All-Electric

Mitsubishi iMiEV in Manitoba

Summary of Operational Experience: Second Year Report

Prepared by the Electric Vehicle Technology & Education Centre,
Red River College, in cooperation with the Energy Division, Manitoba
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Objectives and Reporting

In 2011 the Government of Manitoba began the testing of commercially-available electric vehicles.[1] The overall objectives for testing have been to understand the practicality and public perception of using electric vehicles in our climate conditions, and to publicize and demonstrate the benefits of these vehicles. The primary intent of this and other reports prepared on electric vehicles is to be able to address a variety of practical questions that potential users may have in considering the purchase of such vehicles. As such, this report is deliberately organized according to a series of questions clustered into four areas, regarding: operation; maintenance; economics; and overall suitability. Information in this and other reports is also being shared with respective automobile manufacturers to hopefully help them make their vehicles better in the future.

Introduction

MOU on Electric Vehicles

The Government of Manitoba signed a Memorandum of Understanding (MOU) with Mitsubishi Motor Sales of Canada (MMSCan) in April 2011 regarding electric vehicles, with a key part of this collaboration being the testing of two all-electric iMiEVs for a three-year period.[2] Annual reports on experience with the two vehicles are being prepared at the end of each of the three years. Testing was started using two European-version vehicles on April 20, 2011. A report on their first year operation from April to April was published in September 2012. The operation of these vehicles continued through the second year until May 21, 2013, when they were returned to MMSCan. As such, this second year report covers 13 months using the European-versions. Further testing during the third year of operation until April 2014 will involve two replacement North American versions of the iMiEV.

iMiEV Vehicle Specifications

The iMiEV has an unusual name that requires some explanation. The vehicle was based on the platform of a small gasoline-powered vehicle in Japan called the "i". It was adapted to operate all-electrically and then slightly renamed, adding "Mitsubishi innovative Electric Vehicle" to its descriptor.

The iMiEV is intended as an urban commuting vehicle, with the capacity to carry up to four passengers. The vehicle has some stowage space, but is not intended for any significant hauling.

iMiEV (European) Technical Specifications	
Dimensions	3.4 m long x 1.5 m wide x 1.6 m high
Curb Weight	1.1 tonnes (2,400 lb)
Turning Radius	4.5 metres
Motor	Permanent magnet synchronous; 47 kW max output; 180 Nm torque
Battery	Lithium ion chemistry; capacity of 16 kWh; 330 V (direct current)
Speed	130 km per hour maximum
Range	110 to 120 km under normal operating conditions
Energy Consumption	13.5 kWh per 100 km (under normal conditions; measured at battery)

[1] http://news.gov.mb.ca/news/?item=11605
[2] http://news.gov.mb.ca/news/index.html?archive=2011-4-01&item=11325

Photograph used with permission courtesy of Mitsubishi Motor Sales of Canada.

North American iMiEV

The North American version of the iMiEV was commercially released in Canada in fall 2011, roughly six months after testing began with the two cars. The first purchase of a 2012 model year iMiEV by a private individual in all of Canada happened in Winnipeg (December 2011). The North American version of the iMiEV is slightly different, being most notably longer and wider, with some more-cosmetic differences in appearance. More information is available from the manufacturer (www.mitsubishi-motors.ca/en/i-miev/).

The iMiEV is fully electric. It has no internal combustion engine and requires no gasoline or other liquid fuel. It is recharged using grid-based electricity. This means within Manitoba it uses renewable energy and generates almost no emissions of any kind.

Specifications for the European-version iMiEVs, as used in continued testing during the second year, are summarized in the table on page 1. These vehicles are slightly different from the North American version iMiEV, which is illustrated and described in more detail in the side bar above.

Vehicle Designations

The two iMiEVs tested were each given a unique designation number for reporting purposes, but the vehicles and specific drivers were not otherwise identifiable.

The two vehicles are listed respectively as:

- Unit #AJ; and
- Unit #BA.

Licensing and Insurance

The two vehicles continued to be registered for operation in Manitoba with Manitoba Public Insurance (MPI), and were each covered under standard automobile insurance policies. During the second year, one of the vehicles was transferred to Red River College. There was nothing special required in the registration process or insurance for these electric vehicles, including the transfer of registration to Red River College. They were not practically different from conventional vehicles in this regard.

