1. Introductory Guide to the Relationship between Electric Vehicles and the Electricity Grid

&

2. Identifying Barriers and Methods to Enabling a Transition to Electric Vehicle Infrastructure in Ontario

Brandon Slopack

March 31st, 2016

A Major Project submitted to the Faculty of Environmental Studies in partial fulfillment of the requirements for the degree of Master in Environmental Studies

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Foreword

The area of concentration of my Plan of Study is 'Land Use Planning and Sustainability.' This included the three components 'Land Use Planning,' 'Community Energy Planning,' and 'Transportation Planning.'

Throughout my MES journey, I had difficulty selecting a focus area since there are so many interesting and important topics under the umbrella of sustainability. In the Fall of 2014, I met Christina Hoicka and was introduced to the field of Community Energy Planning. This was a ‘eureka’ moment for me. I discovered that there was a field of study that would cover a wide range of sustainability ideas, disciplines and technologies which when carefully identified could help communities improve their energy efficiency, reduce greenhouse gas emissions, and produce sustainable energy solutions. It was at this point that I felt that electric vehicles in particular, had the potential to make a positive impact towards sustainability.

Additionally, electric vehicles became an increasingly interesting topic to me, because they overlapped with so many fields of interest such as planning, politics, building, electricity, storage, and renewable energy.

Professor Hoicka made it clear that there is an emerging demand for people with the aptitude to communicate in interdisciplinary languages; particularly planners need to learn how to communicate with electrical engineers. This prompted me to teach myself the basics of electricity and electric vehicles. Through interviews and research I learned that interdisciplinary learning would not end here. Planning for electric vehicles required understanding the perspectives and politics of the Province of Ontario, local municipalities, the development industry, property owners, local distribution companies, transportation planners, urban planners, and the general public.

This major research project is the final piece needed to satisfy the requirements of the Plan of Study for the Master in Environmental Studies (Planning) Program in York University's Faculty of Environmental Studies. It is composed of a primer and a research project which in combination meet my learning objective requirements.

The primer introduces the electrical grid, electric vehicles and their relationship, in layman's terms. I met my 'Community Energy Planning' learning objectives by explaining how the benefits of electric vehicles could help to meet the objectives of a community energy plan (L.O.2a and L.O.3b) In addition I explained electricity concepts in accessible language and described how electric vehicles could impact the electrical grid (L.O.2b).

The research project identifies barriers and methods to enable a transition to electric vehicles through the availability of increased electric vehicle charging stations and electrical rough-ins. My primary 'Transportation Planning' learning objective was "To gain an intermediate understanding of electric vehicles, electric vehicle infrastructure, the barriers to implementation, and ways to reduce those barriers". This was the goal of this research project as alluded to by the title (L.O.3b). Additionally, this met my 'Land Use Planning' learning objectives. The first half of the research is a deep analysis of Provincial legislation and policy. I examined and analyzed the Planning Act, Provincial Policy Statements and various other relevant documents (L.O.1a).

This was followed by the same analysis at the Municipal level, looking at Official Plans and Zoning By-Laws (L.O.1a). I then looked at Community Energy Plans, Municipal By-Laws, and Municipal actions. These were often examined in-lieu of a Community Energy Plan, in order to analyze how Community Energy Plan-type objectives were being met (L.O.2a).

The second half of the research consisted of the analysis of interviews. I had met with ten key informants whose interdisciplinary perspectives brought the politics of sustainability to light (L.O.1b). Additionally, the interviews brought the research of my Community Energy Plan to a full circle when the municipal interviewees were asked where electric vehicles fit within municipal plans moving forward (L.O.2a).

Acknowledgements

I would like to thank my supervisors and advisors Martin Bunch, Christina Hoicka, Stefan Kipfer, and Jose Etcheverry for their extraordinary support, guidance, and inspiration throughout my MES journey. Additionally, I would like to thank my incredibly supportive and patient parents Herb and Marlene and sisters Dara and Shawna, who learned alongside me. Lastly, I would like to thank my friends, professors, classmates, and key informants who assisted and encouraged me along the way.

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Executive Summary

In Ontario, transportation is the cause of 34% of all greenhouse gas (GHG) emissions (Ministry of Climate Change and Environment, 2015, p. 30). Converting to electric vehicles (EVs) will significantly reduce GHG emissions if the overall grid is running on clean electricity (Holdway et al., 2010, p. 1825). Ontario has a goal of 80% GHG emissions reduction below 1990 levels by 2050. Research funded by National Resources Canada shows that conversion to EV's would reduce emissions by 85% on its own (Natural Resources Canada, 2009, p. 10). It is clear EVs can provide environmental benefits and opportunities, but the general public must develop a better understanding of EVs and the electrical grid. This is because if EVs are not managed responsibly and infrastructure not upgraded as required, the existing electrical grid will experience overloads as EV market penetration levels increase. This could put neighbourhoods at risk of experiencing blackouts. Key findings are summarized below.

Currently, the electrical grid has very little energy storage. EV's have created an interesting opportunity since at their most basic level, they store energy. A study shows that EV's are only used for transportation 4% of the time. This leaves 96% of the time where they can act as secondary storage (Kempton & Tomic, 2005a, p.268). This secondary storage function is called vehicle-to-grid. In this mode, EV's can provide the benefits of flexible charging and discharging back into the grid. Discharging is when the EV acts as a controllable load and distribution storage device by returning stored energy back into the grid. This ability to feed back into the grid can provide local distribution companies a new tool to stabilize the grid which can be beneficial to all stakeholders (Zakariazadeh et al., 2013, p.43).

EV's will add an additional load to the grid that previously never existed. The concern is that the additional load on top of existing load curves could potentially overload the system. Uncoordinated charging will overload the grid by increasing existing peaks, creating risk of local blackouts (Sundstrom & Binding, 2010, p.5 & 6). The alternative is to coordinate EV charging in order to avoid scenarios that may cause infrastructure failure. This is known as smart charging. In addition to not overloading the grid, it will provide local distribution companies the flexibility to charge EVs when it is most beneficial for all stakeholders. This can include variables such as when electricity is at its lowest price, demand is at its lowest, and when there is excess capacity (Richardson, 2013, p. 248).

EV's were not a variable that was considered in the development of older electrical grids, which is why the widespread implementation of EVs will require some problem-solving as EV market penetration becomes significant. The concern with EVs is that the added EV charging requests will stress the transmission system towards its limits increasing future bottlenecks which could generate blackouts and increase electricity costs. This is why it is important that both electricity requests must be carefully managed, and that existing infrastructure must be carefully monitored to determine when and where infrastructure improvements need to be made in conjunction with EV adoption.

Ontario has excess generation reserves (IESO, 2016b) (Beare, 2012, p. 28), and theoretical potential to supply the charging demands for 100% of the light vehicles in Ontario from 2010 until 2026 if market penetration is staggered (Canizares et. al., 2010. p. 91-93).

The greater concern is the capacity of local electrical infrastructure, and not electricity generation capacity. When considering transmission constraints, the Ontario electricity grid can only optimally charge 6% of the total vehicles in Ontario off-peak without jeopardizing the reliability of the larger electrical grid (Hajimiragha et. al., 2010, p. 10).

In Toronto, local distribution companies are very concerned about the clustering of EVs. They say "If you connect about 10 percent of the homes on any given street with an electric car, the electricity system fails" (Spears, 2010) and a transformer may be required (Gallant, 2011). Toronto studies aligned with this concern. They showed that the system has the capacity to handle 5% EV market penetration levels in 2020, but in 2030, if the EV market penetration level reaches the projected 25% EV market penetration level, there are scenarios where the system lacks the capacity at the local level (Pollution Probe, 2010, p. 46).

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1.0: Introduction

Electricity can be a confusing topic. Most people just take it for granted. They plug their appliance into the wall and expect electricity to be available without any thought as to where it is coming from, or how their use of it might impact the electrical grid and the greater community. Electric vehicles (EVs) are an emerging technology that will greatly impact the electrical grid This primer will help the average person understand energy management in order to prepare them for the transition to EV's. This primer will introduce the basics of EV's, electricity, and discuss how the two interact. The province of Ontario will serve as a case study. Better public knowledge of electricity and EV's will result in a smoother transition to a sustainable future.

1.1 Benefits and Concerns Regarding Electric Vehicles, and Ontario's Energy Mix

In Ontario, transportation is the cause of 34% of all greenhouse gas (GHG) emissions (Ministry of Climate Change and Environment (MOECC), 2015, p. 30). Converting to EV's significantly reduces GHG emissions if the electricity used to power them is produced from mainly clean energy sources (See Figure 1)(Holdway et al., 2010, p. 1825). For instance, many American states, such as neighbouring Michigan, rely heavily on coal. This would see less efficient GHG reductions from EV's than a province like Quebec, that generates a majority of its electricity from hydroelectricity (See Figure 2)(Ministry of Energy (MOE), 2013, p. 10).

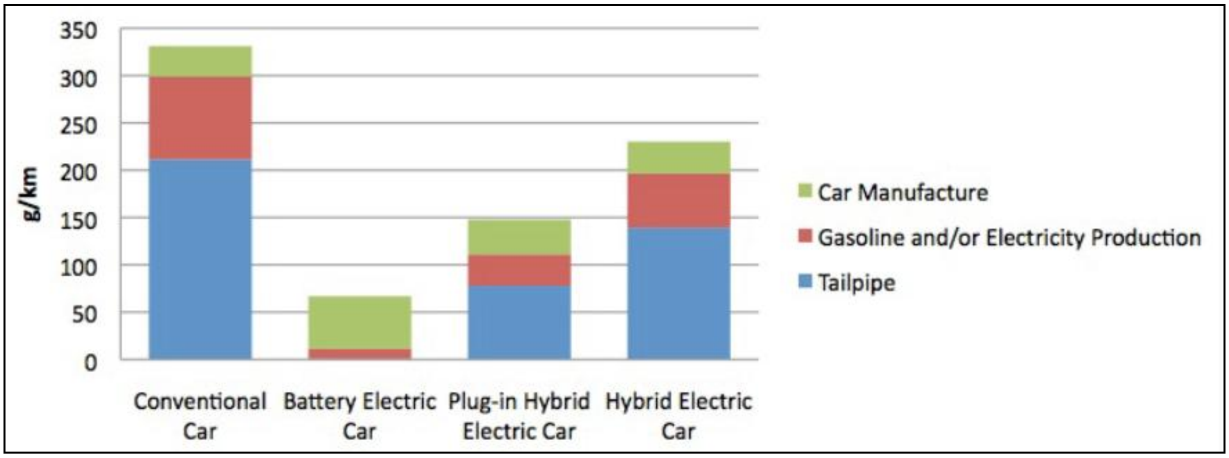


Figure 1: Life cycle GHG emissions by Vehicle Type (Moorhouse & Laufenberg, 2010, p. 10)

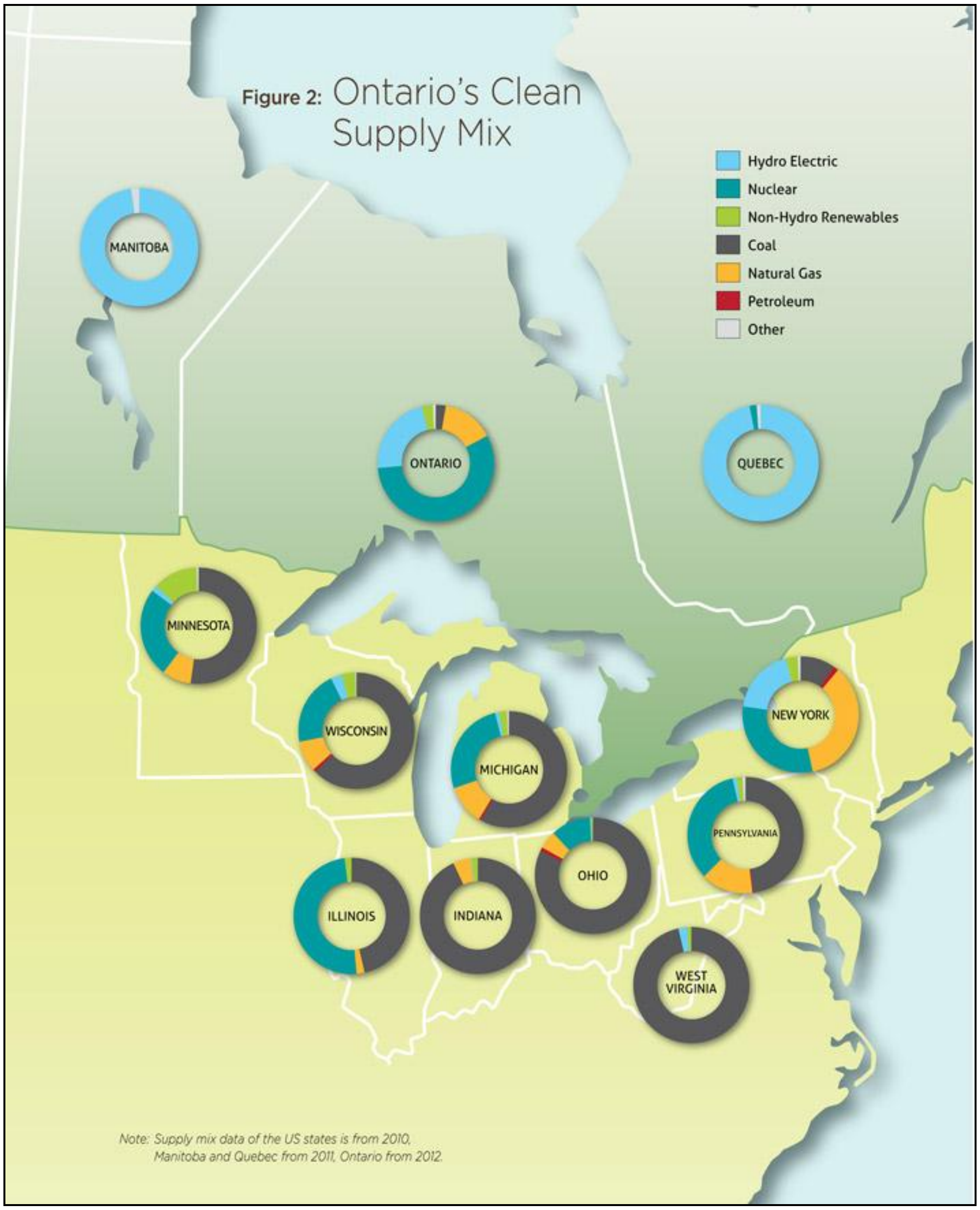


Figure 2. Comparing Ontario Energy Supply Mix to other Jurisdictions (MOE, 2016, p. 30)

Ontario is well positioned to see GHG reductions from electric mobility since it already has a relatively clean energy mix. According to the Independent Electricity System Operators (IESO), as of December 14th, 2015, Ontario has a generation capacity of 35,221 megawatts. 33.4% is renewable generating capacity (composed of 24% hydro, 9% wind, 0.4% solar). 1% is bio-fuel and 37% is nuclear; which is clean in terms of immediate GHG emissions, but can have very dangerous consequences. The final 28% capacity is gas and oil (IESO, 2016a). The MOE plans to increase the capacity of renewable energy to 46% by 2025. In 2025, only 23% of the remaining capacity will be fossil fuel based (See Figure 3)(MOE, 2013, p. 35).Based on this trend, fossil fuels should continue to disappear from the Ontario energy mix.

Furthermore, conversion to EV's coincides with a number of provincial goals and programs. Ontario has a goal of 80% GHG emission reduction below 1990 levels by 2050. Research funded by National Resources Canada shows that conversion to EV's would reduce emissions by 85% on its own (Natural Resources Canada (NRC), 2009, p. 10). To support this GHG reduction, Ontario has set a provincial policy that 1 in 20 vehicles on the road to be electric by 2020 (Ministry of Transportation (MOT), 2009). To support this policy, the province created the Electric Vehicle Incentive Program in 2010. The program provides a maximum $10,000 rebate on new EVs, an added $3,000 for EVs with a larger battery, and added $1,000 for EV's with five or more seats. For charging stations; also known as electric vehicle supply equipment (EVSE), the province offers rebates of up to $500 on a charging stations and an additional $500 rebate on the installation of the charging station. Lastly, in December of 2015 the province announced $20 million from the Green Investment Fund will go towards creating a network of public fast-charging stations across the province, which will be operational by the end of 2016 (Office of the Premier, 2016).

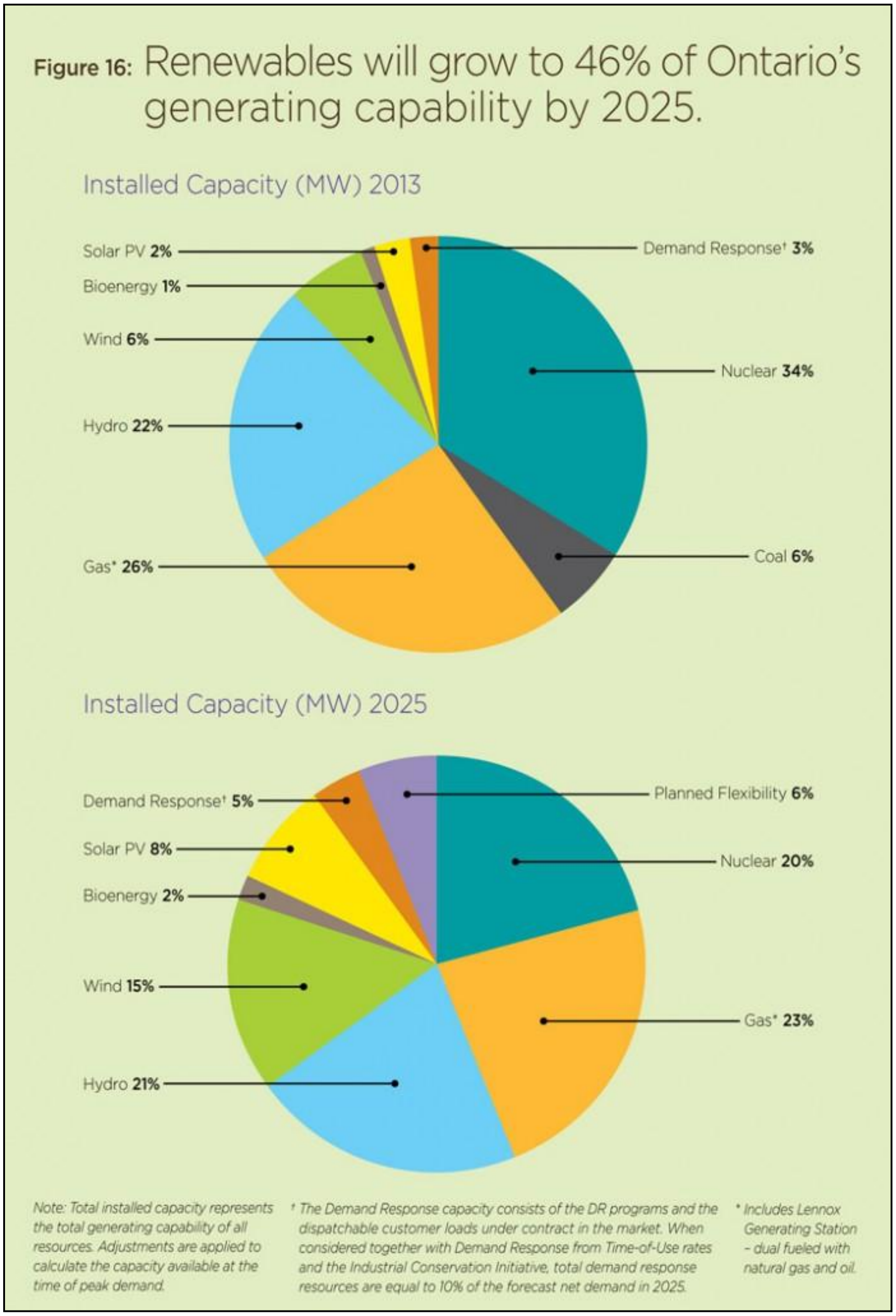


Figure 3. Renewable Generating Capacity will grow to 46% by 2025 (MOE, 2013, p. 35).

