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Engaging Utilities in Transportation Electrification in the US and Europe

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Summary

Utilities could benefit greatly from EV adoption including through: increased electricity sales and revenue, increased asset utilization and management of a flexible load for grid benefits and higher levels of renewable integration. Many utilities are actively engaged in promoting transportation electrification to realize these benefits. But many also remain on the side lines, uncertain about the pace of EV adoption, customer preferences for charging, or how EVs will impact their ability to provide reliable, low-cost electrical service. Across the US and Europe, we find that the same four key challenges are inhibiting more active engagement on the part of electric utilities to promote and shape transportation electrification and provide recommendations to address those challenges.

Keywords: business model, charging, regulation, smart charging, utility

1 Introduction

To meet long-term carbon emission targets, electric utilities can and must be more actively engaged in supporting electrification of the transportation sector in two leading markets for electric vehicles: The United States and Europe. The intersection of electricity and transportation sectors is evolving rapidly in each region, as transportation electrification is emerging as a key pathway GHG emission reductions. Plug-in electric vehicles (PEV's) reduce GHG emissions while also providing substantial benefits in reduced petroleum consumption and tailpipe emissions. The transportation sector is calling upon electric utilities to produce and deliver fuel for a growing fleet of electric vehicles. Although electrifying transportation with today's grid reduces total fuel consumption and GHG emissions, achieving 2050 GHG reduction targets requires that the transportation sector demand be met increasingly with renewable and low-carbon generation.

PEV adoption presents significant opportunities for electric utilities, especially if charging is managed to avoid times of peak electricity demand. The key benefits that transportation electrification provides utilities include:

(1) **Increased sales and revenue from existing assets**: Charging of PEV's increases utility electric loads and utilization of existing infrastructure, increasing gross revenues. Depending on the regulatory scheme, increased revenues may benefit shareholders for investor owned utilities;

(2) **Reduced pressure to increase rates**: Closely related to the previous benefit, increasing sales over with existing capital infrastructure can reduce the need for utilities to increase retail rates. Utilities are facing upward pressure on rates as capital investment and maintenance costs continue to grow even as the rate of load growth has decreased with increased efficiency and distributed generation;

(3) **Opportunities for new capital investment:** Investor owned utilities earn a return on invested capital (rate base). PEVs provide an opportunity for utilities to make new capital investments to serve charging loads. This is also a potential challenge for utilities, if the capital investment required is large for the charging load served. Programs to discourage charging during peak load hours can reduce this risk, providing benefits for shareholders and utility customers alike.

(4) **Providing utilities with a flexible, manageable load**: PEV charging is also an inherently flexible load that utilities can leverage with managed charging to provide cost-effective load balancing services to the electric grid. These services will become increasingly important as decarbonizing the electric sector will pose new operational and reliability challenges, especially in regions where variable wind and solar generation dominate the resource mix.

2 Electric Utility Structures in the US and Europe

The market and policy frameworks differ in important ways across the US and Europe, as does the regulatory oversight and structure of electric utilities. Restructuring and unbundling of the utility sector to introduce completion at both the wholesale and retail level has progressed the furthest in Europe. Competitive wholesale markets have been introduced in some parts of the US, but retail competition for electric service remains limited. Nevertheless, electric utilities are well positioned to support transportation electrification in both regions, supporting infrastructure deployment needed to facilitate PEV charging and adoption. A common feature of electric utilities across both regions is that they operate under government or regulatory oversight to finance long-lived, network assets through gradual recovery of the initial investment from their customers.

The regulatory framework and utility structure differs significantly across the three regions with respect to engaging utilities in transportation electrification. The US has a mixture of vertically integrated utilities that own generation, transmission and distribution assets and predominately 'pipes and wires' utilities that purchase electricity from competitive wholesale markets or independent power producers. Utilities are regulated predominately at the state or local level, with oversight and direction of utility activities ranging from very active to more laissez faire. Retail competition has not made significant inroads in the US with just 5% of customers served by competitive retail providers. Some utilities in select states are investigating sponsoring PEV charging programs, but only one energy company, NRG, is involved in both retail electricity provision and PEV charging.

The utility sector in Europe has undergone more liberalization that in the US. Most customers are served by distribution network operators, unbundled utilities that do not own generation or transmission assets. Like the US, Europe has a mix of investor owned and public utilities and a mixture of more activist and more laisses faire regulatory oversight. Retail competition is far more prevalent in Europe than in the US, with strong implications for how utilities can support transportation electrification. Many distribution utilities are actively deploying PEV charging infrastructure in their own service territories or competing to do so in other regions through subsidiaries or public-private partnerships.

