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Gap Analysis Research Paper: Interaction of Electric Vehicles and the Grid within Canada

Completed by Pollution Probe on behalf of Natural Resources Canada

Contract Number: 3000637166

March, 2017

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ACKNOWLEDGEMENTS

Pollution Probe would like to thank all the electrical utility stakeholders who dedicated their time and expertise to inform this research paper. Their generous participation in Pollution Probe's research made this paper possible, and their candid and pragmatic insights have made the findings presented in this paper meaningful and practical.

While some participating organizations wish to remain anonymous, Pollution Probe would like to acknowledge the support of the following organizations in the development of this paper:

Natural Resources Canada

Alectra Utilities

Burlington Hydro

ENMAX Energy Corporation

ENMAX Power Corporation

Guelph Hydro Electric Systems

Hydro Ottawa

Oxford County

Utilities Kingston

About Pollution Probe

Pollution Probe is a national, not-for-profit, charitable organization that exists to improve the health and well-being of Canadians by advancing policy that achieves tangible, positive environmental change. Pollution Probe has a proven track record of working in successful partnership with industry and government to develop practical solutions to shared environmental challenges. Its *Pathways Initiative* is working to identify and promote transportation pathways which will deliver deep reductions in greenhouse gas emissions while promoting economic development in Canada.

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EXECUTIVE SUMMARY

Pollution Probe was contracted by Natural Resources Canada on February 22, 2017 to develop a gap analysis research paper in order to provide information on the current state of preparedness of neighbourhood-level electricity grids to accommodate electric vehicle (EV) charging, as well as identify key issues being faced by Canadian utility companies associated with EV adoption. The information in this report was collected through discussions that posed a series of eight questions to utility representatives who have experience working with EV-related technologies.

The purpose of the report is to enable Natural Resources Canada to gain an in-depth understanding of the current challenges and opportunities with regard to EVs and their interaction with electricity grids across Canada, as well as identify possible areas for further research.

While the findings of this report touch upon many specific issues related to EV deployment, a general, foundational finding is that at the system level, most grids throughout Canada have a significant amount of excess capacity. Better managing this capacity to optimize existing asset utilization was viewed as a much favourable alternative to adding more generation and distribution infrastructure to accommodate the increased peak usage that could stem from higher levels of EV use.

Other important insights, which are detailed at length in the "Discussion Responses" section and overviewed in the "Key Findings" section of this report include the following:

1. **Encourage and incentivize off-peak charging**. If a large majority of EV charging occurred during off-peak hours, this would significantly mitigate near term threats to the distribution system, deferring the need for infrastructure upgrades and optimizing existing system assets. This behaviour must be communicated, encouraged and incentivized among EV owners.
2. **Tell utilities where EVs live**. As the vast majority of EV charging occurs overnight at home, utilities need to know where EV owners live. Data privacy issues currently prevent utilities from gathering this information from government departments that register vehicles, but if a mechanism were developed that would provide utilities with the addresses/locations of EV owners, it would make utility planning and energy management processes far more straightforward.
3. **Voluntarily limit residential control over charging**. The ideal scenario would be for EV users charging at home to grant a level of control over rate and timing of EV charging to their utility. This would allow utilities to better utilize existing infrastructure.
4. **Purchase incentives drive EV adoption**. The EV and EVSE purchase rebates offered by some provincial governments not only serve to drive increased EV adoption levels, but give regulators and utilities a mechanism by which to track EV ownership data – vital information from a systems planning and management perspective.

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5. **EVs are a gateway to other smart technologies – deploy them right**. The rollout of EVs is a major, fundamental first step in the development of emerging smart, low-carbon energy solutions that will define the future of energy systems and the future of utility business models. It should not be done in an ad hoc manner.
6. **Work towards universal standards for EV hardware**. The standardization of internal and external EV charging hardware will enhance the ability of utilities to manage EV-related loads, and develop products and services that facilitate EV use.
7. **More load means more business**. Utilities generally welcome additional loads coming online as a result of EV adoption, as this essentially expands the scope and volume of their core business. As EV adoption levels increase, utilities will become more engaged in integrating the new loads that EVs bring.
8. **Stress EV affordability to gain mass market appeal**. EVs will never gain mass market appeal based on their environmental benefits alone, but if their cost benefits over internal combustion engine vehicles are stressed to the public, uptake will accelerate, especially in jurisdictions that offer purchase rebates. EVs are also high-performance cars that are fun to drive.

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INTRODUCTION

BACKGROUND

Transportation is currently the second largest source of greenhouse gas (GHG) emissions in Canada, contributing over 170 Mt of emissions each year, or roughly 23% of the national total. In most provinces, however, it is the leading source of emissions, and also has significant negative air quality impacts in urban areas.

As part of global efforts to limit the impacts of climate change, Canada has committed to reducing its total GHG emissions by 30% of 2005 levels by 2030. The achievement of this target will require net emissions reductions of approximately 200 Mt from current levels. The uptake of lower carbon transportation options is seen as a critical area from which to achieve emissions reductions.

Further emissions reductions from Canada's electricity generation sector will be difficult to achieve, as much of the sector has already decarbonized, with over 80% of electricity currently produced from clean sources. Sectors that still use a high proportion of energy derived from the combustion of fossil fuels will be targeted for aggressive emissions reductions.

Roughly half of all transportation emissions in Canada stem from light-duty vehicles – the personal cars and trucks that most Canadians own and use on a daily basis. These types of vehicles are amenable to electrification using existing, commercially available technologies. As the average Canadian only drives about 50 km each day, electric vehicles (EVs) are more than adequate to meet a large majority of our personal transportation needs. Most production EV models now have ranges that exceed 150 km per charge. This is certainly not as far as the range of a typical internal combustion engine vehicle (ICEV), but typical ICEV owners also don't have the option to top up their gas tanks while their cars are parked at home.

As the previous point highlights, there are many ramifications to shifting our primary mode of personal transport from ICEVs to EVs. From behavioural changes to refuelling infrastructure, the shift to EVs will necessitate the development, integration and acceptance of new technologies and practices. Everyone will have a role to play in the greening of our transportation sector, but one of the leading roles must be played by Canadian electrical utility companies if EVs ever hope to supplant ICEVs as the primary mode of personal transportation.

The uptake of lower carbon transportation options such as EVs has been limited due to both financial and non-financial barriers that include: a lack of comprehensive policies, high incremental costs, low consumer awareness and confidence, lack of recharging and refueling infrastructure, and slow commercialization of next-generation technologies.

The large scale deployment of EVs will play a role in contributing to emissions reductions from the passenger vehicle sector. There is a need to better understand the interplay between EVs and recharging infrastructure locally, as well as the greater electricity distribution system within Canada. Pollution Probe has undertaken a wide array of work in this area, specifically in its recently released

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report Accelerating the Deployment of Plug-In Electric Vehicles in Canada and Ontario and through its *Electric Mobility Adoption and Prediction* (EMAP) projects in various Canadian cities, which combined sophisticated market research methodologies with detailed grid integration and impact analyses.

One of the most important considerations related to EV adoption is the impact it will have on neighbourhood electricity distribution systems, which are comprised of distribution feeders, street-level transformers and the secondary cables responsible for running electrical power to individual households. Previous research conducted by Pollution Probe has shown that early adopters of EVs tend to be concentrated in specific neighbourhoods that can often be characterized by residents with a common set of values and lifestyles. This clustering of EV adopters means that streets in certain neighbourhoods could soon have multiple EVs charging simultaneously on a regular basis. While this additional demand is not expected to overload street-level transformers at present levels of EV adoption, as the technology begins to appeal to a broader market there will be a greater need to recognize and proactively address the demand for power required to charge EVs at the local level.

OBJECTIVE

The purpose of the report is to enable Natural Resources Canada (NRCan) to gain an in-depth understanding of the current challenges and opportunities with regard to EVs and their interaction with electricity grids across Canada, as well as identify possible areas for further research. This report is also intended to highlight the extent to which utilities are planning for growth in the EV market as well as their general views on EVs. As the penetration rate of EVs grows within Canada, it is important for NRCan to know possible implications and future considerations in this area.

METHODOLOGY

In order to monitor and report on the current status of utility engagement on EVs and associated demands on power supply infrastructure, this project focussed on attaining and synthesizing first-hand accounts from utility representatives on the challenges and opportunities they are currently facing with respect to EVs. Pollution Probe contacted utility representatives across Canada who were known to work at the interface of EVs and local grids, and requested their participation in a discussion. Eight questions, encompassing the most pressing issues related to EV-grid interactions at the local level, were developed in collaboration with NRCan. Participants were given the option of providing responses via a telephone discussion or in written form. Responses were received from 12 stakeholders representing 10 utilities located in Ontario and Alberta.

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RESPONSES

All responses have been anonymized to protect the confidentiality of respondents, and are presented in a randomized manner under each question. Where applicable, the province respondents are located in has been specified, in order to avoid confusion about provincial programs related to EVs or electrical utilities, or to highlight barriers and opportunities specific to a certain province. Because some responses extend beyond one paragraph in length, responses from each organization are differentiated by alternating background colours.

QUESTION 1: Status update - How have utilities been preparing for EV charging? Is this seen as a pressing issue? If so, how is it being addressed (e.g., has it factored into considerations such as rate application)?

