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Car Ownership Costs in Canada – Internal Combustion Engine vs Electric and Hybrid Vehicles

By Victor Gallardo and Madie Zamzadeh

Editorial Committee: Ganesh Doluweera, Dinara Millington, Allan Fogwill

While electric and hybrid vehicles had been developed and gained popularity in the early 1900s, the discovery of the Permian Basin in 1920 brought an abundant supply of oil to market, triggering their decline. By 1935, electric vehicles (EV) had virtually disappeared, and the affordability of internal combustion engine (ICE) vehicles offered no incentives to continue research and the development of alternative technologies. It was not until the 1970s oil crisis when substantial petroleum shortages caused gasoline prices to soar, and incentives to explore alternative technologies were popular once again. It took another 20 years before alternatives to ICE vehicles began mass-production. In 1997 Toyota introduced the Prius, a hybrid electric vehicle (HEV), and in 2006 Tesla Motors started developing electric sports cars (DOE 2020).

Today, almost all car manufacturers offer EV, HEV and plug-in HEV (PHEV) options as demand for alternative technologies has increased. One of the main selling factors is the potential for fuel savings over the life of the vehicle.[1] In this article, we compare the differences in fuel costs among ICE vehicles and other alternatives and assess whether potential fuel savings are enough to compensate for the price premium when considering all other car-ownership costs.

Differences in Engine Technologies

Cars with internal combustion engines derive their power from a heat engine. These engines consist of a chamber where a gasoline-air explosive mixture combusts, raising the gas temperature and pressure high enough that it applies direct force against a mechanical component within the engine – usually a piston – creating a linear motion that gets further converted into rotational motion. EVs use induction motors which require electric current, stored in battery packs, to create the rotational motion needed for the drive wheel to propel the vehicle. Hybrid vehicles (HEV and PHEV) benefit from a mixture of ICE and electric propulsion. The main differences between HEV and PHEV are the size of the battery and the fact that PHEV have the option to charge their batteries directly from a wall outlet. Electric and hybrid vehicles use a regenerative braking technology to recover the kinetic energy to recharge their batteries.

Fuel Costs Across the Largest Canadian Cities

Each year, Natural Resources Canada (NRCan) publishes a comprehensive dataset with model-specific information regarding fuel efficiency of new light-duty vehicles for retail sale in Canada (NRCan 2020). This includes ICE, EV, PHEV, HEV, as well as the different trim levels of each model. Following NRCan's classification by weight and interior volume, we selected a subset of vehicles within six different classes (Compact, Mid-size, Full-size, Station Wagon: Small, SUV: Small and SUV: Standard[2]) and estimated their annual fuel costs (gasoline, electricity or both) across the largest Canadian cities.

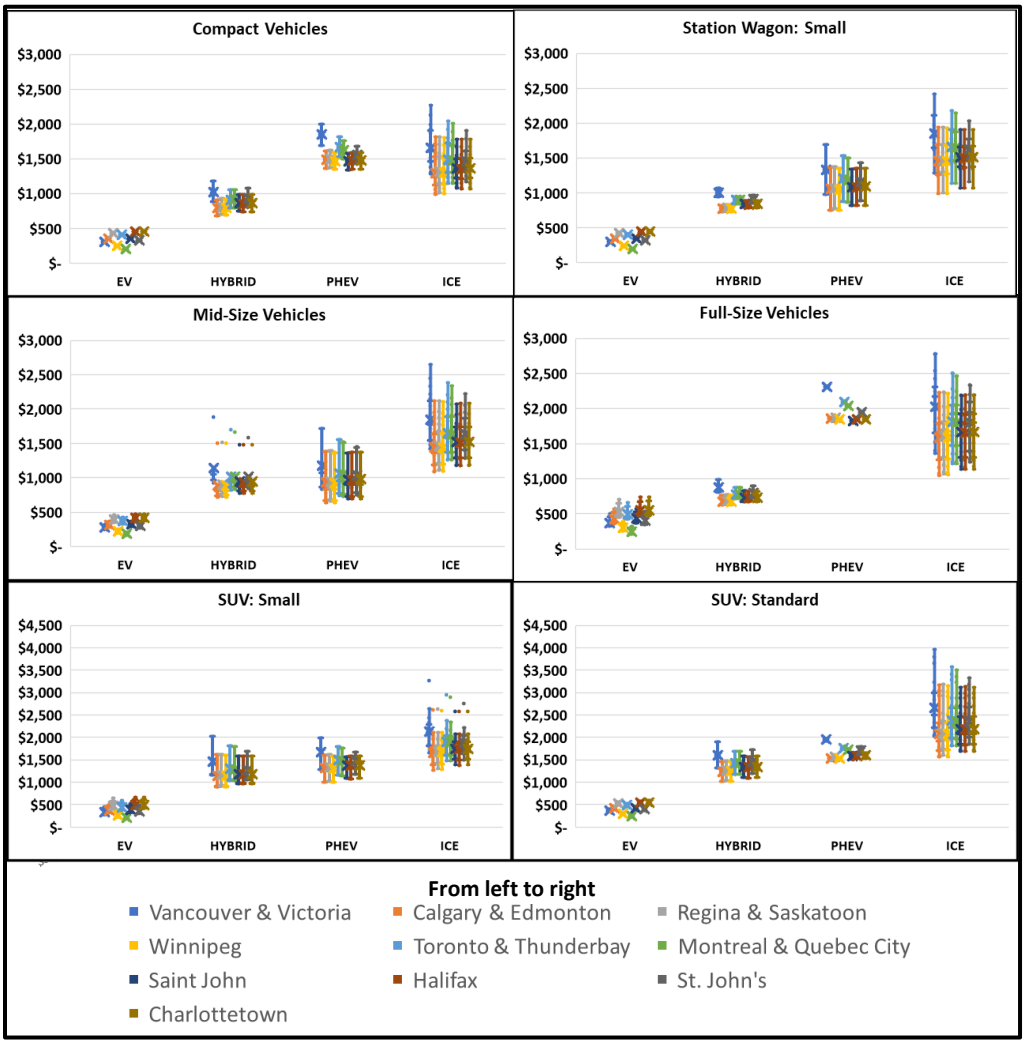
[1] Tesla Motors claims that their Model 3 can potentially save $6,700 on gas expenses over 6 years (Tesla Inc 2020).
[2] *Compact*: 100-109 cu ft; *Mid-size*: 110-119 cu ft; *Full-size*: more than 120 cu ft; *Station Wagon: Small*: less than 130 cu ft; *SUV: Small*: less than 6,000lb; and *SUV: Standard*: more than 6,000lb.

