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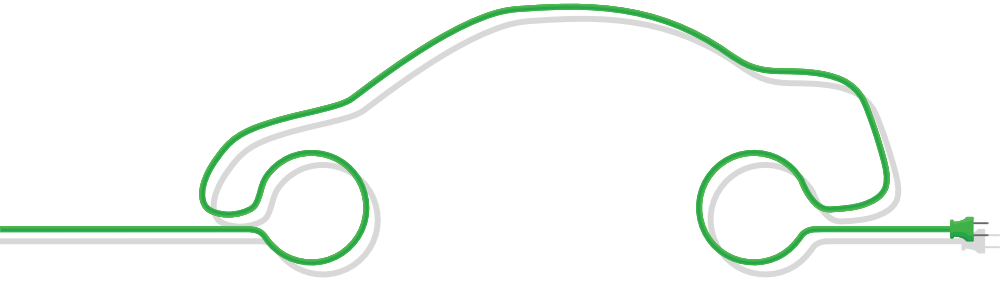

ELECTRIC VEHICLE PRIMER

An Introduction to Hybrid, Plug-in Hybrid Electric and Battery Electric Vehicles

Canada

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Why Electric Vehicles?

We rely on our cars to get us where we want to be, when we want to be there. Most cars and trucks today use gasoline or diesel and produce about 12 per cent of Canada's total greenhouse gas emissions each year. These emissions also produce pollutants that can harm your health and the environment. So, we need to look for ways to make cars use less fuel and produce less pollution.

Electric cars–all vehicles, including cars, trucks, motorcycles and scooters–are a step in the right direction. Unlike gasoline or diesel cars, they produce no emissions or pollutants when operating on electricity. And if people use electricity from clean sources like hydro or wind turbines to charge their car's batteries, these cars can be even cleaner! On average electricity in Canada produces about 200 grams of CO_2 per kilowatt-hour. This means that an electric car produces about 60 to 80 per cent less CO_2 than one that runs on gasoline or diesel.

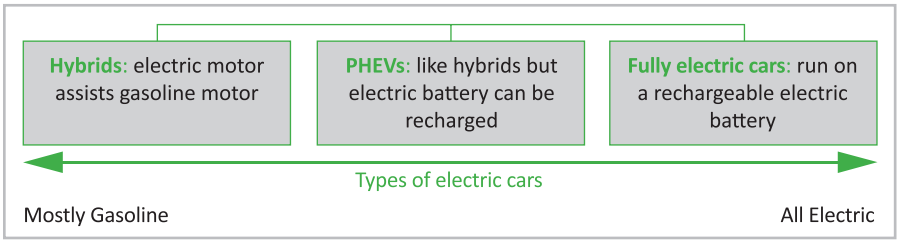
There are different kinds of electric cars. You may have seen some of them on the road, such as hybrids. However, other electric cars, like plug-in hybrids and fully electric cars, will soon be on Canada's roads. This guide provides an overview of the different types of electric cars you will see on the road in Canada in the near future.

So Many Choices!

When we say "electric car", we don't always mean a car that runs just on electricity. There are different kinds of electric cars that use electricity in different ways and in combination with other technologies.

In this guide, you will find information about each of these technologies and some examples of how they could fit into your daily life.

Different Types of Electric Cars

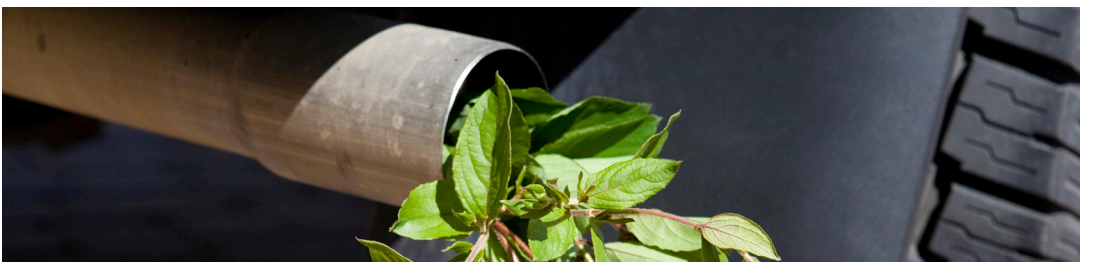


Hybrid Electric Vehicle (HEV)

Hybrids, also known as hybrid electric vehicles (HEVs), are already on Canada's roads. Hybrid electric cars run on two systems—an internal combustion engine that uses gasoline and an electric motor that uses electricity.

