ELECTRIC VEHICLES
Driving the Shift to Greener Transportation

Alberta Infrastructure

DESIGN & TECHNOLOGY SERIES **09**

Electric vehicles (EVs) own a modest 0.2% share of the global passenger light-duty vehicle market. This sector is growing, however. The International Energy Agency[1] reported a 60% year-over-year growth in the EV market in 2016, representing over 2 million (EVs) on the world's roads. The Electric Vehicles Initiative (EVI), consisting of ten member governments including Canada, has set a goal for each member country to achieve a 30% EV market share by 2030. At 29%, Norway is notably leading the way. The replacement of internal combustion engine (ICE) vehicles with EVs is an historic step towards reducing carbon emissions to keep global warming under 2C per the 2016 Paris Agreement. Legislation supporting the growth of the EV market is becoming more prevalent. In response, many automotive manufacturers are adding EVs to their production lines and in some cases, going completely electric. As the performance, efficiency and range of electric vehicles increases, competition and technological advances are decreasing costs - rapidly making EVs an attractive, cheaper and greener alternative to conventional ICE vehicles.

Of the EV options available, only battery electric vehicles (BEVs) rely solely on an externally charged battery and electric motor for propulsion. The exclusion of the internal combustion engine eliminates tailpipe emissions, oil and transmission fluid changes (they contain neither), and dramatically reduces brake wear and maintenance through regenerative braking. EVs include passenger automobiles, buses, low-speed vehicles such as bicycles and golf carts, and commercial semi trucks. Despite their higher energy and resource consumption during manufacture, EVs are still significantly more efficient than ICE vehicles[2]; as Alberta's electricity grid evolves to replace coal with greener power sources, the environmental footprint of EVs will continue to shrink. At present, BEVs represent the best strategy for reducing GHG emissions from the transportation sector.

In 2012, Canada had approximately 100 EV charging stations; by the summer of 2017, this number had grown to about 4000 - a trend that is expected to continue. There are three types of charging stations: Level 1 - 110V (e.g. standard household outlet), Level 2 - 220V (e.g. household dryer outlet), and Level 3 - DC fast-charger (e.g. Tesla Supercharger). Similar to phone charging practices, EV owners commonly charge their vehicles overnight to ensure adequate power for the following day. Most home and public chargers are Level 2 as this provides the best balance of installation cost and convenient charging speed, especially for typical urban trips or commutes.

Although an EV can use a Level 1 outlet, the charging time is generally too slow to be practical for daily use. Level 3 DC quick chargers can add useful range in minutes when a top-off is needed to complete a trip, or they can replenish a battery in about 30 minutes. For long road trips, drivers and passengers will invariably need to stop: this can often be half an hour, during which time the vehicle can be recharged. Lithium-ion batteries charge faster up to 80% capacity and then slow down until they reach full capacity, thus a break shorter than 30 minutes may still be sufficient. Like ICE vehicles, EV users may "top-up the tank" whenever they need to stop, thus maintaining range without adding extra time to the trip. Level 3 charging stations are becoming more common as networks are expanded, especially along highways where longer distances necessitate rapid charging[3].

Driving range varies significantly between pure EV models. Of the vehicles available in Canada in 2017, the range was bracketed between the 100km Mitsubishi i-MiEV and the 539km range of the Tesla S 100D; predictably the cost of each car reflects this range, $30,000 and $122,000 respectively[4].

Electricity for charging stations is either supplied from the grid or from renewable sources

Volkswagen e-Golf (Battery Electric Vehicle)
Photo Credit: www.CleanTechnica.com

Types of Electric Vehicles

There are three categories of electric vehicles: hybrid (HEV), plug-in hybrid (PHEV), and battery EV (BEV)[5].

HEVs pair an internal combustion engine with a small electric drivetrain (motor and battery) to simultaneously propel the vehicle. While the electric drivetrain reduces emissions vs. a comparable ICE, they burn gasoline or diesel exclusively and do not connect to an external electric grid (e.g. Cadillac Escalade Hybrid).

PHEVs combine an ICE with an electric drivetrain that can be plugged into the electric grid. Grid-supplied electricity often reduces fuel costs when compared to HEVs, while the ICE acts as a range extending backup system. Average driving (50km/day) may infrequently use the ICE (e.g. BMW i3).

BEVs plug into an external power source to charge the battery that exclusively drives the electric motor. Unlike HEV/PHEVs, BEVs burn no fossil fuels and produce no tailpipe emissions. Decreasing battery costs and charging times combined with expanding charging networks and battery capacities have significantly reduced range anxiety. Affordable, viable alternatives to ICE/HEV/PHEVs are becoming more widely available (e.g. Tesla Model 3, Nissan Leaf, VW e-Golf).