EV's have a number of other benefits. EV's have a higher capital cost, but far lower operating cost. EV's are much more energy efficient than internal combustion vehicles, benefit from regenerative braking, they require significantly less maintenance and see far less wear and tear (Canizares et. al., 2010, p. 45 & 55,). Research from the Environmental Commissioner of Ontario shows that EV's can save Ontarians up to $20,000 in fuel savings over the vehicle's lifetime (See Figure 4).

Other benefits include a decrease in health concerns linked to climate change, and decreases in the personal financial impacts from carbon taxes, uncertain oil prices, and energy security concerns (Hajimiragha et al., 2010, p.1).

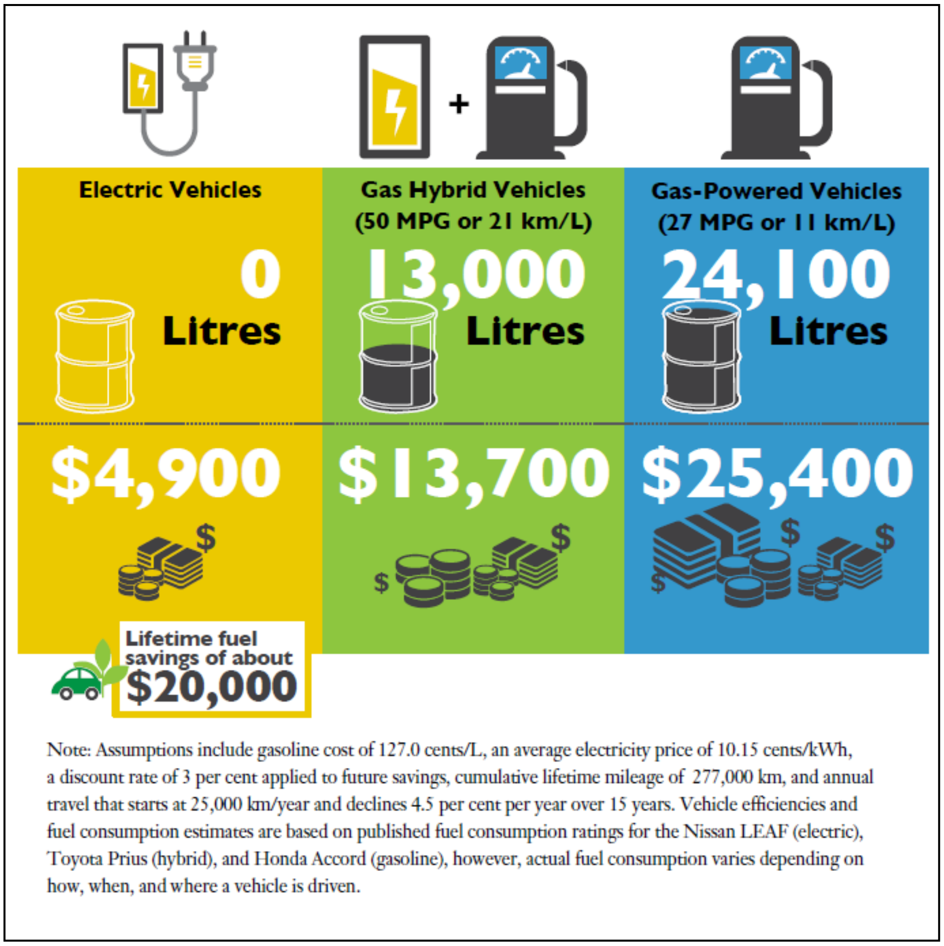


Figure 4. Electric Vehicles can result in lifetime fuel savings of about $20,000 (Environmental Commissioner of Ontario, 2014, p.41).

Despite the benefits, there are concerns regarding EV feasibility based on the cleanliness of today's electricity mix, the impact of high GHG emissions associated with manufacturing EV's, and battery effectiveness over time (Hawkins et al., 2013, p. 57; Lomborg, 2013). The listed concerns are shrinking since the electricity mix is becoming cleaner, and EV manufacturing practices and battery designs are improving on an annual basis.

2.0: Electricity Systems and Electric Vehicles

2.1: How does the Electricity Grid work?

Power systems are made up of the four steps which include energy generation, transmission, distribution, and consumption by the end user (Galus et al., 2010, p. 6737). The British Columbia Ministry of Energy, Mines, and Petroleum Resources has produced a useful figure which illustrates these steps in action (See Figure 5)(British Columbia Ministry of Energy and Mines, 2014). The first step shows how electricity is produced at power plants by hydroelectric or thermal facilities. The electricity then goes through a transformer, to produce a higher voltage. The transmission lines carry electricity at a higher voltage because a higher voltage incurs fewer losses when travelling long distances across transmission lines. The transmission lines carry the electricity to a distribution system infrastructure, including terminal stations, sub-transmission lines, and substations. The distribution system infrastructure reduces the high voltage down to lower, usable voltages for the end users; such as residential, commercial and small industrial customers. For this final leg of the lower voltage journey, the electricity goes through smaller distribution lines which can be below or above ground. The exceptions are large industrial users with higher consumption, that require higher voltages, and use the electricity straight from the higher voltage lines (Galus et al., 2010, p. 6737).

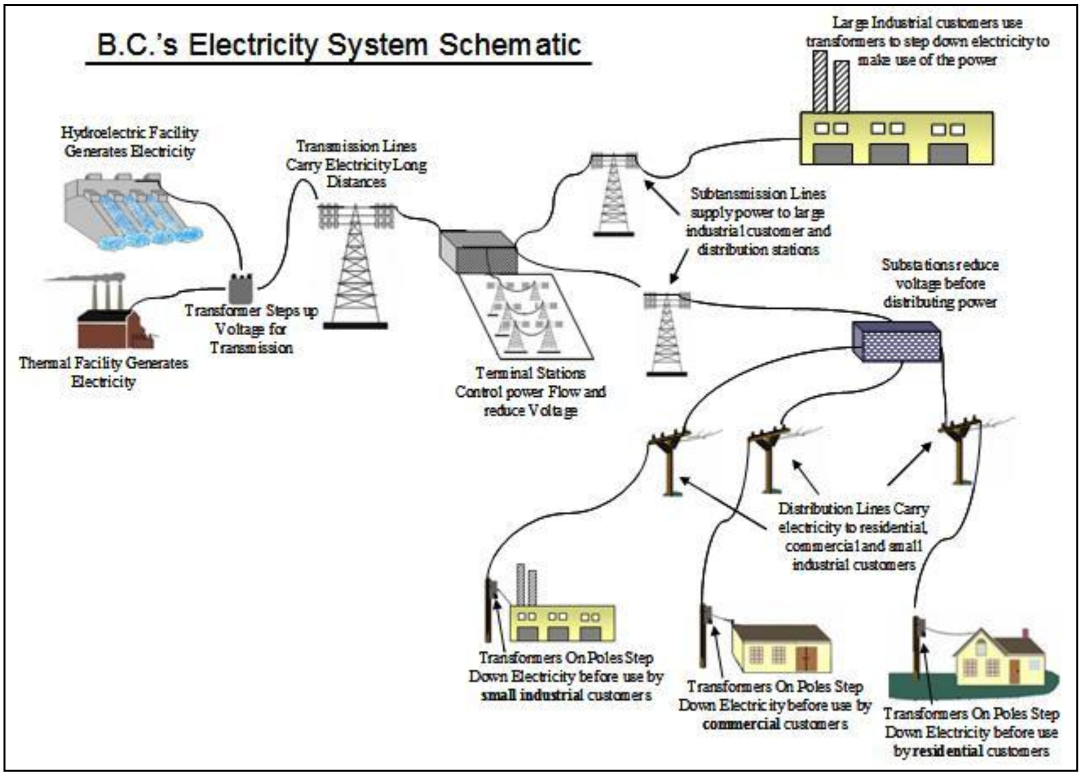


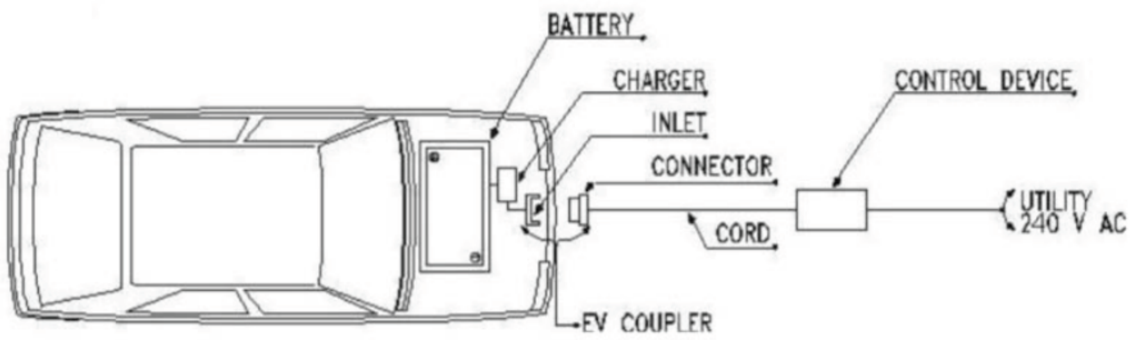
Figure 5. B.C.'s Electricity System Schematic. Reprinted from Electricity in British Columbia (British Columbia Ministry of Energy and Mines, 2014).

2.2: How do Electric Vehicles Connect to the Electricity Grid?

Whereas traditional gasoline vehicles refuel at a gas pump, EV's must connect to an electricity source in order to run the onboard charger, which recharges the onboard battery. The diagram below shows how an electric vehicle draws electricity from a Level 2 AC charge station (See Figure 6). Variables that can factor into charge time include battery size, charging type, the vehicle's battery management system, on-board charger specifications, and the voltage and amperage of the charging station (ECOtality, North America, p. 1-2, 2014).

2.2.1. EV AND EVCS COMPONENTS

EVCS delivers electrical energy from the power source to the EV, and ensures that an appropriate, and safe, flow of electricity is supplied to the vehicle. EVCS is the main interface between user, vehicle, and utility.



- **Battery -** Located on-board the vehicle and is the power (DC) storage component
- **Charger -** Converts power from AC to DC to charge the battery
- **Inlet -** Connection point on the vehicle
- **Connector -** Connection point from the charging station
- **EV Coupler -** Describes the connection between the 'Inlet' and 'Connector'
- **Control Device/Charging Station -** Provides power from the utility (AC)

Figure 6. Diagram of how a standard Electric Vehicle connects to a Charging Station (BOMA Energy Management Program, 2013, p. 3).

Currently, there are three standard charging levels. AC Level 1, AC Level 2, and DC fast charging. AC Level 1 utilizes a conventional 120-volt outlet. The advantage is that they use a standard three-prong outlet. The disadvantage is that they charge very slowly, which can be an inconvenience. They take between 8 and 20 hours to fully charge an EV battery. AC level 2 utilizes a 240-volt outlet similar to heavy household appliances like stoves. They fully charge an EV in 3 to 8 hours. This speed makes level 2 ideal for charging overnight at home or during the day at the workplace. DC fast chargers are the fastest chargers, fully charging an EV in 15 to 30 minutes, but require very expensive equipment and retrofits to be installed. The capital cost for them is large and therefore will likely only be made available at heavy traffic corridors and gas stations (See Figure 7) (BOMA BC Energy Management Program, 2013, p. 6).

	Volt	Amps	Charge Time	Added Range per Hour of Charging
Level 1 AC	120	15-20	8-20 Hours	5-8km miles
Level 2 AC	240	20-90	3-8 Hours	16-30 miles
DC Fast Charger	400-500	<=125	15-30 Minutes	95-125 miles

Figure 7: EVSE Levels (BOMA Energy Management Program, 2013, p. 4).

2.3: Electric Vehicles as Grid Storage

Currently, the electrical grid has very little storage. Essentially, all generated power is being transmitted and distributed directly as needed, on a minute to minute basis. EV's have created an interesting opportunity, since at their most basic level they are battery storage. A study shows EV's are only used for transportation 4% of the time. This leaves 96% of the time where they can act in a secondary storage function (Kempton & Tomic, 2005a, p.268).

This secondary function is called vehicle-to-grid (V2G). In this mode, EV's can provide the benefits of flexible charging and discharge back into the grid. Discharging is when the EV acts as a controllable load and distribution storage device by returning the stored energy back into the grid. This feeding back into the grid could help it remain more reliable. This function could be advantageous to both EV owners and local distribution companies (LDCs). Owners could be financially compensated for discharging while LDCs would gain greater control and flexibility in how they choose to stabilize the grid (Zakariazadeh et al., 2013, p.43).

One study shows that 5 to 10 percent of the cost of electricity is from LDC purchases to adapt to load fluctuations and unexpected failures (Kempton & Tomic, 2004, p.268). Another study says that V2G will provide flexibility and support to three power markets, which implies it could reduce electricity costs. V2G could provide opportunities to the peak market, the spinning reserves market, and the regulation market. The peak market is when electricity is in highest demand. V2G could provide cheaper electricity stored from earlier in the day and also result in putting less stress on generators. The spinning reserves market consists of generators setup to quickly turn-on in case of equipment failures or failures to meet electricity demand. The regulation market buys additional electricity to keep the frequency and voltage steady. V2G will provide both markets the opportunity to take electricity from inactive EVs instead of turning on another generator or buying electricity from another jurisdiction (Kempton & Tomic, 2005b, p.283).

Figure 8 shows how this V2G integration could look on the existing grid structure. The image shows that EV's would be plugged into charging stations at home or work. This connects the EV as a storage device onto the grid, which directly communicates with the rest of the grid so it can charge or discharge based on demand.

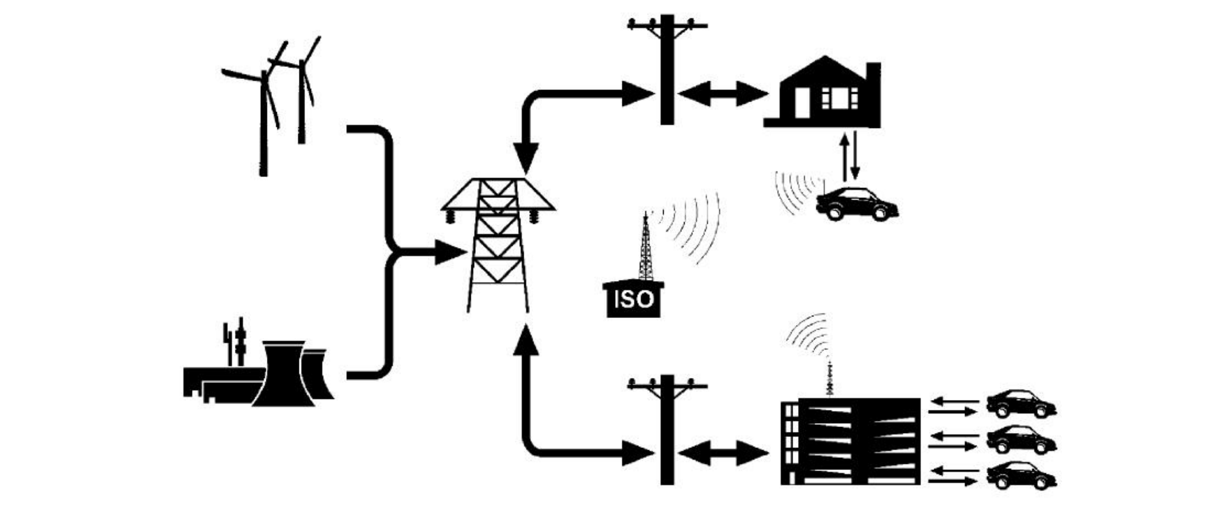


Fig. 1. Illustrative schematic of proposed power line and wireless control connections between vehicles and the electric power grid.

Figure 8. Visual representation of EVs being implemented into electric grid structure (Kempton & Tomic, 2005a, p. 269).

As previously mentioned, the existing grid lacks a primary storage mechanism. One issue with renewable energy is that it can be produced at variable levels, and possibly at off-peak times when it cannot be fully utilized since it may not go into direct use. This opens up exciting possibilities for EV's. This means that EV's can provide storage for renewable energy whenever it becomes available; even at inconvenient times. This method can get renewable energy online and integrated into the grid (Richardson, 2013, p.250).

2.4: Electric Vehicles and Renewable Energy

For EV's to be most effective, the electricity mix needs to be clean. For this to occur, renewable energy, also known as variable energy, must continue to increase its share in the electricity mix. The issue with variable energy, like wind and solar, is that their production varies based on time of day, time of year, and weather conditions, making it unreliable at times. The challenge is that system operators must make sure that the electricity supply must always be in exact balance with demand fluctuations throughout the day. Fluctuations commonly occur due to failing power plants and transmission lines, Production losses are accommodated by having a certain number of power plants held in contingency reserve to increase production when required. Increased variable energy would mean increased uncertainty. This would mean that contingency reserves may need to be increased and better managed to balance the grid (Andersen, 2014).

The concern regarding intermittency of variable energy begins to disappear when energy storage becomes part of the equation. The transportation sector will provide energy storage capacity for Ontario's grid and intermittent energy since EV's are energy storage batteries (Hajimiragha, 2010, p. 2). The current issue with variable energy is that its untimely production does not always match periods of demand. When supply timelines do not meet demand timelines, renewable energy may produce excess energy that goes underutilized. EVs will provide storage so that renewable energy can be discharged to meet periods of demand and help provide balance to the grid (Andersen, 2014).

3.0: Load Curves

3.1: What is an Overload?

An electrical load is the energy consumed by a component that is connected to a source of electricity in order to perform its function (Dictionary of Engineering, 2004). The load can be imagined as the final consumer of the electricity, which in many cases is a household which might use the load to power a television. Owners of EV's will create an added load for households.

A major concern with most North American electricity systems is that although overall electricity demand is increasing, the infrastructure needed to reliably and securely meet these demands is not. Otto Lynch, the vice president of Power Line Systems, said this in regards to existing infrastructure. "I like to think of our grid much like a water system, and basically all of our pipes are at full pressure now [...]If one of our pipes bursts and we have to shut off that line, that just increases the pressure on our remaining pipes until another one bursts, and next thing you know, we're in a catastrophic run and we have to shut the whole water system down" (Halsey III, 2012).

This, in essence, is what an overload is like. In technical terms, an overload or an overloaded circuit is a circuit which is carrying more current or additional load than it is designed to carry. A way to remedy this would be to improve the capacity of the system, such as an improvement to its transmission lines. A power grid can perform in an overloaded state for a period of time in order to meet a peak demand, but it must be monitored carefully. The grid could eventually reach dangerous overheating levels which could potentially cause electrical fires. Fires are generally avoided by overload protection devices. The safeguards are fuses and circuit breakers, which are designed to trip, or break the circuit, in order to prevent overheating (Powercor, 2016). Subsequently, the result of an overloaded circuit is generally a breakdown of equipment, or a collapse of the system, which can result in outages (Business Dictionary, 2016).

3.2: What is a Load Curve?

A load curve or shape is the electricity consumption over a 24 hour period of a component such as a household. The combination of data from all of these curves can give a jurisdiction an idea of how these curves overlap and identify the times of peak or heaviest use.

As well, it can help identify whether the systems' is at risk of overloading. Having strong knowledge of load curves can allow jurisdictions to appropriately plan demand response programs and energy efficiency programs to best suit consumer choices.