The electric motor provides extra driving power when the car is accelerating or going up a hill. Or it can power the car on its own at low speeds and over short distances.

The gasoline engine and a special braking system recharge the electric battery while the car is moving. To save on fuel, the gas engine also shuts off automatically when the car comes to a stop or coasts down a hill, and restarts quickly when it is needed.



Plug-in Hybrid Electric Vehicle (PHEV)

Plug-in hybrid electric vehicles (PHEVs) are like hybrids: they have an internal combustion engine that uses gasoline and an electric motor that uses electricity. However, PHEVs have some added features. Most have more battery capacity than a regular hybrid and can run on their electric motor for longer periods of time, and over longer distances. Typical PHEVs can travel about 20 to 40 kilometres in "electric mode," using just the electric battery, which is enough to meet the daily driving needs of many Canadians. Once the battery charge runs out, the car operates like a regular hybrid, using the gasoline motor to run the car and recharge the battery.

Battery Electric Vehicle (BEV)

Battery electric vehicles, or BEVs, are powered only by an electric motor that gets its energy from batteries. Owners charge the batteries by plugging the car into a standard 110 V or 220 V household outlet.

BEVs do not burn fuel or produce tailpipe emissions (in fact, they don't even have a tailpipe), so they are less harmful to the environment. BEVs drive like regular cars. Because the battery is bigger, they can go for longer distances than PHEVs. A fully charged BEV can go for about 100 to 200 kilometres, which is more than enough to meet most people's daily driving needs.

How Do I Tell the Difference?

The chart below provides some of the key features of hybrid, plug-in hybrid electric and battery electric vehicles.

	Hybrid Electric Vehicle (HEV)	Plug-in Hybrid Vehicle (PHEV)	Battery Electric Vehicle (BEV)
Motor	Internal combustion engine and electric motor	Internal combustion engine and electric motor	Electric motor
Features	Powered mainly by its gasoline engine Electric motor provides assistance during peak power demands and can power the car at low speeds and over short distances	Operates on combination of gasoline and electricity Typical all-electric range of 20-40 km on a full charge Recharge electric battery from domestic 110 V or 220 V outlet in 6-8 hours Gas engine is refuelled like a regular car	All electric (no gasoline or diesel engine) Range of 100-200 km on a full charge Recharge electric battery from standard 110 V or 220 V outlet in 6-16 hours
Environmental Considerations	Uses less fuel Lower tailpipe emissions	Uses much less fuel Very low tailpipe emissions	No tailpipe, so zero "tailpipe" emissions or pollutants

	Hybrid Electric Vehicle (HEV)	Plug-in Hybrid Vehicle (PHEV)	Battery Electric Vehicle (BEV)
Lifestyle Considerations	No need to plug in to charge the battery Uses regular gasoline Driver experience is the same as for conventional vehicles	Uses regular gasoline Can charge battery at home or other locations where an outlet is available Battery can be charged in 6-8 hours, usually overnight Can be driven between 20 and 40 km in electric mode, using no gasoline Gasoline engine takes over when batteries are run down	Car can be charged at home or other locations where an outlet is available Full charge typically takes 6-8 hours at 220 V or 14-16 hours at 110 V Public charging locations are currently limited, so you might have to plan ahead for longer trips
Availability in Canada	Available now	Limited availability, but more expected in 2011-2012	Limited availability, but more expected in 2011-2012

Hybrid, PHEV, BEV—Which One Should I Choose?

If you are thinking about buying a hybrid, a PHEV or a BEV but don't know which one is right for you, the following scenarios may help you better understand how each one might fit your lifestyle and transportation needs.