Data-Logging Devices

With permission from MMSCan, on-board data-logging systems were implemented on both of the vehicles. These involved the OTTO-Link and associated OTTO-Driving-Companion data-loggers as manufactured by Manitoba-based Persentech. The OTTO-Link provides a log of all accessible vehicle-status data at time intervals. Normally it would connect to the standard on-board diagnostic port of a vehicle. Given the nature of the European-version of the iMiEV, MMSCan provided an adaptor unit called the "CAN Gateway" that was fitted into each vehicle.

The OTTO-Driving-Companion, shown in the photograph on the next page, is a dashboard-mounted device associated with the OTTO-Link. It provides audio-enunciated feedback to drivers on both driving and road characteristics. It also acts as an autonomous data logger to generate standardized, GPS-linked trip reports about a vehicle.

Otto-Driving-Companion on dashboard

The OTTO-Driving-Companion reports were employed to quickly obtain two relevant parameters to understand vehicle-use characteristics of the two iMiEVs, specifically:

- trips per day; and
- daily travel distance.

A second monitoring device was also used, but in this case, not actually mounted on either of the vehicles. The IPLC-PM2 meter, manufactured by Manitoba-based Vantera Inc., provides the capability for interactive monitoring of electricity consumption of vehicles when plugged into the grid. These devices, as shown in the photograph above, were carried with the iMiEVs, and externally plugged-in between the vehicle's cord set and Level 1 plug-points (i.e., 110 V, 15 A) where the vehicles were being recharged.

Although vehicle range is ultimately most important for drivers to understand in the operation of an electric vehicle, range estimates can be often vague. In order to objectively address vehicle range, precise measurements of vehicle

IPLC PM2 Meter for electricity consumption

electricity consumption were taken at the wall plug under different conditions using the IPLC-PM2 device. The range of any all-electric vehicle depends directly on the available battery capacity, and on electricity consumption under the conditions of operation. As such, expected range is inversely related to any change in energy consumption, i.e., higher energy consumption means lower expected range.

Operation

What is it like to drive this vehicle?

The European-version of the iMiEV is practically identical to the original Japanese-version, except for the positioning of the driver on the left rather than the right side. These versions of the iMiEV involved the integration of advanced electrical technologies into a pre-existing platform, permitting rapid introduction of the vehicle into the market.

The iMiEV is small and obviously oriented to urban driving, but this makes sense given its intended market as a "second car" for users. During the second year of operation, the two iMiEVs were used essentially as commuting vehicles. The iMiEV was found to be well suited to this role, being small but nimble.

How is this vehicle typically used?

During the second year of operation (13 months), approximate total travel distances for the two iMiEVs were about:

- 1,800 km for Unit #AJ; and
- 5,600 km for Unit #BA

Ongoing data from Statistics Canada's annual Canadian Vehicle Survey shows that vehicles within Manitoba tend to be consistently driven an average of 16,000 km annually. Annual travel distances were lower for both vehicles than during the first year. Consistent with first year operation, the two iMiEVs were driven no more than about 35% of average distances. This corresponds to ongoing commuting travel, i.e., up to about 20 km per day travel, five days per week, for 50 weeks per year, translating to around 5,000 km. The two iMiEVs were driven at highway speeds as high as 100 km per hour, but only on selected occasions on Winnipeg's perimeter highway and never for long periods of time or long distances.

Lastly in terms of driving characteristics, the iMiEV has three selectable forward driving modes, which are summarized in the table below. The three driving modes differ

Mode Setting Function	European iMiEV	North American iMiEV
Main driving mode	D-mode	D-mode
Enhanced regenerative braking	B-mode	Eco-mode
Strong regenerative braking		B-mode
Reduced regenerative braking	C-mode	

slightly between the European and North American versions, as outlined. The two iMiEVs were operated primarily in D-mode. Specific testing of B-mode operation, equivalent to Eco-mode in the North American version, was undertaken as described later. The vehicles were almost never driven in C-mode.

How does recharging work on this vehicle, how long does it take, and how frequently do I need to charge?