3 Engaging Utilities as Enablers of Transportation Electrification in the US

The US experience with utility engagement provides useful insights for Europe. A divided Congress in the US has left federal initiatives on GHG emissions or renewable energy policy largely to the executive branch. The Obama administration has said it will join the Paris Accords by executive order, (bypassing Senate ratification), pursued Environmental Protection Agency regulation of GHG emissions (EPA Clean Power Plan), strengthen vehicle miles per gallon (MPG) requirements and provided substantial funding for clean energy and transportation technologies. Still, implementation of the Clean Power Plan and Renewable Portfolio Standards and many other carbon reduction initiatives must be done at the state level where there is often limited political will for executive or legislative initiatives on climate change. In this environment, both the state and local policy makers have turned to using energy utilities as attractive policy levers, with an appealing balance of some regulatory oversight without the burden and complexity of requiring broad based legislative or political approval. In the US, utility industry associations (Edison Electric Institute and Electric Power Research Institute) have published studies on the benefits of transportation electrification, several state initiatives (e.g. California, Connecticut, Oregon, Washington) have directed utilities to submit transportation electrification initiatives for approval. Even in more conservative states (e.g. Kansas and Georgia) utilities have proposed deploying PEV charging infrastructure. The US is serviced predominately by investor owned utilities, which are required to seek approval of utility programs and investments in formal, public stakeholder processes. This provides information, documentation and opportunity for public input and review that is often limited for smaller, public utilities in Europe.

3.1 Potential Utility Roles in Promoting Transportation Electrification

The close relationship between utilities and government has led to them being used as instruments of public policy. Notable examples include implementing renewable energy purchase mandates, facilitating deployment of distributed generation and delivering and/or educating customers about energy efficiency. Around the US utilities, regulators and other stakeholders have identified several potential roles for utilities in promoting transportation electrification. Whereas initiatives for renewable energy, energy efficiency and distributed generation can challenge the traditional utility business model, transportation electrification is also a business opportunity for the utility, increasing sales and revenues, opportunity to earn a return on capital investment, and reducing pressure to increase retail rates.

Electric distribution utilities are particularly well suited to address the infrastructure development challenges impeding PEV adoption. Their business model is designed to finance long-lived, network assets through gradual recovery of the initial investment from its beneficiaries. The historic regulatory compact between investor owned utilities and their state regulators has kept financing costs in check by providing near certain recovery of capital outlays along with a fair rate of return. Public or Municipal utilities are directly overseen by local government or elected governing boards, and local taxpayers are accountable to repay lenders any costs that cannot be recovered through rates.

Utilities' historic roles in the areas of energy efficiency and demand response also point to other potential roles in educating customers and implementing managed charging. Utilities communicate frequently with their customers and tend to have well-developed outreach arms, so they are well situated to take on the role of educating their customers about the availability and benefits of EVs.

3.2 Challenges for Utility Engagement in the US

Utilities in the US face four main challenges to increase engagement in transportation electrification:

(1) Coordinating policy across energy and transportation sectors,

(2) Defining utility role in charging network business models,

(3) Enabling utilities to promote 'good' load growth.

(4) Implementing electric rates that both encourage and manage PEV charging

Each of these barriers is grounded in institutional factors, fundamental economics and stakeholder politics. Although European policy, regulatory, and market frameworks differ in important ways, at a more general level these the key barriers to PEV deployment are common across both regions.

3.2.1 Challenge 1: Coordinating Policy Across Energy and Transportation Sectors

Transportation Electrification requires unprecedented coordination across the transportation and electricity sectors. This presents an institutional challenge for regulators, industry, environmental advocates and other stakeholders. Overcoming this barrier requires investments of time and resources by all actors, slowing the development of public policy.

Historically the regulators overseeing the electricity and automotive industries have operated independently, implementing and enforcing separate bodies of law for distinct industries characterized by different fundamental economic market failures. Safety regulation and limits on tailpipe emissions address negative externalities and drive technology innovation in the auto industry. These are mainly federal functions, but the Clean Air Act permits California to adopt more stringent laws and other states to adopt them. The natural monopoly characteristic of electricity distribution and transmission networks is the principal focus of state electricity regulators, who are responsible for setting “just and reasonable” rates. Curbing smokestack emissions from power plants is primarily the purview of federal environmental regulators (US EPA), but over time state energy regulators have played an increasing role in this arena by promoting conservation, energy efficiency and renewable energy. While noteworthy, this trend represents a gradual expansion of energy regulators’ oversight of utility capital investment and cost recovery.

On one hand, weighing proposed utilities investments in PEV charging infrastructure and customer outreach and education is quite similar to the role that state utility regulators have played in promoting energy efficiency or renewable energy for ratepayer and regional benefits. On the other hand, it pushes state utility regulators out of their historic area of expertise into the transportation sector and stretches existing statutory guidance. Lacking appointees and staff with relevant experience, energy regulators have had to open lines of communication with environmental regulators and invest in build capacity to take on the policy have issues raised by transportation electrification. Electric utilities accustomed to providing universal service under a monopoly franchise must learn not only become familiar with rapidly changing PEV technology but also how to operate in an industry where consumers have choices and third-party charging companies compete to win PEV owners’ business. Automakers, accustomed to dealing with environmental regulators enforcing the federal Clean Air Act, must develop an understanding of rate design, public utility law and the arcane procedures of public service commissions. Environmental advocacy groups, which have historically had separate teams for electricity and transportation policy, have also had to do capacity building and break down internal barriers. A notable cultural challenge for environmental advocates (and for energy regulators and consumer advocates) has been reconciling a conservation focused mindset that frowns on load growth with the environmental benefits of substituting electricity for fossil-based transportation fuels. We will discuss this topic further under Barrier 3, which deals with institutional and legal impediments to load growth and utility infrastructure investment.