We have been active on EVs for the last five or six years. Because we have been proactive we do not see it as a pressing issue. One area of interest for us is the delivery of DC fast charging networks, especially as a part of the Ontario Ministry of Transportation's (MTO) Electric Vehicle Chargers Ontario (EVCO) program, which is subsidizing the deployment of public Level 2 and 3 charging infrastructure. We are looking at some of the best ways to deploy DC fast charging (Level 3) from a grid integration point of view. We are trying to build relationships with Electric Vehicle Supply Equipment (EVSE [synonymous with EV charging stations and associated hardware]) hosts and organizations related to the deployment of DC fast charging networks. We are engaging in discussions with these stakeholders regarding whether or not separate meters or existing meters should be used to monitor the energy flowing to DC fast chargers. Eventually DC fast chargers will have to undergo a connection impact assessment process. This is currently a nascent field, but will start to become more standardized among utilities in the coming years.

Residential charging is not a big issue right now, as adoption numbers are still small. We use a data analytics company to see if there are too many EVs drawing power from the same transformer. We gather meter data and share it with a data analytics company to isolate homes with EVs. This is a fairly straightforward process right now, but it's not 100% accurate.

Because costs associated with EVSE right now are not very significant, this has not been incorporated into a rate application thus far. However, the incremental load from EV forecasts is now being taken into account in load forecasts. The first step is to identify the load, and the second step is establishing what incremental costs will be required to manage that load, and then EVSE can be integrated into rate applications. We have identified the EV load in our service territory, but it's so small compared to the total load. EVs are therefore not currently an energy supply issue at the grid level, but a peak demand issue.

EV charging is not seen as a pressing issue due to small EV uptake levels. But we do have concerns at the neighbourhood level, especially with regard to the risk of overloading street-level transformers. If four

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to five homes serviced by the same transformer plugged in EVs to charge at the same time this could place a great deal of stress on the transformer. To mitigate this risk, we have reduced the number of homes serviced by each transformer in new neighbourhoods, from 10 to 12 homes per 50 kVA transformer, to 8 to 10. This does not represent a big cost to the distribution system, especially considering that developers cover the costs of transformers in newly developed neighbourhoods.

We installed a charging station in 2012 at a local mall, mainly to help us better understand how they work, including the installation process. We also purchased an all-electric van and added two hybrid vehicles to our fleet. A couple of years later we installed two Level 2 charging stations at our own workplace. These small-scale demonstrations have helped us understand some key practical considerations with regard to EV deployment, so we can be of more assistance to our customers.

As part of our internal EV education process, we invited EVSE suppliers and experts to give presentations to our staff in 2010, with a focus on EV-grid connections. Around the same time, we also surveyed our community to gauge interest levels in regard to EVs.

In regard to public charging, we have not finalized a strategy on how much to charge users. We are leaning towards $1 to $1.50 per plugin, then a fixed price per minute of charging, totalling to an estimated $4 or $5 per charge (at Level 2). We have heard that public charging usage has declined in some jurisdictions after the introduction of fee for service systems.

We consider EV charging to be part of our normal load growth. It is not seen as something separate from existing planning processes.

We see the loading effect of EVSEs the same as if the loading increased because of more large electrical appliances being added in a premises or if there was an overall move to greater electrification for reducing GHGs. How we deal with over loading of grid equipment due to EVSEs is discussed in question 6. We had applied under the custom rate application rules and are not due for another filing until 2020, and have been treating our activities vis-a-vis EVSEs as part of our normal course of business while awaiting further clarification from the regulator on EVSEs.

In the meantime, we have been acting on each of our Electric Mobility Adoption and Prediction (EMAP) study recommendations, which entail: working with a condo board on integrating EVSE; supporting the MTO's EVCO applicants with interconnection feasibility and costing information; improving our website on EVs; participating actively and learning with Canadian Urban Transit Research Innovation Consortium (CUTRIC), Electric Mobility Canada (EMC), and other organizations; addressing our Conditions of Service and standards considering EVSE.

However, we are increasingly seeing the need to be proactive in helping manage the load. We have undertaken in the following activities to that end: engaging with NRCan on a DC fast charger impact study; engaging with NRCan and municipal governments on standards for EVSEs in the road right-of-way; undertaking a smart grid advanced demand response project that helps manage loading on a neighbourhood transformer and upstream assets. Also, we are studying offering EVSE, controlling EVSE, bundling or supporting the grid with energy storage, and so on. Whether these ideas materialize and if

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so, whether they will be delivered under the regulated or unregulated sides of the company is to be determined.

Personally, I think utilities are asleep at the wheel. We created a micro-grid project in part to establish a venue for EV load analysis.

EVs are expected to ramp significantly over the next several years and when the charging stations begin to appear, especially on residential transformer equipment, utilities will be unprepared.

EV on-board charge controllers have steadily increased from a standard of 3.3 kW peak to an over 7 kW peak. In some cases, dual Level 2 chargers with the capacity for up to 20 kW are available. Residential distribution transformers in many regions are rated at 50 kVA or 75 kVA, and supply a dozen or more homes. Quick math suggests there is a potential risk of utility equipment stress or failure.

Utilities should be required to demonstrate EV readiness through their asset management plans. In the absence of better planning, I believe utilities are at risk infrastructure degradation and early failure.

We were a participant in the EMAP Project with Pollution Probe, which gave us a sense of the demand for EVs in our service territory, as well as an assessment of our ability to meet that demand.

Before that, we had an internal pilot where we subsidized some staff members to try out EVs. We were interested in learning about what it was like to connect charging stations at home and at workplaces. We have been in discussions with different customers and municipal governments since then. We are looking at EV integration from every angle at the moment.

To date, we have not seen any impact to our distribution system that can be directly attributed to EV charging. Distributed charging stations (e.g., in residential homes) are not foreseen as introducing a huge demand on the system due to the diversity of usage and locations. Commercial, purpose-built stations on the other hand may have a more significant effect on the capacity depending on the size of the facility and their concentration in the area. So far we have not seen any commercial activity in our service territory. This has not been factored into our rate application filings due to lack of evidence to support it.

Yes, we are preparing for EV charging. Although we have low adoption rates of EVs in Alberta, we see it as a priority for 2017. We are currently exploring models which would allow us to invest in the electrical infrastructure to service EV chargers (not the chargers themselves). We anticipate that we may have to make a case to our Regulator in order to invest in the electrical infrastructure to service EV chargers. There may also be opportunity to make a case for building a rebate program, similar to what is being done in parts of California. We are also in contact with our municipal government and developers to get a better understanding of short and long term public/private charging infrastructure plans and/or mandates.

Most utilities have not done much. Some are not prepared and some do not understand that they need to do anything. If EVs are introduced to the grid randomly, in an ad hoc manner, they will overload distribution assets, especially in regard to peak loads during peak times.

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We are trying to manage charging to achieve two things: relieve the stress on distribution assets and create an optimal pricing signal to customers.

Three EVs charging simultaneously from a 75 kVA transformer feeding 15 homes during peak hours can push transformers beyond their capacity. In the near future, utilities are anticipating higher EV usage rates than this in certain neighbourhoods, and they do not want to have to increase the capacity of distribution assets (i.e., street-level transformers) just to serve a higher peak. It is far less costly and far more of a modern approach to manage loads that are non-essential during peak times.

EVs are starting the trend towards greater grid flexibility and user customization through things like home energy storage. EVs have big loads, they are intelligent, and they are behind the meter at the point where peak usage comes from. But many utilities do not ask and do not care what is going on behind the meter.

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QUESTION 2: Please comment on whether advances in EV technology (e.g., greater on-board charger or battery sizes) have affected earlier predictions for the capacity of distribution systems to accommodate EV charging.

During the EMAP study and after the study was completed, we had always considered that EVSE would likely need the capacity to satisfy customer charging time. We are also considering the introduction of large e-transit bus chargers, and clusters of DC fast chargers.

From the outset, the Ontario Energy Board (OEB) failed to see EV charging as a core distribution activity. Decision-makers saw EVs as a transportation issue, but it is really equally as much an energy issue (due to the size of EV loads and the way the grid was designed). So utilities are not designing systems for EVs yet, but developers are coming to us for solutions, especially for multi-unit residential buildings (MURBs).

Utilities are interested in better managing the throughput of electricity distribution systems, rather than adding infrastructure just to meet an increasing peak demand. This is a major design shift that will have to happen soon. Grids in Canada typically under-utilize 40% of their capacity for most of the year, as this excess capacity is built into systems just to accommodate annual peaks. Planning for greater peaks is very expensive, so a challenge for utilities is to manage peak capacity better, and disperse EV charging times and rates over longer periods.

Utilities are capable of setting up and managing homes to minimize on-peak power usage, a move that could save customers 30-40% of electricity costs. But EVs are a very important initial piece of this new energy management paradigm, and their integration must be handled properly now, before their volumes increase to the point where you start to see the clustering of EV ownership and higher adoption levels.

Several years ago, we participated in Pollution Probe's EMAP study, in collaboration with Georgian College. After that study we future-proofed our EV demand projection numbers, for example by assuming the introduction of larger on-board charger capacities and bigger EV batteries in future years. These technological developments have indeed materialized, and market advancement of EVs has not been faster than anticipated, so we have a good understanding of the impacts that EV technology will have on our system. We actually expected EV adoption in our service territory to progress faster than it has in recent years, so we are well-prepared for further growth in this area.

