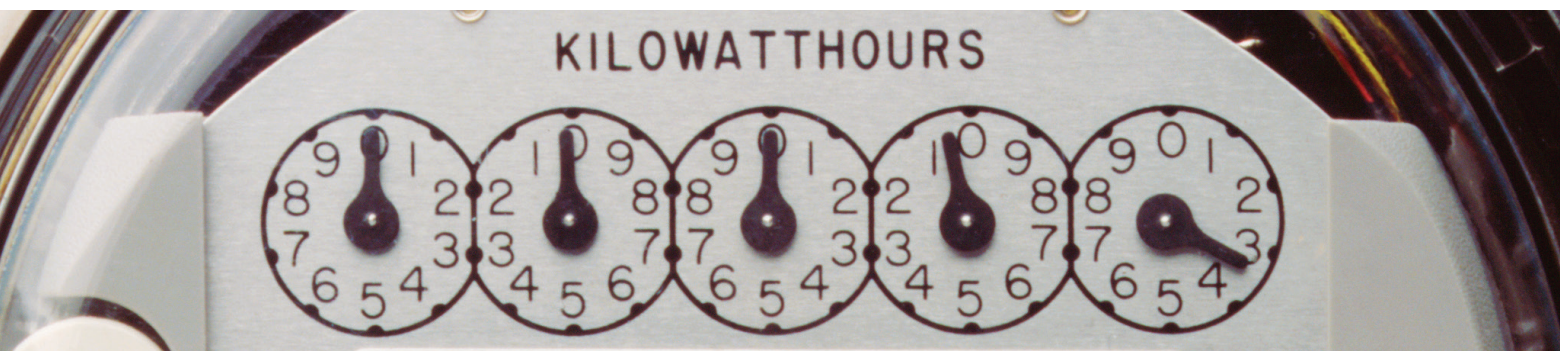
Of course, in spite of the highly complementary nature of automation, ride sharing, and transportation electrification, the future for shared autonomous EVs (AEVs) is still far from certain. Significant technological, political, regulatory, and social barriers will need to be overcome before full autonomy is allowed (and widely accepted) on public roads. Public trust in the technology will need to be earned.

However, the disruptive track record of the companies that are investing in this space to deploy capital suggests that changes could happen much more quickly than many expect. To illustrate this point, Figure 3 compares the market value of just two technology companies with an expressed interest in autonomous vehicle technology – Alphabet (Google’s parent company) and Apple – to the stock market value of essentially the entire global automobile industry. If technology companies like Google or Apple perceive an opportunity to disrupt the transportation sector through aggressive pursuit of autonomous vehicles, they are likely to have sufficient access to capital that they can deploy to make meaningful investments that increase the chances of “disruption” at a pace that exceeds current expectations.

FIGURE 3: MARKET CAPITALIZATION OF SELECTED TECHNOLOGY AND AUTOMOBILE COMPANIES



Sources: Yahoo Finance, Google Finance (March 2017).



ANCILLARY BENEFITS OF IMPROVED DEMAND-SIDE FLEXIBILITY THROUGH ELECTRIFICATION

The power system will need to become increasingly flexible in order to reliably integrate growing amounts of intermittent renewable generation (largely wind and solar). Electrification of the transportation and heating sectors can be complementary in this regard. Both the batteries of grid-connected EVs and the heating elements of electric water (and potentially space) heaters are flexible loads that can be controlled and dispatched to respond to fluctuations in generation supply.

