Section 2: Assessment of EVSE Usage and EVSE Network Gaps in Oxford County

In reviewing the literature sources identified earlier to assess EVSE siting experiences globally, and in assessing the outcomes of the Voronoi method for mapping clusters of pre-existing and potential extended sites of EVSE installations, it is evident that an analysis of existing EVSEs in Oxford County would be – on its own – insufficient for predicting how many EVSEs need to be integrated into the community in the future, or where they ought to be optimally located given future EV adoption rates and driver usage and charging patterns.

Therefore, CUTRIC has developed here a series of predictive and descriptive outcomes that help to map gaps in the EVSE network in Oxford County and identify mechanisms going forward to fill those gaps or ensure efficient clustering of EVSEs in high-use or likely high-use areas based on varied types of commuter (employee) and/or tourist traffic.

The assessment of how many chargers may be needed in the community is followed by an assessment of where those charges may be located optimally in the future.

Data collection opportunities and challenges

Table 1 summarizes the required data to optimally locate new charging stations in Oxford County, as well as barriers CUTRIC faced in acquiring those data sets. The following targeted communities of potential EVSE users have been identified to guide the data collection process:

- Oxford residents
- Transitory and through-way traffic
- Tourists

Despite the fact Oxford County's Manager of Strategic Initiatives is a champion in this project and has supported iterative rounds of data collection activities, CUTRIC has faced several challenges acquiring appropriate empirical data sets related to localized EV adoption and EVSE usage. Developing a robust localized predictive model would be enabled, for example, by having real-time access to EVCO and Tesla charging system databases from Oxford's installed charging systems. Data analysis for Oxford County in this regard requires access to these data sets. Therefore, CUTRIC has identified the benefits to both the MTO (for future EVCO planning) and Tesla (for charging system optimization analysis) that would arise from allowing undisclosed access and analysis of the datasets for the purposes of this study.

Accessing these datasets proved to be challenging under current government and commercial restrictions. To clarify, (1) the Government of Ontario's Ministry of Transportation refused to relinquish access rights to MTO EV charging data sets from chargers co-funded through the province's EVCO 1.0 program (launched in 2016); (2) Tesla similarly refused to allow access to charging system data from Tesla chargers in the community.

Although CUTRIC intends to inform and shape public policy in an evidence-driven fashion, the lack of access to empirical evidence demonstrating real-time charging patterns in the community means the methodology adopted here is largely predictive in nature, and based on reasonable but static assumptions regarding potential EV adoption rates in the community.

TABLE 1: DATA COLLECTION OUTLINE

Required Data	Source(s)	Data Availability
Information about existing charging stations (i.e., location, make, model, quantity)	Inquiry from Oxford County	Received.
	EVCO Map	Publicly available.
	PlugShare Map	Publicly available.
	AddEnergie Flo Map	Publicly available.
Usage patterns of existing charging stations (i.e., number and length of daily EV charging episodes; power level and electricity demand)	Tesla charging system databases (for chargers located at the Quality Inn Hotel parking area)	1. Hotel management does not collect EV charging data despite owning chargers on site. 2. Tesla stated it is "unable to release any charging data for the purposes you have requested. Tesla operates under a very strict privacy policy with respect our proprietary data, which is commercially sensitive in nature."
	AddEnergie Flo Database	Access provided by AddEnergie [facilitated by Oxford County].
	Inquiry from MTO/MyEV (for EVCO funded chargers)	MTO stated: 1. "We will not be able to provide access to their database due to the highly sensitive nature of data and personal information of Ontarians. 2. Moreover, Electric Vehicle Chargers installation was supposedly to complete in March 2017, and first usage data report is due October 31st, thus presently we do not have any information about usage patterns of electric vehicle chargers.

Required Data	Source(s)	Data Availability
		3. We are in the process of modifying our database to cater varying information needs, and may probably be able to provide limited access in future but cannot promise anything right now."
Information about existing EVs in the County	Green License Plate Data (MTO)	Received.
Location of main parking areas for short-terms stays (1hr-3hrs) [Shopping malls, cinemas, hospitals, etc.]	Oxford County & Municipalities Land Use Maps	Not available publicly. Oxford County's Manager of Strategic Initiatives requested each municipality provide an appropriate list. Google satellite imagery data used as a complementary source.
	Oxford County Business Directory	Information retrieved from business directory and mapped manually. Google satellite imagery data used as a complementary source..
Location of employer-owned parking areas for long-term stays (8hrs +) [Hospitals for employees, workplaces, etc.]	Oxford County & Municipalities Land Use Maps	Not available. Oxford County's Manager of Strategic Initiatives requested each municipality provide an appropriate list. Google satellite imagery data used as a complementary source.
	Oxford County Business Directory	Information retrieved from the business directory and mapped manually. Google satellite imagery data used as a complementary source.

