Introduction

Oxford County aims to become a fully accessible electric vehicle (EV) community equipped with ubiquitous charging opportunities in the near-term future. This objective will be reached through the deployment of the County's Electric Vehicle Accessibility Plan (EVAP).

To successfully achieve the County's EVAP goals, it is necessary to map, analyze and strategically locate electric vehicle supply equipment (EVSEs) going forward. The installation of these systems – if properly done – could encourage the uptake of EVs in and across Oxford County in the future. It could also support new incoming traffic based on the charging needs among long-distance commuters travelling along nearby highway routes.

In general, the EVAP aims to promote the practicality and acceptability of EVs as a mainstream mode of personal transportation to, from, and within Oxford County, which requires an informed and strategic EVSE plan. Oxford County partnered with CUTRIC to assist in this planning process.

Oxford County recognizes the environmental implications of continued fossil fuel use and the growing impacts of climate change. The County is therefore developing a 100 per cent Renewable Energy Action Plan intended to:

(1) Catalyze environmental changes in Oxford;

(2) Create opportunities for renewable energy investment in Oxford; and,

(3) Position Oxford as a renewable energy center of excellence and home for renewable energy education, research and development.

Oxford County has begun to address the challenges of energy sustainability through critical first steps in energy conservation and demand management, as well as demonstrated community leadership in the advancement of renewable energy technologies and their applications. This zero emissions electricity generation and distribution system renders the County an ideal energy/electrical "fuel" landscape for the electrification of transportation (including transit) vehicles, as part of a long-term strategy to reduce transportation-related GHG emissions.

Currently, 48 charging stations including 12 Tesla Superchargers, four Level 3 chargers, 23 Level 2 chargers, four home-share Level 2 chargers, and five Level 1 chargers are located across 22 locations within Oxford County. These charging systems encompass a range of manufacturing makes and models. They have been purchased and installed by a variety of private sector interests (e.g., hotel owners, utility owners, etc.). In some cases, the stations installed have been purchased with support from the Province of Ontario via its Electric Vehicle Charging Ontario (EVCO) 1.0 program, which launched in 2016.

The installation of EVSEs across Oxford has resulted, therefore, in an ad hoc distribution of assets. No significant predictive analysis occurred before the purchase and/or installation of these system to determine the best possible locations for EVSEs based on EV-owner usage requirements. Subsequently, little analysis of actual usage rates has been completed, which would help to inform future policies vis-à-vis the optimal location of chargers in the future across the community.

The current feasibility study aims to address persistent data gaps. In doing so, the second aim of the study is to support the County in its efforts to encourage private sector investment into EVCO 2.0 – a provincial funding program expected to launch in the Fall of 2017/Winter 2018 with deployments likely to occur throughout 2018.

Third, the Study is intended to help increase the overall number of available EVSEs across Oxford County in the near-term and to render Oxford a provincial champion of EVs, by making it a known "charging hub" for local and out-of-County residents and transitory drivers. The current feasibility study will assess current EVSE locations and usage rates, and predictively assess future optimal locations of for EVSEs based on empirically evidenced EVSE usage in the County and in comparative communities.

Fourth, the Study assesses the viability of electric transit options in the community of Woodstock, which is currently among the communities with a traditional transit fleet (Appendix I). The Future Oxford Community Sustainability Plan states that electrification of transit vehicles is considered a part of the County's long-term strategy to reduce transportation-related greenhouse gas (GHG) emissions.

Finally, the Study also reviews hydrogen fuel cell vehicle pilot projects active in North America. The purpose is (1) to explore the development, launch and commercial outcomes associated with H2 fuel cell pilots; and (2) to assess the likelihood of H2 fuelling usage and optimal locational variables to consider in such an installation (Appendix II).

Definitions

Electric vehicle supply equipment (EVSEs) is an intermediary between a power source and the vehicle's charging port. Its role is to simply transfer the electric power to the vehicle safely (FleetCarma, 2017).

Level 1 EVSE

Level 1 equipment provides charging through a 120 Volt (V), alternating-current (AC) plug. Level 1 is the slowest form of charging that uses a standard household outlet. Level 1 charging equipment is standard for different vehicle, which is portable and does not require the installation of charging equipment.

Depending on the battery technology used in the vehicle, Level 1 charging equipment generally takes 8 to 12 hours to completely charge a fully depleted battery. The most common place to use a Level 1 EVSE is at the vehicle owner's home, which charging could be conducted overnight (EVTown, 2017).