For example, the more than 50 million electric resistance water heaters in the U.S. (representing 40% of all household water heaters and 9% of total residential electricity consumption) have recently begun to be utilized as behind-the-meter thermal batteries to provide ancillary services and daily load shifting and represent a sizable potential to provide flexibility. Assuming each water heater provides 2 kW of controllable load, these electric water heaters alone, at current penetration levels, could provide 100 GW of flexible load that could be used to help integrate variable renewable resources and thus facilitate further greening the grid. Electrifying any portion of the remaining 60% of water heaters would increase the size of this flexible load resource correspondingly. By comparison, the total need for frequency regulation in PJM in 2016 was 600 MW, an amount that could be served by just 300,000 controllable water heaters.⁵

Close to three times the amount of energy used in the U.S. for water heating is used for space heating and less of 10% of space heating is electric,⁶ mostly in the form of inefficient resistance heating. These conventional heating systems provide a form of flexibility that can be accessed through standard direct load control programs such as those that are currently offered by many utilities and demand response providers. However, less than 10% of existing space heating systems uses boilers to heat water. As a result, electrification of space heating with the use of boilers could provide significant additional flexibility similar to electric hot water heaters.

Electrified transportation would likely also significantly increase the flexibility of demand. A number of pilot projects are currently assessing the potential for Vehicle to Grid (V2G) opportunities. Assuming important challenges can be addressed, the storage potential in EVs would be remarkable. For instance, future EVs may have storage capability on

5. A recent Brattle study found that the net benefits of utilizing grid-enabled water heaters in this manner could exceed \$200 per customer per year under certain market conditions. This would pay for the entire cost of the water heater and associated control equipment and program costs in under five years. See "The Hidden Battery: Opportunities in Electric Water Heating." http://files.brattle.com/files/7167_the_hidden_battery_-_opportunities_in_electric_water_heating.pdf

6. See EIA, Annual Energy Outlook 2017.

the order of 50 to 100 kWh each. Aggregated across one million EVs – less than 0.5% of the current vehicle stock in the United States – this amounts to 50 to 100 GWh of storage capability, or the equivalent of 5 to 15 GW of pumped storage facilities. Of course, the EVs would be connected to the grid at different times of day, in different locations, and with varying constraints around the extent to which the batteries could be charged or discharged, all of which would reduce the amount of storage that could be used to provide grid services including renewable integration. Still, this provides a sense of the magnitude of the opportunity for electric end-uses to provide demand-side flexibility.

Even assuming that V2G barriers will remain significant for some time, the ability to have vehicle charging occur in response to either a pricing signal (such as a time-of-use rate) or under direct control of a third party (such as the utility) would lead to significant additional flexibility of the overall charging demand.

In sum, the electrification of water and space heating and transportation will likely introduce significant additional demand-side flexibility, which will be particularly beneficial to (and thereby support) a further greening of the grid through increases in renewable generation sources.

A PERMANENT AND ESSENTIAL ROLE FOR UTILITIES THROUGH ELECTRIFICATION

Electrification of transportation and heating could lead to a positive, central, and ongoing role for electric utilities. This role involves the efficient and reliable operation of the power system relying on a mix of centralized and decentralized carbon-free electricity production and likely the provision of supporting infrastructure. Overall, this presents a very positive business outlook and opportunity for utilities: continued growth of sales from centralized (i.e., non-distributed) generation as well as a crucial and likely enhanced role for electricity network infrastructure and controls.

For heating, energy efficiency investments such as more insulation or other renewable heating options may be more cost effective decarbonization options than fully electrifying space and water heating. But even partial electrification of both the heating and transportation sectors would fundamentally change the outlook for utilities as core players in the centralized production and management of our electric system.

Still, significant electrification of the transportation and heating systems is far from a foregone conclusion. Even in jurisdictions with a deep decarbonization policy mandate, many hurdles need to be overcome and there are options to decarbonize transportation and heating that do not involve major electrification efforts. And since electrification would mean shifting revenues away from the producers of fossil fuels (i.e., gasoline, diesel, and natural gas), these companies



will have an incentive to develop alternatives to electrification. For instance, one alternative strategy to electrification is to count on further improvements of the performance of the internal combustion engine – in combination with higher percentages of blended biofuels – to eventually lead to a non-carbon-emitting drop-in biofuel substitute for current transportation fuels. Such a path would have the advantage of leveraging existing fueling infrastructure. Consequently, the transportation fuels industry is proposing a gradual decarbonization along those lines.