The two iMiEVs are each equipped with two charging ports:

• SAE J1772-compliant port at the rear passenger-side for charging at Level 1 (i.e., 110 V; 15 A), or at Level 2 (i.e. 220 V, 20 A); and

• CHAdeMO protocol compliant port on the rear driver-side to allow for Level 3 charging (i.e. direct DC, rapid charging).

Each of the iMiEVs was provided with two cord-sets for recharging, one for Level 1 and one for Level 2, both compliant with SAE J1772. During the second year of operation, the main method for charging the two vehicles continued to be using Level 1. Charging using Level 2 is known to be faster. Nevertheless, based on experience, Level 1 charging continued to be satisfactory for both vehicles, and took advantage of broadly available, low-cost plug-points.

In the North American version of the 2012 model iMiEV, released before the beginning of the second year of testing, charging at Level 1 is restricted to a current of 8.0 A. The cord set for the European version of the iMiEV, as tested, did not have the same current level restriction. As such, depending on voltage, the European-version iMiEV would charge at a rate in the range of 1.3 kW to 1.5 kW, or roughly 40%

faster than the 2012 North American iMiEV. This represents a significant difference between the vehicles.

The time required for full recharging at Level 1 was tracked during a winter test (described later), when both cars were driven to full-depletion at very cold conditions. Full recharging of the European-version iMiEV required about 13.5 hours. Neither car in regular operation was typically driven to full-depletion, except for a few deliberate tests. As such, as long as Level 1 was available for a typical 12 hour overnight period, i.e. from 6:00 PM to 6:00 AM, these iMiEVs could be fully charged under practically all circumstances.

As also described later, the Level 1 charger was found to draw in the range of 1.4 to 1.5 kW. A typical block heater plug-in also typically draws in the range of 1.0 to 1.5 kW. As such, at least during winter months, the electrical requirements for recharging the iMiEV are not significantly different from what would be already used by a conventional vehicle for block heating.

During warm months the iMiEVs certainly did not need to be recharged every night. During colder months it was found to be prudent to recharge the vehicles every night. This was to ensure that maximum possible energy was available on-board if required.

A dedicated home-based Level 2 charger represents an additional cost for the owner, likely in the range of $1,000 to $2,000 depending on circumstances.

Although Level 2 certainly allows faster recharging, the decision of an owner to implement Level 2 is not a matter of necessary, but rather convenience. The iMiEV also incorporates a port for Level 3 charging as a standard feature, as noted earlier. This was never used on either vehicle. Level 3 charging stations based on CHAdeMO protocol are still relatively rare, with none currently within Manitoba, and are extremely expensive to implement.

What happens if the vehicle runs out of battery energy while driving?

The iMiEV has a state of charge (SOC) meter on the left side of the driver display, consisting of 16 blocks, essentially one for each kWh of battery charge. On the inside of this meter is a gasoline-like fuel-pump symbol with an electric plug. As battery energy nears full depletion, the vehicle display of the iMiEV proceeds through a series of progressive warning stages. The first occurs when the SOC bar meter drops to two bars. At this point, the electric fuel-pump symbol begins to regularly flash. When the SOC meter drops to a single bar remaining, the last block of charge and the electric fuel-pump symbol flash alternately.

Baseline Energy Consumption for Electric Vehicles in Summer Operation with No Heating or Air Conditioning Involved		
Vehicle Model	**Vehicle Energy Consumption (kWh per 100 km)**	
	Winnipeg Test Results (n = 5 Replicates)	Natural Resources Canada 2012 City-based Official Result*
2011 Mitsubishi iMiEV (European Version)	16.3 ± 0.8 (Test in August 2011)	16.9**
2012 Nissan Leaf	20.2 ± 1.6 (Test in June 2013)	19.6
2012 Chevrolet Volt (Electric-only Operation)	19.9 ± 2.1 (Test in July 2012)	22.3

* Natural Resources Canada. Fuel Consumption Guide 2012. Available at: http://oee.nrcan.gc.ca/transportation/tools/fuelratings/fuel-consumption-guide-2012.pdf
Conversion equation: Electricity use = Litre equiv per 100 km x 8.9 kWh per Litre equiv

** Value for 2012 model North American version of iMiEV.

Flashing continues once all bars disappear, but the vehicle does not yet stop operating. It was found that the European-version iMiEV would continue travel a minimum of 1 km to 2 km after reaching zero bars, ensuring a driver would not be stranded.

