

Vehicle Fuel Costs per km

Type of Vehicle	Fuel	Cost Before Tax	Cost Including Tax	Lost Fuel Tax Revenue
Honda FCV (Fuel Cell Vehicle)	Hydrogen (from natural gas)	9.4 cents/km	9.4 cents/km	2.41 cents/km
Toyota Corolla	Gasoline	5.35 cents/km	7.76 cents/km	-
Toyota Prius HEV	Gasoline	3.89 cents/km	5.64 cents/km	0.66 cents/km
PHEV-30	Electric/ Gasoline	2.24 cents/km	2.98 cents/km	1.67 cents/km
Toyota RAV4 EV	Electric	1.14 cents/km	1.21 cents/km	2.34 cents/km

- Hydrogen manufactured from grid electricity and water via electrolysis is about double the cost of natural gas reforming (18 cents/km).
- Costs vary: gasoline \$1/litre, electricity 6¢/kWh.
- A PHEV-30 has 30 mile (50 km) all-electric range.

How do I get one?

PHEVs are not commercially available today. While several major automobile manufacturers have announced aggressive plans to develop and sell PHEVs over the next few years — in some cases as early as 2010 — they are only available today as vehicle conversions. The demand for these conversion kits is high, and some kit manufacturers will only sell to governments, utilities, and research agencies. The cost of these kits ranges from less than \$10,000 to greater than \$30,000. Installation of a kit will typically void the vehicle manufacturer warranty, and should be regarded as an experimental procedure due to the newness of the technology. It would be reasonable to expect an incremental cost of less than \$5,000 for early manufactured PHEVs, depending on battery size.

Additional Information

For additional information about PHEVs, please visit the internet sites listed below:

- Manitoba Hydro:
www.125mpg.com
- PHEV2007 Conference, Winnipeg:
www.pluginhighway.ca
- The California Cars Initiative:
www.calcars.org
- Plug-In Partners:
www.pluginpartners.org
- Plug-In America:
www.pluginamerica.com
- Hybrid Consortium:
www.hybridconsortium.org
- Green Car Congress:
www.greencarcongress.com



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Plug-In Hybrid Electric Vehicles (PHEVs)

www.125mpg.com

www.pluginhighway.ca



The Plug-in Hybrid Electric Vehicle (PHEV) has the potential to change the way Manitobans travel and commute within the next decade by dramatically lowering gasoline consumption and substituting it with lower cost renewable electricity.

A PHEV is a plug-in battery electric vehicle that also has a gasoline engine to improve range, performance, or both. A PHEV offers most of the environmental benefits of a clean battery electric vehicle without giving up the ability of a gasoline vehicle to refuel away from home if necessary.

Ordinary Hybrid Electric Vehicles (HEVs) run on 100% gasoline, getting all of their electricity from a generator via the gasoline engine. PHEVs are different. PHEVs have electrical plugs and can get over half of their energy from electricity by plugging into any ordinary 120 Volt outlet overnight. When a PHEV battery eventually runs down, the driver does not need to worry because the engine will start up and the vehicle will operate like an efficient HEV.

PHEVs in Manitoba

Manitoba Hydro: On August 14, 2006, EnergyCS, an engineering company based in Monrovia, California, converted a Manitoba Hydro Toyota Prius to a PHEV, one of the first utility



owned PHEVs in North America. The stock 1.3 kWh nickel metal hydride battery was replaced with a 9 kWh Valence phosphate based lithium-ion battery, allowing either 50 km of pure electric driving or 80 km of electric assist at 150 mpg, then 60 mpg with the discharged battery. New control electronics, a battery charger, and a plug were also installed.

University of Manitoba: On April 11, 2007, Hymotion of Toronto, Ontario, a subsidiary of A123Systems of Watertown, Massachusetts, converted a University of Manitoba Toyota



Prius to a PHEV. A self-contained 5 kWh A123 nano-structured, phosphate based, lithium-ion battery system was added in parallel to the stock Prius battery, allowing either 30 km of pure electric driving or 50 km of electric assist at 150 mpg, then 60 mpg with the discharged battery. A plug was also added.

Both of these PHEVs are part of research to:

- Test PHEV characteristics and dependability under Manitoba's four-season ambient conditions.
- Investigate strategies to heat the cabin of the car without operating the gasoline engine.
- Assess the operational impacts and the effects on the Manitoba electricity supply system.
- Compare an unmodified Toyota Prius with the PHEVs under similar conditions.
- Investigate compatibility with vehicle to grid technology (V2G).

Why PHEVs?

PHEVs represent a significant advantage over other near term alternatives to conventional gasoline and diesel internal combustion engine vehicles, particularly in Manitoba. This is due to:

- Low electricity rates.
- Renewable hydroelectricity.
- Very high electrical energy efficiency of battery storage. Out performs hydrogen four-to-one.
- Relatively low cost of the technology.
- Rapid advances in modern batteries (that are still continuing), improving performance, recharge speed, range, durability, and cost.
- Low requirement for new electrical generation.



A province-wide fleet of PHEV vehicles charging overnight would only require filling the nighttime dip in electrical demand.

- Immediate availability of the technology to solve problems such as energy security, global warming, and pollution.
- A PHEV with 40 km all electric range would save half of the gasoline burned in a gasoline hybrid and two thirds of the gasoline of a standard car.
- Most of the infrastructure is already in place, from electrical (generation, transmission, distribution, and block heater plugs) to gasoline.
- Capable of providing a bridge to other technologies, such as pure battery electric vehicles (through incorporating ever larger batteries and lower gasoline consumption) or such as alternative fuels to gasoline (eg. ethanol or biodiesel).

What about the batteries?

Battery technology is advancing at a very rapid pace — mostly driven by the demands of modern power tools and electronics — and the pace is accelerating. Modern batteries, such as lithium-ion or nickel metal hydride, can hold several times the electrical energy of the well known lead acid starter battery still found in the average new car, and responsible for the old misperception that electric cars are slow or unreliable.

Many of the old battery problems are disappearing or have disappeared. Phosphate technology has removed the problem of lithium-ion fires. Nano-technology is allowing a new generation of batteries that can be charged within 5 or 10 minutes — just like fuelling with gasoline. Very cold weather operation (-40°C) is less and less of an issue. Several battery chemistries have demonstrated that they can last the life of an ordinary vehicle or longer — which they need to, because electric vehicles are generally more durable and last longer than ordinary vehicles. Even the old lead acid battery is being reinvented as a light weight, cold weather capable, fast charging battery.

The only problem that remains with batteries is the cost, and that is also continuing to drop. With mass production, PHEVs should compete with gasoline.

Vehicle to Grid (V2G)

V2G is a proposed communications and coordination technology that has the potential to improve electric utility operations by allowing the utility to control the charging and discharging of a plugged-in vehicle's battery. Normal moment to moment electrical system instabilities and time of day peak shifting can potentially be handled through the manipulation of hundreds of electrified vehicle batteries that are plugged in at any time, in exchange for payments or lower charging rates. Besides making the electrical grid more efficient and reliable, studies show that V2G may enable the possibility of connecting much greater amounts of intermittent or variable renewable generation (such as wind or solar) than is currently feasible.