Required Data	Source(s)	Data Availability
Oxford County population and urban density	2016 Census	Publicly available.
Events and attractions attracting outside traffic to Oxford County	Oxford County & municipal tourist catalogues and events guides (inquiry from Tourism Oxford)	Received.
Highway map and traffic flow (annual average daily traffic)	MTO Website	Publicly available.

Descriptive analysis considerations based on literature

Three key variables guided Oxford County's EVSE siting efforts. They include:

1. **Long-term parking opportunities** (Level 1 or Level 2 Systems)
    a. Level 1 characteristics: locations typically involving 8-24 hour stop-overs or overnight stays, such as hospitals, employment sites for employees, train stations (for commuters who park and ride), bus stations (for commuters who park and ride), hotels.
    b. Level 2 characteristic: locations typically involving 1-3 hour stop-overs, such as cinemas, shopping malls, hospitals (visitors), airports, farmers markets, etc.
2. **Special applications for Level 2**, including summer farmers' markets, festival locations, and other tourist attraction locations that experience high-volume at non-uniform periods within the annual year cycle.
3. **Highway intersectionality (Level 3)**, including nearby highway off ramps, and "On Routes" or other similar nearby off-highway stopping points that allow for 10-30 minute stop overs for travellers and highway commuters (ideally), or incoming resident traffic.

Both cost and usage of charging stations (based on local community needs) should be considered in the decision-making process of siting new EVSEs to ensure the effectiveness in location prediction as well as choosing the right type to justify the initial costs of infrastructure depending on the locale. In the Canadian context, the cost of charging stations are as follows:

Level 1 EVSE Costs: The price of Level 1 chargers range from $800 to $1,200 CAD to purchase. The installation costs are [on average] between $800 and $1,000 CAD (both parts and labour), however, the installation cost varies from case to case depending on permits, garage modifications, and additional features (HomeAdvisor, 2017; Plug 'N Drive^2, 2017).

Level 2 EVSE Costs: Established EVSE networks in Canada appear to be: Sun Country Highway, ChargePoint, and FLO.

- Sun Country Highway provides prices for Level 2 chargers ranging from $829 to $2,799 CAD depending upon the durability of the station, including warranties, weather resistance, etc (Sun Country, 2017).
- Level 2 chargers can be categorized according to whether they are "networked" or "non-networked", i.e., smart enabled systems. Networked stations have internet connections and allow the owner to control access to the station, charge a fee for service and print usage/maintenance reports among other features. They range from $8,000 to $10,000 CAD to purchase. Non-Networked units do not have internet connections and cannot be controlled, which range from $2,000 to $4,000 CAD to purchase (Plug 'N Drive^2, 2017).
- Distance to the breaker box is usually the most important factor in determining installation cost, typically ranging from 15 to 30 meters. Runs longer than 45 meters are usually too expensive to justify station installation. Parking garage installations are the easiest and most economical public charging stations. Conduit and wiring can be wall mounted. Curbside and surface lot stations tend to be much more expensive than parking garage installations because they frequently require costly trenching or directional boring to run conduit and wire to the station (CleanTechnica, 2014).
- Installing a multi-port station, or multiple stations at once, reduces the cost per charger, but demand must exist to justify the extra capacity. Cost is reduced mainly because a single trench/bore, conduit, and wire can be used to service the adjacent stations.

Multiple stations are more likely to require a breaker box upgrade, and the feeder wire that is run from the box to the stations will be slightly more expensive, but the added cost can be divided across the extra stations. There are other efficiencies in mobilization, repetition, permitting, etc (ibid).