Scenario #1: Plug-in Hybrid Electric Vehicle (PHEV)

Marc is a mechanical engineer in his late twenties who lives in the city with his wife, Cynthia. They take the bus to work but use their car to run errands and to visit friends and family outside of the city on weekends. So, they generally drive in the city during the week and on the highway on weekends. In the city, they drive less than 40 kilometres a day. However, on weekends, they can drive more than 300 kilometres in a day.

Cynthia and Marc's current car is an older compact diesel vehicle. They like the diesel engine because it gets good mileage on the highway, but it's time for a new car. They'd like one that gets good mileage on the highway and in the city. Plus they'd like an environmentally cleaner car. Marc and Cynthia are not sure of the best choice

for them because:

- they want to be able to go on long trips without having to worry about plugging in along the way;
- they like the idea of lowering their fuel costs when driving around in the city by using a car with an electric motor;
- they also like the idea of driving a car that produces very few emissions.

Cynthia and Marc might want to look into PHEVs. They cost more than regular gasoline cars but they offer some savings at the pump, especially in the city. When running errands around town, they could use the all-electric mode, which would also save them money. On weekend trips, they would be able to get around using the gasoline engine when the electric battery runs down, so they wouldn't have to worry about finding a place to plug the car in. They could charge their PHEV in their apartment building, where the building owners have installed electrical outlets in some of the parking spaces. Marc and Cynthia would be driving a car that is less harmful to the environment.

	Fuel Costs	**Fuel Consumption**	**Electric Range**	**CO_2 Emissions (tailpipe)**
Fuel-Only Car	$1,600/year (gasoline only)	7.8 L/100 km	Not applicable	188 g CO_2/km
Plug-In Hybrid*	$1,000/year (combined gasoline and electricity)	1.9-4.1 L/100 km	20-40 km	84 g CO_2/km

(Based on driving 20,000 km/year, gasoline at $1.00/L and electricity at 10¢/kWh)

**Based on eTV test results of an A123 Systems Hymotion L5 Plug-in Conversion Module*

Scenario #2:
Battery Electric Vehicle (BEV)

Josée is a working mother of three who lives and works in a town of 20,000 people. She drives about 20 kilometres per day, mostly in town. Although Josée lives close to where she works, she drives because parking is free and she can drop her children off at school and daycare on the way. Because she does most of her driving around town, she finds herself in a lot of stop-and-go traffic. Josée's partner also drives to work but has a longer commute, travelling about 200 kilometres round trip on the highway. Josée and her family occasionally go away on weekends to visit family and friends, but they use her partner's gasoline car for these trips.

Josée likes having her own car so that she can easily get around town. She wants a car that is just as safe for her children as the one she drives now but will still save her money at the gas pump. Josée's children are also becoming more interested in doing what is right for the environment, and are pushing for her to get rid of her older car.

Josée might want to consider a BEV. Her daily driving needs are within

a BEV's range, less than 200 kilometres. When driving around town, she could enjoy the BEV's quiet ride. The stop-and-go driving uses a lot of gas. With a BEV, she could save money: she pays less than 10¢/kWh for electricity, which is less than she is paying for gasoline. Josée's children will be happy because Mom will be picking them up from school and their practices in an emissions-free car. As a second car, a BEV could meet Josée's daily driving needs. When she needs to drive more than 200 kilometres, she could use her partner's gasoline vehicle.

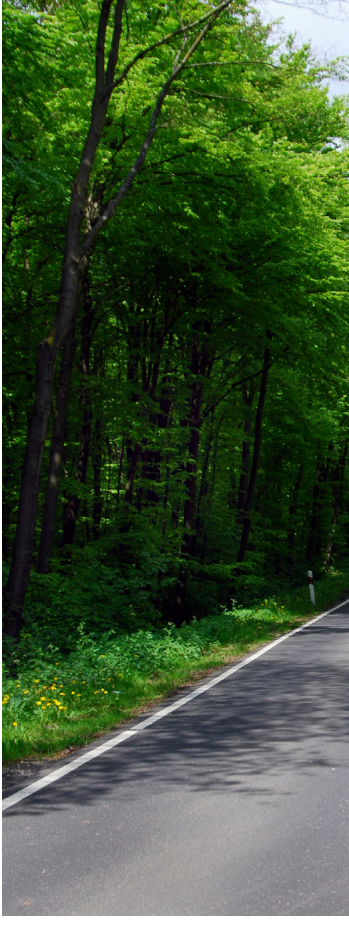
Josée could charge her BEV using the electrical outlet in her garage that she uses in the winter for her block heater. If she plugged in her car at night, it would be fully charged in the morning. This is important, because the utility provider she uses is planning on introducing 'time-of-use' pricing, which will make electricity less expensive at certain times of the day, like in the evening hours.