Indeed, with the rapid increase of charger output, we will need to adjust our past expectations of what "EV load" looks like, and how it could impact our distribution system. We have not yet addressed this.

As the per unit electrical demand of single chargers increases, a significant amount of charging demand would be expected even at a low level of EV penetration. This will advance the timeline of the preparedness of the grid in terms of the need for demand-side management or more significant system upgrades sooner than expected.

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We welcome new loads coming onto the system and will accommodate more demand. But newer charging stations that can communicate with each other and stagger the charging of different vehicles to avoid big peaks would make the impact on the distribution easier to deal with. Utilities are very much aware of the risk of a transformer overloading if five or so EVs are drawing power from it at the same time. This is the number one concern from our perspective. However, smart systems that will facilitate EV-grid communications will go a long way towards addressing these concerns.

FleetCarma's ChargeTO demonstration project is a good example of a study that has a great deal of practical use to utilities. We would like to see more projects like it, and would be willing to participate in such projects.

Advances in EV technology have not affected the distribution system in our service territory.

This should be assumed, and on-board charging systems will only increase in peak demand capacity. As an example, my Smart EV has an onboard 3.3 kW charger and provides a range of about 20 km per hour of charging. A 7 kW charger will provide twice that amount. Tesla now has a 20 kW Level 2 charger, which may be indicative of future charge rate levels. Utilities will need to regulate and monitor peak loads as EV use expands. At this point, utilities typically do not have access to real-time distribution transformer loading data and very few are working on a means of expanding to transformer hourly load monitoring or even aggregating smart and interval metering data for analysis of potential EV load shapes.

In regard to the two areas of advancement mentioned in the question, the most salient factor may not be the size of the battery or the charger, rather the rate of charging that may impact the demand as energy is consumed and charged on per unit basis (i.e., kWh). So far, there are no synergies between manufacturers' technologies and no unified standards to which these units are built. Once these standards are in place, utilities can better plan to support EV systems.

Charging rates over 30 amps start to add up and stress local distribution systems a lot faster than those below 30 amps. The 30 amp range is the breaking point for technologies that are easy to integrate at the neighbourhood level and those that are not. Alberta has no system pressures, no peak pricing, a hugely depressed electricity market, an over-abundance of transmission lines, and a very advanced distribution system. As a result, we do not have anything in the electricity market that requires the kinds of services that batteries or EVs connected to the grid could conceivable provide. Alberta therefore lacks the levers to facilitate EV deployment, so utilities here are in a challenging situation.

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QUESTION 3: What is the current state of utility capacity for predicting/monitoring changes to the grid over time (e.g., has it become any easier to determine where EV users are located? Are new technologies helping with this?)?

Utilities are pretty good at monitoring changes to the grid, and have advanced outage management systems (OMS) that can take smart meter data and infer loading on any part of the distribution system at any time, on any transformer or feeder lines. What utilities generally lack a mechanism for is knowing how many vehicles are in a given city and where they are charging. For example, we know exactly how many EVs are owned by residents in our service territory, but only know the exact location of about 10% of these EVs. This is because there has never been a reason for EV owners to communicate with utilities. So there is a fundamental missing link in getting information from EV owners.

FleetCarma takes data from MTO's Electric Vehicle Charging Incentive Program (EVCIP) from whoever applies for a rebate on the purchase of a charging station and lets utilities know (via participation in Electric Mobility Canada and Plug'n Drive programs) how many charging stations are sold in their jurisdiction. Utilities are not currently permitted to receive government data on exactly where EV owners are located due to privacy issues, but they do have access to the total number of EV owners in their jurisdiction.

To work around this predicament, we run a program that encourages EV owners to contact us by offering a very attractive solution for them. The program offers EV owners low-cost financing on the purchase of a sophisticated EV charging station, with no upfront capital or installation costs. In addition, we are planning to offer customers very attractive rates for the energy needed to charge their vehicles. In exchange for these benefits, customers allow us to manage the rate and timing of EV charging to a degree, with customers specifying a minimum state of charge and the time of day (usually in the morning prior to the drive to work) when they need their EV to be fully charged. To make customers aware of this program we promote it on our website, which is often visited by new EV owners. If customers are interested in this program, we can purchase and deliver EV charging assets via an unregulated affiliate. We have had lots of uptake on the program so far, and expect participation levels to grow. Developers of MURBs have also shown lots of interest in the program. With enough enrollees in such programs, utilities will be able to make prices even more attractive to customers.

Right now, utilities have the most important energy relationship with customers. But some utilities are becoming aware that there are other organizations looking to take that relationship away (e.g., Google, Rogers), and they will do it if they begin offering people equipment and services for home energy management before utilities do. These companies have been working silently in the background for years now, developing algorithms to deliver on such offerings. So if utilities want to maintain their energy relationships with customers they must begin acting now, developing and offering an advanced array of services that more and more of their customers are looking for. Rogers, for example, began entering this space by offering services like Smart Home Monitoring, and then broadened their reach by offering home energy management tools which allow users to control devices throughout their homes

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via smartphones. As utilities have to manage grid assets on behalf of everyone, however, they are best-situated to offer these types of services to customers. From a business strategy point of view, offering these tools and services is a strategic imperative to ensure long-term growth.

Until Alberta shifts to some kind of smart meter system, there is not great capacity for predicting or monitoring EV uptake. When things get more complicated, with bi-directional power flow, etc., the grid in Alberta will not be able to integrate a lot of those technologies. But for now, because the grid has been over-built, there are no constraints for utilities to connect to the grid, and there is time to think about possible long term solutions.

We currently do not have a system to specifically monitor or predict the proliferation of EV charging in our service territory. However, any new EV charging station in Ontario, whether commercial or at the residential level, requires Electrical Safety Authority (ESA) authorization to connect to the grid and this is one way for utilities to track these types of new connections. We do load forecasting, in general, for the short term (1 to 2 years) and long term (5 years or more) in consultation with our municipal partners (for load growth and development data) as well as the Independent Electricity System Operator (IESO) and Hydro One, and make appropriate investments to meet the predicted changes in demand. To our knowledge, EV penetration has not been factored into the forecast model of any of these local or provincial entities, let alone our own model.

We can use a data analytics company to identify hotspots or homes that are highly likely to host EVs. However, this process is not perfect, and EV charging can be confused with hot water heaters (especially if a customer has just switched from a natural gas heater to an electric one), which can have somewhat similar signatures to EVs. EVs do, however, have a fairly unique signature and they are relatively easy to identify, although they can also be confused with marijuana grow operations.

Utilities can access Ontario Ministry of Transportation (MTO) data for consolidated numbers on EV ownership. The data we receive, however, is only at the municipal level. Because of data privacy issues, we cannot get data on specific households where EVs are owned. Utilities would find it very helpful if they could be provided with at least the first three digits of the postal codes of EV owners. We have not had the need for this type of data so far, but we are embarking on projects related to workplace charging and net zero energy communities, and to guide these projects we may need to approach the MTO again to figure out a way we can get more precise data on EV ownership.

The deployment of smart meters across Ontario provides a valuable information resource, however most systems are not robust enough to handle the volume of load-data information required to monitor and aggregate loads. This will evolve over time and as information systems become more capable.

The bigger question is, are utilities asking the right questions and creating the necessary steps required to harvest, process and act on the information that is available to them now.

We currently have no visibility of EVs or load growth behind the meter on our electric system in Alberta. Advanced metering infrastructure (AMI) is required in order to have visibility of load. That information could then be used to determine system equipment loading on transformers and feeders. However, this

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would not identify the load increase as "EV load," just simply a larger load. Further analytic systems are required in order to disaggregate the EV load. We are currently building a business case for AMI implementation to be presented to our regulator later this year. This will not include the analytics required for load disaggregation. We are also working with the City Electrical Inspection/Permits office to gather information on EV charging installation locations as an interim solution. Having access to probability planning methods based on demography analysis and findings of other jurisdictions would provide a high level of prediction on where and how much the charging demand will grow.

To date there are no tools that could be used to determine where EV users are located in our service territory.

We are seeking ways to increase EV visibility within the distribution grid. Smart meter data is being aggregated to the neighbourhood transformer and compared to transformer nameplate capacity; however, resources to regularly prepare reports and take advantage of this information are limited.

We have been supporting the development of a utility-centric line loading monitoring system to better profile distribution feeders. This, with improvements to our System Control Authority IT/OT systems, is anticipated to help with better grid management.

Publicly accessible EVSE locations are easier to locate thanks to publicly available electronic mapping. Yet this is latent information. Announcements of government tendered EVSE funded locations have been the only way to know upcoming EVSE locations. It has not gotten easier to know locations of private EVSE.

Mining smart meter data to profile EV charging is not reliable. This is evidenced by how the Ontario Ministry of Transportation (MTO) is challenged in providing free EV overnight charging to qualified people and knowing how much to credit. The MTO is unable to release EV or EVSE locations.

Perhaps asking for voluntary disclosure of private EVSE locations may help, however, we have not undertaken this step yet.

We do a lot of system planning and distribution grid monitoring. Every year we do a capital project that involves grid capacity expansion or rebuilding. We are in good shape as we conduct semi-regular analyses of smart meter data and can calculate the load on each transformer based on that data. If there is a transformer that gets overloaded regularly we can replace it and/or monitor it more closely.