Level 3 EVSE Costs: The current cost of Level 3 charger is an order of magnitude higher than a Level 2 charger, ranging from $40,000 to $100,000 CAD per station. Installation and civil works ranges from $15,000 to $60,000 CAD depending upon site complexity. There are two main contributors to their high cost: 1) expensive equipment and 2) frequently the need to install a 480V transformer (EVSE, 2017).

Predictive analysis: Assessing future EV adoption impacts on EVSE needs in Oxford County

Predictive analysis offered here adopts a linear model based on current and predicted future EV adoption rates, along with an integrated traffic flow analysis. Additionally, the model assumes two types of electric vehicles as "baseline" vehicle systems – namely, the Nissan Leaf 2017 and the Chevy Bolt 2017 – to determine range performance on a daily and annual basis as applied to a variety of potential in-town and out-of-town commuters and drivers.

These vehicles were selected based on the following variables:

- Price range ($37,000 – $45,000 CAD), which suggests a more affordable vehicle compared to luxury makes of fully electric vehicles (for example BMW and Tesla models);
- Government of Ontario's rebate of $14,000 CAD for both vehicles, which reduce pricing further to a value comparable with a new hybrid vehicle, such as a Prius V, for Canadian households;
- Varying driving range capacity with the Leaf demonstrating approximately 175 km in range and the Bolt demonstrating approximately 383 km (as reported by manufacturers, and depending on ambient conditions and drive cycles).

The selection of these vehicles allows for a comparative assessment between two similarly priced vehicles that demonstrate varying driving ranges. When applied in the context of Oxford County and assumed as a proportion of all cars in the community, these vehicles create differing charging system requirements outside of homes, at workplaces, at common places of extended parking (e.g., shopping malls), and on highways and other road intersections in the community.

The following section outlines the typologies CUTRIC has created to capture potential driver "types". These types of drivers constitute idealizations meant to capture potential categories of driver types and drive cycle requirements (i.e., range requirements among EV drivers in Oxford) that would shape EVSE needs and requirements in the community in the future. The table below outlines assumptions embedded into the definition of these driver idealizations. An optimal source of data that could be generated to justify or characterize data required to conduct the analysis and the assumptions made to assist formulating the final results are described.

Driver typologies: Type A – Type D EV Owners and Drivers

CUTRIC has adopted a "Best Case - Worst Case" predictive model to estimate the number of chargers that a regional location would need to host to *fully satisfy* charging needs based on assumptions regarding battery range, home charging, and travel patterns.

In this model, the Best Case Scenario (as judged from the perspective of an EVSE owner/host) requires the minimum number of EVSEs to be installed to serve a local community or a stakeholder sector (i.e., employee).

- **The Best Case Scenario is the least expensive scenario, as judged from the perspective of the EVSE owner, as it requires the fewest number of EVSE units and the least amount of EVSE installation and/or electricity provision.**

No assumptions have been made in this model regarding priced versus un-priced (or "free") electricity.

The Worst Case Scenario (as judged from the perspective of an EVSE owner/host) requires the maximum number of EVSEs to be installed to serve a local community or a stakeholder sector (i.e., employee).

- **The Worst Case Scenario constitutes the most expensive scenario, as judged from the perspective of the EVSE owner, as it requires the most number of EVSE units and the most amount of EVSE installation and/or electricity provision.**

No assumptions have been made in this model regarding priced versus un-priced (or "free") electricity.

To inform this model, CUTRIC has created a set of EV owner typologies, whose profiles can be characterized as follows:

1. **Type A:** Work Commuter (Principal Car)
    a. **Type A1:** In town commute
    b. **Type A2:** Out of town commute
    c. **Type A3:** Out of town commuting into town
2. **Type B:** Family Commuter (Secondary Car)
3. **Type C:** Tourist Commuter
4. **Type D:** Inter-city Commuter transiting through Oxford County between city locations (for work or leisure)

Vehicle make and model technical specifications and assumptions

Table 2 lists the technical and battery pack information for the Nissan Leaf and Chevy Bolt, which are used in this analysis. Working hours are assumed 7am - 7pm (12 hours). This section provides a short description of the other assumptions made to develop the predictive modeling.