Chevrolet Volt at a Solar Photovoltaic Charging Station
Photo credit: www.greenpulseenergy.co.uk

EV Charging with Solar Photovoltaics (PV)

A greener alternative to coal or natural gas, PV-generated electricity can charge EVs directly, it can be stored on site in batteries, or sent to the grid and consumed later. Battery storage is well-suited to off-grid sites; for grid-tied, net-metered systems, the added cost may be unnecessary. The example below estimates the size and cost of a PV system needed to offset the average daily electricity use of a typical 4-passenger EV (2017 Chevrolet Bolt).

Assumptions:
Average Canadian drives 50km/day;
Car requires 8.75 kWh/day to drive 50km;
One 275W panel generates 0.81kWh/day (at Edmonton's latitude and accounting for a 14% potential loss*).

8.75kWh/day / 0.81kWh/day = **11 panels**

11 PV panels will produce 3.025kW (peak)**

Cost for 3kW PV system = $9000 ***

Cost for single Level 2 charger = $850

Installation cost = $2000

Total cost = $11,850

*US Department of Energy PV Guidelines
**Canadian Solar (CS6K-M 275W-T4 Black on Black)
***Costs from Brooks Crop Diversification Centre ($2500/kW) and Spruce Grove School ($3000/kW).

such as solar or wind. This energy can be used immediately, fed into the grid, or stored on site in batteries. Battery storage is one of the most efficient and flexible storage systems available, however it is still relatively expensive and may be best applied to off-grid sites or where economies of scale can be realized (e.g. utility sized). Alberta's micro-generation regulation allows micro-generators to feed excess electricity from their PV systems to the grid and to draw back from the grid when needed (essentially using the grid as a battery).

EV charging station costs vary depending on the product, charging capability and intended application. The table below summarizes the key characteristics and considerations for Level 1, 2, and 3 charging stations, including the cost for hardware and installation.

Type	Voltage	Time to Full Charge	Average Cost (Supply and Installation)*, **	Remarks
Level 1 (e.g. typical household outlet)	110-120 volts 15 amps	16-20 hours	N/A (same as standard power outlet)	Universally available, slow charge time
Level 2 (e.g. typical household dryer outlet)	208-240 volts 30 amps	4-8 hours	$1750 (residential) $2850 (workplace) $4000 (public)	Most common for residential and workplace charging
Level 3 (e.g. DC fast charger)	480 volts 100 amps	30-45 minutes	$28,950	Expensive to install at present

*US Dept. of Energy, 2016; data collected from 2011-2013, shown in 2017 Canadian Dollars (1USD=1.28CAD): https://energy.gov/sites/prod/files/2016/01/f29/fotw%23910_web.xlsx.
**Technical Services Branch, 2017: Canadian sample data for cost of charging equipment averaged $850 for single chargers and $3100 for dual chargers. Installation range $500-2000; depends on scope, conduit, cable, sub-panels, breakers, permits, electrician's charge (estimates from Edmonton-area contractors, 2017)

Public perception of EVs has evolved as the market matures and diversifies. The underpowered and occasionally odd-looking electric cars of the 1990s have largely been replaced by modern, desirable and responsive EVs with useful driving ranges and lower costs. Charging infrastructure is increasingly available, as is the prevalence of renewable energy sources that further reduce the carbon footprint of EVs.

Alberta Infrastructure's Green Building Standards support the adoption of electric vehicles, specifically through the Leadership in Energy and Environmental Design (LEED) rating system which provides credits for installing charging stations. New projects should include EV charging infrastructure in order to futureproof for the growing EV market and to avoid expensive retrofits. Opportunities to incorporate renewable energy technologies (such as solar) should be sought as a sustainable means of offsetting increased electricity consumption. The Government of Alberta's encouragement of EV implementation will contribute to the reduction of greenhouse gases in the province, resulting in a positive and enduring impact on the health and environment of Albertans.

Information Sourced From:

1. https://www.iea.org/publications/freepublications/publication/GlobalEVOutlook2017.pdf
2.https://thecorrespondent.com/7056/why-electric-cars-are-always-green-and-how-they-could-get-greener/741917761200-afaa6e5d
3. http://www.cbc.ca/news/canada/manitoba/electric-car-chargers-ontario-manitoba-1.4217776
4. www.fleetcarma.com, www.tesla.com/en
5. http://pluginbc.ca/wp/wp-content/uploads/2014/07/EV-Beginners-Guide_Final_Sept2_2014.pdf

TECHNICAL SERVICES BRANCH
3rd Floor, Infrastructure Building
6950 - 113 Street NW
Edmonton, AB
Canada
T6Y 5V7