It has not become any easier to determine where EV users are located. We hope that customers will notify us when they buy an EV charging station, but they are not required to do so, so most do not. Customers are only obligated to call the Electrical Safety Authority and use a certified electrician to install the stations, but there has been no movement on mandating them to notify their utility. If customers were required to contact their electrical utility when purchasing an EV and charging station, it would make the work of system planners and managers much easier.

The free overnight EV charging program recently announced by the Government of Ontario will be very difficult and costly to implement from a utility perspective. The most viable solution to the problems

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posed by providing free overnight charging is to offer all EV owners a blanket monthly discount on electricity bills of approximately $30, in tandem with regular monitoring of smart meter data to ensure that those customers are actually charging their EVs overnight. This solution would still add a burden to the billing systems of utilities, which might end up getting passed on to consumers.

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QUESTION 4: What external factors will most significantly affect the distribution system when coupled with EV charging, and how so (e.g., free overnight charging programs (Ontario), provincial vehicle sales targets and incentives, increases in the use of renewable energy, home battery storage, geographic considerations, codes/standards/regulations, etc.)? What solutions are being explored in this regard (e.g., community battery storage)?

If too many EV charging stations are on at night on the same neighbourhood transformer because of free overnight charging, then at the very least the neighbourhood transformer's health will deteriorate because of a higher load factor than design allows. Also, we need to be cognizant that the system peak may shift and create the need for changing the free overnight timing window.

EV charging station use at home is anticipated to largely be when solar PV is not effective in offsetting peak load. Thus, battery storage at the neighbourhood transformer level may be one of the few mitigation measures available. We are becoming aware of this option, however, we have not included it in any strategy so far, and have not sought any other mitigation measure either. Cost is presently prohibitive. The regulator is behind in becoming aware of such emerging issues and thus is also not aware of acceptable mitigation methods.

All of the above noted technologies and concepts should be considered an opportunity in waiting for utilities. The establishment of smart grids, with renewables, storage, vehicle-to-grid, and other technologies, should now be part of a dialogue that both drives and responds to consumer behaviour. The future grid will make or break utilities, and individual utility decisions will in turn create opportunities or risks for the end consumer.

Utilities are essentially blind to this coming change. Consumers will likely drive innovation with increasing pressure on utilities to provide access to, and even partnership in, this change. Failing that, consumers will gradually isolate themselves from, and reduce their reliance on, the electrical grid.

This is unfortunate. Collectively, we have all paid for the grid we now enjoy and as such, consumers should benefit from the evolution of distribution resources and bi-directional electricity flow. The concepts of energy democracy and 'Prosumer' (a customer who becomes both a load customer and electricity supplier) should not be foreign to utilities, yet most cannot relate.

The proactive, engaging and forward-thinking utility, willing to partner with consumers and be part of the inevitable grid evolution should be profiled and celebrated, for they are a minority among an otherwise stubborn and monopolistic old-guard.

From the outside, it does not look like much is happening in Alberta, and that is partly true. But interest in EVs and smart grid technologies is growing. Alberta's utilities commission does not have legislation to allow the cost of charging stations to be passed on to the rate base. So the system is not well-suited to allowing utilities to deploy EV charging stations. Similarly, on the de-regulated side, it is a tough situation because a business case cannot be made simply through selling electricity through charging infrastructure. Alberta can put together a palatable deal between us and users who want EV charging

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stations, so we could become the provider of equipment and recoup costs on a lease basis. We are looking for as many ways as possible to be helpful in the deployment of EVs.

Low electricity prices, as well as a lack of incentives for reducing electricity use or increasing EV adoption are key external factors influencing the ability of utilities to support EV deployment in Alberta. The province has introduced some programs to try address these issues, such as energy efficient rebates, but at the same time they capped the price of electricity at historically low levels. Utilities are in a dilemma of helping people get want they want even though the economics do not currently add up.

EV charging stations pose a challenge to customers to pay for, but many companies want more of them, and want them to be visible. Charging infrastructure has synergies with rooftop solar that certain organizations want to take advantage of. These types of services require an outside-the-box approach that can be very difficult to implement due to proposals having to be approved by multiple government departments, such as energy, transportation and infrastructure.

Each province has different issues related to EV deployment. As soon as one steps across provincial borders, EVs have different considerations – the way you connect them, get paid for them, whether EVSE are cost-avoidance or revenue generation tools – and that means EVs and their equipment have different value propositions in different jurisdictions.

The provincial nature of electricity markets should not be under-estimated. I would caution against policies like those that have a blanket requirement for even one 30 amp electrical outlet, let alone charging station, for EVs in all parking facilities. When this occurs, the service capacity of grids must be expanded to accommodate a theoretical peak that never happens. This is what happened in Vancouver where people ended up paying lots of money for EVSE that is rarely used. However the good thing about Level 2 charging at 30 amps is that the equipment is easy to integrate into existing building circuitry and the broader system using fairly standard technology. Issues can arise for utilities when EV charging becomes more powerful, in the 100 amp range for example.

Government actions in dealing with coal facilities in Alberta, and the fact that retailers have turned back the long term power purchase arrangements from coal generators, means that the government is now indirectly in control of a lot of coal-fired generation. This allows Alberta's balancing pool to operate these facilities at their minimum incremental costs – there is no margin being built in, so they are basically undercutting the entire market and flooding it with coal-fired power, even though they are trying to get rid of it.

When systems peak during heat waves in the summer, utilities are sometimes asked to cut voltage to mitigate some of that peak. Utilities in Ontario are obliged by the provincial grid operator to cut their voltage by 3 to 5% whenever they are called upon to do so, and large amounts of EV charging during such times would exacerbate that problem.

We are looking into hosting a neighbourhood-level battery storage project to help support the local distribution grid. We are already hosting a 5 MW storage facility using fly-wheels, but that is to support

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the provincial grid. We are also researching residential energy storage options, but are still at the early stages of this research.

Changes to building codes are also key external factors to be considered by utilities. In Ontario it was recently proposed that all new homes require 50 amp outlets in their garages to accommodate EV charging.

We are also trying to get involved in micro-grid research. We are hosting a facility for a customer that combines wind, solar and diesel generation in tandem with battery storage.

Equipping new MURBs to handle EV charging is a simple process, but retrofitting existing buildings is much more difficult.

Consumer behaviour and demand is a big external factor. Different modes of transport like car sharing will change EV charging patterns.

As an area with relatively low adoption of EVs, a government or manufacturer incentive program for EVs or EV charging infrastructure would likely have the most impact to our distribution grid in Alberta. A specific government directive would also have an impact in the sense that it may give justification to argue system costs (building rate base) for EV infrastructure to our regulator.

Supplying all the charging load from the grid is not a good investment option because it would lead to a very low utilization factor of the assets. Demand side management is expected to be sought out in parallel. Time-of-use rate structures and incentives for adopting smarter chargers can shift charge demand off the daily peak; and distributed energy resources (DERs) with battery storage can take the lion's share of the new demand. The so-called 'smart micro-grid' is a viable option on the utility side to mitigate adverse effects on power quality and equipment and achieve better utilization of assets. Even at low EV penetration levels, since concentrated EV charging demand can create localized issues on the system, the adoption of new technologies and other measures would be an imminent challenge to utilities.

We are exploring the intelligent management of the demand slope, while fully respecting user needs. Key external influences include the price of energy (including time-of-use rates in Ontario and other EV-related charging incentives) and the availability of energy through the current asset base that we have. The biggest problem will be around residential energy, as most EV charging occurs at home, but workplaces will be the next biggest challenge. Other forms of public charging will be less of a problem – it will need to be made available, but it is very expensive to install and most EV owners will find they do not need to use it often. Public charging availability is more important to EV users before they purchase an EV than after the fact, as it reassures them that public charging is convenient and accessible.

A major external influence that many stakeholders are not considering is that the total cost of operation is so much lower for EVs than ICEVs. Even now, it is widely reported that the cost of operating an EV *could* be lower than an ICEV, but this is clearly the case, in any jurisdiction in Canada. $6 to $8 worth of electricity can move people the same distance as $100 worth of gasoline. When clear, definitive information on costs gets communicated to the public, it will open the floodgates to EV ownership. EVs

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are not just about environmental benefits, they represent good, smart economics, and the public will catch on eventually.

There is a disconnect between utilities and the OEB rate setting model in Ontario. Utilities can increase endlessly the size of assets to meet demand, but they cannot spend a dime on managing loads. So what some utilities are trying to do is find ways to work their ability to manage loads (rather than simply meeting loads) into their rate models. This is a smart approach. There are lots of smart technologies integrated with the grid already (e.g., smart switches that can perform self-healing and smart meters). Utilities need to install smart technology behind the meter, including smart charging, so they can manage the best of the grid to the best of what they can do with the load. Ontario's grid is full of cheap, available electricity, but not during peak hours. Utilities are just trying to solve this problem in a logical way. There are a lot of other technologies, aside from EVs, including stationary storage and solar, that will take off soon, and they will allow utilities and their customers to do things they have never done before (e.g., fly-through for short duration outages, trade energy/transactive energy, micro-trades between properties).