TABLE 2: TECHNICAL AND BATTERY PACK INFO

	Nissan Leaf 2017	Chevrolet Bolt 2017	Source
Battery Pack (kWh)	30	60	Plug 'N Drive
Time to charge for L1 Chargers (Hours)	≈ 20 (1.5 kWh of charging per hour) - 30 (1kWh of charging per hour)	≈ 40-60	Meo Electric & ChargeHub
Time to charge for L2 Chargers (Hours)	4.5	9.5	Plug 'N Drive
Time to charge for L3 Chargers (Hours)	< 30 min for 80% charge	< 2 hours	Meo Electric
Estimated Range (km)	172	383	Plug 'N Drive

Current and future EV ownership for Type A1

Data received from MTO indicates that the total number of existing EVs in the County is 163 (as of 2017 figures). Based on the *EV Sales Report in Canada* (3rd quarter 2017), the current adoption rate of EVs across Ontario is 0.8 per cent (FleetCarma, 2017).

To generate a predictive model for this feasibility study, CUTRIC assumed an incremental linear increase in EV volumes (one per cent, five per cent, 10 per cent, and 25 per cent) to predict the number of future EVs in Oxford County, assuming 163 EVs (as of 2017) constitutes 0.8 per cent of total vehicles owned in Oxford County currently (Table 3).

TABLE 3: NUMBER OF TYPE A1 EVS

Adoption Rate	Number of EVs
0.8%	163
1%	204
5%	1019
10%	2038
25%	5094

Current and future EV ownership for Type C

To create a predictive tool to assess incoming EV traffic into the Oxford County community, CUTRIC explored tourist events that would attract predictable estimations of incoming traffic flow based on annual occurrences.

Tourism Oxford advises there are **two** rural and **four** urban "high attendance" venues in the County with rural events attracting approximately 4,000 people and urban events attracting 10,000 people per instance. However, there are no data identifying how many event goers constitute out-of-town travelers versus in-town visitors. Therefore, CUTRIC has utilized the general approximation provided by Tourism Oxford that 48,000 tourists visit Oxford County annually.

To generate a predictive model for incoming tourists, CUTRIC has assumed four visitors travel in each incoming vehicle (i.e., a standard family unit). This generates a value of approximately 12,000 cars traveling into the County annually, which CUTRIC has utilized as the base value to assess EVSE needs for Type C EV owners.

Considering the incremental adoption rates noted above, Table 4 demonstrates the number of Type C EVs estimated as entering Oxford annually for events and festivals.

TABLE 4: NUMBER OF TYPE C EVS

Adoption Rate	Number of EVs
0.8%	96
1%	120
5%	600
10%	1200
25%	3000

Current and future EV ownership for Type A3 & D

To assess EVSE requirements among commuters (both in town and out of town daily commuters), CUTRIC has leveraged Annual Average Daily Traffic (AADT) data associated with the busiest highway routes surrounding of Oxford County. The AADT for Oxford County (2017) ranges between 67,151 and 74,200 vehicles with a median value of 70,675 vehicles commuting through or into Oxford on a daily basis, as based on surrounding highway traffic flow.

Using the linear adoption rates identified above, and assuming one per cent of the AADT constitutes vehicles that actually stop in Oxford County for work/daily commuting purposes, this model estimates the number of cars entering the County as commuter vehicles is approximately 707 per day. Considering the incremental adoption rates notes above, Table 5 demonstrates the number of Type A3 EVs that **may stop in Oxford** County and require charging infrastructure.

TABLE 5: NUMBER OF TYPE A3 EVS

Adoption Rate	Number of EVs
0.8%	6
1%	7
5%	35
10%	71
25%	177

In addition, assuming 99 per cent of the AADT constitute inter-city commuters who transit through or across Oxford County en route to a work location outside of or adjacent to Oxford County another estimated 69,968 vehicles may require a stop over in Oxford County along highway route intersections.

Considering incremental EV adoption rates identified above, Table 6 demonstrates the number of Type D EVs (inter-city commuters) who may require a stopover for brief "fuelling" or "charging" in Oxford County, as assumed in this model.

TABLE 6: NUMBER OF TYPE D EVS

Adoption Rate	Number of EVs
0.8%	560
1%	700
5%	3,496
10%	6,997
25%	17,492

Usable battery range assumptions

The predictive model presented below utilizes two electric vehicles (Nissan Leaf, 2017 and Chevy Bolt, 2017) to demonstrate possible charging requirements for Type A-D EV owners/drivers *in and around* the Oxford County.