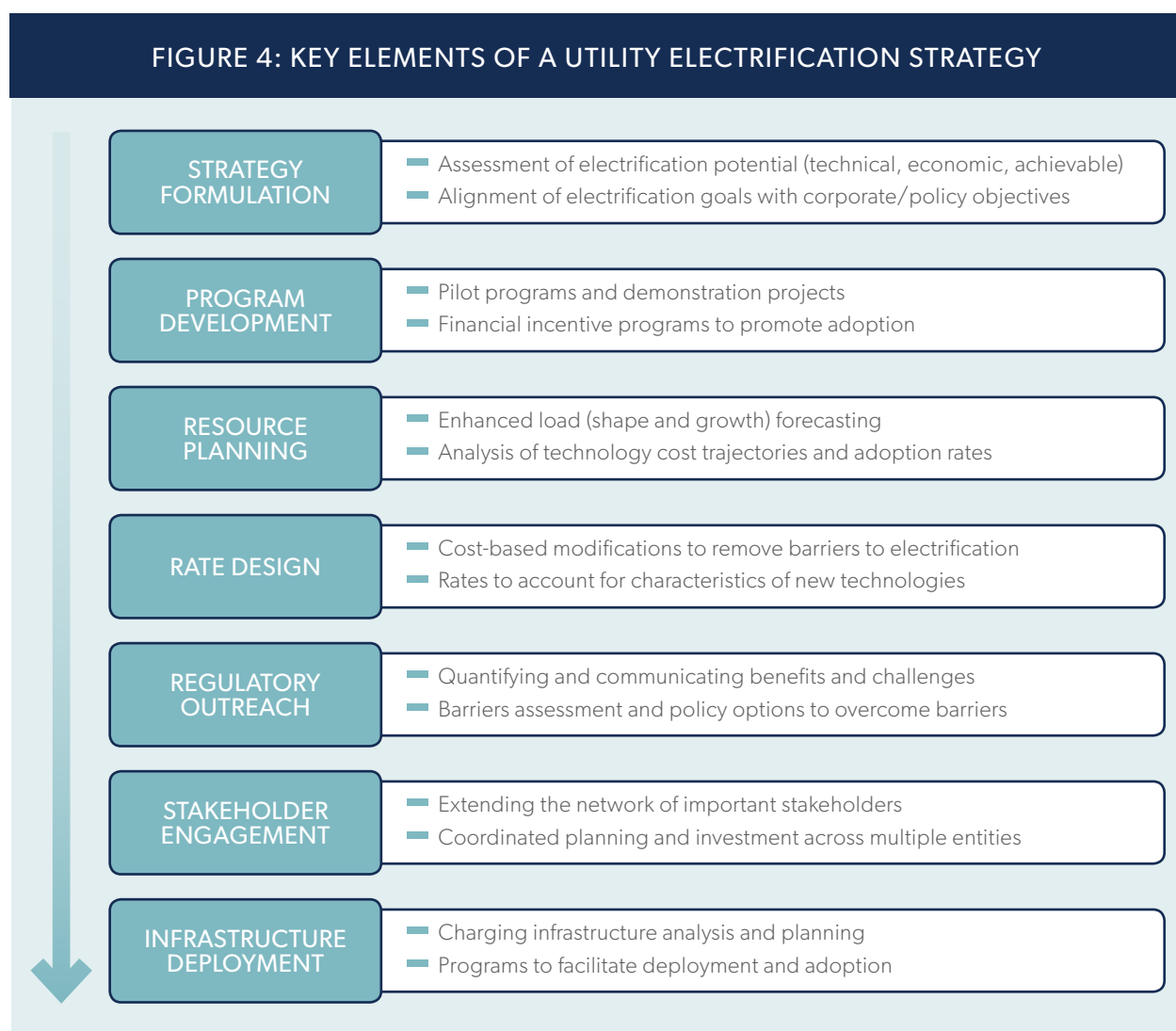
Given the significant uncertainties related to the costs and implementation challenges of any future decarbonization pathway, there is not a clearly dominant, preferable pathway from society's perspective. This means that the future becomes "path-dependent" in the sense that the degree and form of electrification will depend on facilitative and preparatory actions taken early and along the way, including many actions under the control of the utilities.