Some utilities are trying to lay the groundwork necessary to facilitate such technologies, so the way they handle the integration of EVs today is critical to ensuring that other emerging technologies can be integrated into the system. EVs are a major component of a fundamental shift in the way people use energy. This shift will bring benefits to all customers if EV integration is managed properly, and systems are set up now that can be grown and that help utilities modernize their business models to offer the kinds of new services that customers are beginning to ask for. Utilities will soon be in a position to offer premium services, with relatively short payback periods, to customers that will allow them to do things like avoid outages. Even today, utilities have the ability to let customers save 30-40% on their energy bills by deploying a minimum amount of equipment that would allow customers to do things they have never done before. While utilities currently are not allowed to pay for this through the rate base, such solutions are technically feasible.

To our knowledge, there are two business models for EV penetration, dedicated charging stations and battery swap stations. The impact of the former is limited by technology and the latter by lack of synergies and standards between various manufacturers. One area that may have an impact on the distribution system is not the additional loading imposed by EVs but rather the ability of these systems to put power back onto the grid. We have already seen the level of regulation, planning and monitoring that has gone towards supporting Ontario's Feed-in Tariff (FIT) and microFIT programs with significant strain on our available resources (in terms of labour and direct costs). If EVs are to become the next generation of mobile distributed-resource on the grid, it would require a significant amount of additional resources on the part of local utilities to safely integrate these into their systems without impacting the quality of service to their existing rate payers.

The biggest external factor will be the price of electricity being discounted in Ontario.

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All of the examples from the question will have impacts. Anything that has an impact on adoption levels and customer behaviour with regard to how they charge their car will have a direct impact on the distribution system.

Ontario's free overnight charging program will further push EV sales and increase awareness. If implemented properly, it will also promote behaviour that defers more charging to off-peak times. That one move alone would automatically eliminate any near term threats to the distribution system. An internal study we undertook showed that even if half of the homes serviced by a given transformer had an EV, they could all simultaneously charge off-peak and the transformer could handle the load. Ontario electricity system features like time of use pricing will play a huge role in ensuring EVs do not stress grid infrastructure.

Further, if Ontario's proposed Green Bank, which was announced in its 2016 Climate Change Action Plan (CCAP), incentivizes home solar energy storage technologies, then those homes will be a better fit for EVs. Firstly, those customers will be more open to trying new technologies such as EVs, and secondly, there will be an energy buffer in the home. Utilities are not expecting solar-storage-EV systems to have a large volume of uptake in the near term (due mainly to high costs), but do feel that this trio of technologies is an ideal combination.

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QUESTION 5: What are some emerging opportunities for EVs as part of broader distributed energy/smart grid solutions (e.g., vehicle-to-grid, vehicle-to-home)? Have utilities been looking into how to capitalize on the potential for EVs, or is their focus primarily on planning to manage the implications of EV charging?

No, utilities are definitely focussing on how to manage EV power needs rather than how to capitalize on what essentially amounts to a major system asset. EVs are a tremendously large resource that will be connected to the grid frequently in a distributed manner. It would be crazy for utilities not to think about how to use such an asset, and how to optimize the roles of EVs to best serve the needs of the grid and the users themselves. For example, a recent report from the U.S. Energy Storage Monitor found that by 2020 there will be more available energy connected to the grid in the batteries of EVs than all of the generation capacity in the US combined at any given time. And this projection was based on conservative estimates for EV adoption and the average EV battery sizes of several years ago.

By way of example, if an auto-reclosure occurs (which is usually a 50 to 100 millisecond interruption of power), and an EV is plugged in at someone's home, the EV battery can fill that gap and prevent that home from experiencing an outage. This would be a valuable use of vehicle-to-building (V2B) technology, and one that would not impact battery health. Even deferring/managing vehicle charging is an example of a vehicle-to-grid (V2G) benefit. But there are other benefits that will also occur, such as transactive energy issues, or trading parcels of energy. Eventually, an EV ownership model could emerge in which individuals purchase and own the vehicles themselves, but the batteries would be leased from utilities, in exchange for the right to manage charging and the use of stored energy in a limited capacity. That way, EV owners would take no risks in terms of battery health and longevity, which can be impacted by the frequent charge-discharge cycles associated with certain V2G or V2B services. Customers would get a new battery from their utilities when the capacity of their current battery degrades, without incurring additional costs. Such a separation of car and battery would take the pressure off of EV manufacturers in terms of worrying about battery and warranty issues. Used EV batteries could then be put to secondary applications somewhere on the grid, as they would still have a significant amount of capacity left. Battery leasing could be conducted through a third party organization rather than utilities, but this is one business model that some forward-looking utilities are considering.

I think the response to this will vary depending on the utility providing the answer. Some utilities are focused on new offerings, while others put value in being stable and responding in a more reserved way, and focusing more on managing the implications of the load. We have not taken the step to consider EVs an opportunity yet.

Our primary focus thus far has been on planning the system to manage the integration of EV charging loads. Smart chargers which could be communicated with to manage charger output levels at specific times look promising. To date, vehicle-to-grid appears to be in its infancy and will be considered as the technologies develop.

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EVs pose both threats and opportunities to utilities and the grids that they manage. The most imminent threat is in terms of managing and safeguarding distribution assets. This can be mitigated through modifications in consumer behaviour, or through smart grid infrastructure (such as smart EV charging which throttles and toggles charging between homes).

We have been carefully tracking EV research and demonstration projects throughout Ontario, and have undertaken an EV workplace charging project in our service territory. Emerging technologies are becoming available that will help utilities manage the threats EVs pose to the grid.

In terms of opportunities, the potential of demand response systems is huge – peak management, peak shaving, helping utilities become load-shaving entities, and the need to aggregate platforms across communities. We are not sure yet whether this business model is something that utilities will pursue via their core role as an utilities or through their affiliates, and we do not have any insights into upcoming regulatory changes. However, even today, utilities in Ontario are allowed to rate base actions that will be useful in terms of demand response. EVs and their charging infrastructure could be a gateway to demand response systems because they are highly dispatchable loads. And this is only taking a uni-directional flow of energy into account, and does not account for vehicle-to-grid (V2G) or vehicle-to-home (V2H) systems.

Those systems, which will use bi-directional charging stations with the capability to use EVs as a mobile storage source, will be the next step in terms of technological development. Society is still far away from V2G becoming reality, but we run a V2G demonstration project out of our head office, so we understand the technology quite well.

I understand this two be different thoughts: (1) Vehicle-to-Infrastructure (i.e., either V2H, V2B, V2G or V2C (cottage)) to help grid integrity; and (2) EV business opportunities.

Regarding (1): Internally, ideas on how, V2I has a role in grid management are varied. Much of the reason is due to a lack of understanding on this matter. Some see V2I as a great potential help. Others see this leading to: surfacing of battery warranty or health issues; rising EV costs because of bigger batteries; rising EVSE costs to allow for safe two-way power flow; increasing administration overhead trying to account for electricity injection credits (extremely complex); needing to revise rate structures since EVSE injection into a V2B will change the business's peak load. If any sign, Nissan has been quiet of late on any further efforts in regard to V2I.

From a personal perspective – I'm an electrical engineer who has worked in many positions with many groups in a utility, enjoys novel technology and renewable energy, and enjoys broad and detailed discussions on many technical and non-technical topics. After discussing V2I with researchers who have completed studies in V2I, evangelists for V2I, and EV enthusiasts I can say that: a) from a technical standpoint V2I is possible and more likely feasible in a V2H or V2C application during a power outage to support very critical loads; b) from an administrative standpoint, it will be a nightmare to allocate costs and credits that may not be cost effective; c) from a grid management standpoint, this may only be beneficial for the 0.0001% of the time the grid is not available and only if the V2I is happening where it is

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needed and in sufficient quantity. Likely, EVSEs will need support from energy storage rather than be energy storage for grid support.

Regarding item (2): Indeed, our focus has been on how to deal with EVSE as loads. However, thought is being put into EV and EVSE business cases to help their proliferation while limiting adverse impacts on the grid.

We are looking into it. We would like to see vehicle batteries act as home energy storage systems. Right now there are very few manufacturers that offer DC charging features that would allow batteries to export energy onto the grid. AC connections are not allowed to have two-way power flow, but more DC systems are expected to become available shortly.

At the provincial level, micro-grids are the focus of emerging technologies for Ontario utilities, where some have implemented pilot programs as technology demonstrations. EVs may be contributors within such suites of technologies.

EVs provide an unprecedented load/energy source opportunity for utilities. The question is, are utilities asking the right questions, or are they asking any questions at all? EVs provide the promise of both distributed load and distributed energy supply, with the added ability to harvest mobilized renewable generated electricity.

As compared to stationary energy storage devices (which will also create an increased level of opportunity/threat to utilities), EVs have the ability to relocate stored energy. This is a concept not really understood in terms of opportunity. Think about the ability for an employer to deploy medium to large-scale PV at a place of work. An employer could leverage unused lands to create renewable energy, which could in turn power employee vehicles, which could in turn become part of the two-way electricity flow for both renewable generation and production loads.

In cases where employees do not have access to renewable energy, they can effectively power their commute from renewable energy at an offsite location (in this case, via their employer). Depending on commuting distance from home to work, this renewable energy could form part of their home electricity supply via V2G.