We calculated the annual average gasoline prices between 2015 and 2019 (Statistics Canada 2020) of regular and premium grades. Following the manufacturer's recommended grades for each vehicle, we estimated their annual average fuel cost (i.e., total fuel cost for ICE vehicles and HEV, and partial fuel costs of PHEV).

For EV and PHEV, we assume that most owners charge their vehicles at home. Thus, the fuel costs for these vehicles are a function of the electricity rates that residential customers pay in each province. Hydro Quebec (2019) publishes a report comparing the monthly electricity bills (all-in $/kWh) that residential and other customers pay in the main cities across North America. We used estimates between 2015 and 2019 to calculate the average cost of charging EV and PHEV.

The vehicle fuel cost calculations are based on the combined city and highway rating and a driving distance of 15,000 km/year. Figure 1 summarizes our findings. Table 1 provides a summary of the electricity and gasoline prices across Canada.

Figure 1: Annual Average Fuel Costs Across Largest Canadian Cities (2015 – 2019)



Data source: *Natural Resources Canada (2020), Statistics Canada (2020), Hydro Quebec (2019). Figure by CERI.*

Table 1. Average Gasoline Prices and Average Electricity Prices for Residential Customers

		Gasoline		Electricity
		Regular 2015-2019 Average ($/litre)	Premium 2015-2019 Average ($/litre)	Residential 2015-2019 Average ($/kWh)
Vancouver & Victora	BC	$1.31	$1.49	$0.11
Calgary & Edmonton	AB	$1.01	$1.20	$0.13
Regina & Saskatoon	SK	$1.03	$1.20	$0.16
Winnipeg	MB	$1.02	$1.19	$0.09
Toronto & Thunderbay	ON	$1.17	$1.35	$0.15
Montreal & Quebec City	QC	$1.17	$1.32	$0.07
Saint John	NB	$1.10	$1.17	$0.13
Halifax	NS	$1.09	$1.18	$0.16
St. John's	NL	$1.19	$1.26	$0.12
Charlottetown	PEI	$1.10	$1.18	$0.16

Data source: *Statistics Canada (2020), Hydro Quebec (2019). Table by CERI.*

The Compact and Full-Size PHEV alternatives are entirely represented by luxury brands[3], and these manufacturers recommend the use of premium gasoline for optimal performance and fuel efficiency. Thus, the annual fuel costs for PHEV alternatives is higher than the average fuel costs of ICE vehicle brands within these classes (i.e., Compact and Full-Size). The impact that the gasoline grade has on the annual fuel costs can also be appreciated in the Mid-Size vehicle class, as one of the HEV in the sample recommends the use of premium gasoline,[4] almost doubling the annual fuel costs of this specific model compared to the average fuel cost of the other HEV brands in the Mid-Size class[5].