How much electricity does this vehicle use?

Electricity use was measured for the two iMiEVs using the IPLC-PM2 meter for Level 1 charging, as described earlier. Combined with odometer changes over logged periods, this permitted calculating vehicle energy consumption in units of kWh per 100 km. This calculation method is consistent with that employed by Transport Canada as part of the ecoTechnology for Vehicles (ETV) program in evaluation of electric vehicle performance.[3]

Three different types of commercially available electric vehicles have been evaluated for energy consumption in the same way during summer operation in the vicinity of Winnipeg, with no AC or heating employed. In addition to the iMiEV, these include the Nissan Leaf and the Chevrolet Volt. Baseline energy consumption data for all three vehicles are provided in the table above, with mean and standard deviation shown, based on actual monitor data with five replicate tests for each vehicle (n = 5).

Official baseline energy consumption results for these same three vehicles have also been determined by Natural Resources Canada under conditions for city-based driving with no AC or heating employed, albeit in this case based on specific dynamometer cycle operation. These results are also included in the same table above.

Baseline energy consumption during the summer was determined for the iMiEV as part of the first year report, and indicated as 16.3 ± 0.8 kWh per 100 km (n = 5). This value for the iMiEV is significantly lower than both the Leaf and Volt, which makes sense given the much smaller size and mass of the iMiEV.

Summer-based testing with AC fully-on was undertaken during the first year, and showed energy consumption of 20.2 ± 1.1 kWh per 100 km (n = 5), or roughly 25% higher than without AC. Summer testing in 2011 also showed that energy consumption values for the iMiEV, both with or without AC, were not statistically different from results collected for electrical operation of the factory-built 2010 Toyota Prius Plug-in Hybrid Vehicle, and a 2008 Toyota Prius converted to PHEV using technology from A123Systems Inc. as part of the Manitoba PHEV Demonstration. This was not surprising given the similar masses of the three types of vehicles. Effects of cabin heating on energy consumption (and range) are discussed in the next section.

Energy Consumption for Tests of B-Mode versus D-Mode		
Drive Mode Setting	**Energy consumption at wall plug (kWh per 100 km)**	
	Unit AJ	**Unit BA**
D-mode	16.9 ± 1.6	16.2 ± 2.0
B-mode	17.8 ± 1.5	17.3 ± 3.0

[3] http://www.tc.gc.ca/media/documents/programs/i-MiEV_testplan_ENG.pdf

ANOVA for Energy Consumption in B-Mode versus D-Mode Operation

Source	df	SS	Percent Explained	MS	F-statistic
Drive mode	1	2.88	7%	2.88	0.64 (F < 1)
Vehicle unit	1	1.10	3%	1.10	0.25 (F < 1)
Interaction	1	0.01	0%	0.01	0.00 (F < 1)
Error	8	35.8	90%	4.47	

df = degrees of freedom; SS = sum of squares; MS = mean square; F-statistic = ratio of mean square for source (drive mode, vehicle, or interaction) to mean square for error.

The European-version of the iMiEV has three drive settings, as described earlier. The B-mode setting is most similar to the Eco-mode in the North American version of the iMiEV, and provides for enhanced regenerative braking. To evaluate impacts on energy consumption of driving in normal D-mode versus B-mode, the two iMiEVs were driven in a test lasting for a total of six days under summer conditions. On each day, one of the vehicles was set to D-mode while the other was set to B-mode. On each progressive day, the vehicle settings were switched. In all cases, AC or heating were minimized during operation.

This procedure permitted a 2 x 2 x 3 Analysis of Variance (ANOVA) evaluation, with two main effects tested under two conditions (i.e. two vehicle units and two drive-mode setting), and with three replicates for each case condition. Energy consumption data (at the wall plug) from the tests are summarized in the table on page 5, with mean and standard deviation shown for each case based on three replicates.