This scenario involves the bi-directional flow of electricity, using both grid and non-grid supply with the three participating entities of customer, employer and utility (and potentially a fourth player should the utility not be the same between home and employer).

The bigger question is, why are utilities not investing more time considering the challenges and opportunities of two-way electricity flow? Why are they not rushing to understand the concept of a ‘Prosumer,’ where a customer becomes both a load customer and electricity supplier? Why are they not creating pilot and demonstration projects that engage multiple entities to better understand where the business of delivering electrons is heading in the very near future?

EVs represent a source of demand growth for utilities. As much as they might place a pressure on the distribution system, EVs represent a growth opportunity for electricity retailers.

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EVs can also contribute to GHG reductions. Alberta is aggressively pushing to lower the carbon intensity of its grid. Alberta also has a significant amount of solar energy potential and utilities recognize the many synergies between solar power and EVs. There are also synergies between wind energy and EVs, as most charging occurs at night when wind speeds are greatest. But there needs to be more of a market for EVs before utilities in Alberta can begin offering incentives like free overnight charging to customers.

We are motivated to have discussions that represent outside-the-box thinking about EVs. We are conceptually exploring the linkage between energy contracts and how we can provide car chargers to those who want them; for example, by spreading out costs over longer term energy contracts.

We want to be a provider of enhanced energy services. This would be to help customers, especially commercial customers, understand their energy use better; perhaps through some kind of energy management service that may encompass sub-metering and information portals so customers can monitor energy use. For larger customers we are doing things like helping to deploy LED streetlight retrofits and other types of services that might previously have been considered internal matters for companies. We eventually want to be a provider of equipment like EV charging stations. We already do rooftop solar, and combined heat and power, and there is potential for comparable types of equipment and services to grow in demand. Utilities need to find ways to add value to customers, in part by helping customers reduce energy consumption and emissions, and cut costs.

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QUESTION 6: What are some specific considerations for the distribution system related to planning for multi-unit residential building, workplace or public charging (considering more significant uptake of any of these)?

The planning considerations we make for higher EVSE penetration levels are the same as for any other introduced load. Who pays depends on whether EVSE are introduced in existing premises and it forces a service entrance upgrade, or the overall introduction of EVSE forces grid infrastructure upgrades.

On the topic of site servicing, when a customer introduces more loads that necessitate a service entrance upgrade, the customer pays 100% of the costs. If this change forces upstream upgrades, then the customer contributes to that upgrade too, if no one else benefits.

With respect to off-site upgrades, the asset planning team regularly monitors load growth and reforecasts need for grid equipment upgrades. These upgrade costs are rate based.

We just embarked on a workplace charging project. As employees start driving EVs more often, workplaces will be motivated to install more EVSE, which also aligns well with green corporate mandates. But with more EVSE, EV charging will consume a bigger percentage of the electrical load at workplaces, and these sites will start receiving a much higher demand charge on their monthly bills. Workplaces may not be prepared for the incremental expenses, and may try to pass these on to employees, which could create a bad impression of EVs. We are researching how to help workplaces avoid such a scenario by employing load management practices that reduce a site's peak demand.

Electrical capacity within existing buildings, and costs associated with providing EVSE, are both key considerations. There is also the risk of installed EVSE assets becoming unused or stranded, especially if EV regulations are not sensitive to market pull, as opposed to push. It is critical that the big infrastructure build out related to EVs does not lead to significant increases in a theoretical peak demand that will never actually materialize.

The build out of EV charging infrastructure can force the expansion of the service capacity of grids in order to ensure that the power needs of all installed hardware can be met at any given time. If an over-abundance of charging infrastructure is installed before this infrastructure is needed, this can force utilities to plan and build to accommodate a theoretical peak that never actually materializes (e.g., if 1,000 Level 3 chargers were installed in the service territory of a utility, that utility would have to expand its service capacity guided by the assumption that, in theory, all 1,000 of those charging stations could be in use at the same time). To ensure that this theoretical peak does not grow too large, EVSE should be limited to Level 2 charging stations at 30 amps wherever this level of power is sufficient to meet the needs of EV users at a given site (e.g., MURB parking facilities, workplaces). While it is true that many utilities currently have excess service capacity, this concern is nonetheless worthy of consideration, especially in light of possible provincial or municipal government policies mandating that a fixed proportion of public and private parking areas be equipped or pre-wired for EV charging.

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Electric service sizing for new or retrofitted buildings is very important – the service supplied must be able to match anticipated demands.

Planning load forecasts for future years, which is tied closely with revenue forecasting, is an important consideration. We have put allowances into our system load forecasting for conservation and demand management, to account for increased energy use, but this is still at an early stage. Uptake levels of EVs are still low in our service territory.

So far we have no special considerations with regard to accommodating charging stations at these facilities.

All of the locations indicated will have existing limitations on capacity. We expect that in existing facilities any significant program to install charging stations will require a service upgrade (unless there is a novel approach with energy storage of some kind – which is not expected to be broad in the near term). We work with customers to accommodate service upgrades and complete these when feasible.

Public charging is fairly straightforward – if an EV user is charging in public, it is likely that they do not want that charging to be managed, so as to make the experience as fast and convenient as possible. At workplaces, however, people will only drive an average of 25 km to get to work, so they will not need to charge at full capacity. Charging management is very important at workplaces, as building operators do not want to have dozens of EVs charging simultaneously at full capacity, which would significantly increase that building's peak demand. Charging can be managed at workplaces in a comparable way to homes, as most users will not need to be fully charged for many hours after initially plugging in. Given adequate charging infrastructure at workplaces, EV charging can be staged and rotated in accordance with user needs. Different fees could be charged to users for different levels of charging autonomy and speed.

Level 2 charging (240 volts at 40 amps) will likely be the most common systems used in homes, workplaces, and MURBs. This level fits nicely with existing electrical systems and offers system managers and users plenty of flexibility. It is important to remember that vehicles are typically only used about 4% of the time during any given day, and need to charge about 10% of the time (at a Level 2 rate).

Developers of MURBs have approached us asking them to solve the problem of providing charging in parking garages. But utilities do not know how to provide enough power using conventional technologies. Developers have comparable problems as utilities – they have miniature distribution systems in their buildings and they cannot exceed maximum capacity. A typical on-peak household draws 4 to 6 kW, while a typical EV charging draws about 7 kW, so charging an EV is like adding another residence. We have found a solution to charging multiple EVs on a single site, by managing loads. We do this by throttling simultaneous charging, which does not leave anyone without energy. By doing this, we can get a lot more throughput on the distribution assets, both in the building and the distribution system, than we can by just increasing the peak capabilities of these systems, which is extremely expensive. The role of utilities will be to manage the delivery of available energy to meet the needs of their customers.

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MURBs have a common element meter (which controls basic, shared building functions such as elevators, staircase lights, etc.) and then have individual suite meters. But no one wants non-EV owners to feel like they are paying for others to charge their EVs. So developers, with the help of their utilities, are installing a second common element meter specifically for EV charging. The energy going to the charging stations is isolated from the building's primary common element meter. This avoids having to charge all residents for EV charging, and EV charging costs can be built into the monthly parking fees of EV owners. The addition of a second common element meter represents a fundamental change in how MURBs are designed and operated, but it is a change that does not inconvenience building developers and operators or their utilities, and one that works well with existing distribution infrastructure.

The challenge with MURB charging is that charging stations are typically designated not for public use. This makes it difficult to invest rate-payer dollars into the charging infrastructure. In retrofit examples, the electrical costs to install an EV charger may outweigh the cost of the charger by so much that it makes an infeasible option for MURB owners. Planning new MURBs to be EV ready is ideal, but this requirement would need to be driven by local, provincial, or federal rules.

For public charging, it could be argued that the EVSE is for the good of the general rate payer as it is available to the entire public. This option may be optimal for MURBs or commercial areas where customers do not install their own chargers. Workplace charging would depend on whether the chargers could be used by the public, or only employees.

General distribution system constraints would be the potential requirement to upgrade transformers or feeders.

The large scale of EV charging load interconnection pushes the system impacts beyond the local level of circuitry such as tap-offs, service transformers and secondary voltage cables. System upgrades might be required at branch or feeder levels of primary voltage circuitry. It will cause significant changes in design and system planning standards. Furthermore, highly concentrated and high demand charging infrastructure such as EV bus depots would require substation upgrades or new points of delivery (PODs) and transmission system upgrades. The large scale of system upgrades driven by a few specific customers are always challenging to the utility because of short lead time and the volatile nature of their projects.

MURBs provide a unique opportunity for the development of renewable, energy storage and V2G technologies. Picture a parking garage (or similar dense parking location) with consumer access to EV chargers that are V2G equipped. While much of this can play out behind the utility meter, the utility could play a significant role in load balancing, power quality, renewable energy harvest and energy storage value by partnering with building owners and consumers.

Again, the story needs to be told, shaped and understood before options can be considered. At this point, most utilities do not have clear direction from government nor regulator. In the case of Ontario utilities, an interesting observation is the fact that three of the five directives to utilities from their

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regulator, the Ontario Energy Board (OEB) include the development of smart grids, the expansion of renewable energy and the creation of a culture of conservation.

Most utilities pay this nothing more than lip service, with few participating in anything more than IESO-led conservation programs with any real enthusiasm.