Make-Model (1): Nissan Leaf 2017

Usable battery (estimated) range is calculated as follows:

- Nissan Leaf 2017 average range is approximately 172 km (in normal ambient conditions).
- Buffer/battery SOC loss assumptions:

    - Over the life of the car, approximately 25% degradation (43 km loss) in a worse
    - case scenario over a 10-year lifecycle.
    - Cold or extreme hot weather conditions, 30% temporary loss in range (51 km loss) in a worse case scenario.
- Total usable battery estimated range under all conditions (i.e., 10 year lifecycles, and extreme weather conditions): 78 km

Make-Model (2): Chevrolet BOLT 2017

Usable battery (estimated) range is calculated as follows:

- Chevy Bolt 2017 average range is approximately 383 km (in normal ambient conditions).
- Buffer/battery SOC loss assumptions:
    - Over the life of the car, approximately 25% degradation (96 km loss) in a worse case scenario over a 10-year lifecycle.
    - Cold or extreme hot weather conditions, 30% temporary loss in range (114 km loss) in a worse case scenario.
- Total usable battery estimated range under all conditions (i.e.,10-year lifecycles, and extreme weather conditions): 173 km

CUTRIC has developed a map of current usage to predict future usage in the community based on current EV sales, as well as future EV sales growth; in addition, CUTRIC has mapped current and future EV charging behavioural patterns in and around the community.

The results of these analyses are presented in Table 7 for both the Nissan Leaf estimation model, and Table 8 for the Chevy Bolt estimation model.

TABLE 7: PREDICTIVE ANALYSIS FOR NISSAN LEAF 2017 APPLICABILITY: LEVEL 1, 2, & 3 CHARGER REQUIREMENTS

EV Owners Charging Profile (Nissan Leaf)		Base Minimum Number of Level 1 Required Chargers				
Type A: Work Commuter (Principal Car)	Description	**0.8%**	**1%**	**5%**	**10%**	**25%**
Type A1: In town commute	**Best Case Scenario**: Assume Type A1 commuter travels less than 78 kilometers per day (to and from work and in-between stops, e.g., shopping, pick ups, etc.).	In this case, there is no need for L1 chargers in the County because there is enough charge to complete travel based on home charging.				
	Worst-Case Scenario: Assume Type A1 commuter travels more than 78 kilometers per day (to and from work and in-between stops, e.g., shopping, pick ups, etc.). Requires top up at work of minimum 8 hours. Assume one, 8-hour charging block over a 12-hour work day period, equates to one charging episode.	163	204	1,019	2,038	5,094
Type A2: Out of town commute	Charging at home, leaving with 100% SOC, requires a full or significant charge at work, but it is outside of Oxford County.	In this case, there is no need for L1 chargers in the County because commuters travel outside of the County.				
Type A3: Out of town commuting into town	Charging at home, leaving with 100% SOC, requires a full or significant charge at work.	In this case, there is no need for L1 chargers in the County because significant or full charge for Leaf takes 20-30 hours which exceeds a 12-hour working episode/period.				
Type B: Family Commuter (Secondary Car)	Leaving home with 100% SOC, requiring a potential 30-45 minute top up charge.	In this case, there is no need for L1 chargers in the County because a 30-minute charging period with an L1 charger does not provide enough charge to justify EVSE installation.				
Type C: Tourist Commuter	Leaving home with 100% SOC, requiring a full charging period upon entry to Oxford.	In this case, there is no need for L1 chargers in the County because a full charging episode for the Leaf takes 20-30 hours, which is not practical for a tourist who may stay less than a 24-hour period.				
Type D: Inter-city commuter transiting through Oxford County between city locations (for work or leisure)	Leaving home with 100% SOC, requiring a full charge period upon entry to highway location (DCFC required).	In this case, there is no need for L1 chargers in the County because a full charging episode for the Leaf takes 20-30 hours which is not applicable to a commuter who may spend a maximum of 30-45 minutes at a transit point on route.				