3.2.2 Challenge 2: Defining Utility Role in Charging Network Business Models

The importance of an accessible and reliable charging network to support customer adoption of EVs is widely appreciated. The business model for unsubsidized, competitive charging network remains unclear. Revenues from PEV charging revenues are not sufficient to recover the capital and operating costs for charging networks. In the US a primary challenge is the dominance of at-home charging. In the US, early adoption of PEV’s has been supported predominately, though not exclusively, with at home charging. This is possible because ~70% of car owners have a garage or off-street parking space. Most PEV owners can charge at home conveniently and at relatively low cost. Furthermore, many workplaces that do offer charging to employees do so for free. Both factors put competitive pressure on the prices that can be charged at public locations.

Early on, charging networks in the US have relied on public funding, most significantly federal stimulus funding that subsidized the installation of chargers beginning in 2009. As federal funding tapered off, states and municipalities took up funding of public charging infrastructure, albeit at a reduced pace. Charging networks have turned increasingly to site hosts and automakers for funding in recent years. Municipalities, workplaces and retail locations pay a fee for charging to be installed. This is predominately driven by cities and companies striving for emissions reductions or a green image on a voluntary basis. The business appeal for installing charging is limited, particularly in early years of limited PEV adoption, as it is difficult to make a strong link to increased revenue or customer traffic to the installation of a charger.

As described in Section 3.1, public and investor owned utilities alike see potential benefits for their ratepayers and shareholders in promoting deployment of charging infrastructure. Utilities seeking to develop charging infrastructure have also been welcomed by environmental advocates and automakers among other stakeholders. But others have raised questions about the appropriate role for utilities in the charging network business model. Consumer advocates are leery of potential stranded costs that will be borne by utility ratepayers if PEV adoption is lower than expected. They also argue that utility shareholders, not just ratepayers, should bear some of the risk for infrastructure investment, as they too stand to benefit. Some third-party charging companies see the utility as a stabilizing influence and a large customer for equipment, technology and services. Others have protested utility proposals to own and operate charging networks as unfair, subsidized competition that will undermine innovation in the competitive marketplace. The California Public Utility Commission has recently authorized small-scale utility pilot programs that entail very different roles for the utility relative to third party charging companies: Southern California Edison will rate-base upgrades at the customer premise and provide rebates for hosts to buy down the cost of chargers, while San Diego Gas & Electric will own and operate its own network of chargers. Energy regulators will most likely continue to wrestle with the competition versus innovation conundrum for some time, and ultimately different models may prevail across regions.

3.2.3 Challenge 3: Enabling Utilities to Promote 'Good' Load Growth

In most regions in the US, utilities have been directed to varying degrees to promote energy efficiency and demand side management. Decoupling revenues from sales has been a major focus for advocates of energy efficiency, to remove disincentives for utilities to invest in reducing their sales. In other areas, historical competition between electric and gas utilities has led to a prohibition against utilities promoting load building or fuel switching. These policies have created a momentum and regulatory structure almost reflexively views increased load as bad.

Utilities are facing flat or declining sales with increased adoption of PV as well as EE. Even as load growth slows, the capital investments need to maintain and improve an aging grid, much less realize the vision of the smart grid for the 21st century are growing. Utilities do have an incentive to grow rate base, but with limited load growth, this is countered by desire to keep rate increases to a politically acceptable level. Thus, utilities are not necessarily inclined to see PEV driven infrastructure investment as a good absent confidence that they can obtain regulatory approval to recover cost of those investments within politically acceptable levels of annual rate increases. The cost-benefit analysis in the US has been instrumental in demonstrating the potential for load growth from EVs to decrease rates, if managed properly, encouraging support from regulators and stakeholders alike.

In the US, the primary cost challenges for installing PEV charging have been found to be at the end of the distribution line and for the 'make-ready' costs on the customer's side. Historically, for EE and DG, utilities in the US have been very limited in the role they can play on the customer's side of the meter, and what utility efforts there have been to provide DG as a utility service have met with little success. Though there is a clear need to support infrastructure investment on the customer side of the meter, utilities either do not see that as their role, or want explicit regulatory permission before making such investments. The regulated monopoly prevented from large scale investment where it is needed on the customer side of the meter with expectation of cost recovery without explicit regulatory approval.

3.2.4 Challenge 4: Implementing Electric Rates to Both Encourage and Manage PEV Charging

Initially, utilities feared that PEV adoption would drive significant distribution system upgrade costs, especially if clustered in specific areas. With several years of experience, near-term grid impacts of PEV loads are now expected to be manageable. Nevertheless, introducing managed or smart charging of EVs sooner rather than later is important. At some point, new grid infrastructure will be required to serve transportation electrification loads, and managed charging can defer grid upgrades. With managed charging, utilities have a greater level of assurance that they increase the utilization of existing infrastructure and reduce average utility rates relative to an unmanaged charging scenario. It is important to have customers familiar with smart charging from the beginning – it is hard to impose fees or rules after something has been provided for free or without restriction (e.g. cell phone, internet news).