Each load shape usually has one or more peaks throughout the day that allows LDCs to categorize the general shape into a market segment. The study, *Household Energy Consumption Segmentation Using Hourly Data* analyzed load shapes in California and determined that 40% of the shapes accounted for the traditional evening peak (Kwac et al., 2014, p. 426). Figure 9 displays the 20 most common load shapes from the study. Figure 10 details the seven general load curve market segments based on the study.

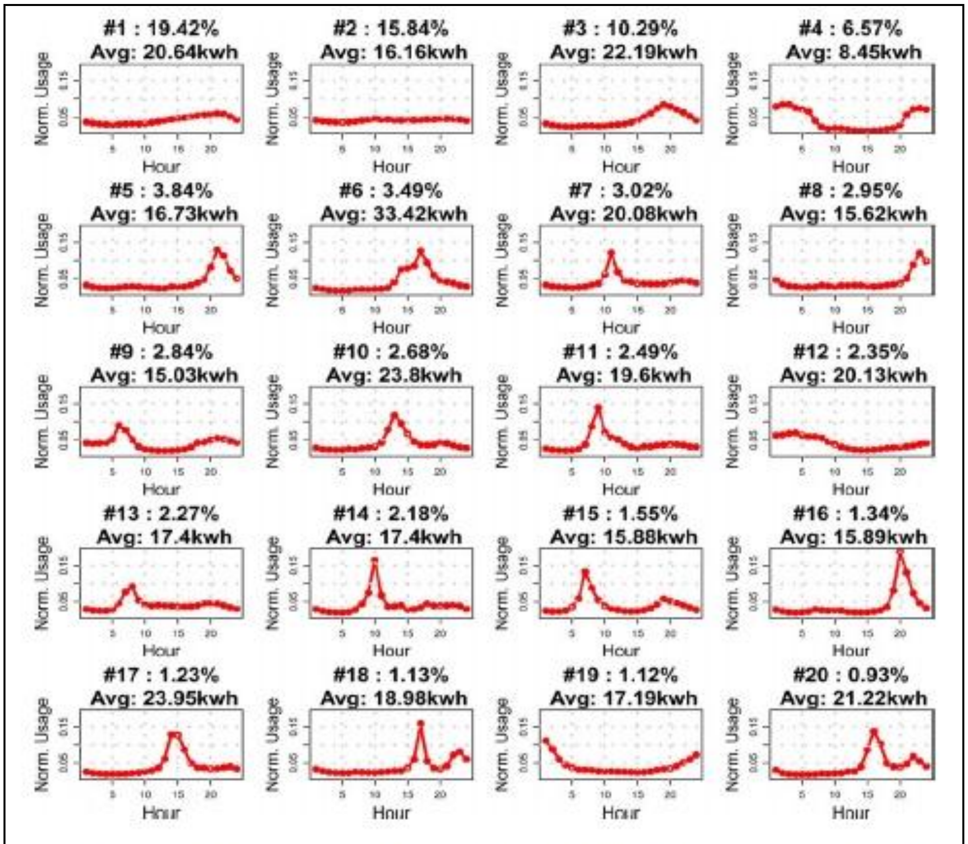


Fig. 16. 20 most frequent load shapes of whole households using the dictionary of size = 100.

Figure 9. Examples of 20 Most Frequent Load Curve Shapes (Kwac et. al., 2014, p. 426).

Example of the seven load curve market segments: Morning=#9,11,13; Daytime=#7,10,17; Evening=#1,3,5,6,16; Night time=#4,8,12,19; Dual Peak Morning & Evening=#2,15; Dual Peak Evening & Night time=#18; Dual Peak Daytime & Evening=20 (Kwac et al., 2014, p. 426)

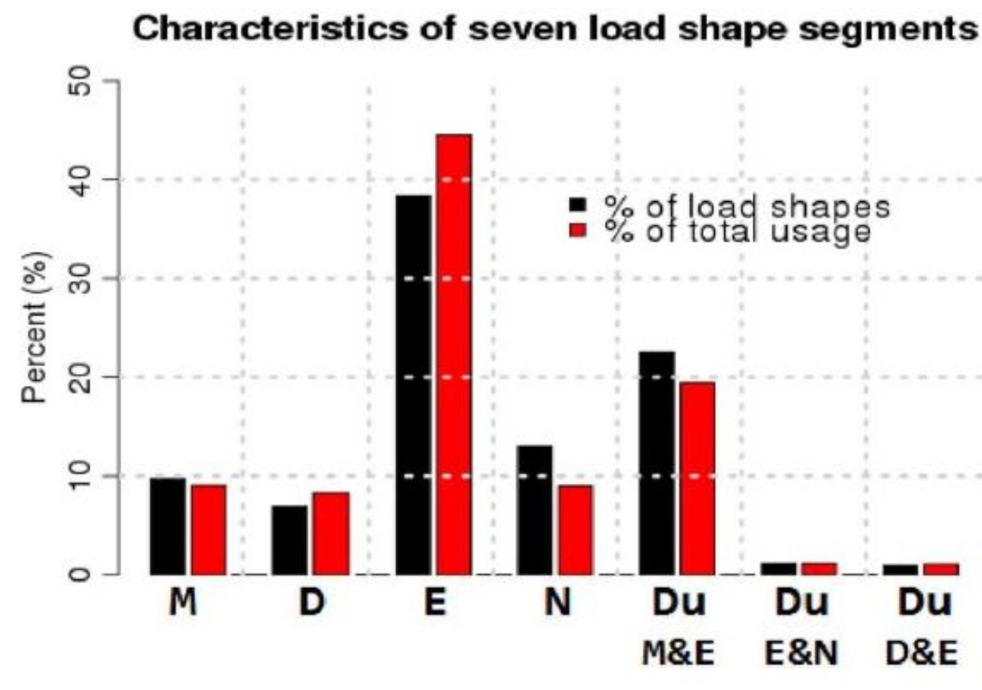


Fig. 17. Characteristics of seven load shape segments.

Figure 10. Based on the seven load shape market segment characteristics described above this chart displays the frequency of those characteristics based on load shape and total usage (Kwac et al., 2014, p. 426).

Top 5 load curve market segments based on total usage: Morning (M) near 10%, Daytime (D) near 10%, Evening (E) near 40%, Night time (N) near 10%, Dual Peak M&E near 20% (Kwac et al., 2014, p. 426).

3.3: Load Curves and Electric Vehicles

Similar to the discussion regarding capacity and EV's, the concern is that the additional load on existing load curves could potentially overload the system as illustrated in Figure 11 below. This model is based on uncoordinated direct charging, as it is done today (Sundstrom & Binding, 2012, p.28). Driving patterns, charging characteristics, charge timing, the quantity of vehicles and market penetration are all additional factors to load curves which will need to be accounted for (Green et al., 2011, p.544). Uncoordinated charging is when "vehicle charging takes place only at home, starting upon arrival and ending upon departure." (Canizares et. al., 2010, p. 105). The scenario of concern is that when the workforce arrives at their homes in the evening around 6 PM which is a grid peak, they will all plug their cars in during the same period and overload local transformers (See Figure 12).

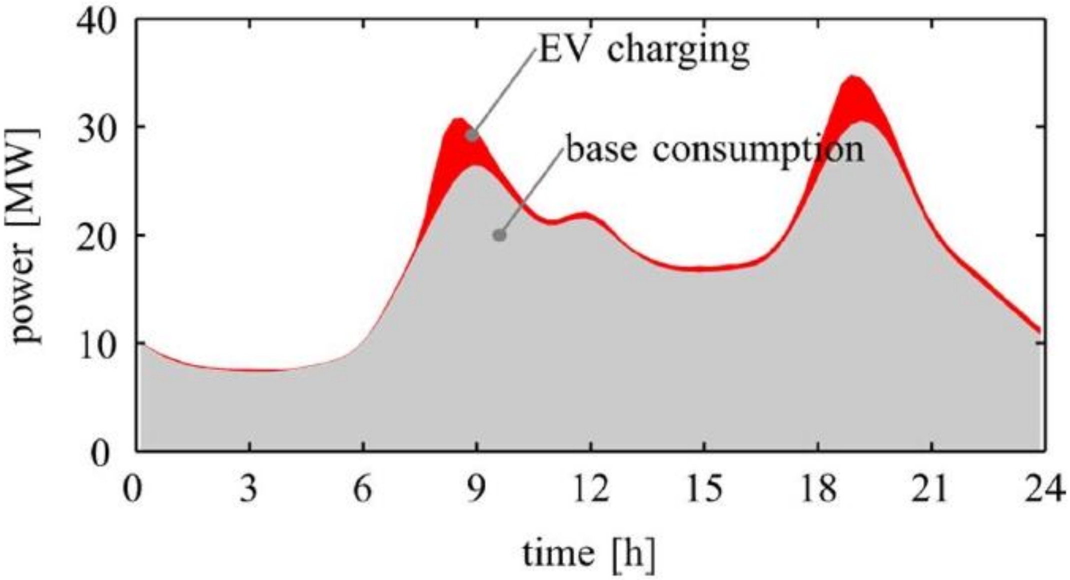


Fig. 3. Base load of the system and total aggregated EV charging using unco-ordinated direct charging of all the EVs.

Figure 11. Effects of Uncoordinated Direct Charging on Household Load Curves (Sundstrom & Binding, 2012, p. 28).

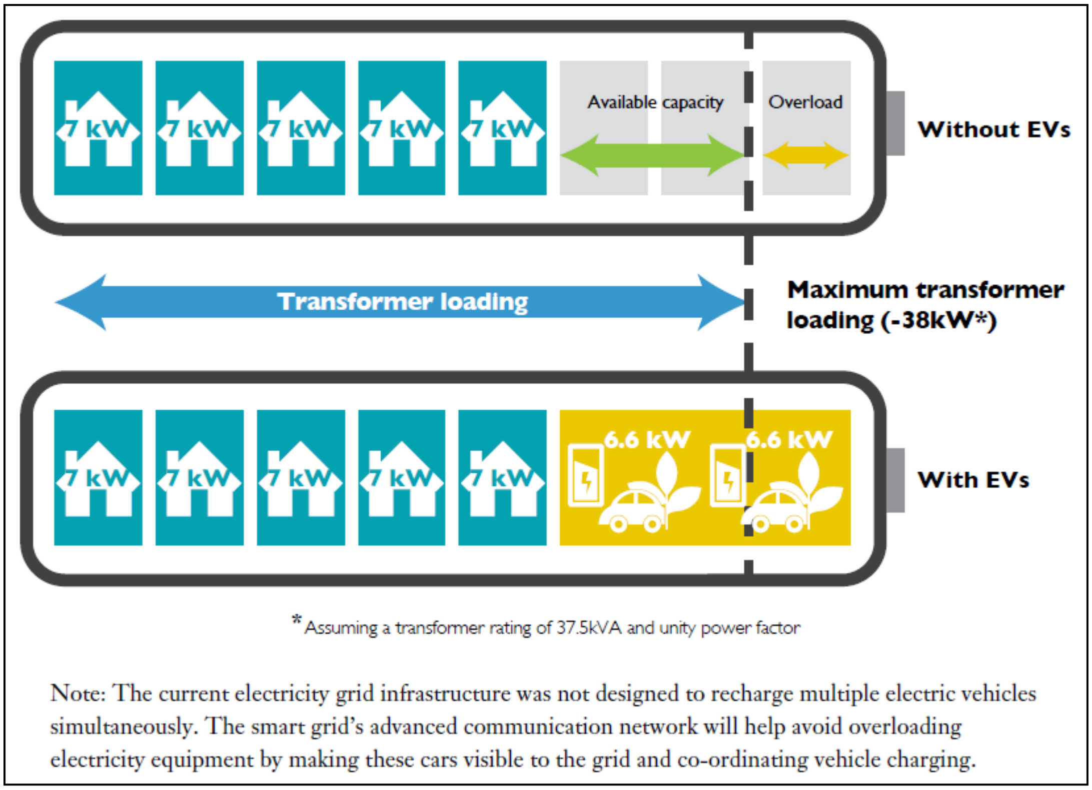


Figure 12. Example of Transformer Overloading due to Uncoordinated (Environmental Commissioner of Ontario, 2014, p. 40).

The solution is smart charging. The idea behind smart charging is to make most efficient use out of existing infrastructure by giving LDCs the flexibility to charge EVs when it is most beneficial for all stakeholders. This can include variables such as when electricity is at its lowest price, demand is at its lowest, and when there is excess capacity (Richardson, 2013, p. 248). In a smart charging model, the idea is that there would be a flow of communication between the owner, EV, grid, market, and distributors. For instance, the owner might make the single constraint that the vehicle must be fully charged by the following morning. The owner leaves it up to the distributor when to choose to charge, which will likely be off-peak demand, when electricity is cheaper and in less demand, or when it can store renewable energy such as wind.

Figure 13 shows how a load curve might look if a smart charging strategy was followed. In the example, EV charging takes place when there is low demand.

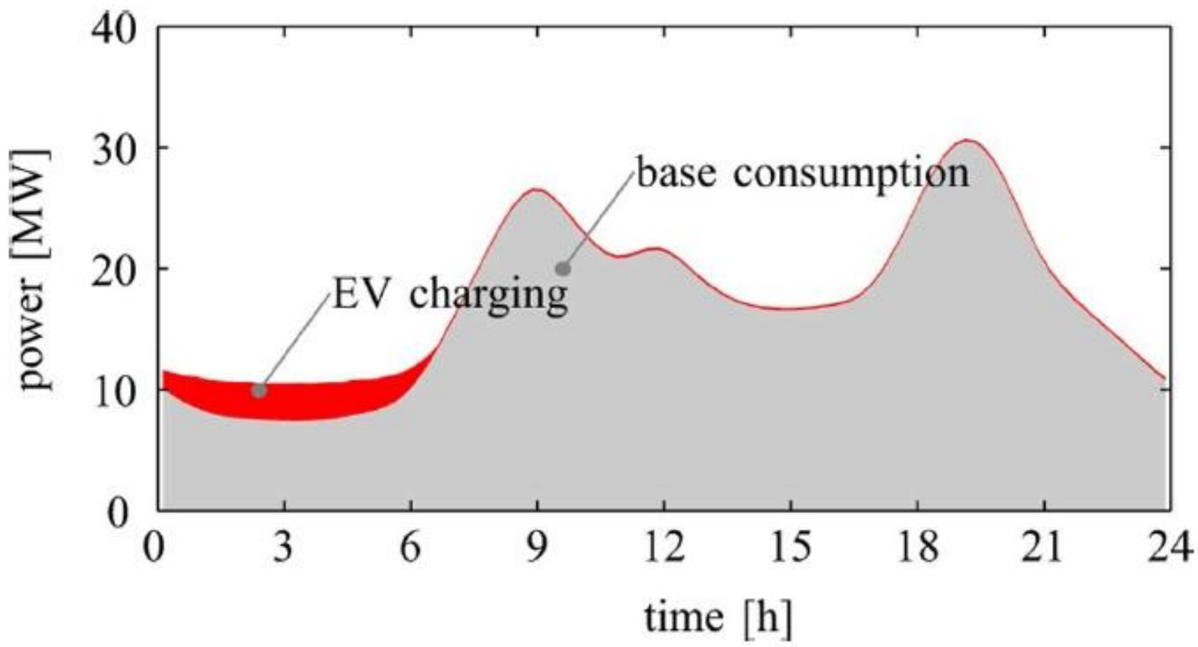


Fig. 7. Base load of the system and total aggregated EV charging for the reference power curve P_{ref}.

Figure 13. Shows how a load curve might look alternatively if a coordinated charging strategy was followed (Sundstrom & Binding, 2012, p. 34).

Figure 14 shows how variables and data can be communicated. Figure 15 shows how smart charging decision-making might occur. The following will discuss how Figure 14 and Figure 15 could occur in reality. An EV owner will contact their electricity provider using the internet and provide information detailing the following day's trips, including variables such as time and distance requirements. This data along with other information (which could include other client requirements, historic load curves, grid constraints such as local transformer capacity, electricity prices, overall grid demand, and incoming renewable loads based on weather patterns) will be fed to databases. This data will be analyzed to make sure all EVs are charged by the desired time, while ensuring that transformers and the grid are not overloaded, and that the most efficient source of energy is used.

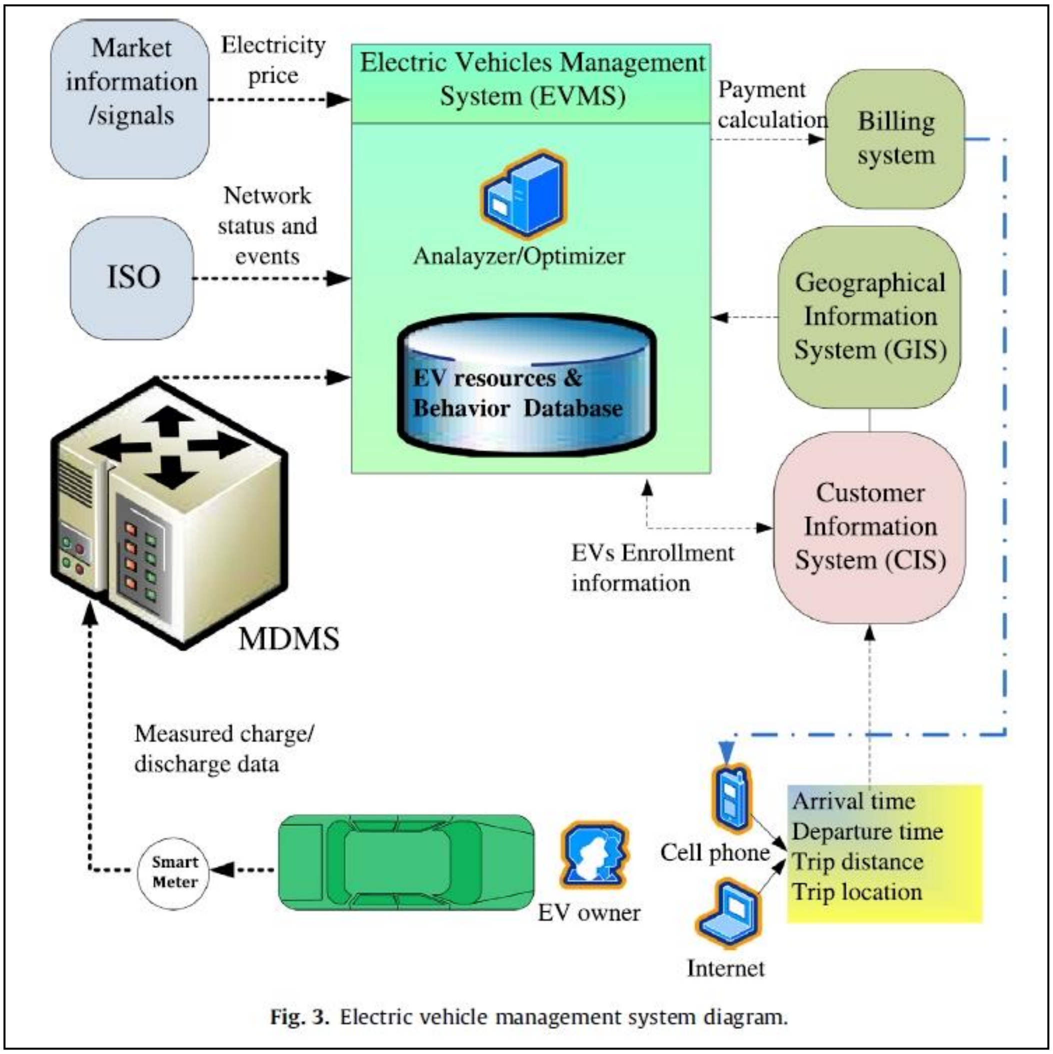


Figure 14. Diagram showing how all stakeholders and data could be communicated through a smart charging system (Zakariazadeh et. al., 2013, p. 46).