The positive outlook outlined in this brief is not likely to occur without utilities playing a leading role in modernizing and decarbonizing sectors in which they have not traditionally been involved. Important activities will include investing in renewable generation, deploying assets, and providing access to electric power infrastructure.

Electrification of transportation in particular is likely to require very significant investments by consumers (in EVs and home chargers), utilities (in network infrastructure and potentially chargers), and generators. Further, deep and rapid electrification would require significant behavioral changes in customers and would fundamentally alter the transportation industry, with negative impacts on traditional fuel suppliers and some car manufacturers. Given that electrification of transportation remains a relatively new field, it is also characterized by rapid technological change, which, combined with the need to invest in significant infrastructure, results in complex challenges related to making the right investments at the right time. Many of the behavioral changes are occurring rapidly with the introduction and acceptance of new forms of urban transportation, such that the seeds of change required for electrified transportation are already being planted. Relatedly, political mechanisms to encourage (or require) such electrification are emerging, and there is a clear need for utilities to be involved in their specification, including timetables and mechanisms.⁷

7. Examples include New York's 80x50 GHG reduction policy, AB32 in California, and laws under consideration, for example, in Norway, France, and the UK, which would mandate that all new cars be zero emission vehicles in the time frame 2025 to 2040.

All of this implies that utilities can likely increase the chances of electrification becoming the primary path towards economy-wide decarbonization efforts with actions that lower the barriers to electrification. Figure 4 lists key elements for utilities to consider in developing a near-term electrification strategy, which we discuss briefly in the remainder of this brief.





ELECTRIFICATION STRATEGY:

Given the many options for electrification, utilities should develop an electrification strategy to guide regulatory policy, stakeholder engagement, rate design and program development, and infrastructure roll-outs.

An important first step in strategy formulation is a detailed, service territory-specific assessment of electrification opportunities. Such an assessment needs to start with taking stock of existing sources of non-electric energy use, but should go beyond a simple extrapolation for the purpose of defining the potential impact of electrification on future average and peak electricity use. In particular for transportation, advances in EV technology and behavioral changes toward new forms of transport may significantly impact the stock of vehicles and average vehicle miles driven. This would have significant implications for the speed of adoption of electrified transport and the frequency, speed, and timing of charging, all of which impact how quickly total electricity sales as well as peak use could be affected by electrification.

Understanding the technical and economic potential is only the first necessary step in developing an electrification strategy. Given the long lead times for anticipated regulatory approvals, the longevity of some of the required investments, the rapid technological change creating stranded investment risks, the different impacts of various electrification options on average and peak use (and hence the need for incremental grid investments), the different degrees of interconnectivity with non-electric stakeholders such as urban and transportation planners, and the different benefits provided by various electrification alternatives for various customer groups, an electrification strategy needs to carefully evaluate the various options taking these and other factors into account. Especially since investments by regulated utilities in electrification initiatives will typically require regulatory approval and many regulators will need to evaluate proposals made by utilities with frameworks that expand beyond current practice, an electrification strategy is likely a key element of being able to convincingly articulate the rationale for proposed investments to the regulatory community. It also helps understand how the benefits to the utility, its shareholders, and the broader community can be optimized.

PROGRAM DEVELOPMENT:

Utilities could be proactive in enabling (and incentivizing) the provision of new services that can be provided from behind-the-meter electric devices.