In the US, the requirement for revenue grade meters imposes a cost of $600 or more to install the meter, not including the customer cost for an electrician and panel upgrade. This has severely limited the deployment of dedicated meters for PEV charging. PEV owners then face the choice of opting in for a whole house

TOU rate that is offered by many utilities for PEV charging. However, TOU rates can increase costs for customers with significant daytime loads, such as air conditioning. PEV customer adoption of TOU rates in California is thought to be less than 60%. New approaches for encouraging optimal charging behaviour that do not require expensive metering and are attractive to home and business owners are needed.

3.3 Transportation Electrification in Europe

The principles that drive the benefits of transportation electrification and require cross-sector coordination between the electric utility and transportation sectors are common across the US and Europe. Even the most optimistic PEV adoption forecasts lead to manageable increase in the demand for electricity in the near-term. There is ample policy space and physical capacity on the grid to promote PEV adoption and learn from experience how to manage PEV loads before they begin to require more significant grid upgrades. Higher utilization of generation and grid capacity and charging with lower cost electricity during off-peak periods and periods of high solar and wind generation provide benefits for electric utilities. In the longer-term managing PEV charging to support grid operation and higher penetrations of low-carbon generation will be essential.

We find also that the challenges for engaging utilities in transportation electrification are common across both regions. In Europe, as in the US coordination of policy across the electric utility and transportation sectors is challenging with historically separate institutional and regulatory structures. Defining how public policy in general and utilities in particular should support charging infrastructure deployment is difficult in the face of competing business models and technologies. Although it has taken a different path than the US, utility regulation in Europe also discourages utilities from investing in and promoting load growth. Finally, with more advanced deregulation and a larger number of involved parties, implementing retail electric rates to both promote and manage PEV charging may be even more challenging in Europe than it is in the US.

While Europe faces these same four challenges, the market, institutional and policy context is quite different. To describe the challenges and develop recommendations for overcoming them we must first briefly describe the market and policy contest in Europe.

3.4 Market Structure for Electricity and PEV Charging

The energy sector in Europe operates under a 'liberalized' regulatory scheme that has since the 1990's increasingly introduced markets and competition in place of monopoly utilities. As a result, there are several actors in the supply chain delivering electricity to fuel electric vehicles. The three key features of the liberalized electricity market relevant for electric vehicle charging are:

- **Competitive wholesale energy markets:** electricity is produced by independent power producers and sold in competitive wholesale markets. Broadly the provision of electricity is separated into three types of markets: 1) energy markets for the sale of the electricity itself, 2) capacity markets to ensure sufficient generation capacity is available to meet peak demands and 3) Imbalance Energy and Ancillary Service markets to balance supply and demand in real-time and ensure reliable operation of the transmission system.
- **Regulated transmission and distribution utilities**: electricity is delivered through two layers of regulated monopoly electric utilities. Electricity is first delivered through high voltage transmission systems managed by the Transmission System Operator (TSO). Distribution Network Operators (DNO) receive and distribute electricity to retail customers. Regulators oversee transmission and distribution utilities, approving the network charges and the return on investment that utilities may earn to be fair and reasonable.
- **Retail Choice**: With liberalization, the function of selling electricity to retail customers has been unbundled from the regulated monopoly utilities in order to introduce competition and retail choice. Competitive Retail Service Providers (CSP) provide a variety of rate and service options that retail customers may choose from for electricity service. CSPs purchase electricity from the competitive wholesale markets and pay transmission and distribution regulatory approved network charges to deliver energy to the retail customer.

In the simplest case for PEV charging, the PEV owner charges at home and pays the CSP the same fees that apply to electricity consumption. However, a majority of PEV owners in Europe do not have dedicated parking at home for their vehicles. For electric vehicle charging, therefore, several additional actors may be involved is the supply chain.

- **Site Host:** A building or property owner that provides a site and parking space for Electric Vehicle Supply Equipment (EVSE) to be installed. This includes the PEV charger itself, and all the supporting infrastructure to deliver electricity to the charger.
- **Charge Point Operator (CPO):** the charge point operator installs, operates and maintains the EVSE to facilitate a reliable charging experience for PEV owners. (aka Charge Spot Operator or CSO)
- **Market Service Provider (MSP):** The market service provider is the interface with the PEV driver, similar to the role that the CSP provides for traditional retail electricity service. The MSP provides rate and service options for PEV drivers to choose from as well as the payment mechanisms such as payment cards or RFID tags that customer use to pay for charging. The MSP contracts with CPO's to provide PEV charging services and contracts for the purchase and delivery of electricity to the PEV charging stations.
- **Aggregator:** increasingly, aggregators are stepping into a role of facilitating ready interconnections across multiple CPOs and MSPs and between CPOs and MSPs and the DNOs and TSOs that provide electricity service. Broadly aggregators serve two roles: to expand the size of charging networks that PEV customers can access seamlessly, facilitating back-office transactions and billing across networks and 2) aggregating a number of EVs and CPOs to provide useful grid services to DNOs and TSOs. Grid services may be provided entirely with managed one-way charging of the EVs or with the EVs discharging electricity back to the grid (Vehicle-to-Grid or V2G).