Level 2 EVSE

Level 2 equipment provides charging through a 240V, AC plug and requires installation of home charging or public charging equipment. Level 2 charging equipment is compatible with all electric vehicles and plug-in electric hybrid vehicles.

Depending on the battery technology used in the vehicle, Level 2 charging equipment generally takes 4 to 6 hours to completely charge a fully depleted battery. Charging time can increase in cold temperatures. Level 2 EVSEs are commonly used in residential settings, public parking areas, places of employment and commercial settings (EVTown, 2017).

Level 3 EVSE

Level 3 equipment is often called *DC Fast Charger* that uses a 480V, direct-current (DC) plug. In this case, the charger is a gas pump-sized machine. Most Level 3 EVSEs provide an 80% charge in 30 to 45 minutes. Cold weather can lengthen the time required to charge (EVTown, 2017).

This type of Level 3 equipment is not compatible with all vehicles; only fully electric cars have access to it. There are three standards for Level 3 EVSEs (Plug 'N Drive[1], 2017):

- **CHAdeMO** is an Asian standard used by Hyundai, Nissan, Kia and Mitsubishi.

- **SAE Combo** is a European/North American standard used by BMW, Chevrolet, Ford and Volkswagen.
- **Supercharger** is a Tesla-only standard. All Tesla vehicles can be purchased with adapters for the other two.

Section 1:Literature Review

Vehicle owners have historically relied on long ranges due to the high energy density associated with petroleum fuels in gasoline and diesel vehicles. The low-cost of carbon-based fuels (especially in jurisdictions that do not price carbon) combined with more than a century of development and now ubiquitous fueling/gas station networks across the developed world has ensured drivers can travel far distances with relatively little planning required to ensuring fuel availability (Delmas *et al.*, 2016; Langer *et al.*, 2017).

The rise of electric vehicles (EVs) – due to a combination of U.S. Corporate Average Fuel Economy Standards (CAFÉ) and European Fuel Standards over the past 15 years, combined with nascent carbon pricing regimes and gasoline/diesel punitive measures intended to reduce emissions from greenhouse gases (GHGs) in the transportation sectors in North America, Europe and Asia today – has resulted in a budding need for new “fueling”, i.e., “charging”, infrastructure.

Municipal, regional and federal governments are therefore struggling against the private market pull of ongoing gasoline and diesel car demand (which protects the status quo in petroleum fueling infrastructure) with public pressures to reduce emissions by encouraging fuel switching and EV adoption whereby EVs are charged from renewable power sources (e.g., hydro, wind and solar power, among other renewables) overtime.

This tug-of-war between the status quo and a necessary low-carbon future of transportation has produced demands for electric vehicle supply equipment (EVSE) – or “charging station” – optimization analyses that assess where, when and to what extent governments and private sector entities should be investing in or be forced to invest in charging system infrastructure to enable EV adoption for both light-duty vehicles (e.g., passenger cars and light trucks) and heavy-duty vehicles (e.g., heavy-duty trucks, buses, shuttles, and coaches).

The financial investments associated with these choices are enormous. Thus, a paradigm shift in transportation and mobility thinking towards a low-carbon future requires the most optimal, strategic and efficient investments into EVSEs as possible. This is a complex process given the current lack of general EV adoption today (EVs still represent less than 1% of all new vehicle purchases in North America, including Canada, today), which means there is precious little descriptive and empirical data demonstrating how human drivers behave when the range of vehicles is limited by the lesser energy density associated with relatively expensive battery technologies compared to relatively cheap petroleum fuels in propulsion applications.

Prospective EV adopters will need to perceive EV technologies as suitable to existing or desired lifestyles, while private sector stakeholders will require a reasonable return-on-investment (ROI) for upfront investments into new vehicle fueling technologies as a push out market shift strategy.

To encourage the uptake of EVs and their market economic viability, visibility and access to essential charging infrastructure has been cited as a critical factor to consider from a public policy and private investment perspective (Sierzchula *et al.*, 2014). Yet, many programs – including Ontario’s own first round of “Electric Vehicle Charging funding, has proceeded with mostly ad hoc installations of EVSEs leading to the concern that trivial or non-optimal implementations of the technology can hinder EV adoption rather than support it by negatively influencing public perception towards the value of EVSE investments and EVs in general.