At first blush, the values for B-mode operation appear to be somewhat higher, however the ANOVA, presented in the table above, shows that there were no significant statistical differences between either the two vehicles under either of the driving-modes employed, or due to interaction of these main effect variables. F-statistics were less than one in all cases, showing no effects. At least for the European-version of the iMiEV, there appeared to be no difference in energy consumption when B-mode was used in preference to D-mode. As such, in this case the overall resulting mean energy consumption for all these cases was calculated as 17.1 ± 1.9 kWh per 100 km (n = 12). Although appearing somewhat higher than the value listed on page 5, this was also not statistically different from earlier results for the iMiEV. Further testing of the Eco-mode versus normal D-mode in the North American version of the iMiEV will be considered during the third year.

How well does this vehicle operate in the winter?

Operation in Manitoba's winter conditions is a challenge for all vehicles, including those that are electric. During first year operation, significantly higher energy consumption and shorter travel-range were experienced during the winter. Such winter operational characteristics, thus, were not a surprise to drivers during the second year.

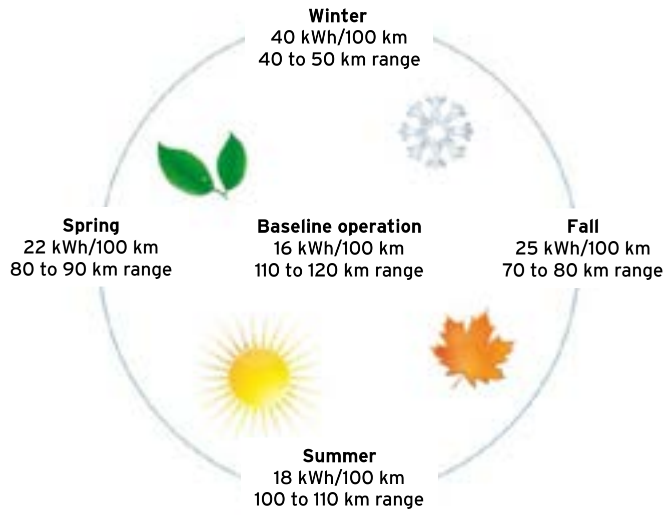
In order to fully test the limits of the vehicles, both iMiEVs were driven continuously to full-depletion on two different occasions covering a range of winter temperatures. This was the first time vehicles were deliberately tested to full-depletion, a method later adopted for other vehicles as well. On one of these occasions, one of the iMiEVs was driven at an average temperature of -29°C. This is literally the coldest verified operation of an electric vehicle within Manitoba (excluding any proprietary testing operations), and is lower even than the recommended operating temperature as outlined by MMSCan.

Travel Distance Results for iMiEVs in Winter Drives to Full-Depletion

Date	Temperature (°C)	Travel Distance to Full Depletion (km)	
		Unit #AJ	Unit #BA
January 21, 2013	-29		41 km
January 22, 2013	-26	38 km	
February 21, 2013	-14		49 km
February 22, 2013	-15	49 km	

Under these conditions, the vehicle operated satisfactorily, albeit with significantly reduced range.

In both cases the same driver used both vehicles on sequential days, and covered generally the same route. The vehicles were operated solely in D-mode, with all necessary heating systems operational, including: main heater; driver-seat heater; and rear-window defogger. Given the need to keep windshields clear, in all cases heat from the main heater system was directed almost entirely to the windshields. This did leave the rest of the cabin colder.



Travel distance results are summarized in the table on page 6 and were consistent for similar temperatures. At the lower temperature range, averaging around -27°C, the vehicles covered an average distance of about 40 km, while at the temperature of around -15°C, the vehicles both traveled 49 km. As such, the winter travel range for the iMiEV could be reasonably indicated as 40 to 50 km.

The heating systems continued to operate on both vehicles up until the point when the charge indicator was depleted to zero bars. At that point, the heater cut out, and both cars rapidly began to cool off. Both vehicles continued to travel at least 1 to 2 km after the zero bar point was reached, and with no main heater operating. This meant that drivers could continue to drive for a short distance and not be stranded, albeit limited by driver comfort, i.e., it became too cold for the driver, particularly cold feet.