3.4.1 Revenue Gaps in Transportation Electrification

Although there are net benefits overall for transportation electrification, the costs and benefits are unevenly distributed across all the actors in the supply chain. To describe the key barriers to expanded transportation electrification, it is first important to understand key gaps in the flow of payments and benefits for PEV charging. Here we focus on three key revenue gaps where we expect costs to exceed revenues and discourage the necessary investment in the infrastructure needed to support growth in PEV adoption.

The first gap is for the site host. There are significant costs in time, usable space and money for a site host to install and maintain EVSE. Understanding the complexities of electricity rates, billing, permitting and engineering can be a time-consuming distraction for a home or business owner or government employee. For many sites, parking space is at a premium. Business owners often do not want to lose scarce sparking space for charging infrastructure or dedicated parking for PEVs. It is not uncommon for a site host to ask for payment from a charge point operator (CPO) to lease space rather than pay for the privilege of having a charging station. The business appeal for installing charging is limited, particularly in early years of limited PEV adoption, as it is difficult to make a strong link to increased revenue or customer traffic to the installation of a charger.

The second gap is for the CPO. It is difficult for a CPO to cover the cost of installing and maintaining EVSE with revenues from PEV charging alone. Additional funding is required to cover upfront costs. In some cases, this can come from site hosts motivated to install charging, but for the reasons just described above, those opportunities are limited. Most charging infrastructure installed to date in Europe (as in the US) has relied on some form of public subsidy.

The third gap is for the distribution network owner (DNO). As we describe in more detail below, revenue cap regulation limits or delays the ability of DNOs to recover costs for investments in new distribution infrastructure that are driven by increasing PEV charging loads. Revenue cap regulation is designed to reward utilities for reducing costs; added costs to serve growing PEV loads can diminish those rewards. Furthermore, DNO network access charges are often based at least in part on peak demand (kW). As such, selling more energy (kWh) for PEV charging may not lead to an increase in revenue for the utility commensurate with its costs.

The revenue gap driven by revenue cap regulation and demand (kW) based network access charges is, in principal the same for the transmission system operator (TSO) as it is for the DNO. For transportation electrification, the DNO revenue gap presents the most immediate challenge. The cost and impact of PEV charging on the grid is more pronounced and direct at the distribution level. Only at higher levels of adoption will PEV load grow to pose a material impact for transmission networks.

Two of the four challenges described in the next section are related to overcoming these three revenue gaps.

3.5 Challenges for Utility Engagement in Europe

3.5.1 Challenge 1: Coordinating Policy Across Energy and Transportation Sectors

In Europe, as in the US, institutions regulating transportation and electricity have evolved independently with little need historically for cross-sector coordination. In the transportation sector, European regulations set GHG targets for new passenger cars and vans and the Fuel Quality Directive requires fuel suppliers to reduce GHG intensity in transport fuels by 2020. In the energy sector, the Renewable Energy Directive sets a target of 20% renewables by 2020 and 27% by 2030. Cross-sector initiatives have evolved in the last decade. For example, the Renewable Energy Directive includes a requirement that 10% of transportation fuel come from renewable sources by 2020 and several electro-mobility programs include initiatives that cross both transportation and electricity sectors. Still, as in the US, transportation electrification is requiring cooperation across regulatory and governmental institutions that have not historically worked closely together. This poses a steep learning curve for policy makers in each sector to learn the language, institutional framework and policy making mechanisms of the other.

The challenge extends to NGO's working on transportation electrification as well. Typically, groups engaged in transportation have had little need historically to work closely with their counterparts in energy. This poses the same challenge translating complex technical and regulatory information into language understandable for newcomers to the field.

3.5.2 Challenge 2: Defining Utility Role in Charging Network Business Models

The revenue gaps for the site host and CPO described in Section 4.1.1 impede the established of a compelling business model for charging networks. There is no clear pathway for private companies to install charging infrastructure and recover their full costs (plus a rate of return) in the rates charged to PEV drivers. The two dominant mechanisms to bridge these gaps have been providing public subsidy for EVSE deployment and for DNO's to sponsor or directly engage in installing EVSE. Differing opinions about the level and type of public or utility support that is necessary for widespread charging infrastructure deployment.