EV Owners Charging Profile (Nissan Leaf)		Base Minimum Number of Level 2 Required Chargers				
Type A: Work Commuter (Principal Car)	Description	**0.8%**	**1%**	**5%**	**10%**	**25%**
Type A1: In town commute	**Best Case Scenario**: Assume Type A1 commuter travels less than 78 kilometers per day (to and from work and in-between stops, e.g., shopping, pick ups, etc.).	In this case, there is no need for L2 chargers in the County because there is enough charge to complete travel based on home charging.				
	Mid-Case Scenario: Assume Type A1 commuter travels more than 78 kilometers per day (to and from work and in-between stops, e.g., shopping, pick ups, etc.). Requires top up at work of minimum one hour. No access to L1 Chargers. Chargers are smart-enabled and give warning to the drivers to move the vehicle at end-of-charge period (or face a penalty).. Assume 2-hour charging blocks over a 12-hour workday period, equating to 6 charging episodes.	27	34	170	340	849
	Worst Case Scenario: Assume Type A1 commuter travels more than 78 kilometers per day (to and from work and in-between stops, e.g., shopping, pick ups, etc.). Requires top up at work of minimum one hour. No access to L1 Chargers. Chargers are smart-enabled and give warning to the drivers to move the vehicle at end-of-charge period (or face a penalty). Assume 4-hour charging blocks over a 12-hour work day period, equating to 3 charging episodes.	54	68	340	679	1,698
Type A2: Out of town commute	Charging at home, leaving with 100% SOC, requires a full or significant charge at work, but it is outside of Oxford County.	In this case, there is no need for L2 chargers in the County because commuters travel outside of the County.				
Type A3: Out of town commuting into town	**Best Case Scenario**: Charging at home, leaving with 100% SOC, requires a full or significant charge at work. Assume 2- hour charging blocks over a 12-hour workday period, equating to 6 charging episodes.	1	1	6	12	30
	Worst Case Scenario: Charging at home, leaving with 100% SOC, requires a full or significant charge at work. Assume 4-hour charging blocks over a 12-hour workday period, equating to 3 charging episodes.	2	2	12	24	59

Type B: Family Commuter (Secondary Car)	Leaving home with 100% SOC, requiring a potential 30-minute top-up charge within the County; assume 1% of Drivers are EV owners with after-work activity requirements.	The longest route across and around Oxford County roads is 52 kilometres in length; thus, there is no need for L2 chargers within the County because there is enough charge to complete travel based on home charging.				
Type C: Tourist Commuter	**Best Case Scenario**: Leaving home with 100% SOC, requiring a top up charge upon entry to Oxford. Assume 2-hour charging blocks over 16 hours, equating to 8 charging episodes.	12	15	75	150	375
	Worst Case Scenario: Leaving home with 100% SOC, requiring a full charging period upon entry to Oxford. Assume 4-hour charging blocks over 16 hours, equating to 4 charging episodes	24	30	150	300	750
Type D: Inter-city commuter transiting through Oxford County between city locations (for work or leisure)	Leaving home with 100% SOC, requiring a full charge period upon entry to highway location (DCFC required),	In this case, there is no need for L2 chargers in the County because a full charging episode of the Leaf takes 4.5 hours, which is not applicable to a commuter who spends a maximum 30-45 minutes at a transit point on route.				

EV Owners Charging Profile (Nissan Leaf)		**Base Minimum Number of Level 3 Required Chargers**				
Type A: Work Commuter (Principal Car)	Description	**0.8%**	**1%**	**5%**	**10%**	**25%**
Type A1: In town commute	All Scenarios	Not required due to the high price and available time at work for Work Commuter to use L2 chargers.				
Type A2: Out of town commute	Charging at home, leaving with 100% SOC, requires a full or significant charge at work, but is outside of Oxford County.	In this case, there is no need for L3 chargers in the County because people travel outside of the County.				
Type A3: Out of town commuting into town	Charging at home, leaving with 100% SOC, requires a full or significant charge at work. 24 charging episodes within 12 hours (working hours).	0	0	1	3	7
Type B: Family Commuter (Secondary Car)	Leaving home with 100% SOC, requiring a potential 30-minute top-up charge.	In this case, there is no need for L3 chargers in the County because L2 chargers would fulfill the local needs.				