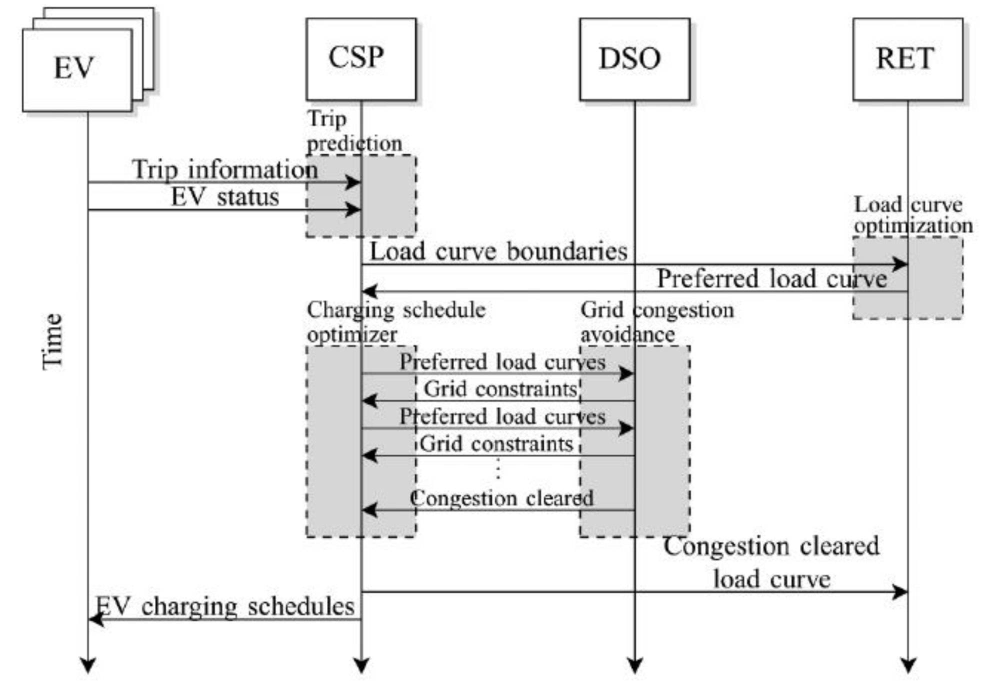


Fig. 4. The flow of information between the charging service provider (CSP), the electric vehicles (EV), the distribution-system operator (DSO), and the retailer (RET).

Figure 15. Shows how smart charging decision making might occur (Sundstrom & Binding, 2012, p. 29).

The study *Planning Electric Drive Vehicle Charging under Constrained Grid Conditions* looked at the impact of EV's on load curves under different charging simulations. The results are shown in Figure 16 below.

The first of the three simulations is eager charging, which is the present day model of starting a full charge of the EV the moment it is connected. Under this model, the load would overlap with the existing load curve making the morning and evening peaks even greater than they currently are. This model should be avoided (Sundstrom & Binding, 2010, p.5).

The second simulation is pure price-based charging. The goal of this unconstrained grid model was "to derive a charging schedule for each vehicle that ensures sufficient energy for the predicted trips, while, minimizing the total cost of the electricity used for the fleet" (Sundstrom & Binding, 2010, p.3). Under this model, the primary concern becomes monetary savings. In this scenario, you see an increased peak in the middle of the night which has off-peak prices (Sundstrom & Binding, 2010, p.5).

The third simulation is grid-aware price based charging. This constrained model was very similar to the pure price based model except for the additional constraint to respect grid capacity (Sundstrom & Binding, 2010, p.3). This model has very similar results except some of the demand is moved to other (possibly more expensive) off peak hours to avoid grid congestion (See Figure 16) (Sundstrom & Binding, 2010, p.5).

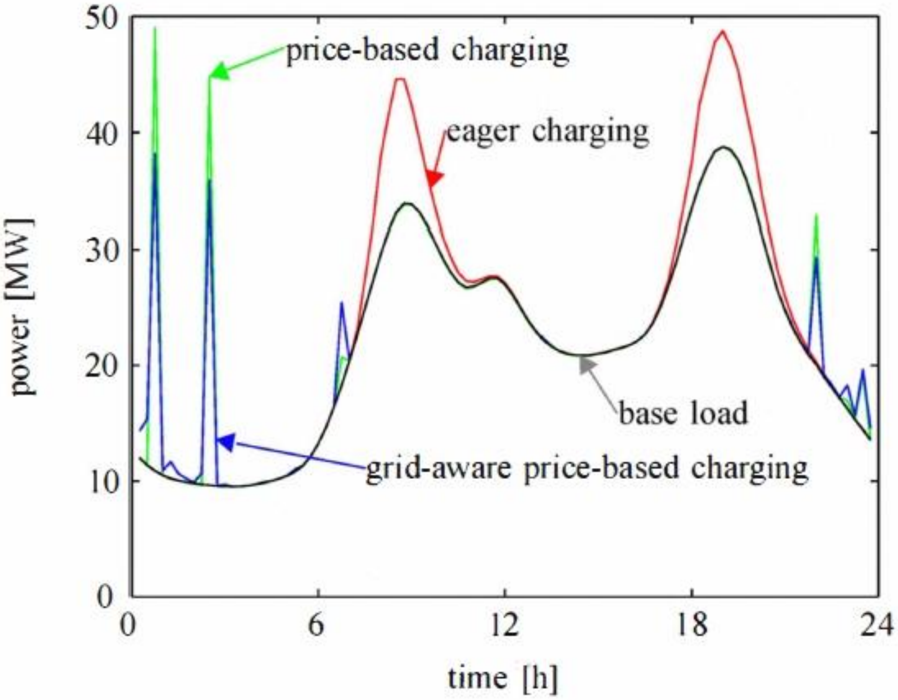


Figure 3. The base load excluding EV charging and the total load including EV charging during the day of operation. The total load is shown for the three different levels of charging management.

Figure 16. Diagram of Load Curve Simulations (Sundstrom & Binding, 2010, p. 5).

The maximum that the grid is recommended to run at is 100%. Anything above this represents overloading. Simulations showed that both eager charging and pure price based charging significantly overloaded portions of the grid up to 100% above recommended operational capacity (the equivalent of running at 200%). The grid aware method gets a majority of the charging done without ever overloading the grid. In the rare occasion it did overload the grid, portions of the grid were only overloaded 10% above recommended operational capacity (the equivalent of running at 110%) (Sundstrom & Binding, 2010, p.5 & 6). This study shows it is important to implement smart charging strategies as EV market penetration increases.

4.0: Bottlenecks

4.1: What is a Bottleneck?

A bottleneck is when there are more electricity requests than can be met, due to various constraints in the transmission system infrastructure. In order to prevent transmission lines from becoming overloaded LDCs must limit or deny some electricity requests (Lesieutre & Eto, 2003, p. 1).

4.2: What are causes of Bottlenecks?

There are three common causes of bottlenecks. The first is because parts of the transmission system infrastructure, such as a transformer, could have power flow limitations (U.S. Department of Energy, 2004, p. 3). For instance, old energy infrastructure is unlikely to be capable to transmit as high volumes of energy as modern infrastructure (Bryant, 2013). In many areas of North America, transmission lines have not been maintained or upgraded to meet increasing demand (Johnston, 2006).

The second cause of a bottleneck is an operational limit, which is set to protect the reliability and security of the system. This might be done to prevent the collapse of the system (U.S. Department of Energy, 2004, p. 3). For instance, laws and codes determine permitted standard voltages to flow through power lines. Going beyond them could have undesirable consequences such as power failures. The North American Electric Reliability Council notes criteria that are effectively the codes which produce operational limitations in which the market operates (Phillips, 2003, p. 14). A couple are particularly relevant. One is a stability limitation which limits power flow to prevent the system from becoming unstable. Another is the thermal limit which refers to the amount of energy that can flow without breaking components such as the transformers or transmission lines (Dyer, 2003).

The third cause of a bottleneck is a "lack of adequate transmission system capacity to deliver electricity from potential sources of generation without violating reliability rules" (U.S. Department of Energy, 2004, p. 3). In the article by Hoicka and Rowlands, the authors discuss how the local power distributor in Ontario (the Ontario Power Authority) is concerned that additional generation sources, in the form of renewable energies from feed-in tariff programs, will create this form of bottleneck. In fact, the Ontario Power Authority has stated that for the time being, in certain areas, there is no room in the transmission system to accommodate new generation projects (Hoicka & Rowlands, 2011, p.98).

4.3: What are the impacts of Bottlenecks?

There are a number of impacts from bottlenecks. The most commonly noted issue is that electricity becomes more expensive. For example, everyday demand must be met, but if bottleneck limits do not allow transmission of that electricity, replacement power must be bought and supplied from somewhere else with transmission capability (Lesieutre & Eto, 2003, p. 9). This generally increases the cost to the consumer. Another issue becomes energy security and reliability. Severe bottlenecks can cause failures which can produce unanticipated blackouts (Office of Electricity Delivery & Energy Reliability, 2014).

4.4: How can Bottlenecks be Mitigated?

The U.S. Department of Energy suggests three ways to mitigate bottlenecks. The first is to reduce electricity demand in congested areas through energy efficiency and demand management programs. The second is to build more generation capacity near the demand areas. The third is to build additional transmission capacity to permit more generators (Office of Electricity Delivery & Energy Reliability, 2014).

4.5: Electric Vehicles and Bottlenecks

EV's were not a variable that was considered in the development of older electrical grids, which is why the widespread implementation of EVs will require some problem-solving as EV market penetration becomes significant. Overall the primary concern regarding EV's as they relate to bottlenecks, is that EV's will produce additional transmission strain or requests upon the grid. A fear is that these requests could occur during peak demand.

The limitations which produce bottlenecks are necessary as they also serve the purpose of protecting the grid from the danger of overloading. The concern exists that EVs could stress the transmission system towards its limits increasing future bottlenecks which could generate blackouts and increase electricity costs. This is why it is important that electricity requests must be carefully managed, and that existing infrastructure must be carefully monitored to determine when and where infrastructure improvements need to be made in conjunction with EV adoption.

5.0: Studies of Electric Vehicle Loads on Ontario Grids

According to the IESO, the province has the generating capacity of 35,221 megawatts (IESO, 2016b). The 2015/2016 average peak demand in normal weather ranges was between 22,360 and 22,649 megawatts, and in extreme weather, peak demand ranges were between 23,261 megawatts and 24,623 megawatts. The peak demand record was 27,005 MW and occurred on August 1st, 2006 (IESO, 2016b). According to a research by Devon Beare, based on the peak record, uncontrolled EV charging would likely not exceed the maximum generating capacity during peak hours. He does note, "however, due to transmission line constraints and the distribution of centralized electricity generating stations across the province, it is likely that a clustered group of EV's in a single urban centre would exceed the capacity of local transmission systems during peak demand periods" (Beare, 2012, p. 28).

This capacity assessment is supported by two studies. The first study states that the present and projected electricity grid during off-peak periods can optimally charge 6% of the total vehicles in Ontario without jeopardizing the reliability of the larger electrical grid by 2025 (Hajimiragha et. al., 2010, p. 10). The second paper, produced by the Waterloo Institute for Sustainable Energy is more optimistic and says that the grid "has the theoretical potential to supply the charging demands for over 90% of the light vehicles in Ontario" starting from 2010 until 2026, and 100% if the market penetration is staggered. The author concludes overall capacity may exist, but does acknowledge that other grid reliability issues will need to be explored (Canizares et. al., 2010. p. 91-93).

As Beare highlighted, at this infancy stage of the transition to electric mobility, the greater concern is the capacity of local electrical infrastructure, and not electricity generation capacity. The California Public Utilities Commission declared that neighbourhoods with a large number of EVs' were stressing local transformers. They are called Prius clusters. They believe the grid can handle the stress. It can be contained through proper planning, and communication amongst dealerships and utilities as to where new EV owners are located (Green Car Reports, 2011).

With respect to Toronto, Tom Odell, a manager of capital projects and electric vehicles at Toronto Hydro, says EV's use 3 to 5 times the power requirement of a typical inner city home while it is charging (CBC News, 2013). Anthony Haines, the chief executive of Toronto Hydro, is concerned about Prius clusters. He says, "If you connect about 10 percent of the homes on any given street with an electric car, the electricity system fails" (Spears, 2010). This is further supported by Don Tench, the director of market assessment and compliance for the IESO. He says, "one EV in a neighbourhood is not a problem, but two or three might require an upgrade to the transformers, especially in urban areas where the infrastructure isn't up-to-date" (Gallant, 2011). Odell says, despite this, they are very supportive of electric vehicles and want to accommodate them. They just need an effective way to know where all of these electric vehicles are landing so they can plan. (CBC News, 2014).

Pollution Probe further explored this. They have produced scenarios examining the impact of different EV market penetration levels on Toronto's electricity system. Results showed that the system has the capacity to handle 5% EV market penetration levels in 2020, but in 2030, when the EV market penetration level is projected to be 25%, there are scenarios where the system lacks the capacity at the local level (See Figure 17)(Pollution Probe, 2010, p. 46).

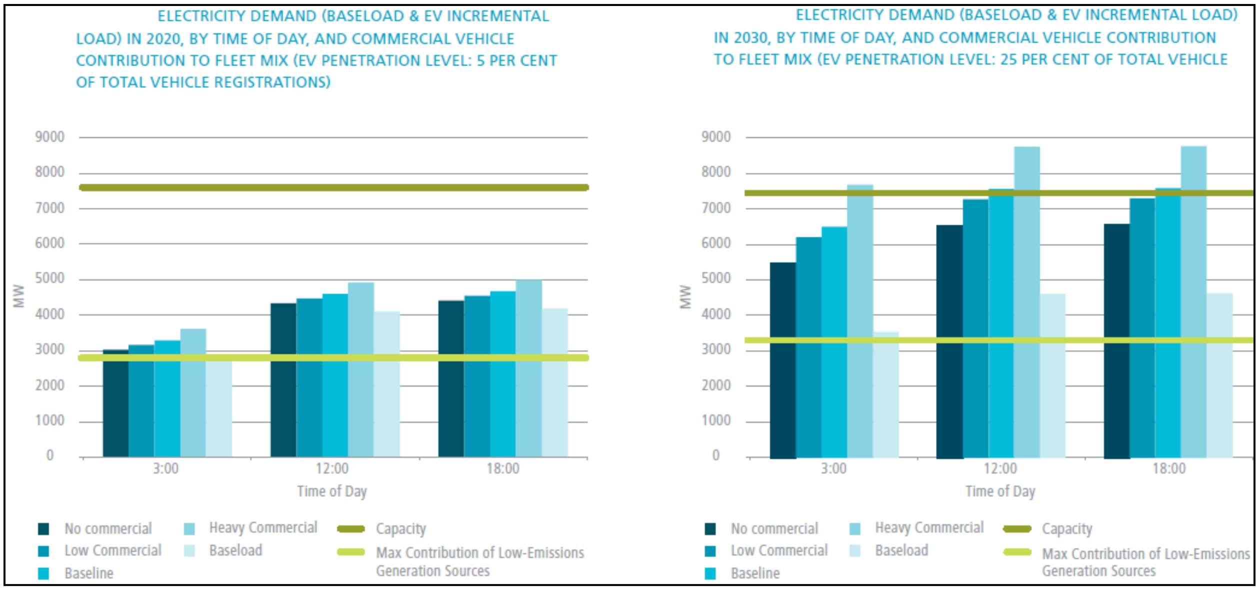


Figure 17. Comparing Toronto's System Capacity for Electric Vehicle Penetration in 2020 and 2030 (Pollution Probe, 2010, p.46).

To summarize, studies show that provincial generating capacity is not a concern. The real concern is local electrical capacity such as transformers. According to the most conservative projections, the province can safely and reliably handle 6% EV market penetration across until 2025. This aligns with the provinces goals of reaching 5% EV market share.

6.0: Summary

The goal of this primer was to increase the general public's understanding of electricity, EV's and how they will interact. EV's have the potential to be an important tool for decreasing GHG emissions, incorporating storage and renewable energy into the grid, and smoothing out load curves. In order to see the maximum benefits, EV owners' will need to charge their EVs' in a responsibly coordinated manner to minimize strain on the grid, and local jurisdictions must upgrade local electrical infrastructure where necessary to allow EV market penetration to increase. Managed correctly, EV's are an exciting technology that can integrate the energy and transportation sectors, provide efficient solutions, and make communities more sustainable.

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2. Identifying Barriers and Methods to Enabling a Transition to

Electric Vehicle Infrastructure in Ontario

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March 31st, 2016

A Major Project submitted to the Faculty of Environmental Studies in partial fulfillment of the requirements for the degree of Master in Environmental Studies

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Executive Summary

The transition to electric mobility may well be in the near future. Electric vehicles could possibly be viewed as a key part of the solution to reducing greenhouse gas emissions. Beyond climate change itself, a number of other concerns could push the issue. These might include health issues associated with climate change, future carbon taxes, political issues related to energy security, peak oil and uncertain oil prices (Canizares, et. al., 2010, p. 29). Lastly, total cost of ownership of an electric vehicle could be far lower than that of a total combustion vehicle. Once society sees these savings, the transition could be rapid (M3, personal communication. 2016, January 7). With the assumption that this transition will occur, the question then becomes whether the province of Ontario and its municipalities will be prepared to meet the electric vehicle infrastructure demand. Currently it appears that the province will not.

In order to identify the barriers and methods for implementing electric vehicle infrastructure, provincial and municipal legislation, policies and actions were analyzed. Additionally, ten key informants were interviewed to share their knowledge, experiences, and opinions. Key barriers and methods to implementation are:

Key Barriers to Implementation

Electric Vehicles and Charging Infrastructure Unidentified in Provincial Legislature:

- If electric vehicles were identified in the legislature, then municipalities would need to conform by creating by-laws, policies, and programs to provide opportunities for electric vehicles.

- Electrical Rough-ins for Electric Vehicle Charging Stations are not Mandatory in the Ontario Building Code:

- If electrical rough-ins were mandatory every new dwelling and building would be future proofed. This would be the simplest solution.

- Whose Role is it to Lead and Provide Public Electric Vehicle Charging Stations:
    - Currently both the public and private sectors are unsure what their responsibility should be regarding public charging stations. As such, no one is taking initiative to invest in adequate widespread public infrastructure in Ontario.
- High Capital Costs Combined with Negative Monetary Return on Investment for Public Electric Vehicle Charging Stations:
    - Currently, monetary business cases for public electric vehicle charging stations are not viable.
- Lack of Citizen Appetite for Electric Vehicles:
    - Not enough households are purchasing electric vehicles. This may be due to a lack awareness of rebates or lack of trust in the technology. Regardless it is discouraging the public sector (i.e., municipalities) and private sector (i.e., developers, existing retail and commercial establishments, potential charging businesses) from making investments.
- Development Industry Currently Not Providing Electrical Rough-Ins:
    - Installing rough-ins during the construction phase is significantly cheaper than retrofitting later, but there is no reason for developers to include them since there are no *Ontario Building Code* requirements, market demand, or other incentives.
- Lack of Municipal Initiative to Drive Electric Vehicle Policies:
    - At the time of this writing no Ontario municipalities have strong policies, by-laws or programs in place to increase the purchase of privately owned electric

vehicles and charging stations. Part of this could be a lack of political champions and lack of creativity needed to implement electric vehicle policies among the existing suite of municipal powers.