The Netherlands alone provides three different business model examples. Publicly available charging is crucial as roughly 80 percent of residents to not have a dedicated parking space at home. In one case, DNO's took the lead. The Elaad foundation, supported by 8 DNOs established a network of 3,000 public charging stations from 2009 to 2014. In some cases, municipalities provided funding to have EVSE installed in their area, but in other cases installation was fully funded by the utilities. Amsterdam has pursued a model led by the municipal government. EU requirements threatened to halt construction of new homes unless Amsterdam reduced per capita GHG emissions. The municipal government supported EVSE installation in part to meet carbon reduction goals. Amsterdam has a goal to electrify the entire transport system of the city by 2040, targeting 200,000 electric vehicles in the urban area. Amsterdam has issued tenders in which CPO's bid on the level of subsidy required to install EVSE. Amsterdam has 1,300 charging stations and recently awarded a tender to have 4,000 charging stations by 2018 to Vattenfall subsidiary Nuon and Heijmans. Finally, there is the example of Fastned, a private company that is installing DCFC on highways in the Netherlands without any public subsidy, funded largely by the company's founder.

In the absence of a compelling business model, it is far from clear that private investment alone is sufficient to support the level of EVSE investment necessary to meet GHG reduction targets. Some argue that deploying EVSE as a DNO owned grid network asset that is deemed in the public interest is necessary to ensure sufficient investment to support the PEV adoption necessary to meet GHG reduction goals. Private companies such as Nuon and Heijmans and Fastned pursuing a competitive charging network business model view DNO's installing EVSE with ratepayer funding or lower financing and tax burden as creating an unfair playing field. In the Netherlands, these opposing viewpoints led to Elaad being directed to cease further installation of EVSE at DNO expense and transfer ownership of the existing stations to the municipalities. Elaad has since evolved into ElaadNL, a knowledge and innovation center that developed the open charge point protocols (OCPP), and EVnetNL, a company that manages the existing charging stations in coordination with the municipalities.

The issue is further complicated in that state-owned enterprises may own companies operating in both the public and private sector. Alliander NV is a Dutch public limited liability company with all shares held by Dutch provincial authorities and municipalities. Alliander NV owns both Liander, the largest DNO in the Netherlands and Alliander AG a DNO operating in Germany and headquartered in Berlin. The company also owns Allego, a charging point operator that installs charging stations for cities and businesses. In 2016, the Dutch-German consortium including Allego and Alliander AG won a contract for installing and running 220 charging points for electric cars in Berlin. Competitors of Allego will argue that its business model is only viable because of its connections to and support from a state sponsored enterprise and access to low cost capital.

This presents public policy makers with a confusing landscape. Propose that DNO's install charging infrastructure and privately held companies competing to grow their charging network operations will argue their business model is be impeded. That business model, however, may only be viable due to indirect state or DNO support in the first place. The challenge then, is to develop schemes in which DNO's can support EVSE deployment in a way that is seen as fair and unbiased.

3.5.3 Challenge 3: Enabling Utilities to Promote 'Good' Load Growth

This section describes how current regulation schemes reward DNO's for reducing investment and operating costs while still meeting service reliability and quality targets. Under the dominant revenue cap incentive regulation scheme, load growth, whether from transportation electrification or other sources pose a risk of lower, not higher returns for DNOs. Fortunately, there are mechanisms that can be readily adopted to address this challenge and allow DNO's to view EVs as an opportunity rather than a threat.

EU directives give national regulatory authorities (NRA) wide latitude in implementing electric distribution policy and tariffs. Incentive regulation is implemented in most member states, with a form of revenue cap regulation being the most common. Maximum DNO revenues are pre-determined based on load and customer growth forecasts and other factors for a certain period, typically 4-5 years, but as long as 8 years. For example, In Germany, the first regulatory period was set for five years from 2009 – 2013 and a second review from 2014 – 2018. Revenue cap regulation is intended to encourage operational efficiency, with savings from efficiency shared between DNO ratepayers and shareholders. The longer period of 4-8 years between regulatory review relative to the US where rate cases typically occur every 3 years is designed to provide the DNOs a longer period to reap the reward of investments in cost reduction and operational efficiency.

Revenue cap regulation takes on many forms. Many countries implement a form of benchmarking, comparing total and/or operating costs across different DNOs to determine an appropriate allowed revenue cap. Other countries establish performance metrics for reliability and customer satisfaction that a DNO must meet to earn an authorized level of revenue or return on assets. In some, but not all countries, DNO's are permitted revenue increases only for corresponding increases in specific metrics such as number of customers, meters or 'exit points' on the distribution system. Once the revenue cap is established The DNO then seeks to serve the actual load and meet established metrics at lower than projected costs. The savings realized are generally shared in some form between the customer and DNO.

Common across most regulatory schemes is some form of annual adjustment to account for unanticipated costs or loads that are largely beyond the DNO's control. Though it is not labelled as such, this has the same effect as the revenue decoupling implemented in the US to encourage utility investments in energy efficiency that would otherwise decrease their revenues (and shareholder earnings). Annual revenue adjustments in and of themselves do not necessarily discourage utility investments in PEV charging that increases load, but neither does it provide any incentive.