Exploration of multi-unit, residential or public charging opportunities will flounder until a vision and clear expectations for utility participation are understood.

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QUESTION 7: What are some considerations or opportunities related to public versus private EV charging? (e.g., have government policies on utility eligibility to provide fee-based public EV charging affected future planning for utility involvement or created potential new business models?)

Utilities are not allowed to include EV charging infrastructure into their rate base, but they are allowed to own EVSE through their affiliates. Current rate base regulations dictate that utilities must stay away from directly providing public EV charging, and must instead conduct such work exclusively through affiliate companies. This is a potential new business for utilities, but we do not expect it to become profitable until there is greater EV uptake.

There is a bad business case for public EV charging in Alberta, but we can help improve this by pulling together the technicians, hardware and knowledge required to deploy charging infrastructure, especially for clients that have multiple facilities. We would likely do this on a cost-recovery or, in certain circumstances, a partial cost-recovery basis to try to create a business case for the installation and use of EV charging infrastructure. We would be third party owner or lease financier of EVSE and a facilitator through electricity contracts. We just want to find a way to glue the pieces together to advance EV deployment. EV charging in fleets (e.g., municipal or provincial government fleets) could be an excellent application for this type of utility support.

A regional approach to deploying EVSE might make sense in the short term, as companies cannot make money off of usage of EVSE, in part because the stations will have low utilization rates initially. Also the purpose of having many public EV charging stations is probably more psychological than real, as EV users find that they rarely need to charge in public, with the exception of long trips. If utilities tried to recoup EVSE expenses based on electricity sales, they would have to charge 10 times or 100 times more than the market value of the electricity and users would resent them for that.

In Alberta, the rollout of EVSE is likely to be private sector led, unlike some other jurisdictions in Canada, unless a provincial regulation or program allowing EVSE costs to be rate-based happens. In the absence of such a development, funding for EVSE can only come from the private sector. In a time when EVSE installation is not an obvious choice (or not profitable) for the private sector, it can still be a symbol of leadership and can have branding benefits. If EVSE roll out is paid for by the government, that would still contribute to environmental goals and would be a positive step, but it could erode the leadership value proposition to the private sector. But anything that takes EVs from niche to mainstream applications would be a welcome step.

We are interested in becoming a provider and enabler for systems to power a wide array of electrified transportation, from personal EVs to electric fleets and electrified public transit vehicles (e.g., by providing power to electrified bus lines).

Only Tesla has a strong value proposition for providing public chargers. If public chargers have any operation and management (O&M) costs, the value proposition of hosting them will decrease. Even if

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EVSE hosts were to receive charging equipment for free, the O&M costs for maintaining the equipment (e.g., due to vandalism, or annual inspections) causes the value proposition to break down. The current value proposition for providing EVSE is not in the electricity that hosts sell, but the symbolism the EVSE represent and the potential clientele that symbolism can attract.

In Ontario, the regulator presently implies that EVSEs are to be in the unregulated business and the argument otherwise will come under intense scrutiny. Utilities will install EVSE under: (1) the regulated part (if they feel comfortable with explaining this to the regulator), in trials, for the public good, or to control load impact on the grid; (2) under the unregulated part of the company for profit. Profitability with EVSE is still a decade or more off even if heavily funded by governments, as is done through the MTO's EVCO program. Some utilities, ourselves included, may be looking at leasing or financing EVSE, or incenting EVSE if they can control them to avoid infrastructure upgrades, or help customers avoid costly upgrades on their side.

It is very difficult to make a business case for public charging, and there will need to be some degree of subsidization to support it initially, especially for Level 3 charging.

The challenge becomes the willingness to pay for electricity. A number of early charging stations in our territory were provided free of charge, so the expectation is that public charging should be free. In our service territory we do not have any charging stations that are fee-based. As it stands now we do not see enough demand to warrant a business model where public charging stations are viable. There may be a market to "rent" home charging stations, and I believe at least one utility in Ontario is doing so.

If utilities were given the directive by regulators to invest in public charging infrastructure (similar to California), there would be a clearly defensible opportunity for utilities to plan out public charging infrastructure locations to best suit the distribution system's capacity. This would extend the usage of the existing distribution assets, rather than being forced to upgrade assets in areas where customers or third parties decide to install chargers. Essentially, investing in public charging could save rate payer dollars.

Utilities' participation in the charging market would be a catalysis in EV adoption since it can break up the chicken-egg game of EV first or charging station first. Electrical utilities are well positioned in entering this market because they tap into the wholesale price of electricity and their knowledge of the system.

Utilities in Ontario are part of a regulatory framework with a very limited scope to expand business within their service territories. These ventures have to be approved and supported by the Ontario Energy Board (OEB). Whereas we cannot understate the significance of future opportunities, available data does not support the OEB being part of our long term planning at this point in time.

In this case, the question is 'who should own the charging infrastructure' and 'what is the business case'? Government programs (similar to Ontario's EVCO program) are admirable in their intent, however they lack vision. My county participated in the installation and ownership of four Level 2 and two Level 3

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EV chargers. While a good start, the question remains, who will create a business case and continue to install EV chargers that will support ongoing maintenance and continued investment?

The EVCO program was intended to kick-start Ontario's investment in EV chargers, however it does not go far enough to establish an ongoing structure of continued investment by private or public players. Unlike Tesla Motors, who manufacture, sell, maintain and ensure their customers enjoy a robust and well maintained charging infrastructure, all other EV owners must make do with a scattering of vaguely understood technologies operated by a seemingly infinite number of owner/operators who again, have little to no understanding of the direction EVs are going. Furthermore, most Level 2 and Level 3 EVSE owner/operators have no stake in the manufacture or vision of EVs in Canada. In most cases, utility participation in the EVCO program is nothing more than 'just another load customer'. This is not necessarily the fault of utilities, but does underscore the absence of direct participation in EVSE and EV equipment by utilities.

Personally, I am in my fifth year of EV ownership and continue to wonder at the growing divide between a business case like that of Tesla, who has single-handedly created a vehicle, range, enthusiastic customer base and robust EV charging platform, all based on a long-term vision, to that of every other OEM who have seemingly arrived to market reluctantly, and with no real vision for the future of EV charging infrastructure required to support their own customers.

Based on the success of Tesla to date and the explosive growth of their own EV charging network, the real question may be, why should public and private sector players be involved at all in the development of an EV charging network? Where are the rest of the manufacturers who are creating EVs, and why are they not required to participate? What does Tesla see that they apparently do not? Finally, why are utilities not front-and-center of a technology that holds so much promise and potential risk to their own infrastructures?

It is important for public EV charging to be standardized. Proprietary charging networks are not good from a user perspective. Public charging stations should be compatible with as many types of EV charging hardware as possible, and all should accept multiple modes of payment – without any membership or subscription requirements.

Workplaces might eventually adopt closed networks for EV charging (i.e., EVSE that are only for employees of a certain company), but this type of network should be limited to Level 2 charging. As many DC fast chargers as possible should be accessible to the public, as people who use them will likely pay a premium rate for a faster charge because they will be in a hurry.

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QUESTION 8: Are utilities currently offering, or considering to offer, any EV-related incentives or programs to customers? If so, what types of hardware, software, and/or financing options are being offered/considered?

We currently lease charging stations to customers, install them, and will upgrade their building's service if necessary. It is basically a turn-key service in which customers simply buy their EV and notifying us, and we take care of everything else. We then charge customers a small monthly management fee. This is not a highly profitable line of business for us, but the key consideration here is not profits but maintaining energy relationships with customers. The fact that this service adds valuable grid management assets to us is a bonus.

We ask customers to voluntarily enroll in this program, then lease them intelligent EV charging stations, and manage the energy. We do this with residential customers first and foremost because that is the source of peak usage, that is where most EV charging occurs. Under this program, customers specify two things: the time they leave for work in the morning, and the minimum state of charge they want their vehicles to be at at all times (we will not manage charging at all if an EV is below the specified minimum state of charge). Knowing the time customers leave for work allows us to know how much time we have to charge the vehicle (we do not just shift the charging times, but throttle the rate of charging to manage loads) and what rate we can ramp the charge to the vehicle to get the customer ready for their use of the vehicle in the morning.

Most customers still tend to plug in as soon as they get home, as time of use rates are not enough to incent them to defer charging to off-peak hours. But utilities do not want this situation to occur during peak hours, we want as much off-peak time as possible to charge at reduced rates of power. The average Canadian drives about 50 km per day, which takes about 5 to 6 kWh of energy in an EV. So if an EV owner needs 5 to 6 kWh per day and the average EV can charge at a rate of about 7 kW, that is just over an hour of charging required to fully charge most batteries. Utilities do not want customers to do all of this charging during the evening peak period between about 5:30 and 7:30; we want as much time as possible to give customers that energy at a reduced rate of charge.

Utilities currently cannot do this because we do not have access to surplus electricity rates (e.g., excess nuclear generation is often sold off for as little as 1 cent per kWh) to offer to customers. The time is coming, however, when utilities will be able to pass these surplus rates on to customers. Leading utilities are trying to create systems that allow them to pass along these surplus rates to customers so they can optimize the system based on price and its impact on distribution assets.