Overall, assuming a driving distance of 15,000 km/year, the average fuel cost for EV, across all classes, is $375/year, with a sample standard deviation of $72. The average fuel cost for ICE vehicles, on the other hand, is $1,735/year across all classes, with a sample standard deviation of $438. Thus, on average, switching from ICE vehicles to EV could save ~$1400/year on fuel costs.

Car Ownership Costs Across Canada

Fuel costs usually represent about 20% of the total costs associated with operating a vehicle (NJC 2019). Depreciation, insurance, taxes, rebates, licensing, registration, and monthly car payments (including principal amount of a loan and interest payments) make up the rest of the car ownership costs.

We selected twelve different vehicles, two in each class, to expand the costs comparison beyond the fuel costs. To keep the physical characteristics and, to the extent possible, the market appeal constant, we are comparing EV models with their ICE or HEV versions when available. For EV models with no ICE or HEV versions available, we selected a model from a different manufacturer in the same class and within the same retail price range. The car ownership costs are calculated over a five-year period[6]. Table 2 presents a brief description of the selected vehicles, as well as their fuel and all other ownership costs, highlighting the impact that federal and provincial rebates have in improving the economics of EV alternatives. Figure 2 offers a visual comparison of the ownership costs across the different provinces in Canada.

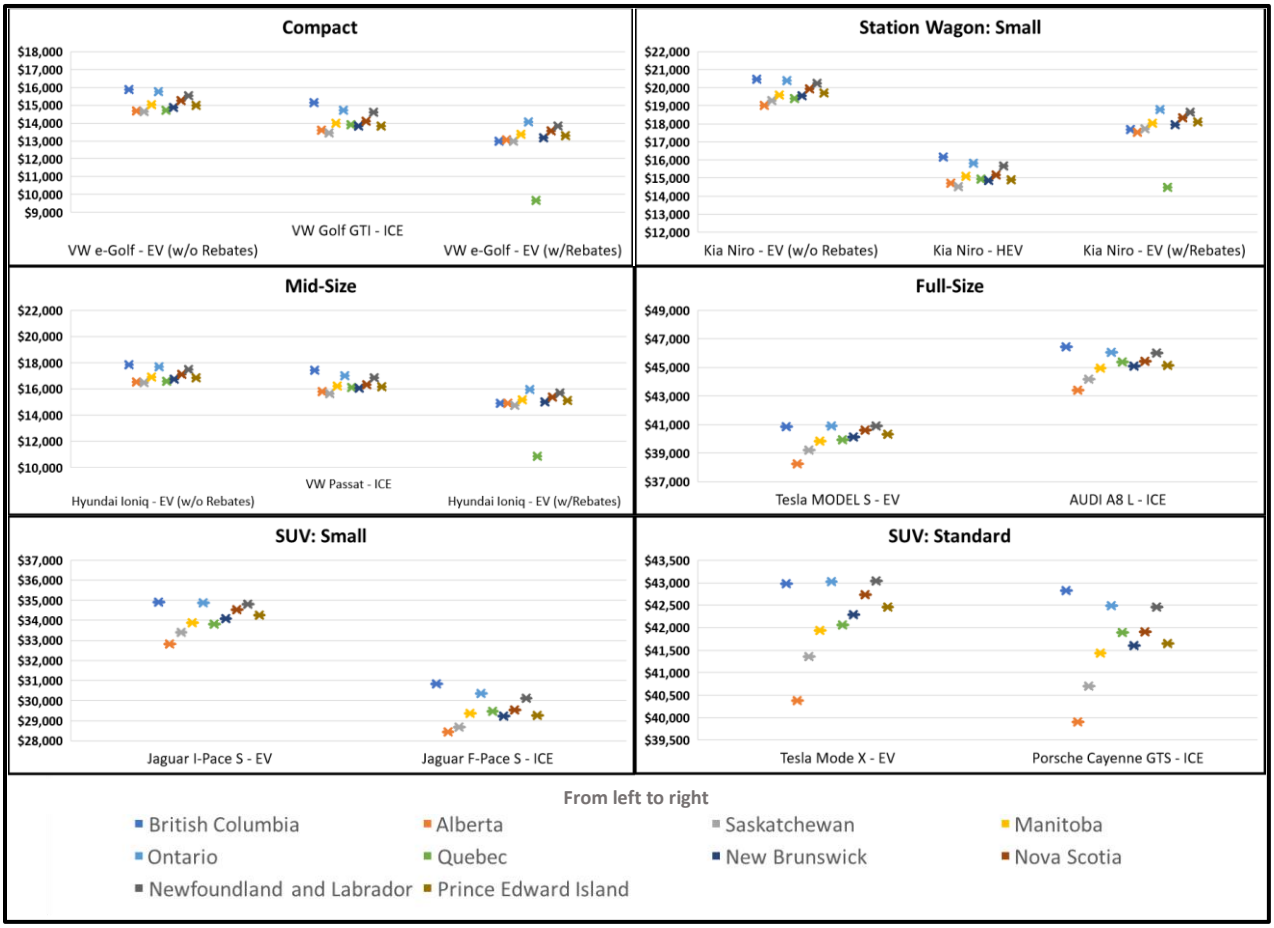
[3] Volvo, BMW & Porsche.
[4] Acura – RLX Hybrid.
[5] Assuming an annual driving distance of 15,000 km.
[6] Depreciation, licensing and registration fees, maintenance and insurance costs for each vehicle were gathered from the Canadian Automobile Association (CAA 2020). Rebate program information can be found at Transport Canada (Government of Canada 2020) as well as at provincial specific websites (BC Government 2020; Quebec Government 2020a). Monthly payments for these vehicles were calculated assuming a 15% down payment (15% of the manufacturer's suggested retail price (MSRP) minus rebates if applicable) with the remaining being financed at a 2.99% interest rate over 60 months (5 years).