Key Methods to Implementation

- Negotiate Leverage through Site Plan and Subdivision Agreements:
  - Municipalities can negotiate for EV designated parking stalls and rough-ins using site plan approvals and subdivision agreements as leverage.
- Create EV Parking Rate Zoning By-Laws:
  - Municipalities can pass zoning by-laws to require designated EV parking rates as part of the development process.
- Lobby for Changes to Ontario Building Code:
  - EV stakeholders can form a group to educate the general public and the development industry and to lobby for mandatory rough-ins in the *Ontario Building Code*.
- Re-work Existing Rebates:
  - The province could rework the installation and charging station rebate "to provide 100% up to $1,000 for installation and EVSE combined."
  - Alternatively, create a new fund that can be utilized by the development industry to pay for the installation of rough-ins during the construction phase such as '100% up to $300 rebate that can only be redeemed during the construction phase for pre-wiring rough-ins'.
- Adopt EV Policy in OP and CEP to provide Future Opportunities:

    - Have council pass by-laws to include EV policies in both the OP and CEP in order to provide objectives and policy that staff can leverage in the developing of future EV policy initiatives and programs.
    - Alternatively the MMAH can identify EVs in a policy statement in order to have all municipalities provide EV policies in their OPs following the 5-year review period.
- Encourage LDCs and Private Sector to Lead EVSE:
    - The province and municipalities should encourage those that can make a business case in EVSE service such as LDCs and the private sector including retailers to take leadership.
    - Municipalities can work as facilitators and help to identify partnerships and bring together organizations that will serve the greater community.
- Increase Public Education and Awareness:
    - In order to increase interest and participation in EV ownership, the province must better educate the public regarding the benefits of EVs, the total cost of EV ownership, and better advertise the existing EV and EVSE rebates.
- Update Municipal Green Building Standards:
    - Municipalities must provide for indoor and outdoor rough-in options in municipal Green Building Standards.
- Provide Incentives for Rough-ins:
    - For those willing to provide a rough-in, municipalities can provide an incentive such as discount in a development charge, additional points towards municipal Green Building Standards, or money from a potential green building fund.

- Find Political Support:
    - Locate municipal champions to push for EV policies and programs.
- Encourage Municipal Staff Negotiation Culture:
    - Create a culture in which staff always negotiates with developers to participate in EV rough-in policies.

These were some of the more significant barriers and methods for implementing electric vehicle infrastructure that were identified through this study.

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1.0 Introduction

The incorporation of electric vehicle charging stations, also known as electric vehicle supply equipment (EVSE) is challenging, but this not the first time that new transportation and energy-related infrastructure have been introduced into the urban fabric. In cold climates, block heaters are needed in order to keep automobile engines from freezing. In cold climate regions, 120 volt outlet receptacles are made available in front of parking stalls to enable the charging of block heaters (See Figure 1). This precedent of block heater outlets has been common for decades and has similarities to EVSE (See Figure 2).

Figure 18: Example of Block Heater Outlets used to Charge Block Heaters (Kaltire, 2016).

Figure 19: Example of Electric Vehicle Charging Stations used to Charge Electric Vehicles (Lutz, 2015).

Despite the past precedent of 120 volt receptacles in cold regions, there is resistance by the public and private sector to provide EVSE at this point in time. One of the most prevalent issues regarding new technologies is what is called 'the chicken and the egg obstacle'. A barrier to implementing electric vehicle infrastructure is that neither the governing jurisdiction nor the citizens want to make the first move. The authority expected to be responsible for building such infrastructure will not invest until there are enough electric cars to use the infrastructure. On the other hand, the potential consumers will be less inclined to buy electric cars (EVs) until there is sufficient EVSE infrastructure (Leiby & Rubin, 2004; Melaina, 2007; Melaina & Bremson, 2008; Bento, 2008; Wang & Wang, 2010; Canizares et. al., 2010; Silver Springs Network, 2013; Chung & Kwon, 2015).

The province does appear to be making the first move to shrink this obstacle, by outlining a number of provincial goals and programs to support EVs. Ontario set a goal that 1 in 20 vehicles on the road should be electric by 2020 (Ontario Ministry of Transportation, 2009). To encourage this, they have created the Electric Vehicle Incentive Program. It provides a $6,000 to $10,000 rebate on new EVs, an additional $3,000 for EVs with larger batteries, an additional $1,000 for EV's with five or more seats, and up to $1,000 on the purchase and installation of a charging station for home or business use. As well, in December 2015, the province announced an additional $20 million from the Green Investment Fund that will go towards creating a network of public fast-charging stations across the province (Ontario Office of the Premier, 2016). This is a start, but does not provide an implementation plan to take complete advantage of this funding and produce widespread EVSE across the province.

The push for the transition to electric mobility is occurring because it helps resolve concerns related to greenhouse gas (GHG) emissions, health issues associated with climate change, future carbon taxes, political issues related to energy security, peak oil and uncertain oil prices (Canizares, et. al., 2010, p. 29). The assumption is that this transition will occur. The question becomes will the province of Ontario and its municipalities be prepared to meet the electric vehicle infrastructure demand.

This report is split into two sections. The first section will analyze existing provincial and municipal policies related to the barriers and methods in implementing electric vehicle infrastructure. The second section will summarize the findings of barriers and methods in implementing electric vehicle infrastructure. This information will come from attendance at a workshop and interviews. The workshop was the Canadian Standards Association (CSA) EV workshop exploring EV infrastructure requirements in the *National Building Code of Canada* and the *Canadian Electrical Code*. The interviews included nine semi-structured interviews with key informants sharing their knowledge, experiences, and opinions regarding the barriers and methods for implementing EVSE and the electrical rough-ins required to easily install EVSE in the future.

2.0 Analysis of Ontario's Planning Policies, Legislation, and Actions for Compatibility with Transition to Electric Vehicles

Policy and legislation are key tools for enabling, permitting and implementing the widespread construction of EVSE and rough-ins moving forward. The following section will review key provincial and municipal documents to see if EVs and associated infrastructure are included in the documents and if not, determine whether EVs align with the documents. As well, it will examine what barriers and methods each document presents.

2.1 The 2014 Provincial Policy Statement

"The *Provincial Policy Statement* (PPS) provides policy direction on matters of provincial interest related to land use planning and development" (Ministry of Municipal Housing and Affairs (MMAH), 2014, p. 1). The listed policy statements provide direction that all stakeholders involved in planning are expected to conform at minimum when applicable (MMAH, 2014, p. 2 and 3).

EVs are not mentioned in this policy, but they do align with the general concerns of the document. As seen below, EV implementation could resonate directly with a number of policies including:

1.1.1 Healthy, liveable and safe communities are sustained by:
e) promoting cost-effective development patterns and standards to minimize land consumption and servicing costs (MMAH, 2014, p. 6).
COMMENTS: Developing EV ready buildings and installing higher capacity electrical infrastructure such as transmission boxes would prevent expensive future retrofits.
g) ensuring that necessary infrastructure, electricity generation facilities and transmission and distribution systems, and public service facilities are or will be available to meet current and projected needs (MMAH, 2014, p. 6).
COMMENT: This is directly applicable to ensuring that the electrical grid is EV ready.
1.2.1 A coordinated, integrated and comprehensive approach should be used when dealing with planning matters within municipalities, across lower, single and/or upper-tier municipal boundaries, and with other orders of government, agencies and boards including:
d) infrastructure, electricity generation facilities and transmission and distribution systems, multimodal transportation systems, public service facilities and waste management systems (MMAH, 2014, p. 11).
COMMENT: Electricity generation facilities and transmission and distribution systems need to be communicating in order to handle the eventual load of EVs.
1.3.2.1 Planning authorities shall plan for, protect and preserve employment areas for current and future uses and ensure that the necessary infrastructure is provided to support current and projected needs (MMAH, 2014, p. 13).
COMMENT: Projecting into the future, employees may own EVs and require EVSE in order to have sufficient charge for their journey home.
1.6.1 Infrastructure, electricity generation facilities and transmission and distribution systems, and public service facilities shall be provided in a coordinated, efficient and cost-effective manner that considers impacts from climate change while accommodating projected needs. Planning for infrastructure, electricity generation facilities and transmission and distribution systems, and public service facilities shall be coordinated and integrated with land use planning so that they are:
b) available to meet current and projected needs (MMAH, 2014, p. 13).
1.6.8.1 Planning authorities shall plan for and protect corridors and rights-of-way for infrastructure, including transportation, transit and electricity generation facilities and transmission systems to meet current and projected needs (MMAH, 2014, p. 18).
1.6.11.1 Planning authorities should provide opportunities for the development of energy supply including electricity generation facilities and transmission and distribution systems, to accommodate current and projected needs (MMAH, 2014, p. 19).
COMMENT: These three policies all support the requirement that electricity generation facilities and transmission and distribution systems need to be coordinated in order to support the eventual and smooth transition to electric mobility. As well, it supports the requirement to project the capacity demand and transmission needs for EVs.
1.8.1 Planning authorities shall support energy conservation and efficiency, improved air quality, reduced greenhouse gas emissions, and climate change adaptation through land use and development patterns which: (MMAH, 2014, p. 20).

b) Promote the use of active transportation and transit in and between residential, employment (including commercial and industrial) and institutional uses and other areas (MMAH, 2014, p. 20).
COMMENT: A policy statement could be amended to become "promote the use of 'electric vehicles', active transportation and transit in and between residential, employment (including commercial and industrial) and institutional uses and other areas."

RECOMMENDATIONS:

Mentioning EVs in the PPS would show that the province firmly believes in transitioning to electric mobility. Two recommendations include:

- Amend PPS statement 1.8.1 section 'b' to include electric vehicles. It could become, ”Promote the use of *electric vehicles*, active transportation and transit in and between residential, employment (including commercial and industrial) and institutional uses and other areas.”

- Amend the definition of 'infrastructure' in the PPS to include requirements for EVSE. The definition of infrastructure could become: "Infrastructure: means physical structures (facilities and corridors) that form the foundation for development. Infrastructure includes: sewage and water systems, septage treatment systems, stormwater management systems, waste management systems, electricity generation facilities, electricity transmission and distribution systems, *electric vehicle infrastructure*, communications/telecommunications, transit and transportation corridors and facilities, oil and gas pipelines and associated facilities" (MMAH, 2014, p. 43). Numerous policy statements discuss developing towards projected needs. The inclusion of electric vehicle infrastructure would encourage municipalities to negotiate the inclusion of rough-ins in new developments and to ensure that future infrastructure could accommodate EV loads.

2.2 The Planning Act

"The *Planning Act* (PA) sets out the ground rules for land use planning in Ontario and describes how land uses may be controlled, and who may control them" (MMAH, 2015b). The MMAH governs the PA. The MMAH makes no mention of EVs or associated electric vehicle infrastructure. Despite this fact, the PA does have a number of sections that depending on interpretation may imply municipalities have the leverage to request or negotiate for EV parking stalls and rough-ins in future developments. The table below identifies potential opportunities.

Section 3 - Provincial Policy Statement: These are the policy statements section of the PA that look at how the PPS can be amended. These also define their influence; specifically s.3(1) and s.3(5)(a) states: **"3. (1) The Minister, or the Minister together with any other minister of the Crown, may from time to time issue policy statements that have been approved by the Lieutenant Governor in Council on matters relating to municipal planning that in the opinion of the Minister are of provincial interest" (MMAH, 2015).** **"(5) A decision of the council of a municipality, a local board, a planning board, a minister of the Crown and a ministry, board, commission or agency of the government, including the Municipal Board, in respect of the exercise of any authority that affects a planning matter, (a) shall be consistent with the policy statements issued under subsection (1) that are in effect on the date of the decision" (MMAH, 2015).**
COMMENTS: This implies that the Minister of MMAH can issue new policy statements regarding provincial interest pending approval of the Lieutenant Governor in Council. This provides opportunity to produce an EV statement (continued in Section 26 - Updating Official Plan).

Section 26 – Updating Official Plan: In the official plan, the rules section of the Planning Act, that refers to updating the official plan; specifically s.26(1)(a)(iii) is written as such: **"26. (1) If an official plan is in effect in a municipality, the council of the municipality that adopted the official plan shall, not less frequently than every five years after the plan comes into effect as an official plan or after that part of a plan comes into effect as a part of an official plan, if the only outstanding appeals relate to those parts of the plan that propose to specifically designate land uses, (a) revise the official plan as required to ensure that it,** **(iii) is consistent with policy statements issued under subsection 3 (1)" (MMAH, 2015a).**
COMMENTS: This implies that a municipal Official Plan must be updated every 5 years to be 'consistent' with the PPS discussed above. If an EV policy statement is created, the MMAH has the authority to ensure EV policies are included in Official Plans.

<u>Section 34 - Zoning By-Laws:</u>
The zoning rules section of the PA; specifically s.34(1) part 6 states:

"34. (1) Zoning by-laws may be passed by the councils of local municipalities:
6. For requiring the owners or occupants of buildings or structures to be erected or used for a purpose named in the by-law to provide and maintain loading or parking facilities on land that is not part of a highway." (MMAH, 2015a).

COMMENTS: This implies that a municipal council may pass a zoning by-law that could require designated EV parking rates.

<u>Section 41 - Site Plan Approval:</u>

The site plan rules section of the PA examining site plan approval conditions, specifically <u>s.41(4)(d) and s.41(7) part 3</u> states:

(4) No person shall undertake any development in an area designated under subsection (2) unless the council of the municipality or, where a referral has been made under subsection (12), the Municipal Board has approved one or both, as the council may determine, of the following:

(d) matters relating to exterior design, including without limitation the character, scale, appearance and design features of buildings, and their sustainable design, but only to the extent that it is a matter of exterior design, if an official plan and a by-law passed under subsection (2) that both contain provisions relating to such matters are in effect in the municipality;

"(7) As a condition to the approval of the plans and drawings referred to in subsection (4), a municipality may require the owner of the land to, (a) provide to the satisfaction of and at no expense to the municipality any or all of the following:

3. Off-street vehicular loading and parking facilities, either covered or uncovered, access driveways, including driveways for emergency vehicles, and the surfacing of such areas and driveways" (MMAH, 2015a).

COMMENTS: This implies that in addition to a discussion with an expert, the municipality can use site plan approval to require a landowner to designate exterior EV parking and exterior rough-ins (E1, personal communication. 2016, February 4).

<u>Section 51 - Subdivision Agreements:</u>

The subdivision rules section of the PA looking at the subdivision agreement; specifically <u>s.51(25)(b1) and 51(26)</u> states:

"(25) The approval authority may impose such conditions to the approval of a plan of subdivision as in the opinion of the approval authority are reasonable, having regard to the nature of the development proposed for the subdivision, including a requirement, (b.1) that such land be dedicated for commuter parking lots, transit stations and related infrastructure for the use of the general public using highways, as the approval authority considers necessary" (MMAH, 2015a).

"(26) A municipality or approval authority, or both, may enter into agreements imposed as a condition to the approval of a plan of subdivision and the agreements may be registered against the land to which it applies and the municipality or the approval authority, as the case may be, is entitled to enforce the provisions of it

against the owner and, subject to the Registry Act and the Land Titles Act, any and all subsequent owners of the land"(MMAH, 2015a).
COMMENTS: This implies that the municipality can impose and enforce conditions that land can be dedicated to 'related infrastructure for the use of the general public using highways' as part of the subdivision agreement. This opens many opportunities for EV-related infrastructure.

These five sections provide opportunities for municipalities to theoretically request dedicated EV parking stalls and rough-ins; with the strongest being zoning by-laws, site plan approvals, and subdivision agreements. Since passages in the *Planning Act* do not specifically include EVs there is the possibility that the municipality could be challenged. It could be brought to the Ontario Municipal Board if a property owner had a differing interpretation and did not think the municipality had the power to make EV related requests.

RECOMMENDATIONS:

- Municipalities should pass zoning by-laws to require designated EV parking rates as part of the development process for parking lots.
- Municipalities can negotiate for EV designated parking stalls and rough-ins using site plan approvals and subdivision agreements as leverage. They can require these elements on the exterior of the site at a minimum.

2.3 The National Building Code and Ontario Building Code

The *National Building Code* (NBC) is operated by National Research Canada, but a number of provinces have their own building codes such as Ontario's *Ontario Building Code* (OBC) operated by the MMAH. Provincial building codes tend to harmonize with the NBC, except for sections that cater to provincial issues and priorities (E2, personal communication. 2016, January 21).

The NBC is reviewed on a 5-year cycle and anyone can participate and submit a request. The requests are put through stringent analysis. According to an expert, for any request to have a strong chance to be included in a future amendment it must usually have support of at least one major province. The single voice of a municipality does not pull much sway (CSA, personal communication. 2016, January 28). In addition, the expert mentioned the code changes occur at a slow rate and always see resistance, even when the proposed change is a life saving amendment such as fire detectors (CSA, personal communication. 2016, January 28). With this is mind it might be slightly less challenging to pursue changes through the OBC.

Figure 20: Ontario Building Code 2012 (Humber College, 2016)

"The *Ontario Building Code* is a regulation under the [Building Code] Act that establishes detailed technical and administrative requirements as well as minimum standards for building construction. The purposes of the *Ontario Building Code* include; public health and safety, fire protection, resource conservation, environmental integrity and accessibility although its primary purpose is the promotion of public safety through the application of appropriate uniform building standards"(Ontario Building Officials Association, 2014).

According to the MMAH, the primary purpose is to provide builders with "clear and consistent" standards to follow "while allowing for the advancement of government's key priorities" (MMAH, 2011, pg.1). One expert mentioned that codes are useful tools since they can encourage and embed adoption (CSA, personal communication. 2016, January 28). With this in mind, the province has the opportunity to make enabling EVs a key priority.

Currently, the OBC has no mention of EVs. According to an expert, one purpose of codes is to allow innovation and technology to flow (CSA, personal communication. 2016, January 28). EVs in a building are unobstructed, but neither encouraged nor discouraged. A positive note worth pointing out is that, as of the 2011 OBC review consultations, the MMAH has identified electric vehicles as an area of interest to be discussed for amendment (MMAH, 2011, pg.1).

According to Stephen Bieda, the Ontario regional director for Sun Country Highway, 80 to 90% of EV charging is done at home and workplaces. He would like to see the prewiring for EVSE called rough-ins become part of the Ontario home building code. That will make it less costly for people buying houses to install EVSEs in the future. During the development process, pre-wiring can cost around $300 whereas the typical cost to retrofit and install a charger in an existing house is around $1,070 (Simone, 2013). A rough-in is the installation of the electrical receptacle at the planned EVSE location with a conduit running from the power source to the receptacle location (See Figure 3).

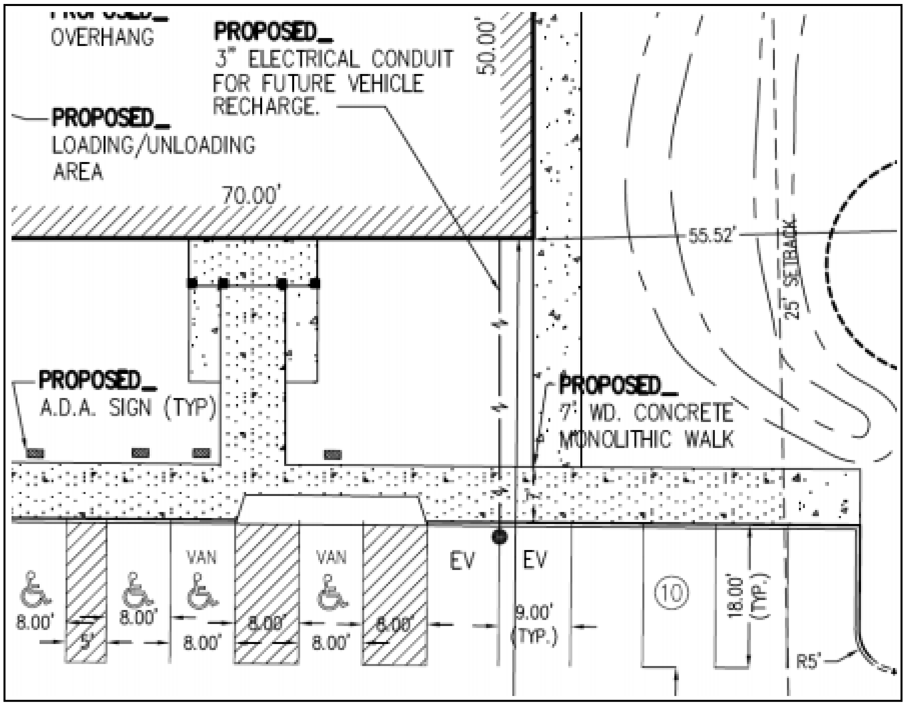


Figure 21: Example Site Plan featuring a 'Rough-in' of Electric Vehicle Charging Stations (Cohen, 2016, p. 3).