The implementation of revenue cap regulation in Germany provides some additional detail. The revenue cap is established based on three sets of costs, inefficient, efficient and non-influenceable. Each DNO is benchmarked against its peers that have similar characteristics. Costs in each benchmark category that are above the peer group are deemed inefficient costs and subtracted from allowed revenues. Efficient costs are likewise costs that are found to be less than those of the peers. Savings from efficient costs are shared between the DNO and its ratepayers. Non-influenceable costs include employee benefits and TNO use of network charges are approved as a pass through and not subject to change under incentive regulation. Annual revenue is adjusted through an expansion factor based on the number of new connections and the size of the service territory. Finally, some include tariff structures that place more weight on fixed or capacity (kW) related charges to minimize exposure to fluctuating load growth. DNO revenues in the United Kingdom, Netherlands and parts of Germany are entirely capacity based.

Under incentive regulation revenue increases may not be approved or approved only if specific conditions are met. DNO's therefore face an asymmetric risk that can discourage infrastructure investment. Revenues may be increased based on the number of customers, meters or 'exit points' for the DNO. This in theory would compensate DNO's for new charging stations (though perhaps only if metered), but may not compensate for general upgrades to the distribution network to accommodate increased load.

To the extent DNO tariffs are weighted towards fixed or capacity charges, they earn little or no revenue for increased load. This provides a further disincentive to load growth if there is a long regulatory lag before revenue increases are made. As described above, revenue increases may be made through annual adjustments, but usually only related to specific metrics decided in advance under the incentive regulation scheme. Longer periods in between regulatory review are designed to encourage DNO investments in efficiency, reliability and customer service improvements and earn returns for a longer period before revenue forecasts and baselines are reset. This provides exactly the opposite effect for load increases not fully accounted for in annual adjustments in between review cycles. If per kWh energy charges are not sufficient to cover increase costs, DNO's are foregoing revenues and earnings until the next review which may be as much as eight years away.

3.5.4 Challenge 4: Implementing Electric Rates to Both Encourage and Manage PEV Charging

At a policy level transportation electrification is different from other types of electric load in two key respects. PEV charging is 'good' load that, on net, reduces overall energy consumption and GHG emissions. Second PEV charging load is potentially very flexible and can be managed to increase use of renewable generation.

At a more practical level for utilities, EVs are also fundamentally different from historical customer loads that electric rates have been designed for. PEV loads are potentially large; charging a single PEV can impose a load on the grid that is as large as a small or even medium size household. PEV loads are potentially very flexible; as long as the vehicle battery is full when needed, there is no inconvenience to the customer of changing when the charging occurs. Finally, EVs are, of course, mobile; a single driver will want to charge at a known rate in any number of locations, not just at or near home.

Ideally, EVs would be tracked and metered separately from other loads to both account for and take advantage of these unique aspects. However, as in the US, requirements for a revenue grade meter add significant costs to PEV charging installation for L1 and L2 chargers. In Stuttgart, some locations have elected to forego metering entirely and charge PEV drivers based on the time connected rather than the kWh consumed. A higher degree of regulation in Europe also poses barriers. For example, strict requirements on tracking (and taxing) company benefits provided to employees has also raised legal concerns in Germany with providing free charging at the workplace (for cell phones as well as EVs).

Electric rates for PEV charging should also be designed specifically to encourage managed charging of EVs that minimizes grid costs and maximizes the use of renewable energy. This requires not only the separate metering described above, but also new rate designs that are more dynamic that traditional utility rates. With more advanced and widespread deregulation of the energy sector, Europe faces additional challenges relative to the US: there are more actors involved. In addition, many actors have interests that conflict with the utility. A site host may want to offer free charging or charge more during peak business hours when parking is scarce. The MSP may want to offer a simple, predictable rate that is easily understood by drivers.

Auto manufactures and CPOs may not want to share information that would facilitate managed charging, but that they deem proprietary or sensitive.

In Europe, most customers receive electric service from competitive retail suppliers rather than directly from the DNO. This makes the connection between the DNO and the retail customer more tenuous that in the US and puts the rates charged to retail electricity customers (including charge point operators) outside regulatory control. DNO rate structures that may be weighted toward fixed and capacity charges should provide competitive retail service providers an incentive to shift loads away from peak demand periods, but visibility into how and how effectively they are doing so is limited.

Finally, rates should be designed to encourage growth in PEV load, but historical rate designs can do the opposite. DNO network access charges that are demand (kW) based, impose a high cost for L2 and DC chargers. If the chargers are not heavily used in early years of lower PEV adoption, PEV charging revenues may well not cover the network access or demand charges due to the DNO. Utilities will argue, correctly, that the network access and demand charges are there to recover actual infrastructure costs imposed on the grid. Cost allocation and rate design for electric utilities has evolved for more traditional customer loads that are less flexible or easily managed. However, with some investigation, it may well be possible to design rates that recover utility costs without imposing such an upfront cost burden for new charging stations.

The benefits of managed charging are not well quantified and understood, and are spread across many actors. Managed charging for load balancing and reserves can provide benefits for TSOs, but must be coordinated across DNOs, charging market service providers, competitive retail suppliers, with enabling technology and back-office systems for each actor.