Table 2. Annual Car Ownership Costs

Vehicle	Year	Class	Type	MSRP	Annual Fuel Cost (Canadian Average)	Other Annual Ownership Costs (without Rebates)	Other Annual Ownership Costs (With Federal Rebates) - Excluding BC and QC	Other Annual Ownership Costs (Federal + Provincial Rebates) - British Columbia	Other Annual Ownership Costs (Federal + Provincial Rebates) - Quebec
VW e-Golf	2020	Compact	EV	$37,895	$354	$14,776	$13,037	$12,675	$9,482
VW Golf GTI	2020		ICE	$32,245	$1,461	$12,657	n/a	n/a	n/a
Kia Niro Sx Touring	2020	Station Wagon:	EV	$54,495	$354	$19,405	$17,760	$17,367	$14,267
Kia Niro Sx Touring	2020		HEV	$35,695	$907	$14,271	n/a	n/a	n/a
Hyundai Ioniq - Preferred	2020	Mid Size	EV	$41,499	$301	$16,723	$14,918	$14,619	$10,698
VW Passat Execline	2020		ICE	$36,495	$1,461	$14,893	n/a	n/a	n/a
Tesla Model S 100D	2018	Full Size	EV	$122,000	$392	$39,697	n/a	n/a	n/a
AUDI A8 L	2018		ICE	$112,200	$2,331	$42,874	n/a	n/a	n/a
Jaguar I-Pace S	2020	SUV: Small	EV	$89,800	$523	$33,615	n/a	n/a	n/a
Jaguar F-Pace S	2020		ICE	$70,900	$2,219	$27,309	n/a	n/a	n/a
Tesla Model X 100D	2018	SUV: Standard	EV	$123,800	$457	$41,766	n/a	n/a	n/a
Porsche Cayenne GTS	2018		ICE	$111,300	$2,369	$39,318	n/a	n/a	n/a

Data source: *Canadian Automotive Association (2020), Natural Resources Canada (2020), autoTRADER.ca (2020). Table by CERI.*

Figure 2: Annual Ownership Costs Across Canada



Data source: *Canadian Automotive Association (2020), Natural Resources Canada (2020), autoTRADER.ca (2020). Figure by CERI.*

Given that British Columbia has the widest price difference between the two fuel options (~$1.29[7]), consumers in this province could realize the most fuel savings when switching away from ICE vehicles. On the other hand, the price difference between these two fuel options is less favourable for residents of Saskatchewan (~$0.96), reducing the potential for fuel cost savings. Fuel costs, however, are just a fraction of the overall car ownership costs. Depreciation, as well as provincial and federal rebates, have a greater impact on the EV economics compared to the fuel costs alone. The $8000 rebate for new EV that the Quebec Government (2020b) offers, on top of the $5000 federal rebate for new EV, significantly improves the competitiveness of some EV models compared to the ICE and HEV alternatives (see Compact, Mid-Size and Station Wagon examples in Figure 2).

In terms of the overall car ownership costs, we found that if the MSRP is greater than $45,000, then the applicable tax rate in each province becomes the largest determinant for the affordability of vehicles (see Alberta for Full Size and SUV's in Figure 2). This tax advantage, however, does not favour any specific type of vehicle technology.

For a thorough analysis of the economic impact of different transportation options in Canada, please see CERI's study, *Economic and Greenhouse Gas Emissions Impacts of Alternative Transportation Scenarios for Canadian Cities*, at www.ceri.ca/studies.

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[7] Average price of regular and premium gasoline ($/lt) minus electricity price ($/kWh).

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