There are three primary ways the OBC changes can be initiated. They can be initiated by a ministerial order, a building code change request form, or during the five-year review of the building code.

The process to initiate an OBC change by a ministerial order is outlined in Section 29 of the 1992 *Building Code Act* and reads:

> "29. (1) The Minister may, subject to such conditions as the Minister in his or her discretion considers appropriate, make rulings,
>
> (a) approving the use of innovative materials, systems or building designs evaluated by a materials evaluation body designated in the building code;
>
> (b) adopting an amendment to a code, formula, standard, guideline, protocol or procedure that has been adopted by reference in the building code; or
>
> (c) approving the use of alternative materials, systems and building designs which, in the opinion of the Minister, will achieve the level of performance required by the building code." (MMAH, 2015c).

This implies that at any time, the minister of the MMAH can adopt an amendment to the OBC. The use of this power would be the least likely scenario, and likely only used in emergencies like other ministerial orders.

The second option is to submit the '2012 Building Code Change Request Form.' A sample submission of a filled in 2012 Building Code Change Request Form is below. It includes the type of requests that might be proposed to encourage EV implementation (MMAH, 2015d).

Requested Change/Addition:
1. Requesting the addition of definitions including electric vehicle, electric vehicle charging station, electric vehicle rough-in, and inclusion of technical standards.
2. Requiring that all new homes be EV ready by requiring rough-ins in garages of all new residential dwellings and a percentage of all parking spaces have rough-ins in new multi-unit residential buildings.
Problem:
1. Ontario has a number of EV related goals, but no way to implement them through the development process.
2. EVs and related infrastructure are currently not recognized in OBC. This means builders have no standards to follow. Without direction builders will install using various methods, which may trigger safety concerns.
Justification/Explanation:
1. Definitions and clear minimum standards would provide rules for builders to follow increasing safety.
2. Mandatory rough-ins would help support provincial EV goals.
Objectives [Which OBC objectives does the proposed addition meet?]:
Additions and changes must meet OBC objectives to be strongly considered. The OBC is an "objective-based format that sets out the rationale underlying the technical provisions of the Code. These relate to: health and safety (including fire protection, structural sufficiency and sanitation), barrier-free accessibility, energy and water conservation and environmental integrity, and conservation of buildings" (MMAH, 2011, p. 3). This requested addition aligns with the energy and water conservation and environmental integrity objective as providing rough-ins enables people to convert to EVs which put significantly less stress on the natural environment.
Cost-Benefit Implications:
There are significantly lower capital costs if pre-wiring of the home with a rough-in is completed during construction. It costs about $300 to rough-in during construction, whereas retrofitting a home costs about $1,070.

There are added societal and environmental benefits to converting combustion vehicles to EVs that cannot easily be quantified with dollars.
Enforcement Implications:
Rough-ins can be enforced during standard building inspections by municipal building officials and inspectors.
Effects on other Codes:
The *Ontario Electrical Safety Code* already includes standards for EVSE. This code along with the *Ontario Fire Code* will need to be updated on a continuous basis to reflect changes in the technology.

The third and most likely option for change is during the OBC review. "New editions of the building Code [*sic*] and significant interim amendments undergo public review which consists of public consultation on potential Code changes, followed by evaluation by one or more Building Code Technical Advisory Committees. The Technical Advisory Committees in turn make recommendations to the Ministry of Municipal Affairs and Housing." (MMAH, 2011, p. 3 & 4).

The following is a sample of the format for code change evaluation. It is a sample of how EVs could be evaluated:

Government Priorities:
COMMENT: The province has a number of EV related goals, but no method to implement goals through the development process.
Changes in other Jurisdictions:
COMMENT: 13 other North American jurisdictions, including Vancouver, require mandatory rough-ins as part of residential building codes (Denver Community Planning and Development, 2015).
Proposals from the Public and Stakeholders:
COMMENT: Non-emergency OBC change request forms from EV lobbyists would be received and reviewed.
Changing Technology and Industry Standards:

COMMENT: EVs are annually gaining in popularity with advances in technology. They also empower the public to combat climate change and reduce energy security concerns. The occurrence of the CSA workshop exploring standardization of EVSE is one sign transition to EVs is a serious consideration.
Stakeholder impacts, including cost and implications for design choice:
COMMENT: There are significantly lower capitals costs if pre-wiring of the home with a rough-in is completed during the construction. It costs about $300 to rough-in during construction, whereas retrofitting a home costs about $1,070. Rough-ins future proof homes. An issue is that the rough-in may not be used immediately creating an equity debate. The initial homeowner may pay for the rough-in capital cost, but may never own an EV while living at that home. The argument is that this is a societal cost. That initial home owner may not benefit, but 25 years in the future when they sell that home it is possible that most vehicles will be electric and they will regardless recoup that cost. Additionally, it is likely at their next residence they will require EVSE or that their children will.
Effectiveness in meeting stated aims:
COMMENT: Changes would help meet EV goals of 1 in 20 vehicles be electric by 2020.
Consistency with underlying Code objectives:
COMMENT: This change aligns with the energy and water conservation and environmental integrity objective.
Capacity of building sector to implement changes in a safe and effective manner:
COMMENT: For an electrician wiring and installing a 240-volt rough-ins is no more difficult than installing rough-ins for a stove, or washer and dryer.
Workload and liability implications for municipalities:
COMMENT: No foreseeable liability concerns, but there will be an initial increase in workload due to a learning curve regarding EVs and EVSE infrastructure for municipalities regarding installation, operation, and maintenance. As well, there will be an increased cost in developing various documents including policies, departmental standards, guidelines, and possibly permits. There could be added work in educating internal staff and the development community. Lastly, this would be an additional element for building inspector review.
Enforceability:
COMMENT: Rough-ins can be enforced during standard building inspection.
Support for the economy through promoting innovation, reducing costs, increasing certainty, and increasing harmonization with national codes:
COMMENT: The inclusion of EVs will create certainty of the transition to electric mobility, and additionally the EV industry will spawn local jobs in energy, building, and maintenance.
Support for enhanced energy and water conservation, greenhouse gas reduction, climate change adaptation, and environmental protection:
COMMENT: As discussed earlier wide adoption of EVs has the potential to drastically reduce GHG emissions.

Enhanced public health and safety:
COMMENT: EVs can help to reduce the threat of climate change which is an intergenerational concern. As more combustion vehicles are retired, there could be a reduction in local smog, which is in part responsible for many respiratory ailments.

RECOMMENDATION:

This review shows that EVs align with many criteria and objectives of the OBC. One expert from the CSA workshop provided a strategy to have NBC requests approved. The general ideas are likely transferable to OBC requests. The first step is to have a large province lobbying for the change, the second step is to have support of champions, and the third step is to demonstrate how this request benefits a building's occupants (CSA, personal communication. 2016, January 28).

With these suggestions in mind, one recommendation is to:

- Form an EV stakeholder group. This group should be interdisciplinary in order to cover all points of concern in the OBC. Additionally, this group must include champions to have leverage. Champions could potentially be high-ranking provincial and municipal leaders. Utilizing the interdisciplinary stakeholder group, complete the OBC request form in order to provide in-depth responses. This form should be circulated amongst stakeholders in order to cover all angles with the most supportive and complete answers. The final product would be the OBC change request form along with a detailed background report that would be available for the next round of OBC consultations.

2.4 The Canadian Electrical Code and the Ontario Electrical Safety Code

The electrical code "defines the legal requirements for safe electrical installations and products/equipment" (Electrical Safety Authority, 2016). Currently, the *Ontario Electrical Safety*

Code (OESC) harmonizes closely with the *Canadian Electrical Code* (CEC). The CEC includes requirements for EVSE and as of May 2012 the OESC has adopted the same requirements (Olechna, 2011). It is positive that EVSE code currently exists in the OESC, but an expert notes that EVs and EVSE technology are still changing faster than code policy development can keep up with, which is a challenge (CSA, personal communication. 2016, January 28).

Figure 22: Ontario Electrical Safety Code (Electrical Safety Authority, 2016)

2.5 Provincial Actions

Over the past few years, the Province of Ontario has shown greater interest in electric mobility. Ontario has set a goal of 1 in 20 vehicles on the road to be electric by 2020 (Ontario Ministry of Transportation, 2009). To help encourage this goal, they have created the Electric Vehicle Incentive Program. It provides between a $6,000 and $10,000 rebate on new EVs, an additional $3,000 for EVs with larger battery capabilities, an additional $1,000 for EV's with five or more seats, and up to $1000 on the purchase and installation of a charging station for home or business use. As well, in December 2015, the province announced an additional $20 million from the Green Investment Fund that will go towards creating a network of public, fast-charging stations across the province by the end of 2016 (Ontario Office of the Premier, 2016).

This funding is a very positive sign and it makes EV and EVSE ownership more affordable, but still not enough that citizens and businesses are taking advantage of this rebate program. With high participation, this rebate could significantly increase the amount of existing EVSE. One municipal employee wondered if citizens were even aware of the rebates, or if affordability, range anxiety, and lack of public EVSE were discouraging participation (M1, personal communication. 2016, January 20).

Still, the province lacks an implementation plan to take advantage of the funding and increase the build-out of EVSE. The $20 million for a network of public fast-charging stations is a good start to create a presence, but will require an annual investment to develop a large network. This $20 million is expected to go mostly towards level 3 fast charging stations which cost $50,000 to $100,000 per station (Agenbroad & Holland, 2014). This is equivalent to 400-800 stations, which is a good start, but not enough across a large province.

RECOMMENDATION:

The province needs to take action to implement EVSE on a larger scale and take advantage of available opt-in funding.

- The province should rework the installation and charging station rebate to become "to provide 100%, up to $1,000 for installation and EVSE combined."
- Alternatively, the province should create a new fund that can be utilized by the development industry, to pay for the installation of rough-ins during the construction phase, such as 'to provide 100% up to the $300 rebate that can only be redeemed during the construction phase for pre-wiring rough-ins'.

Research shows it costs between $200 and $800 to retrofit a home, and between $450 and $1,000 for a level 2 charging station (Agenbroad & Holland, 2014). Clearly funding for rough-ins stretches a lot further early in the development process.

The 'current' up to $1,000 installation and charging rebate is misleading. It currently provides 50% up to $500 on installation, and 50% up to $500 on EVSE. It could be very effective if the province stepped up and showed it was will to spend the full $1,000 on every participant. It could be reworked to provide 100%, up to $1,000 for installation and EVSE combined. Reworked this $1,000 incentive could be enough to pre-wire a home for $300 during the construction phase, and provide a remaining $700 to purchase an above average level charging station.

The other possibility is paying developers 100%, up to $300 to pre-wire home rough-ins during construction. The remainder of the $1000 would be available to the homeowner to spend on an EVSE.

Figure 23: Connecting Electric Vehicle Charging Station to the Electrical Rough-in (Paul Gipe, 2014)

3.0 Analysis of Ontario Municipal Actions and Policies for Compatibility with a Transition to Electric Vehicles

At the municipal level council and staff can use policy to push ideas and by-laws to create enforceable rules. For this research, documents from Toronto, Markham, Richmond Hill, and Guelph were analyzed and a senior staff member from each municipality was interviewed.

3.1 Official Plan

"An Official Plan (OP) is a statutory document which sets out land use policy to guide future development and manage growth. The Plan lays the foundation for building a good community. It provides a vision of the City, identifies how the vision can be reached, and establishes a monitoring program for checking progress and making necessary adjustments. All development must conform to the City's approved Official Plan" (City of Markham, 2014a). Identifying EVs in a municipal OP would provide a policy direction for which to strive. Only one of the four OPs names EVs or EVSE in their vision.

The City of Toronto's OP was the one municipality to identify EVs in their OP. Section 2.4 policy 9 'd' is the following; "in support of the TDM and environmental policies of this Plan, the City may: encourage parking providers to install plug-in stations for electric vehicles" (City of Toronto, 2015).

None of Markham's OP policies specifically lend themselves to EVs. Although 7.1.4 "introduction to policies" does encourage "other sustainable modes of transportation" (City of Markham, 2014b, p. 12).

Similarly, none of Richmond Hill's OP policies specifically lend themselves to EVs. In section 3.5.1 policy number 14 does say, "the town shall support clean air initiatives and air quality protection" (City of Richmond Hill, 2015, p. 110).

The Guelph OP also does not mention EVs, but does provide the open-ended policy in section 3.15 number 1 part 3 saying, "The City's transportation system will be planned and managed to: be sustainable, by encouraging the most financially and environmentally appropriate mode for trip-making" (City of Guelph, 2012, p. 20).

Recommendations:

OPs are key tools, since all policy and by-laws must conform with the OP policies. Recommendations using the OP are below.

- EVs should be identified in the PPS since municipal OPs must be consistent with the PPS. Following the 5 year OP review period, all municipal OPs would conform and include an EV policy.
- Alternatively, municipal councils can implement EV policies as by-laws to include in the OP.

3.2 Municipal By-Laws

"Municipal by-laws are the legal instrument municipal councils use to exercise its [*sic*] powers" (City of Toronto, 2016). A municipality's spheres of jurisdiction are defined by the 2001 Municipal Act. One of the spheres is 'parking, except on highways.' This allows each municipality to "regulate or prohibit the parking or leaving" of vehicles in "parking lots' and on 'other land'. This is very open-ended. Within this section, municipalities have the right to enforce and designate parking spaces. This act implies municipalities have the ability to designate EVs parking spaces even on private land. This could be stretched to be interpreted inside a private homeowner's garage, but this could be challenged (MMAH, 2016).

RECOMMENDATIONS:

- Use the *Municipal Act* to pass a zoning by-law relegating EV parking rates for parking lots in new developments.

The act is limited in that it cannot require rough-ins or EVSE, but combined with Site Plan Approval it gives municipalities the power to request exterior rough-ins. EVSE cannot be required, but one would imagine that an owner might be more inclined to provide an EVSE once the rough-in and the designated stall is already there.

3.3 Zoning By-Laws

Zoning by-laws are the by-laws used to put the OP vision into action. They describe how land may be used, where buildings and other structures can be located, the types of buildings that are permitted and the lot and building technical standards (MMAH, 2015d). None of the municipalities have definitions of EVSE, nor contain zoning by-laws to have EVSE as a permitted use. None require EVSE parking stalls or EV parking rates.

RECOMMENDATION:

- Council should have staff research and write a report on EVs recommending a zoning by-law to proceed with. The zoning by-law should provide definitions for EVs and associated vernacular, vehicle charging as a permitted accessory use, as well as parking rates.

3.4 Municipal Actions and Community Energy Plans

All the municipalities have taken an interest in EVs but none of them have explicit EV policies pushing for greater expansion of infrastructure. One way municipalities can include EVs is by including them in their Community Energy Plans (CEP). "A CEP is a comprehensive, long-term plan to improve energy efficiency, reduce greenhouse gas emissions and foster local sustainable energy solutions in the community" (Quality Urban Energy Systems of Tomorrow, 2013, p. 2). EV policies align with objectives of CEPs and provide a good municipal entry point.

Toronto's Actions

The City of Toronto has taken three EV initiatives. First, they identify EV promotion within their fleet in their 2009 sustainable energy plan called the *Power to Live Green*. As a result, the corporation has 19 charging stations for fleet vehicles and continues to buy EVs when deemed cost beneficial. Second, Toronto has their own green building standard called the Toronto Green Standard. In it there are no points for rough-ins, but in the rare occasion that a developer requests additional parking stalls they must include rough-ins. Third, the city has formed an EV working group that does discuss issues, shares information, and which initiated a pilot program that was never completed. Unfortunately, there has not been much movement by the working group or City since 2012, due to a lack of political interest, but the belief is that could change with provincial funding (M2, personal communication. 2016, January 9). Lastly, the City of Toronto does not have a traditional CEP. They do have neighbourhood-bounded CEPs with a heavy focus on energy efficiency and building based solutions. Unfortunately, EVs are not included in their CEPs.

Markham's Actions

Markham was the first municipality in Ontario to provide a public level 3 charger. Additionally, they have a level 1 charger at their facility. They are optimistic that they can develop future EV and renewable ready developments because they previously were successful in requesting rough-ins to build a solar ready subdivision. Additionally, Markham has adopted LEED silver as their green building standard, which provides points for a rough-in (M4, personal communication. 2016, January 14).

Figure 24: City of Markham's DC Fast Charger (City of Markham, 2016)

The City of Markham is currently working on their CEP and say they expect EVs to possibly be a large component (M4, personal communication. 2016, January 14). In the mean time, the 2011 *Green Print* serves as their visionary tool. They do not identify EVs, but do emphasize reducing emissions from fossil fuels (Town of Markham Sustainability Office, 2011).

Richmond Hill's Actions

The City of Richmond Hill is in discussion to develop a CEP (M1, personal communication. 2016, January 20). As of 2004 they have a *Clean Air Local Action Plan*. EVs are not identified, but transportation is identified as a problem accounting for 20% of the municipal emissions (ICLEI Energy Services, 2004, p. iv).

Guelph's Actions

Currently the City of Guelph has a significant number of hybrids in their fleet and has worked to provide a level 2 charging station at Stone Road Mall. The City of Guelph has had a CEP since 2007. Its goals are heavily oriented towards reduction in energy use, energy efficiency and incorporation of renewable energy. It does however, identify that transportation accounts for 45% of the municipality's GHG emissions, and suggests 'effective alternative transport options' (Guelph Community Energy Plan Consortium, 2007, p. 14 & 15).

Most of the CEPs are five or more years old. One of the municipal employees said that one reason EVs were not specifically included by name, is that the technology was still in its infancy, and did not appear as a viable policy at the time (M3, personal communication. 2016, January 7). The former mayor mentioned that municipalities know it is very difficult to control market behavior. So rather than picking a specific mode like EVs, flexible objective oriented terms like alternative or sustainable modes of transportation are used to provide opportunity (E5, personal communication. 2016, January 25).

RECOMMENDATION:

- Municipalities should review CEPs on a more frequent basis to incorporate new opportunities and technologies like EVs. Additionally, they should name EVs as an alternative sustainable option among the other sustainable transportation options in future CEPs to provide municipal staff with leverage for future EV programs and policy.

4.0 Barriers and Opportunities Identified by Key Informants

In order to identify the municipal level barriers and methods to increasing the amount of electric vehicle rough-ins and charging stations I interviewed 9 key informants. Four informants were active senior staff members at municipalities including the City of Toronto, the City of Markham, the City of Guelph, and the City of Richmond Hill. The remaining five key informants had expertise in relevant areas. They included a former mayor, a former director of transportation planning, an EV expert from a non-profit organization, a building code professor, and a building and development professional.