Very few utilities own an EV, understand the benefits of an EV or even query the opportunities or threats that EVs present to their systems. It should be of no surprise that utilities in general have not even started the process of evaluating whether to incent the purchase of EVs, home/business chargers, V2G, power quality, static and mobile energy storage or any other value inherent in EV infrastructure.

We do not currently have such programs in place.

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We are currently not offering any incentives. As the utility we would have to have a reason for offering that incentive, and today there is not a business case to do so as a utility.
No. The incentives being offered by the MTO are ample. EVs are actually far cheaper to own than internal combustion engine vehicles. Some automakers offer some very affordable, low-risk lease options on EVs, and even people who lease them are eligible for provincial purchase rebates. And of course the price of fuel cannot be beat. EVs should be marketed more based on their economics than their environmental benefits. They will never gain mass market appeal based on environmental benefits alone.
We currently have no mechanism to offer incentives to customers, as this would need to be a directive from our regulator. Again, similar to California's investor owned utilities.
Until we can have something to work with, in terms of system pressures, electricity market volatility, day time versus night time pricing, etc., it is really difficult for retailers to do much, and it is difficult for utilities to do much unless regulations allow associated costs to be passed on to the rate base.
We are currently considering business case options.
None right now. We are considering doing something on EV charging station installation with on-bill financing, but this would probably be through an affiliate. The primary motivation for such a program would be to gain data on EV charging as well as a level of control over charging rates and timing, to better utilize existing system assets. Our website simply points customers to government programs and incentives related to EVs.
We provide basic EV-related information on our website, and promote related initiatives via social media. We also participate in working groups related to EVs whenever possible.

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KEY FINDINGS

The variety of responses are indicative of the fact that utilities differ, sometimes significantly, with regard to their level of EV preparedness and awareness. In many cases these differences are a direct factor of EV uptake levels within the service territories of utilities. Some utilities have only seen a handful of EVs purchased in their service territories to date, while others have seen hundreds, or even thousands. Typically utility EV preparedness and awareness increases commensurate with customer interest in, and adoption of, EVs.

Question 1 asked for a status update on utility preparedness in regard to EV deployment. In general, utilities stated that they were not under immediate pressure to accommodate private or public EV loads, mainly due to low uptake levels. However, some utilities indicated that they were being proactive in planning for increased EV adoption, with actions ranging from conducting assessments of local grid capacity, to participating in EV-related working groups, conducting pilot or demonstration projects, providing educational materials on their websites, and expanding the range of products and services they offer to customers.

Question 2 asked how advances in EV technology have impacted utility load forecast predictions. Although increasing EV battery and on-board charger sizes mean that EVs represent a bigger load now than they did several years ago, most stakeholders stressed that the grids they manage still have a lot of excess capacity to accommodate EV charging – especially if that charging is managed properly to defer most of it to off-peak times. Several utilities with experience working with EVs have built assumptions around increases in EV power capacity and storage into their load forecasts.

Question 3 enquired about utility capacity to predict and monitor changes to the grid stemming from EV use. A major barrier utilities are facing across the country in this regard is a lack of accessible data on EV ownership; specifically, the addresses of EV owners and the type of EV and charger that they own. Provincial government departments do have access to this data through vehicle registration databases, but they cannot share it with utilities due to privacy issues. If this data could be made available to utilities across Canada, perhaps by tying the provision of that data to EV incentive programs, it would greatly facilitate their EV planning and preparedness.

Question 4 asked about external factors that will impact utility management of EV charging. Costs associated with electricity, EVs, charging infrastructure, grid infrastructure, and smart grid technologies were generally held to be the major barrier to increased EV adoption and improved utility management of EV charging. Also, utilities across the country lack the ability to pass on costs associated with EV charging and general EV support to their rate base, and are being forced to do so through affiliates. Consumer behaviour was another key factor impacting utility management of EV charging, and mechanisms through which to incent EV users to charge off-peak are needed.

Question 5 aimed to capture some emerging opportunities for utilities with respect to EVs and advanced energy management solutions. The potential role of EVs as mobile energy storage units that could

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provide backup or on-peak power to homes, buildings and the grid itself was highlighted by several utility stakeholders. In order to achieve this, however, hardware facilitating the bi-directional flow of power and communication between grid assets is needed. While some utilities are piloting such systems, they are not expected to be commercially available for some time. These systems would also allow for more distributed energy resources to be brought online – key assets for enhancing grid integrity and renewable energy production.

Question 6 asked about special considerations for EV charging in MURBs, workplaces and in public. Public EV charging, such as Level 3 charging at highway rest stops, will not need a lot of utility oversight beyond ensuring adequate capacity. MURB and workplace charging, however, presents ample opportunities for utility involvement. These sites share characteristics that make them amenable to managed charging such as: a) EV users will be plugged-in/parked for much longer than is required for a full charge at the full rate of power; b) site owners/operators do not want to enhance their peak capacity to meet theoretical peaks in demand from EV charging (in part because this would be very expensive); c) site owners/operators do not want to pass on the costs of EV charging to all tenants. Solutions were discussed such as installing a separate common element meter at these sites exclusively for EV chargers, and/or installing systems that would allow EV charging rates to be dispersed over time while still meeting user needs.

Question 7 sought to uncover considerations or opportunities related to public versus private EV charging. There was a high degree of consensus on this question, with utilities stating there is currently not a viable business case for them to become public charging station providers; and even if they wanted to provide them, they could not cover costs through their rate base, but would have to operate and pay for the stations through an affiliate company. It was mentioned that a government-led program that directed utilities to deploy public charging infrastructure and supported these efforts would be ideal, as it would allow them to deploy stations in areas where grid infrastructure was adequately robust. It was also mentioned that automakers could play a greater role in the deployment of charging infrastructure, as this would serve to support and drive more sales of their EVs. The need for the standardization of public chargers, from both a hardware compatibility and payment method perspective, was also highlighted as a key issue.

Question 8 asked about specific products and services being offered by utilities related to EVs. There was a wide range of responses to this question. The most innovative service offered was one in which utilities became a one-stop-shop for home EV charging. New EV owners can lease a charging station at a low rate, and have that station installed at no cost, in exchange for allowing the utility to manage the rate and timing of overnight EV charging. This allows utilities to defer most charging away from peak hours.

The following findings were found to be particularly salient, either because there was general consensus around them or because they were deemed to be at the forefront of innovation in EV integration.

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1. **Grid management is always preferable to grid expansion**. Better *managing* existing grid capacity to accommodate EV charging is a much favourable alternative to *expanding* capacity. EVs do not currently represent a system-level energy supply issue, but they are a peak demand issue.
2. **Encourage and incentivize off-peak charging**. If a large majority of EV charging occurred during off-peak hours, this would significantly mitigate near term threats to the distribution system, deferring the need for infrastructure upgrades and optimizing existing system assets. This behaviour must be communicated, encouraged and incentivized among EV owners.
3. **Tell utilities where EVs live**. As the vast majority of EV charging occurs overnight at home, utilities need to know where EV owners live. Data privacy issues currently prevent utilities from gathering this information from government departments that register vehicles, but if a mechanism were developed that would provide utilities with the addresses/locations of EV owners, it would make utility planning and energy management processes far more straightforward.
4. **Voluntarily limit residential control over charging**. The ideal scenario would be for EV users charging at home to grant a level of control over rate and timing of EV charging to their utility. This would allow utilities to better utilize existing infrastructure.
5. **Purchase incentives drive EV adoption**. The EV and EVSE purchase rebates offered by some provincial governments not only serve to drive increased EV adoption levels, but give regulators and utilities a mechanism by which to track EV ownership data – vital information from a systems planning and management perspective.
6. **EVs are a gateway to other smart technologies – deploy them right**. The rollout of EVs is a major, fundamental first step in the development of emerging smart, low-carbon energy solutions that will define the future of energy systems and the future of utility business models. It should not be done in an ad hoc manner.
7. **Work towards universal standards for EV hardware**. The standardization of internal and external EV charging hardware will enhance the ability of utilities to manage EV-related loads, and develop products and services that facilitate EV use.
8. **More load means more business**. Utilities generally welcome additional loads coming online as a result of EV adoption, as this essentially expands the scope and volume of their core business. As EV adoption levels increase, utilities will become more engaged in integrating the new loads that EVs bring.
9. **Stress EV affordability to gain mass market appeal**. EVs will never gain mass market appeal based on their environmental benefits alone, but if their cost benefits over internal combustion engine vehicles are stressed to the public, uptake will accelerate, especially in jurisdictions that offer purchase rebates. EVs are also high-performance cars that are fun to drive.

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NEXT STEPS

To further explore several key issues highlighted in this report, Pollution Probe suggests that a workshop on grid-EV interactions from an electrical utility perspective would be a good starting point. Bringing together utility representatives and policy-makers would facilitate an exchange of information and ideas that would serve to further advance the efforts of both stakeholder groups related to the deployment of EVs. Subsequent initiatives and events could be broadened in scope to include stakeholders from the electricity generation sector, other alternative fuel providers, automakers, and academia, as well as provincial and municipal governments.

As planning for meaningful levels of EV deployment is a process that will entail much foresight, innovation, and cooperation, it would be best for all stakeholders involved to be included in the planning process from the outset. The result will be programming for EV deployment and preparedness that sets out achievable targets and timelines, offers support where it is most needed, and is delivered in the most efficient, cost-effective, and transparent manner possible.