Type C: Tourist Commuter	Leaving home with 100% SOC, requiring a full charging period upon entry to Oxford.	In this case, there is no need for L3 chargers in the County because L2 chargers would fulfill local needs.				
Type D: Inter-city commuter transiting through Oxford County between city locations (for work or leisure)	Leaving home with 100% SOC, requiring a full charge period upon entry to highway location (DCFC required). 48 charging episodes within 24 hours	12	15	73	146	364

TABLE 8: PREDICTIVE ANALYSIS FOR CHEVY BOLT 2017 APPLICABILITY: LEVEL 1, 2, & 3 CHARGER REQUIREMENTS

EV Owners Charging Profile (Chevy Bolt)		**Base Minimum Number of Level 1 Required Chargers**				
Type A: Work Commuter (Principal Car)	Description	**0.8%**	**1%**	**5%**	**10%**	**25%**
Type A1: In town commute	**Best Case Scenario**: Assume Type A1 commuter travels less than 173 kilometers per day (to and from work and in-between stops, e.g., shopping, pick ups, etc.).	In this case, there is no need for L1 chargers in the County because there is enough charge to complete travel based on home charging.				
	Worst Case Scenario: Assume Type A1 commuter travels more than 173 kilometers per day to and from work and in-between stops, e.g., shopping, pick ups, etc. Assumes no Level 2 charger at home. The Bolt requires approx. 40-60 hours to charge via AC Level 1, depending upon voltage and amperage, meaning a Bolt owner cannot fully charge up over a 24-hour period at home. This may require top-up charging at the workplace, leading the Bolt owner to use or demand workplace charging to accommodate battery capacity needs. In this scenario, workplace charging allows a Bolt owner to use the workplace as a complement to home charging at AC Level 1.	163	204	1,019	2,038	5,094
Type A2: Out of town commute	Charging at home, leaving with 100% SOC, requires a full or significant charge at work, but is outside of Oxford County.	In this case, there is no need for L1 chargers in the County because the commuter travels outside of the County.				
Type A3: Out of town commuting into town	Charging at home, leaving with 100% SOC, requires a full or significant charge at work.	In this case, there is no need for L1 chargers in the County because the Bolt requires approx. 40-60 hours to charge via AC Level 1, depending on voltage and amperage which far exceeds an assumed a 12-hour working episode/period.				

Type B: Family Commuter (Secondary Car)	Leaving home with 100% SOC, requiring a potential 30-minute top-up charge at AC Level 2.	In this case, there is no need for L1 chargers in the County because 30 minutes with a L1 charger does not provide enough charge to justify EVSE installation.
Type C: Tourist Commuter	Leaving home with 100% SOC, requiring a full charging period upon entry to Oxford.	Only applicable if overnight opportunity available (i.e., at least a 24-hour period)
Type D: Inter-city commuter transiting through Oxford County between city locations (for work or leisure)	Leaving home with 100% SOC, requiring a full charge period upon entry to highway location (DCFC required).	In this case, there is no need for L1 chargers in the County because the Bolt requires approx. 40-60 hours to charge via AC Level 1, depending upon voltage and amperage which is not applicable to a commuter who might spend a maximum of 30-45 minutes at a transit point on route.

EV Owners Charging Profile (Chevy Bolt)		**Base Minimum Number of Level 2 Required Chargers**				
Type A: Work Commuter (Principal Car)	Description	**0.8%**	**1%**	**5%**	**10%**	**25%**
Type A1: In town commute	**Best Case Scenario**: Assume Type A1 commuter travels less than 173 kilometers per day (to and from work and in-between stops, e.g., shopping, pick ups, etc.).	In this case, there is no need for L2 chargers in the County because there is enough charge to complete travel based on home charging.				
	Mid-Case Scenario: Assume Type A1 commuter travels more than 173 kilometers per day [which is unlikely] (to and from work and in-between stops, e.g., shopping, pick ups, etc.). Assumes no Level 2 charger at home. Bolt requires approx. 9.5 hours to charge fully via AC Level 2, depending on voltage and amperage, meaning a Bolt owner cannot fully charge up over an 8-hour work period, but could over a 12-hour work period. In this scenario, workplace charging allows a Bolt owner to use the workplace as a complement to home charging at AC Level 1, assuming 2-hour charging blocks with smart enabled chargers that penalize owners for overstaying their charge period, resulting in 6 charging episode periods in 12 hours. This assumes access to a charger for 2 hours, every second workday.	14	17	85	170	425