There were eight main thematic barriers that were discussed. The two most popularly discussed themes were the 'Undefined Municipal Identity,' and the 'Chicken and the Egg' often with 'Return On Investment' in the same conversation. These themes were identified by all four municipalities, as well as the barrier of 'Capital and Associated Costs'. The other thematic barriers that were widely discussed included: 'Lack of Municipal Institutional Knowledge' along with 'Public Awareness and Education,' 'Parking,' 'New Developments and the Development Industry,' 'Retrofits and Existing Infrastructure,' and 'Lack of Policy.'

4.1 Undefined Municipal Identity

At this early stage of electric mobility, the question discussed by municipalities' related to identity. Questions flared up such as, 'what is our role?', 'is it our role?,' 'whose role is it?' Municipalities' are designed to look after tax payers and provide services. "Traditionally this has not included fueling vehicles" said the EV expert. Even so, the nature of EVs being green aligns with municipal policies and has pushed all four municipalities to install demonstration projects.

What is the Municipal Role with EVSE?

The Richmond Hill informant stated that assuming municipalities choose to take a role, there are questions to be answered. Is it the municipalities' role to nurture adoption and provide EVSE service; or only invest once the technology is mature? Would this include maintaining and operating EVSEs, or could this simply mean only providing public space for someone else to take the role of the EVSE service provider?

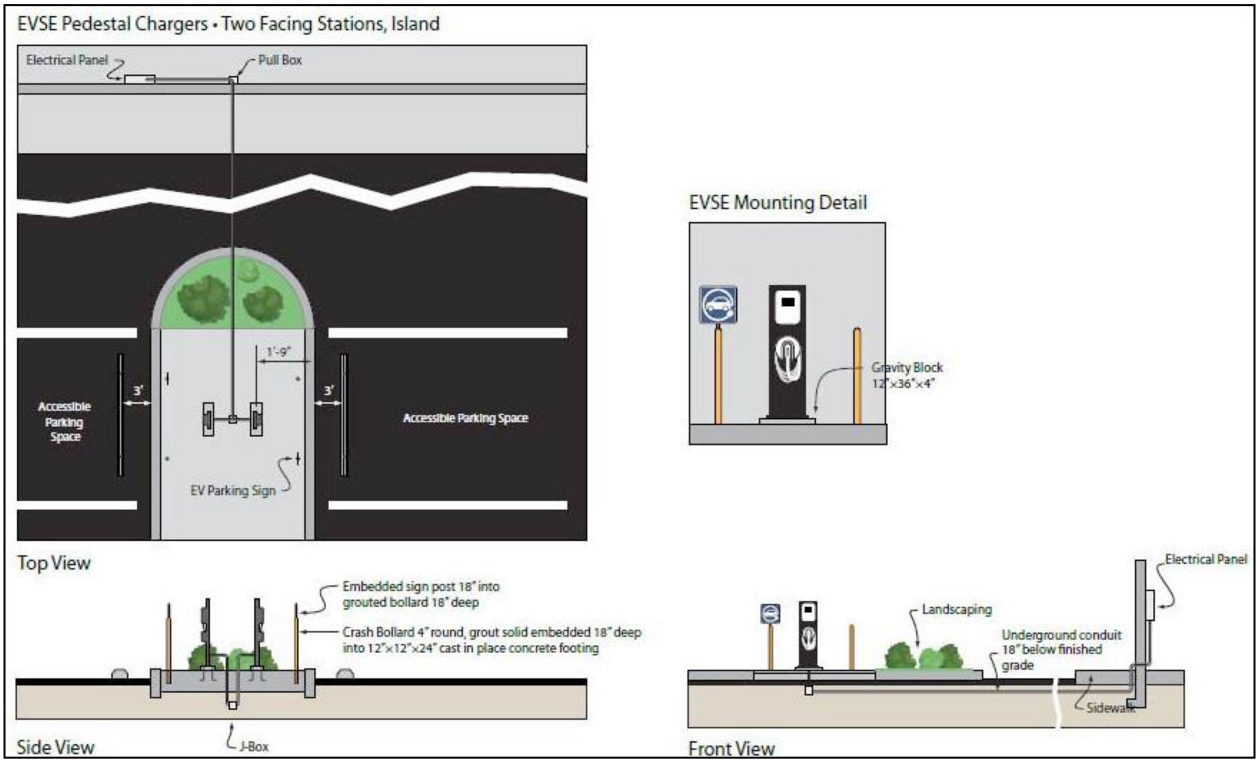
Do Municipalities Benefit Most from EVSE?

The Markham informant brought up the business perspective; Who is 'best suited' to most efficiently and effectively provide charging stations, operate and maintain them, and ultimately reap revenue benefits? The EV expert, and the staff from Guelph and Markham felt that local distribution companies (LDCs) should take a hard look at it, as it is just another way to sell energy, and they make their revenue based on volume.

The Guelph informant indicated that he believed both municipalities and LDCs had merits, and could benefit from EV participation in the community and as a municipal corporation. He felt that the energy landscape is where municipalities' have the least control. They lose local money since a large portion of transportation related energy leaves the municipality as gasoline. EVs could provide storage capacity for the municipality and LDCs to recoup funds that are currently lost to fossil fuels. This should provide incentive for involvement in local EV and local energy generation policies.

Do Municipalities want to Pursue EVSE?

The Toronto informant said that EVs are of interest because they align with their climate change action plan, but the mode is not the municipality's priority. In Toronto, they want to make sure EVs do not replace transit or active transportation on the hierarchy of transportation. They want EVs to be the third choice. The informant acknowledged that curing congestion is the priority, and that EVs and additional EV parking would not help reduce congestion. Their preferred model would be relying on the citizens and the market to take the lead with EVSE. The Guelph informant added that consumer bases should be pushing the private sector (I.E., commercial and retail) to provide EVSE where they spend income.



Potential Private Sector Electric Vehicle Charging Station Setup (ECOtality North America, 2014, p. 48).

Municipalities as Facilitators for Private Sector EVSE Services?

Both the Guelph informant and former transportation planner said that regardless of other factors, the municipality should accept the role of facilitator. The expert gave the facilitation example of a car sharing company. The municipality cannot get into partnerships for profit, but they can act as a middle person, introducing and bringing groups together that are beneficial to each other in providing a positive public service. He gave an example in which the City brought a car sharing company founder and the local parking authority manager with excess parking together. Likewise, the Guelph informant said that they could connect local employers with LDCs and not-for-profits like Plug'N Drive and Electric Mobility Canada.

Municipalities Future Role with EVs and EVSE?

The former transportation planner thought that it is important that municipalities remain involved, since the federal and provincial governments may provide funding, but they should rely on the on the municipal governments to implement the programs since they would look after regulation and the planning process. On the municipal front, the former mayor thought that the mayor or council could take leadership if they want their community to be EV ready. Ultimately, both the Markham and Richmond Hill informants said that they would not be surprised if municipalities became involved with EVs. They see involvement in the planning process, and regulations if building code change comes to pass.

4.2 The Chicken and the Egg and Return On Investment

The chicken and the egg barrier, as they relate to EVs, is that the public does not want to purchase EVs until they feel that sufficient EVSE is available from public or private corporations. On the other side, corporations do not want to invest in EVSE until they feel that a sufficient amount of vehicles are EVs. This game of chicken prevents the growth of the transition.

The Markham informant specifically stated EVSE is not a service they want to provide at a loss. There needs to be a business case for future EVSE. The determining measure for additional EVSE would be an increase in EV ownerships and sufficient usage of existing municipal EVSE. The Richmond Hill informant stated that it is challenging since EV projections and EVSE usage for the next five years are not expected to reach sufficient numbers. The question that came up is, "Are we putting something in the ground that won't be close to fully utilized?".

Municipalities want to see that a base demand level of EVSE is demonstrated before spending more resources. Richmond Hill and Guelph informants believe this step will only occur once the consumer barriers regarding EV technology are overcome. They believe that the perception of the total cost of an EV needs to be fully understood, and that the range, performance, design, and battery capacity must all improve. The Richmond Hill informant expects a quick jump in ownership and EVSE demand once the right EV comes along.

The Richmond Hill informant warned about relying on perception and projections of any new public service. The example of bike facilities usage in the winter was given. He insinuated that sometimes you don't know if there is a demand for a service until it is visible to the community. There had been a perception that there was no demand for bike facilities in the winter, and that they would go unused. They found out once they were made available, they were used. The same story could be possible for EVSE. There is a danger of relying on perception.

To summarize, municipalities are waiting for the public before doing anything greater than pilot demonstrations. They want a return on investment (ROI) to move forward. Numerous examples and ways of measuring the value of ROI are discussed below.

Charging for Revenue Measure Currently not Viable

Under ideal circumstances, the concept of a municipality providing EVSE service for a fee makes a lot of sense, if profitable. In theory, EVSE would provide a public service, stimulate the industry and generate new local jobs in the public and private sector. Charging would hopefully use unutilized existing base electricity generation capacity which is going to waste. Charging revenue would pay for the EVSE and the associated fees. Additional revenue could be reinvested in the municipality to serve the taxpayers. Unfortunately, at the current stage, there are simply not enough EVs in any given municipality to break-even with a reasonable charging fee. For instance, one municipality started with a free EVSE service and even the free EVSE was underutilized. They recently added a charging fee, and this has resulted in usage plummeting even more. At this point in time other ROI must be relied on to make EVSE viable. Options are discussed below.

Consumer Spending Measures

A number of informants discussed EVSE being similar to the 120-volt electricity outlets for block heaters in cold regions. The ROI case is, if outlets are not provided, customers will not go to that store or that location if they are anxious they will not be able to start their cars when they want to leave. Making the comparison, he said a commercial establishment might provide charging stations to attract EV owners to their mall instead of a competing mall. They may realize that investing a few cents to charge your vehicle may result in you spending $100 in the mall. If other commercial and retail establishments notice the trend, they will imitate. An informant from the City of Toronto said that it is up to the private corporations to make the business decisions and decide whether they will benefit from providing EVSE.

Green Corporate Strategy Measure

The EV expert felt that some corporations will simply include EVSE as part of meeting a green corporate strategy. The Richmond Hill informant said that this is very much a leadership question. From green policy and optic perspective, it makes sense for some corporations to do it, even if it is a losing venture.

Figure 25: Richmond Hill's Ford Transit Connect Electric and Charging Station to Demonstrate Leadership Environmental Sustainability (City of Richmond Hill, 2012)

Long-Term Savings Measure

The Guelph informant said that there is merit for municipalities and LDCs to electrify their own fleets and share EVSE created in the process. From an ROI perspective, electrifying their operations fleets to save the municipal corporations money over the long term. Additionally, as mentioned previously, more energy dollars would remain within the municipality.

Political Demand Measure

The ROI debate is very politicized; especially as it relates to 'taxpayer' dollars since there are clear immediate winners and losers. One municipal informant said that it is difficult to put together a policy or invest in public EVSE when there are so few EVs in the city. There is certainly an equity case to be had regarding spending public tax dollars on public chargers that will only benefit a small minority of the population.

The EV expert said that he has not heard complaints about public money being used for EVSE but felt it was possible. He said that he could imagine the 'gas crowd' complaining about the use of funds since public money is not directly used to build gas stations where people traditionally refuel. It is private corporations such as PetroCanada, ESSO, and Shell that build gas stations; not municipalities. Despite equity concerns, one municipal staffer said that if the public shows real interest in EVSE and starts lobbying councilors, that EVSE development would move faster in the city.

4.3 Lack of Municipal Institutional Knowledge and Public Awareness and Education

The barriers of education can be split into a lack of institutional knowledge at the municipal level and a general lack of education and awareness amongst the general public regarding EVs.

Lack of Municipal Institutional Knowledge

The CEP expert and Markham informant spoke about the 'newness' of the technology and infrastructure itself being a learning curve. Departments of a municipality such as planning, building services, engineering, and inspectors need to think about how it affects them and how they are going to accommodate EVs and EVSE. Additionally, EVs create a new workload that demands staff time to develop documents and standards. Potentially, external help will be required if the workload is too much or there is a lack of internal expertise. One municipal informant mentioned that they experienced a number of technical problems installing their EVSE for the first time and, as a result, went over budget.

Lack of Public Education and Awareness

The Richmond Hill and Guelph informants questioned whether the general public is really engaged in EVs and if they are, do they fully comprehend the payback period? At this point, the Guelph informant believes there is a lack of understanding in the minds of the vehicle purchasing public regarding the benefits of EVs. Certainly there is a higher capital cost, but far lower operating costs. There are a number of variables that beneficially influence the payback period. The Guelph informant said, "The total cost of ownership of an EV is far lower than that of a total combustion vehicle." EVs have a much more reliable projection on the cost of fuel, and far lower fuel and maintenance costs. Additionally, the Richmond Hill informant thought that the public was not aware of the large government rebates, which provides a significant cost reduction when considering the total cost of ownership.

The EV expert talked about how people are still learning about EVs and GHGs, but that they are now starting to understand the link between transportation and GHGs. He believes people feel powerless against a problem as large as climate change, but providing solutions such as EVs empowers people. He compares the education process that needs to occur to that of recycling programs that took place 10 to 15 years ago. He said teaching the benefits of recycling took many years, but now it is common knowledge and increasingly a part of our culture. This process needs to occur with EVs.

One interviewee said that the auto sector is partially at fault for failing to educate the public about EVs. He said that the auto sector has only met minimum government requirements in terms of providing EV options, and have done very little to promote or market those EV options, in contrast to their other models. Another interviewee said that the dealership network does not help to educate either. Dealers don't understand EVs and are not pushed or incentivized to pitch them.

4.4 Parking

Parking is a challenging issue for municipalities because traditionally when a planning application is submitted, a ratio is used to determine the minimum amount of traditional and handicap parking stalls for vehicles. Developers generally do not want to supply beyond the minimum amount of parking stalls because every stall takes away from potentially developable land. Still, municipalities could require developers to provide additional EV designated stalls and request the associated EVSE infrastructure. From that point forward, the operation, maintenance, and enforcement of the stalls could be a potential unwanted headache for the property owner. For all these reasons, there could be resistance from land owners.

Figure 26: Example of Designated Electric Vehicle Parking Stall and Signage (Cohen, 2016, p. 1 & 4).

Parking Stall Competition

The Richmond Hill informant could imagine competing interests for parking stalls becoming a political issue. For example, a building has a high usage parking lot, but only has a limited amount of parking stalls. If one stall is permanently reserved for EV users, this could generate complaints that visitors cannot find parking. Councilors in public sites and property managers of private sites would hear the brunt of the complaints and have to deal with them. This debate could escalate as the EV market share increases and there are increased parking demands amongst the haves and have-nots.

EVSE Parking for those Without Permanent Designated Parking Stalls

Toronto is the densest of the municipalities interviewed. Here, parking for EVs was a large concern. According to the Toronto informant, the city is full of situations without designated parking spots. This is particularly apparent at the residential street permit parking level. This is a concern because without a designated parking space, such as a driveway or a garage, where do residents install an EVSE?

The question for the city is where to locate EVSE when street permit parking is so inconsistent? They have considered installing EVSE on the public right-of-way but think the excavation and construction would be very disruptive, so it would only be considered if part of a planned sidewalk renovation. As well, this could all be all for not, if non-EV users block EVSE street spaces due to existing high competition for street parking spaces.

An interesting alternative for overnight EVSE service was utilizing parking lots at municipal facilities after hours for EVSE service. Public schools, community centres, and libraries were particularly identified since they are often located in the middle of residential neighbourhoods making them walking distance in many cases.

EVSE Parking Enforcement and Image

The Guelph informant spoke about how some retail and commercial establishments might be concerned about providing EVSE stalls because they are worried that the spaces will not be respected and it could be challenging to enforce. Additionally, special category stalls are often used for handicap parking and mothers with children. EV owners do not necessarily want to be perceived as being special. On the other side, some retailers may not want to have reserved parking for EV owners and thus appear to place a higher value on some customers than others.

4.5 Capital Costs and Associated Costs with Public EVSE from a Municipal Perspective

All four municipalities agree that providing EVSE is a substantial cost considering immediate positive monetary ROI for charging is not expected in the near future. All four municipalities have accumulated experience with pilot project demonstrations. What they have learned from their experiences and involvement will be shared below. The general lessons are likely applicable to most corporate or private scenarios as well.

Capital Costs and Lack of Funding

The general consensus is that municipal EVSE service is not economically viable without funding. The cost of putting in the required infrastructure was also expensive. One municipality said what they budgeted was not enough, and it was much more than they were comfortable with.

Municipalities said that without a partnership or funding, the cost prevented them from participating further in EVSE. In December of 2015, it was announced that $20 million of Provincial money from the *Green Investment Act* would be going towards creating an EVSE network across the province. The belief is that additional unannounced funds from the *Green Investment Act* are earmarked for EVSE as well. The available funds have acted as a participation catalyst to municipalities. All four municipalities appeared reinvigorated, and they said this spirit was shared amongst colleagues throughout the province.

Figure 27: Installation of a costly DC Fast Charging Station (ECOtality North America, 2014, p. 84).

Associated Costs

Beyond the capital cost, there are a number of associated costs municipalities need to consider. The two most common associated costs were operations and maintenance. Both these costs are ongoing which provides a sense of cost uncertainty to whoever is responsible for future EVSE management.

The inclusion of EVSE, as a municipal service, would cost additional staff time. Internal staff or external consultants would need to be hired to create or revise design guidelines, safety guidelines, operational safety standards and likely additional unidentified policy and documents.

Future of Funding Capital Costs

The EV expert said that it is great that the province is providing funds to nurture EV and EVSE technology, but was of the opinion it is 'not right' as a permanent solution. He spoke about how sometimes there is a great technology, but there is no business case for it at that moment, so the government needs to step in and provide 'seed' money. He drew a parallel to the growth of the renewable energy industry through the *Green Energy Act*. The *Green Energy Act* provided initial funds to create a whole industry and institutional knowledge around renewable energy technologies. Now that industry is getting to the point that it is self-sufficient and won't require provincial funding to be viable. Ideally, the EV industry will follow a similar path beyond the 'seed' funding and that a private corporation will eventually find a viable business case around EVSE service.

A common belief among interviewees was that in the future it should be up to the private sector, such as Tesla, retail locations or the power producers to make the investment in providing public EVSE service, as they make business cases for involvement.

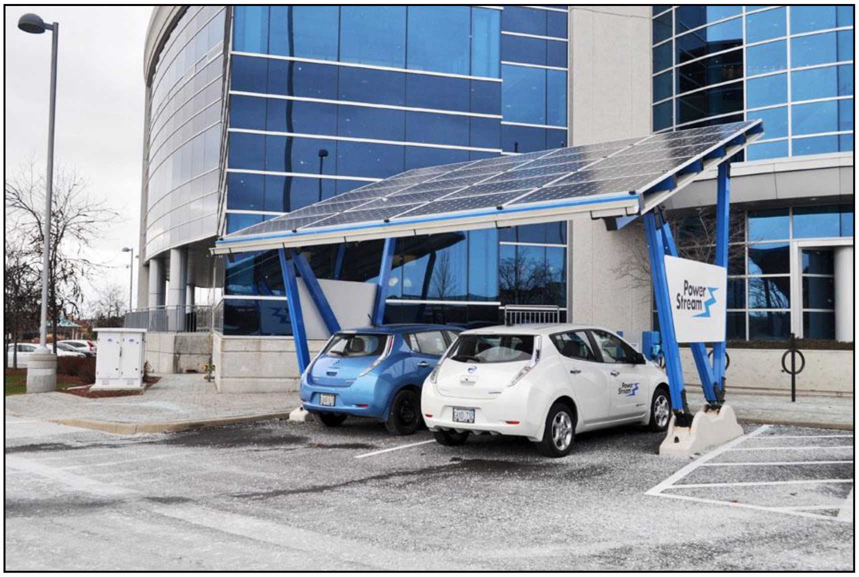


Figure 28: Local Distribution Company PowerStream has provided Public DC Fastcharger with Solar Port at their Vaughan Head Office (Bettencourt, 2014).