In the winter, if she finds that the cold affects her battery capacity, she could look for a way to charge her car at work. On days when she is in a hurry, Josée could use the public "quick-charging" stations that her community is planning on installing to charge her car in 30 minutes or less.

	Fuel Costs	**Fuel Consumption**	**Electric Range**	**CO_2 Emissions (tailpipe)**
Fuel-Only Car	$1,600/year (gasoline only)	7.8 L/100 km	Not applicable	188 g CO_2/km
Battery Electric Vehicle*	$400/year (electricity only)	Not applicable	100-200 km	0 g CO_2/km

(Based on driving 20,000 km/year, gasoline at $1.00/L and electricity at 10¢/kWh)

**Based on average performance specifications provided by manufacturer*



Scenario #3:
Hybrid Electric Vehicle (HEV)

Dan is a retiree living in a rural area. Since retiring, Dan has become interested in camping and fishing. Dan drives to the nearest town every day to run errands–about 60 kilometres a day. He also likes to go fishing and camping with friends and family, which can take him over 300 kilometres away. Dan's current vehicle is a mid-sized truck, with enough cargo space for his camping and fishing gear. Because he lives in a rural area, Dan values a reliable truck that will be ready to use whenever he wants or needs it. He also likes the space it offers for people and cargo.

Dan likes his truck, but it is getting old. He is thinking about a sport utility vehicle (SUV) but wants something that will be just as fuel-efficient, reliable and convenient as his truck. Dan is also concerned about the future in terms of the health and well-being of his grandchildren. He wants to do the right thing but isn't sure what that is.

Dan might consider a hybrid SUV. When he is running errands or driving into town, Dan could cut down on emissions and fuel costs because of the anti-idling feature that kicks in when the SUV stops. This means he would use less gas than with his current truck. There is enough room in a hybrid SUV for Dan to store his camping and fishing gear or to take

his grandchildren to the park on the weekend. When he wants to join his friends on a camping trip, he knows that he will get good gas mileage and will be able to rely on the gas stations he has always used when needed.

	Fuel Costs	Fuel Consumption	Electric Range	CO_2 Emissions (tailpipe)
Fuel-Only SUV	$2,213/year (gasoline only)	11.1 L/100 km	Not applicable	265 g CO_2/km
Hybrid SUV*	$1,678/year (gasoline only)	8.4 L/100 km	Only at low speeds	201 g CO_2/km

(Based on driving 20,000 km per year and gasoline at $1.00/L)

**Based on average performance of hybrid SUVs listed in the 2010 Fuel Consumption Guide*

Scenario #4:
Battery Electric Scooter

Tina is single and lives in a small apartment in the downtown area of a big city. She walks, rides her bike or takes the bus to get around the city. She travels about 25 kilometres a day. Tina spends most of her time in the city, working, visiting friends or exploring different neighbourhoods. When Tina leaves the city to visit her family, she takes the train or bus, or carpools with her sister.

Tina gave up her car when she moved to the city because she didn't think she needed it. Now she is looking for a quick and convenient way to get around on the days she has a lot of errands to run. Tina is living on a single income and wants to limit the impact that owning a vehicle will have on her bank account and the environment. Tina would also like to avoid burning gas while in stop-and-go city traffic.

Tina might want to consider an electric scooter. With an electric scooter, Tina could travel around town faster than on a bicycle. A scooter is less expensive than a car to buy and maintain. At her apartment, Tina could charge her scooter in the parking garage at night, using an outlet that the building manager has installed. Tina doesn't have a parking spot at work, but she lives in a city that allows users to park scooters on the sidewalk. Since she lives in a city that doesn't usually get much snow in the winter, she could safely drive her scooter nine to ten months out of the year.