	Worst Case Scenario: Assume Type A1 commuter travels more than 173 kilometers per day [which is unlikely] (to and from work and in-between stops, e.g., shopping, pick ups, etc.). Assumes no Level 2 charger at home. Bolt requires approx. 9.5 hours to charge fully via AC Level 2, depending on voltage and amperage, meaning a Bolt owner cannot fully charge up over an 8-hour work period, but could over a 12-hour work period. In this scenario, workplace charging allows a Bolt owner to use the workplace as a replacement to home charging at AC Level 1 and/or AC Level 2. Assuming 9-hour charging blocks (does not require smart enabled charger), resulting in one charging episode in 12 hours. Assumes a full daily charging period (i.e. work period).	163	204	1,019	2,038	5,094
Type A2: Out of town commute	Charging at home, leaving with 100% SOC, requires a full or significant charge at work, but it is outside of Oxford County.	In this case, there is no need for L2 chargers in the County because the commuter travels outside of the County.				
Type A3: Out of town commuting into town	Charging at home, leaving with 100% SOC, requires substantial charge at work, and is located inside of Oxford County.	Assuming incoming commuter expends approx. 25% SOC upon arriving due to highway travel of up to 100 kilometers inbound, outbound and return to home, which exists within the Bolt range with no workplace top up charging required.				
Type B: Family Commuter (Secondary Car)	Leaving home with 100% SOC.	In this case, there is no need for L2 chargers in the County because the high battery capacity and resulting range.				
Type C: Tourist Commuter	**Best Case Scenario**: Leaving home with 100% SOC, requiring a top up charge upon entry to Oxford. Assume 4- hour charging blocks over 16 hours, equating to 4 charging episodes.	24	30	150	300	750
	Worst Case Scenario: Leaving home with 100% SOC, requiring a significant or full charging period upon entry to Oxford. Assume 8-hour charging blocks over 16 hours, equating to 2 charging episodes.	48	60	300	600	1,500
Type D: Inter-city commuter transiting through Oxford County between city locations (for work or leisure)	Leaving home with 100% SOC, requiring a full charge period upon entry to highway location (DCFC required).	In this case, there is no need for L2 chargers in the County because the Bolt requires 9.5 hours to charge via AC Level 2, which is not applicable to a commuter who might spend a maximum of 30-45 minutes at a transit point on route.				

EV Owners Charging Profile (Chevy Bolt)		Base Minimum Number of Level 3 Required Chargers				
Type A: Work Commuter (Principal Car)	Description	**0.8%**	**1%**	**5%**	**10%**	**25%**
Type A1: In town commute	All Scenarios	Not required due to the high price of EVSE installation, and available time at work for Work Commuter to use L2 chargers.				
Type A2: Out of town commute	Charging at home, leaving with 100% SOC, requires a full or significant charge at work, but is outside of Oxford County.	In this case, there is no need for L3 chargers in the County because the commuter travels outside of the County.				
Type A3: Out of town commuting into town	Charging at home, leaving with 100% SOC, requires a full or significant charge at work. 6 charging episodes within 12 hours (i.e. working hours).	1	1	6	12	30
Type B: Family Commuter (Secondary Car)	Leaving home with 100% SOC.	In this case, there is no need for L3 chargers in the County because of the high battery capacity and resulting range.				
Type C: Tourist Commuter	Leaving home with 100% SOC, requiring a full charging period upon entry to Oxford.	In this case, there is no need for L3 chargers in the County because L2 chargers would fulfill local needs.				
Type D: Inter-city commuter transiting through Oxford County between city locations (for work or leisure)	Leaving home with 100% SOC, requiring a full charge period upon entry to highway location (DCFC required). 12 charging episodes within 24 hours.	47	58	292	583	1,458

Summary

The results of CUTRIC's predictive analysis indicates the number of required EVSEs are as follows (based on the current adoption rate, 0.8%):

- Level 1: 163
- Level 2: Min: 54 – Max: 163
- Level 3: Min: 12 – Max: 47

This aggregated estimation summarizes the results of Table 7 and Table 8 considering worst Case Scenario for all types of drivers.

Assuming an average price of $1000 CAD for Level 1, $2,500 CAD for Level 2, and $60,000 CAD for Level 3 chargers, Oxford County should invest minimum $ 1,018,000 CAD - excluding installation costs which depends on the selected location – to meet the needs of different types of EV drivers including work commuters (Type A), family commuters (Type B), tourist commuter (Type C), and inter-city commuters (Type D).