4.6 New Developments and the Development Industry

A majority of interviewees agreed that installing rough-ins during the construction stage is significantly easier and cheaper than during the retrofit stage. The low cost makes rough-ins in new developments, particularly in residential dwellings' cheaper. The primary hurdle is that the development industry is not taking initiative and the OBC does not require rough-ins.

Lack of Building Code Requirement and Amendment Challenges

The EV expert says that the lack of a OBC requirement is a huge barrier that needs to be changed. It is important that this change because, as an expert that formerly worked for a developer put it, "building code is king." If rough-ins are ever to be consistently included in new developments, it needs to be required by the OBC.

The OBC professor said that the OBC is a very green and EVs are "in keeping" with the document, so it is a reasonable expectation that it eventually be included. Despite this, it appears unlikely to be imminently included. A couple of interviewees said that the primary concern of the OBC is health and safety, so the question becomes do EVSE produce hazards? A secondary concern would be if the existing code acts as a barrier to new technologies such as EVSE. Both these issues would trigger discussion for amendments if they were proven to be cases of concern. Findings show EVSE do not create any "hazards" and do not have any codes restricting their inclusion in buildings. This mean changes will not occur on this basis.

The former developer said that one of the challenges for amendments is the rigorous cost-benefit parameter. GHG emissions and avoided infrastructure costs are two of objectives in determining cost-benefit feasibility. The issue is that the MMAH cannot attach any GHG emission reductions to a rough-in, whereas the Ministry of Transportation can attach GHG emission reductions to an EV. This weakens the MMAH case for rough-ins as a requirement.

The former developer also said that one of the challenges to making a rough-in amendment is that if they do make an amendment, they want to make it applicable to all dwelling and building types, not just new residential dwellings. They do not want to make a situation of different rules for different types. This would be more agreeable to all builders since all would play by the same rules.

Lack of Market Demand

One interviewee said that generally the building industry has the perception that there is no demand for green initiatives whether it is net zero homes, solar options, or EV rough-ins. They do not want to put money into something people don't require. Another interviewee believes developers have the impression that currently EV-ready homes do not drive purchase decisions of homeowners. The former developer believes that this should naturally change over time. She felt that when rough-ins are viewed as a selling point the industry will respond with EV ready buildings. Until a visible change in market demands, three interviewees felt that open minded developers were needed. The Guelph informant said that there was a reason for optimism since there are some innovative builders leading the market now, and that should help move things along.

Cost

The former mayor spoke about how the development industry feels like there are continuing layers of requirements that they need to address, which add to the cost. One interviewee was of the opinion that builders' are cheap and will build only to the letter of the law and perceived market demands to sell units. Another interviewee said that there is a resistance by the industry to add elements as they want to keep building costs down.

Tools for Change: Negotiation

The former developer said developers may be very cost conscious, but the vast majority of them are very reasonable and want to provide value, because that is how they are going to sell units. The former mayor agreed that many developers are reasonable and said negotiating is an option with some developers. Some developers are willing to negotiate with planning departments regarding the inclusion of elements, but will draw the line from a business perspective.

Tools for Change: Green Building Standards

The former developer said nobody builds to the minimum standards as they are trying to anticipate what people will want, and very often include elements to acquire points to meet green building rating systems (I.E., LEED or Toronto Green Standard) required by many municipalities or as internal corporate targets.

Site plan approval gives municipalities the power to require elements outside the building. They use this approval to empower local green building rating systems. In these systems, each suggested element accrues the development a certain amount of points or credits towards the minimum required total to receive approval. Though the municipality can only require outdoor elements, they can provide point values for the inclusion of in-building elements and let the developer choose the combination that provides the most value or decide what the most cost-beneficial mix for them is. Potentially, if the municipality had the policy to increase the number of points for rough-ins in developments, they could provide the trade-off of an inflated amount of credits for rough-ins. In fact municipalities could potentially even offer more credits for indoor rough-ins where they have no jurisdiction or leverage otherwise.

Site (S) Metrics												
Category	Indicator	Metric #	Metric	Mandatory Target	Recommended Minimum Target			Aspirational Target			Precedent	Total Available Points
					Single Family Home	Multi-Fam Buildings (>3 storeys)	Commercial/ Retail/Inst	Single Family Homes	Multi-Fam Buildings (>3 storeys)	Commercial/ Retail/Inst		
Built Environment	Parking	12	Bicycle Parking	Satisfy Municipal Standards	N/A	Provide a minimum 0.6 bike parking spots per unit Provide a minimum 5% of bike parking at grade (1 POINT)	0.13 bike parking spots for permanent employees for every 100m2 GFA. Provide 0.15 bike parking spots for visitors for every 100m2 of GFA. (1 POINT)	N/A	Provide a minimum of 0.8 bike parking spots per unit Provide a minimum 10% of bike parking at grade (1 POINT)	Place bike parking in weather protected areas in close proximity to building entry (1 POINT) For office or institutional buildings, provide 1 shower (for men and women) for every 30 bike parking spots and a change room. (2 POINTS)	TIER I & TIER II	6
		13	Off-Street Parking	N/A	N/A	Locate all new off-street parking at the side or rear of buildings (1 POINT)		N/A	Less than 20% of the total development area is allocated to new, off-street surface parking facilities. (1 POINT) Consolidate 85% or more of the surface parking to parking structures in Intensification Areas. (5 POINTS)		LEED ND NDPc5	7
		14	Surface Parking	N/A	N/A	Develop and implement a strategy to minimize surface parking for permanent employees and residents. (1 POINT)		N/A	N/A			1
		15	Carpooling and Efficient Vehicle Parking	N/A	N/A	N/A	3% of the site parking spots (or a minimum of 4 parking spots) to be dedicated to car pooling and/or fuel efficient / hybrid vehicles and/or car share/zip car (does not apply to compact cars). Dedicated parking spots located in preferred areas close to building entries. (1 POINT)	N/A	N/A	5% of the site parking spots to be dedicated to car pooling and/or fuel efficient / hybrid vehicles and/or car share/zip cars (does not apply to compact cars). Dedicated parking spots located in preferred areas close to building entries. (1 POINT)	TGS LEED NC SSc4.3	2

Figure 29: Sample of Richmond Hill's Sustainability Metrics and Point Scoring (City of Richmond Hill, 2016)

Tools for Change: Incentives

The former developer said that municipalities should be encouraging and compelling the builders to do "better than code", but there should be a trade-off. This could be green building credits, a break on something like a development fee or possibly, the province could generate a green building fund that municipalities can use to incentivize developers to build green elements in buildings.

Tools for Change: Lobbying

The Guelph informant said that it is important that the EV industry gets somebody lobbying for them. This has helped the solar industry see a change in the OBC. An EV lobby should be formed to lobby for change in the OBC, to educate developers and help change their perception of EVs and show that demand is coming. He suggested Plug N' Drive or Electric Mobility Canada take a lead. Lastly, a number of interviewees believed that developers can be lobbied to include rough-ins. They think developers are willing to 'pony up and pay' for new elements as long as they know everyone else is being asked to do it.

4.7 Retrofits and Existing Electricity Infrastructure

Retrofitting is challenging because EV owners need to work and adapt to the existing building stock and infrastructure which in many cases is inadequate.

Infrastructure Costs

All interviewees agreed retrofits are significantly more costly and technically challenging than providing rough-ins to new developments. The Markham informant said the costs add up quite significantly if trenching or new electrical infrastructure is needed. Both the Markham and Richmond Hill informants said the cost and benefits need to be weighed before making a potentially expensive investment.

Electrical upgrades can add up. For instance, residential infrastructure might not support a 240-volt line in the garage or driveway; an electricity panel might be maxed out and have no breaker slots remaining, which means a subsidiary breaker would be required, or even the amperage of service might not be supported requiring another upgrade. In a parking lot setting, the existing infrastructure may not be laid out to be accessible to EVSE and require expensive trenching. At the municipal level, a local transformer might not support the load and need to be upgraded. All the issues have costs associated with them, which could require thousands of dollars for the building owner, LDC, and municipality.

Figure 30: Expensive Trenching Required to Install Charging Station in an Existing Parking Lot (U.S. Department of Energy, 2015, p. 14)

Condominium Act

Multi-unit residential buildings were not the focus of this research, but three interviewees identified the condominium board, enabled by the Condominium Act, as a barrier to retrofits. In theory, a shared EVSE should be treated like any other amenity, but it is complicated by the fact that everyone would pay for it, but only EV owners could benefit from it. The challenge is that the condominium board would need to approve the addition of any new elements and the alteration of any existing elements that may be affected by a retrofit (Tzventarny, 2016).

Retrofit Programs

The EV expert said that EVs have never been on the radar for retrofits. The Richmond Hill informant said that part of the reason is because retrofit programs need to demonstrate savings, but with an EV, you are adding a new load to the grid. Automobiles traditionally have not been associated with the household load like a refrigerator and HVAC. This makes EVSE ineligible under the current setup of retrofit programs because traditional retrofit program look to replace traditional large low efficiency appliances with high efficiency models in order to save electricity. Those savings pay for the upgrade over time. The case cannot be made for EVs since they are not replacing a preexisting household load.

4.8 Lack of Policy, Programs and Political Support

All four municipalities lack policies that strongly push for wide-scale implementation of EVSE across their municipalities. As previously mentioned, only Toronto made mention of EVs in their OP and Sustainable Energy Plan. The Guelph informant said that the lack of existing explicit policy for vehicle electrification is a barrier itself. With the absence of a policy, there is nothing driving transformation. He believed that it would not be difficult to make a case for such a policy. The municipality would need an overarching policy to drive it, such as community GHG emissions or corporate cost reductions in case of fleet electrification.

Lack of Champions

One informant said that currently there is no political support, which is needed to induce change. He said that this will not occur until EVs are identified as a real need.

He said a mayor or city councilors should take leadership if they want their community to be EV ready. He said that the way to get some "mileage," would be to get the mayor of a big city like Toronto to jump on board and lobby Queen's Park for funding or partnership opportunities.

He emphasized the importance of having a champion by drawing parallels to the present bike parking requirements in the City of Toronto. He said that years ago bike parking was never required, but Jack Layton, during his time as a Toronto councilor; took the initiative and was persistent. The informant said anything new will be resisted, so it is very important to get out there and make sure it is a priority, and keep pushing until they are tired of listening to you and finally do it like Layton did.

Staff Support for Policies

As previously discussed, it is important to have a municipal champion, but according to the former mayor it also very important that staff is unified and support policies laid out by municipal leaders. She used her former municipality's sustainability initiative as an example. She said that one member of council would ask every developer 'what are they doing to take part in the sustainability initiative?' This was a signal to staff that they were expected to discuss involvement in the initiative with every developer during pre-consultation. Staff never wanted to get in hot water by having a developer say staff never spoke to them about this initiative. This set a culture of staff negotiating to get more sustainable elements out of every development.

The former transportation planner talked about how councilors are often lobbied by frustrated stakeholders regarding new policies being discussed. Often, they would want to meet with councilors to discourage or vote against a policy. He shared an effective strategy. He recommended bringing staff members as reinforcements to those meetings to back up the councilor. This would often catch the lobbyist by surprise. The staff would have more intimate knowledge of the policy and topic than the lobbyist, and the lobbyist knew he or she could not win the argument. Furthermore, staff could often spin the policy in a positive manner to satisfy the lobbyist.

Policy Creation Process

Two interviewees discussed the policy creation process such that a rough-in or an EVSE policy would likely follow. First, public interest or an internal recommendation for an EV policy would need to come to the attention of the mayor or councilors. Then they would assign a few department heads to assign research and come up with a report. Alternatively, an existing committee would be assigned this or formed to work on this. The staff would brainstorm and identify all the issues, recommend a process and identify what would be needed to implement the actions. This would go through the political process and get adopted by council. Following this step, the planning department would likely be in charge of operationalizing the policy and integrating other departments and stakeholders like LDCs.

Tools for Change: Official Plan as a Starting Point

The former mayor said that an appropriate first step would be including an EV policy in the OP during the five-year review. She said that a policy in the OP would go a long way in setting the playing field for the City as a whole. Municipalities have a top-down approach, with the Official Plan being the top document. An EV policy could have a cascading effect on documents below it, as well as providing influence and support to creating a more dedicated EV policies and programs moving forward.

Tools for Change: Site Plan Approval and Bill 51

The former developer clarified the extent of municipal powers. She said that municipalities cannot make rough-ins mandatory inside buildings. Buildings and the interiors of buildings are strictly determined by the OBC and are outside the limits of municipal jurisdiction. If a municipality wanted to require better than code buildings, the *Municipal Act* would need to be amended to give the ability to the council. The only wiggle room is the fact that municipal staff can negotiate with developers on a project to project basis for better than code. If the developer agrees, the Building Official can enforce the better than code agreement.

Whereas the OBC dictates the standards of the building, the site plan which the municipality has final approval on dictates the site surrounding the building. Municipalities can use site plan approval to request outdoor elements such as outdoor rough-ins in the driveway or parking lot to allow easy installation of an EVSE in the future.

Requested outdoor elements should abide by section 41 of the Planning Act, but the former developer implied that municipalities have some leeway in what they can request. She said when she worked for the developer, municipalities would write all kinds of things into the site plan agreement whether they concurred with the *Planning Act* or not. She said that the developer would not want to tarnish their image and look like a bad citizen by complaining about the inclusion of energy efficiency and GHG emission reducing elements requested in the site plan agreement.

Specifically, the 2006, *Planning Act* amendment *Bill 51* has allowed municipalities to request sustainable design elements as part of site plan control. Many municipalities have used this to initiate municipal Green Building Standards. Generally, every new development had to accumulate a certain amount of points to meet the minimum standard requirements. Each potential element had a point value attached to it. The developer was given the flexibility to pick and choose whatever combination of elements they desired for their development, as long as by the end, the minimum amount of points was met. Rough-ins for EVSE could easily be included as an element choice.

Being that this standard picks and chooses, there is nothing restricting it from including indoor elements like rough-ins inside a garage which is the domain of the *Ontario Building Code*, from being on the list as an option to the developer; not a request or imposition by the municipality. The developer always has the opportunity to build better than code. A municipality could simply incentivize a developer to pick an interior garage rough-in by providing a high value of points. This is a strategy that could be used to promote construction elements outside the municipal domain and push policies forward.

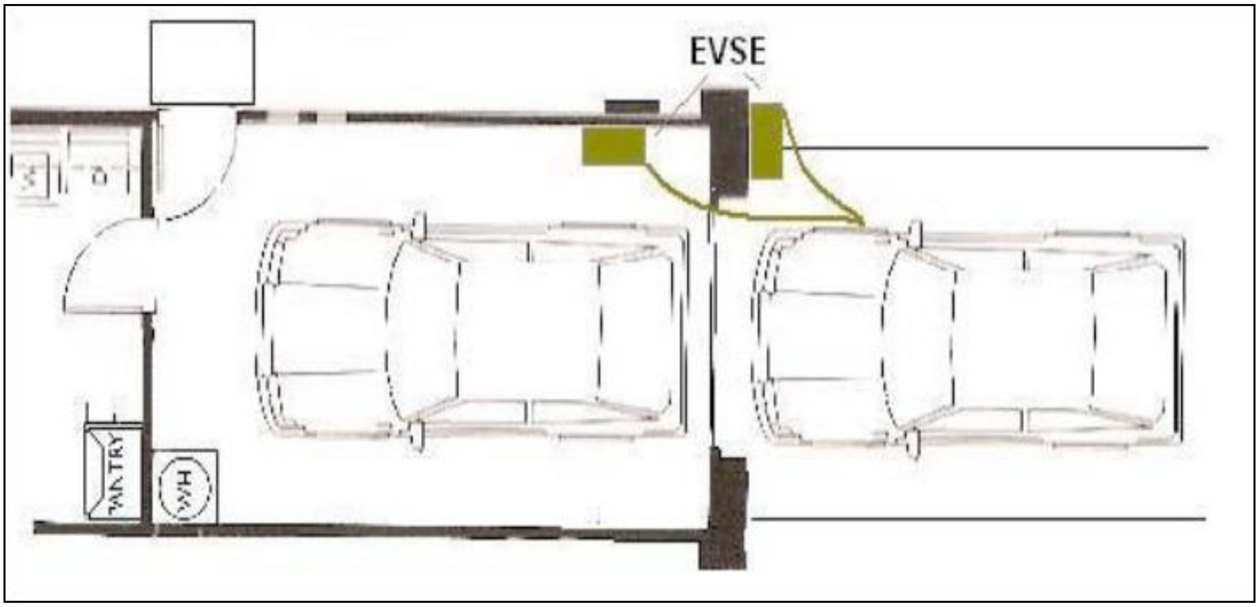


Figure 31: Example of Electric Vehicle Charging Stations Installation Options in Residential Garage or Driveway (ECOtality North America, 2014, p. 41).

5.0 Summary

Many cities across North America have EV related policies such as EV ready building codes and zoning by-laws that already enable a transition to EVs. Vancouver and many American cities have the power to amend existing building code through council. Ontario municipalities cannot do this. As a result, municipalities and the province must be creative in how they enable EVs.

Below is a summary of the methods municipalities and the province have to enable EVs.

- Negotiate Leverage through Site Plan and Subdivision Agreements:
    - Municipalities can negotiate for EV designated parking stalls and rough-ins using site plan approvals and subdivision agreements as leverage.
- Create EV Parking Rate Zoning By-Laws:
    - Municipalities can pass zoning by-laws to require designated EV parking rates as part of the development process.
- Lobby for Changes to Ontario Building Code:
    - EV stakeholders can form a group to educate the general public and the development industry and to lobby for mandatory rough-ins in the *Ontario Building Code*.
- Re-work Existing Rebates:
    - The province could rework the installation and charging station rebate "to provide 100% up to $1,000 for installation and EVSE combined."
    - Alternatively, create a new fund that can be utilized by the development industry to pay for the installation of rough-ins during the construction phase such as '100% up to $300 rebate that can only be redeemed during the construction phase for pre-wiring rough-ins'.
- Adopt EV Policy in OP and CEP to provide Future Opportunities:
    - Have council pass by-laws to include EV policies in both the OP and CEP in order to provide objectives and policy that staff can leverage in the developing of future EV policy initiatives and programs.

    - Alternatively the MMAH can identify EVs in a policy statement in order to have all municipalities provide EV policies in their OPs following the 5-year review period.

- Encourage LDCs and Private Sector to Lead EVSE:
    - The province and municipalities should encourage those that can make a business case in EVSE service such as LDCs and the private sector including retailers to take leadership.
    - Municipalities can work as facilitators and help to identify partnerships and bring together organizations that will serve the greater community.
- Increase Public Education and Awareness:
    - In order to increase interest and participation in EV ownership, the province must better educate the public regarding the benefits of EVs, the total cost of EV ownership, and better advertise the existing EV and EVSE rebates.
- Update Municipal Green Building Standards:
    - Municipalities must provide for indoor and outdoor rough-in options in municipal Green Building Standards.
- Provide Incentives for Rough-ins:
    - For those willing to provide a rough-in, municipalities can provide an incentive such as discount in a development charge, additional points towards municipal Green Building Standards, or money from a potential green building fund.
- Find Political Support:
    - Locate municipal champions to push for EV policies and programs.
- Encourage Municipal Staff Negotiation Culture:

- Create a culture in which staff always negotiate with developers to participate in EV rough-in policies.

Most of these recommendations can be completed rather easily and go a long way towards increasing the amount of future rough-ins and EVSE. This can provide a signal to the general public that it is finally approaching the time to convert to EVs.

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