For example, as discussed earlier in this brief, grid-enabled water heaters can be controlled to increase or decrease load in real-time to provide balancing services. These balancing services could become increasingly valuable in markets with large adoption of intermittent sources of renewable generation. EVs could potentially provide similar services when plugged into the grid.

There are many options for promoting the use of electric end-uses in this way.⁸ Customers could be provided with participation incentive payments, akin to conventional demand response (DR) programs. They could be exposed to more time-sensitive retail price signals and adopt automating technologies that allow them to respond to those price signals. Or they could participate through a third party aggregator, who would sign up customers and provide these services to the utility or grid operator. In any of these scenarios, customers benefit financially from adopting an electric end-use that displaces other fuels and utilizing it in a way that is beneficial to the power system or at least minimizes any negative impacts. To demonstrate that the programs would provide meaningful benefits, it may be desirable to first offer them on a pilot basis.

RESOURCE PLANNING:

Utilities will need to carefully incorporate the implications of electrification into their resource planning activities.

Utilities, regulators, and stakeholders who are exploring a transition to electrification will need to analyze in detail the impacts of electrification, taking into account idiosyncratic attributes of the regional market and local utility service territory. At a minimum, this will require a deep understanding of the economics of the “supply side,” such as the cost trajectories of sources of clean generation and incremental costs of incorporating these resources into the power grid. It will also require a more in-depth understanding of “demand side” drivers, including a thorough understanding of customer adoption rates of emerging energy technologies, the benefits that could be achieved by using these technologies to provide around-the-clock demand response, and the potential distribution-level changes in load shapes and associated costs of incorporating large amounts of additional electricity demand into the power grid. Due to the rapid arrival of new transportation modes, such as autonomous driving, shared vehicles, etc., charging patterns based on even large-scale pilots with existing EV owners may not be sufficient for planning electric infrastructure to support a rapid expansion of electric driving in particular.

STAKEHOLDER ENGAGEMENT:

Utilities will need to extend their stakeholder engagement to a broader set of participants.

Especially for transportation electrification, the number of important stakeholders will extend beyond the parties that are traditionally engaged in utility regulatory matters. For instance, the revolutionary transformation that may occur in transportation as a result of the confluence of EVs, autonomous driving, ride sharing, and changing preferences and demographics could have profound impacts on urban and transportation planning. Often, city planners and transportation officials will be completely unaware of the electric sector implications of significantly electrified (urban) transport. Also, investments in electric infrastructure may only be one of several investments made by many of the same stakeholders.

8. Ryan Hledik and Jim Lazar, “Distribution Pricing with Distributed Energy Resources,” prepared for Lawrence Berkeley National Laboratory’s Future Electric Utility Regulation series, May 2016. <https://emp.lbl.gov/publications/distribution-system-pricing>



The interaction between electrification and urban/transport system planning may be particularly important as charging options evolve away from the current model of providing a few relatively low-rate chargers for public use in parking lots and at curbside towards much faster and perhaps more concentrated urban fleet charging.

Unlike decentralized off-peak home charging, enabling fast urban charging (or even faster highway charging) may involve significant alterations and upgrades to local distribution networks, which would benefit from being coordinated with other changes to urban infrastructure (roads, parking garages, etc.).

Hence, there are likely substantial benefits from early and frequent coordination among the many players involved, and identifying the projects with the highest future benefits may only be possible by assessing the full set of investments (and resulting benefits). For these reasons, utilities interested in a more forceful nudge of electrification, in particular of transportation, would likely benefit tremendously from developing an ongoing dialogue and perhaps more formal collaborations with transportation and urban planners as well as urban sustainability officers.

REGULATORY OUTREACH:

It will be critical to effectively communicate the benefits and complexities of electrification to regulators and policymakers.

Electrification will create new challenges not only for utilities, but also for their regulators. Perhaps most importantly, utility actions that facilitate electrification would increase electricity use at a time when regulatory incentives are often focused on reducing electricity use, primarily through energy efficiency measures. Also, many of the investments needed to facilitate electrification may be beneficial to customers and society only when looking beyond the classic electricity sector.