	Fuel Costs	**Fuel Consumption**	**Electric Range**	**CO_2 Emissions (tailpipe)**
Fuel-Only Scooter	$250/year (gasoline only)	3.9 L/100 km	Not applicable	90 g CO_2/km
Electric Scooter*	$65/year (electricity only)	Not applicable	60-70 km	0 g CO_2/km

(Based on driving 6,500 km/year, gasoline at $1.00/L and electricity at 10¢/kWh)

**Based on eTV test results for the Vectrix electric scooter*

Which Vehicle is Right for Me?

Now consider the features of electric vehicles. How do they meet or not meet your expectations and daily driving needs?

	Marc	Josée
Profile	• Lives in the city with wife • Buses to work • Uses car during week to run errands and visit friends • Uses car on weekends to go outside of city–about 300 km a day • Looking to replace his older compact diesel vehicle	• Working mother of three • Lives and works in a town of 20,000 • Drives short distances to work • Drops children off at school and daycare • Drives mostly around town, in stop-and-go traffic • Uses partner's gasoline car for longer trips on weekends
Wants and Needs	• Good mileage on highway and lower fuel costs in the city • A less polluting car • Ability to go on long trips without having to plug in or plan ahead	• Needs her own car • Wants a safe car for her children • Wants to save money on gas • Children want to do what's right for the environment
Could Consider	PHEV	BEV
Why?	• Operates on gasoline and electricity • Uses much less fuel • Idle start-stop helps to reduce fuel consumption further • No need to plug in on longer trips • Uses regular gasoline • Lower tailpipe emissions	• Operates on electricity only • Range of 100-200 km per charge • Recharge electric battery from domestic 110 V or 220 V outlet • Can charge car at home • Public charging locations are currently limited so you might have to plan ahead for longer trips • No tailpipe, so no "tailpipe" emissions

The chart below may help. It sets out the features of electric vehicles and the driving needs of the users in the scenarios. This information may help you decide whether an electric vehicle is right for you!

	Dan	Tina
Profile	• Retiree living in a rural area • Camping and fishing enthusiast • Drives about 60 km every day • Some weekends, drives about 300 km	• Single and living in the city • Walks, rides her bike or takes the bus • Travels about 25 km a day • Takes train or bus on weekends to visit family and friends • Gave up her car when she moved to the city
Wants and Needs	• Reliable car that is ready when he is • Lots of space for his camping and fishing gear • Fuel efficiency on the highway • Wants to do the right thing about the environment for his grandchildren's sake	• Convenience when running errands • Cost of car a factor • A less polluting vehicle, especially in city driving
Could Consider	Hybrid SUV	Electric Scooter
Why?	• Operates on gasoline and electricity • Uses less fuel • Idle start-stop helps to reduces fuel consumption further • No need to plug in • Uses regular gasoline • Driver experience is the same as for conventional vehicles • Lower tailpipe emissions	• Faster and more convenient than bicycle and walking • Operates on electricity only • Recharge electric battery from domestic 110 V or 220 V outlet • Can charge scooter at home in 6-8 hours • Public charging locations are currently limited so you might have to plan ahead for longer trips • No tailpipe, so no "tailpipe" emissions

Electric Vehicles
Calculating Energy Use and Costs *(kWh vs. L/100 km)*

You are probably used to seeing a car's fuel consumption rating in litres per 100 kilometres (L/100 km) or miles per gallon (mpg). But what about cars that don't use gasoline or diesel, like BEVs? Industry experts are developing new ways of thinking about a car's energy efficiency. For example, with electric cars, energy use is measured in kilowatt-hours per kilometre, or kWh/km. A kilowatt-hour (kWh) is a unit of energy equal to 1,000 watt-hours. Think of it as the amount of energy required to power ten 100-watt light bulbs for one hour. Now divide kWh consumed over the total distance travelled in kilometres and you get a car's kWh/km energy use.