3.6 Recommended Strategies to Promote Utility Engagement

3.6.1 Country Specific Cost-benefit Analysis

Cost-benefit analysis in the US has been instrumental in motivating regulatory proceedings and individual actors to propose specific programs promoting transportation electrification. Though the fundamental principles are consistent across international boundaries, the framing of cost-benefit analysis must be tailored to the institutional and regulatory landscapes to motivate specific actions by individual actors in Europe. Cost-benefit analysis is not the common currency of utility regulation in Europe the way it is in the US. Nevertheless, the costs and benefits of transportation electrification are spread across a number of parties that must work together to promote PEV adoption. Cost-benefit analysis will support development of specific initiatives and policies to promote the needed cooperation across different actors. We recommend a follow up project implementing an economic analysis for Germany in partnership with consulting firms with EU expertise. Germany is actively supporting transportation electrification with recent high-profile announcements and nearing the end of the second regulatory period for DNO revenue cap regulation in 2018. Though there is broad support for transportation electrification, developing more specific programs and proposals targeted at the main barriers will require a more detailed assessment of key categories of the costs and benefits for specific actors. In particular, we recommend:

1. Assessing the costs and revenue gap for key categories of site hosts installing L2 and DCFC chargers
2. Assessing the charging infrastructure costs for different PEV adoption and charging scenarios, including different charger types and levels
3. Quantifying short- and long-term DNO revenue and rate impacts with increased PEV loads
4. Describing and quantifying the benefits of managed charging for DNOs, Charging Market Service Providers and Competitive Retail Suppliers respectively (focus on distribution upgrade costs).
5. Quantifying the benefits of EVs as a flexible resource for TSOs in relation to other options, such as energy storage and flexible loads (focus on bulk power system and wholesale energy/AS markets)

For the three remaining challenges, we recommend convening key stakeholders and developing case studies or concept papers. Below we describe how thought leadership can fill in information gaps and support policy makers to develop concrete proposals.

3.6.2 Develop Framework for Impartial DNO Public-Private Partnership Models

Europe has more experience than the US with government issued tenders for CPO's to bid on the level of public subsidy required to install charging infrastructure. According to conversations as EVS 29 in Montreal, Germany is developing a proposal for 1.2 billion euro to subsidize installation of chargers and is establishing eligibility requirements. In addition, unlike in the US, several DNO's in Europe are actively investing in subsidiaries providing charge point operations and market services for EVs. Vattenfall recently won a bid for deploying up to 4,000 stations in Amsterdam by 2018 and reportedly offered payment to Amsterdam rather than requiring a subsidy (the tender also provided access to 800 existing sites with revenue potential for Vattenfall).

DNO's can be a key actor in spurring investment in EVSE, but their role must be defined in a way that enables public support without discouraging or crowding out private investment. There is an opportunity to provide thought leadership in this area, identifying best practices from prior experiences with subsidized municipal tenders and public-private partnerships with DNOs in Europe. Research and workshops to propose how public subsidy and DNO support and investment can be provided in an effective but impartial manner for a variety of CPOs and business models. Participants could include companies such as Alliander, Allego, Vattenfall and others that are actively pursuing unregulated investment in charging networks to characterize promising business models and public-private partnership approaches. This work can also suggest the requirements that charge point operators should meet to be eligible to participate. The requirements would be designed to maximize the vehicle adoption and eVMT realized though public subsidy and/or DNO investment. For example, the requirements could include interoperability, open access, ongoing O&M and other requirements to maximize impact on consumer PEV adoption.

3.6.3 Develop Mechanisms for Tracking Transportation Electrification Loads in Revenue Cap Regulation

Identifying simple mechanisms that work within existing revenue cap regulation to remove risks and disincentives for DNO infrastructure investment would be an impactful next step. Many revenue cap regulation schemes already include metrics though which utilities can increase revenues to account for increasing size or number of customers. Explicitly adding incentives and metrics related to transportation electrification in revenue cap regulation would be a natural extension - for example, including the number of PEV chargers at each respective charging level (L1, L2 and L3) to the calculation of allowed revenue and annual revenue adjustments. It is a particularly opportune time to begin this discussion in Germany, to propose specific improvements to implement after the end of the second regulatory period in 2018. Stakeholders could be convened to flesh out and propose specific mechanism that could be readily incorporated in revenue cap regulation.

3.6.4 Design and Propose Managed Charging Pilots

There are many theories, but limited empirical evidence regarding how customers will accept and react to incentives for managed charging. Cost/Benefit analysis can determine the technical potential for value from managed charging, but customer facing models to capture it must be proven in the field. Utilities and charging companies should be encouraged to implement programs with rigorous experimental designs and data collection in order to inform policy makers regarding the most effective approaches. In Europe, unlike the US, competitive retail service providers could prove a good resource as nimble, unregulated partners. As just one example in the UK, regulated DNO/TSOs are being bypassed with direct TSO payments for control of devices in-home via aggregators, which has both positives and negatives. Developing ideas for programs that engage customers in managed charging without cumbersome and expensive metering requirements would be particularly helpful.

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