Beneficial electrification would therefore likely increase both customer electricity use and electricity bills, both of which are often viewed critically by the regulatory community if not understood in a broader context. Specifically, customers' overall energy bills, including bills for heating and transportation fuel, might decline as a result of electrification, and society would benefit from lower GHG emissions, even though electricity bills would increase.⁹ In addition,

9. In general, it is also possible, if not likely, that decarbonization will be somewhat more costly than business-as-usual. In that sense, customer energy bills may increase due to decarbonization efforts, even before considering shifting energy use in transport and heating towards electricity. But it could be that electrification is the least costly decarbonization approach.

widespread adoption of AEV fleets could have urban traffic, safety, and modernization benefits – positive externalities that are outside of the standard benefit-cost frameworks for utility commissions and thus not captured in any utility-centric assessment. Thus, beyond broadening the scope of benefits that public utility commissions (PUCs) include in their evaluation of proposed utility investments, coordinated planning between urban managers and large industrial transport fleet owners may also be helpful.

All of this suggests that for utilities to engage in activities that support meaningful electrification, regulators will need new approaches to evaluating such activities. In many instances, this may require changes in laws and regulations guiding the actions of PUCs. Such efforts take time. It is therefore quite possible that unless utilities engage early and actively with PUCs, the regulatory constraints on what PUCs¹⁰ can approve will turn out to be a significant hurdle for utilities when it comes to actively pursuing electrification strategies.

A number of actions utilities can take may be considered “pilot projects” even if relatively large in scale. Rather than being primarily designed to gather information, there are likely opportunities to use pilots also to create immediate benefits for a larger (and perhaps otherwise underserved) portion of ratepayers (such as low income ratepayers relying on public transportation or otherwise unlikely to be among early adopters of EVs) and to create important visibility/information benefits. The list of potential pilot efforts of this type is large, but could include:

- Providing a dedicated lane for autonomous EV shuttle service along an important transit corridor currently underserved by public transit.
- Electrifying a portion of the local school or mass transit bus fleet.
- Encouraging the electrification of some special purpose vehicles with high local visibility such as garbage trucks, street cleaning vehicles, or commercial delivery trucks.
- Providing well-designed public charging infrastructure and distributed generation (such as solar PVs and charging stations).
- Promoting the benefits of customer-interactive, grid-enabled smart thermostats, and integrated, controllable appliances.

10. For further discussion of new regulatory models, see the first brief in Brattle’s Retail Energy Practice Briefing Series, “Evolving Business and Regulatory Models in a Utility of the Future World.” http://files.brattle.com/files/5654_evolving_business_and_regulatory_models_in_a_uof_world_may_2017.pdf



RATE DESIGN:

Utilities should explore how modified retail rate designs could help remove unintended disincentives for electrification and potentially encourage beneficial electrification.

Some existing rate designs may create economically inefficient disincentives for electrifying additional end-uses. For instance, an inclining-block rate (IBR) structure charges customers an escalating price as their consumption increases over the course of the month. This rate design has largely been used as a policy tool to promote electricity conservation in a world where lower electricity demand is considered to be socially desirable. But since both electric heating with heat pumps and home charging of EVs for the purposes of achieving further decarbonization would significantly increase total electricity consumption, IBR structures provide a financial disincentive to adopting a heat pump water heater, heat pump space heater, or an EV.

Further, public high-speed EV charging stations present particularly interesting and challenging rate design questions. Until EVs are adopted in larger numbers, many new high-speed chargers will be infrequently utilized and, when in use, they will produce temporary large spikes in electricity demand.