Calculating the cost of operating an electric car: $/kWh vs. $/L

For a BEV or PHEV, you will pay for electricity to charge your battery, which is measured in kilowatt-hours. With a regular car, you will pay to fill up at the pump, which is measured in litres of gasoline. So, how can you compare the cost of electricity versus gasoline?

Consider the following example:

Jack travels an average of 30 kilometres per day (210 kilometres per week). He wants to know how much he will spend on energy to power a BEV compared to the cost of filling up at the pump with gasoline.

He has decided to compare a BEV to a gas-powered car with a combined (city/highway) fuel consumption rating of 6 L/100 km. Electricity in his area costs 10¢/kWh. The BEV he is planning to buy has a usable battery capacity of 24 kWh and a maximum range of 160 kilometres.

VEHICLE A: Gasoline Costs

210 km @ 6 L/100 km = 12.6 L of fuel used per week

So: At $1.00 per litre and driving 210 km/week,
Vehicle A's fuel (gasoline) costs are $12.60 per week.

VEHICLE B: Electricity Costs

$$\frac{\text{Battery's usable capacity (kWh)}}{\text{Total vehicle range (km)}} \text{ X Cost of electricity (\$/kWh)} = \textbf{Cost per km}$$

So: Cost per km X Weekly distance = **Cost to drive per week**

Given the information in the example above, we can assume that the vehicle can travel 160 km on a 24 kWh battery, using 100 per cent of its capacity. The cost per kilometre would then be as follows:

$$\frac{24 \text{ kWh}}{160 \text{ km}} \text{ X } 10¢/\text{kWh} = 0.15 \text{ kWh/km X } 10¢/\text{kWh} = 1.5¢/\text{km}$$

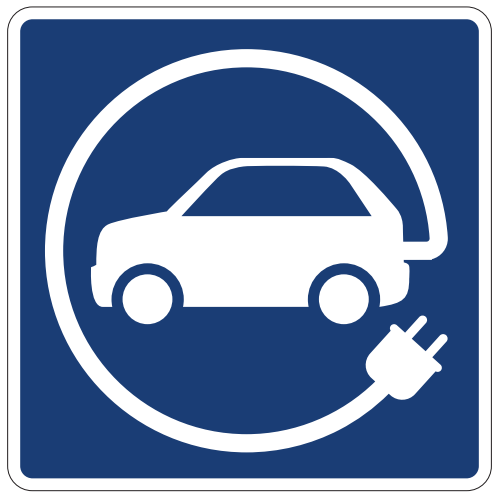
So: At 1.5¢ per km and driving 210 km per week,
Vehicle B's fuel (electricity) costs are $3.15 per week.

When Will They Be Available?

Hybrids have been available in Canada since the late 1990s. A few PHEVs are available now, but you can expect to see more of them in the near future. In fact, a number of carmakers have announced that they will introduce BEVs in Canada in the next few years. The price of these cars will depend on the battery capacity, performance and design.

Where Will I Plug In?

You will be able to recharge your electric vehicles using a standard household outlet. Public charging stations may soon be available, too. Quick-charging stations could let you charge your car in as little as 30 minutes.



More Information

If you want to learn more about advanced vehicle technologies, including hybrids, PHEVs or BEVs, you can visit Transport Canada's ecoTECHNOLOGY for Vehicles (eTV) website at **www.tc.gc.ca/eTV**.

eTV's website contains videos, animations and in-depth technology articles. You can also find detailed test plans and reports on the latest technologies.

About ecoTECHNOLOGY for Vehicles

Transport Canada's ecoTECHNOLOGY for Vehicles (eTV) program is helping to reduce the environmental impacts of passenger vehicles by working with manufacturers to acquire and test advanced vehicle technologies and by reducing barriers to their introduction in Canada.

About Pollution Probe

Transport Canada gratefully acknowledges the input of Pollution Probe in development of this document.

Pollution Probe is a Canadian charitable non-profit environmental organization that works in partnership with all sectors of society to protect health by promoting clean air and clean water. Established in 1969, Pollution Probe is a national organization that has a broad science-based policy program in the areas of climate change, transportation energy, air quality, chemical management and water pollution.