This load pattern could require costly distribution system upgrades. However, if EV adoption grows over time, utilization of the charging stations should increase and may ultimately lead to an average retail rate decrease (i.e., as fixed costs are spread out across a higher volume of electricity sales), thus benefitting all consumers. Important rate design questions to be explored in this context include: To what extent are the near-term cost increases outweighed by the longer-term benefits? How (and from whom) can costs of the charging infrastructure be recovered without creating a counterproductive barrier to achieving the longer-term benefits of significant EV adoption? To what extent should this dynamic be addressed through modifications to rate design versus other mechanisms (e.g., rebates that offset the distribution infrastructure upgrade cost for a capped number of initial charging stations)? And if the issue is addressed through rate design, what options are available to transition from rates that facilitate initial deployment versus those that are appropriate once demand for charging has matured?

INFRASTRUCTURE DEPLOYMENT:

Utilities can play an important role in promoting the deployment of charging infrastructure.

In the near term it is likely that “range anxiety” will remain a major barrier to EV adoption. Ubiquitous and easy access to charging infrastructure, at home and on the road – making EV charging as easy as possible – will therefore likely be an important precondition for rapid wide-spread adoption of individually owned EVs. Furthermore, EVs used by ride sharing applications (like Uber and Lyft) may relieve some of those anxieties, especially in urban settings, but how quickly they grow may depend on the availability of high-speed charging infrastructure in convenient locations.

Public, fast charging stations and, in particular, charging hubs for fleet-operated EVs will potentially require significant distribution infrastructure upgrades, depending where they are located, which suggests utilities will need to be substantially involved in making sure such infrastructure gets developed quickly and in places that properly balance infrastructure costs and the demand for charging at specific locations.

Even if utilities only provide “make ready” infrastructure for charging, the rapid evolution of charging technology towards ever faster charge speed will likely require careful planning to avoid wrong-sizing or wrong-locating network infrastructure upgrades. Even though the provision of charging as a service will likely be a competitive activity in many locations over time, utilities may have a role as owners or operators of charging stations where other market players will not (yet) provide the charging stations needed to facilitate EV adoption. Also, since even the simplest EV home chargers will be amongst the more electricity-hungry “appliances,” utilities could also play a role in making home charging easier. For example, they could provide financial incentives or installation and maintenance support. To the extent that upgrades to electrical service are needed, utilities could provide financial incentives to help defray upfront costs.



CONCLUSIONS

Many factors are coming together to make electrification, in particular of transportation, an accelerating phenomenon with profound implications for electric utilities.

In contrast to the prevailing narrative of slow or declining sales, utilities could see significant growth in sales and assets as a result of electrification. Given the dynamic interaction of innovation on various transportation fronts, the growth could come sooner than many industry observers believe. There will be a multitude of players, long lead times for investments and changes in certain regulatory practices, and gaps between existing regulatory structures and planning procedures for what will likely be needed to foster electrification that is beneficial for consumers. As a result, utilities and society will require early and proactive utility action on several critical fronts. Beyond careful planning and evaluation of the right sequencing of electrification incentives, early interactions with other stakeholders, regulators, and policy makers are needed. This will allow utilities to play a positive and central role in an increasingly electrified economy.



ABOUT BRATTLE'S RETAIL ENERGY PRACTICE

As distributed energy resources (DERs) become more widespread and utility managers and regulators look toward incorporating new business models, the "retail" side of the electric utility industry is receiving increased attention. The Brattle Group's Retail Energy Practice helps clients address the critical issues that impact the utility industry at both the distribution system and retail service levels.

Brattle's Retail Energy team has extensive experience developing benefit-cost analyses for next generation investments in smart grid, system reliability and resilience, and overall grid modernization, as well as for investments at the system edge, such as electrification opportunities. We have also worked extensively on assessing business and financial models applicable to the evolving electricity market ecosystem, and are at the forefront of marginal cost and benefit analyses that are becoming increasingly important in determining efficient and equitable pricing constructs and incentives for DER compensation. Our expertise is grounded in foundational principles of economics and finance, in order to better align load forecasting, rate design, and risk management with industry trends and developments.

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