Also important, the 12-volt systems of the vehicles appeared to continue operating throughout. All instrument displays and the heated driver seat continued to work. This was even after the main-battery was depleted to zero.

The intended end-point for these drives to full-depletion was the CARSI building at Red River College, i.e., to permit recharging inside. However, due to other work ongoing at the site on one occasion, one of the vehicles ended up having to be charged partly outside and then partly inside. The rate of charge was measured and noted to be somewhat lower when the car was outside in the cold. Outside, the mean charge rate was 1.4 kW ± 0.4%, while inside, the mean charge rate was 1.5 kW ± 0.7%. Although obviously statistically different, the difference in rates of charge was not practically significant.

For the coldest travel at -29°C, with distance of 41 km, energy consumption at the wall plug for the car was measured to be 43.7 kWh per 100 km. Previous testing without heating or cooling loads, as noted earlier, had established baseline energy consumption as approximately 16.3 kWh per 100 km. Winter operation thus was roughly 2.68x higher than summer (i.e., 43.7/16.3). Given baseline travel of approximately 110 km on a single charge in the summer for the car, the expected travel range was calculated from energy consumption to be 41.1 km (i.e., = 110 km/2.68), almost exactly the same as the actual travel distance achieved. This result confirmed the validity of estimating available travel distances using the ratio of energy consumption to baseline conditions.

How far will this vehicle travel (on a single charge), particularly in the winter (i.e., range by season)?

The electricity consumption and resulting range of the European-version iMiEV depended significantly on the season. Any combination of heating and/or cooling would have an impact. Based on experience with the vehicle so far, rough estimates of seasonal energy consumption and associated travel ranges were determined, as presented in the figure above. These values provide preliminary guidelines on what could be expected for the iMiEV, based on a single charge. The anticipated range could be extended by additional plugging-in, such as at work. Additional plugging-in is most important during winter months when expected range is significantly reduced. The expected-range data, as presented, will be updated in future reports as more experience is obtained, in particular for the North American version of the vehicle.

Are there any important issues to be aware of in the operation of this vehicle?

The iMiEV in general has been the first commercial electric vehicle into the market. It became available in its European or Japanese format significantly before others. This speed to market was facilitated both by its small and basic nature, and its being adapted from an already-existing gasoline vehicle. Also, compared to other vehicles, the overall priority of the vehicle systems appeared oriented toward practical operation, rather than passenger comfort.

For some drivers, the iMiEV continues to represent a simple and fun vehicle to drive. On the other hand, for a majority of drivers, its more-basic nature, especially compared to more well-appointed competitors such as the Nissan Leaf and Chevrolet Volt, has been viewed as its main draw-back. When the iMiEV was the only electric vehicle available, it was a true novelty. But, now, newer and better performing electric vehicles have been coming into the market.

Maintenance

What maintenance is required for this vehicle?

The extent of maintenance required for electric vehicles tends to be much lower than for conventional internal combustion engine (ICE) vehicles, but appropriate maintenance is still required, i.e., they are not completely maintenance free. This represents a saving both in terms of convenience and economics. This situation was borne out with the iMiEVs during the second year of operation.

The practical longevity of batteries is a key issue for electric vehicle operation that still remains uncertain. MMSCan, like other electric-vehicle manufacturers, currently offers an eight year battery warranty for their North American version iMiEV. At the same time, there is insufficient long-term experience yet to be able to predict how long batteries may actually last. This uncertainty has been reflected in the economic evaluation (next section) by including differences in the assumed resale value of electric versus conventional vehicles. Although several drivers noted a distinct pleasure in being able to drive past gasoline refueling stations, the iMiEVs were still occasionally taken to such stations, notably for windshield washer fluid purchases and car-washes.

What battery degradation would be expected, both seasonal and long-term?

Over the second year of operation, there was no noted degradation of the main battery for either of the iMiEVs.

How long will the batteries last, and will replacement be required?

The practical longevity of batteries is a key aspect for electric vehicle operation that still remains uncertain. Insufficient long-term experience exists yet to be able to predict battery life. This uncertainty has been reflected in the economic evaluation (next section) by including differences in the assumed resale value of an electric versus conventional vehicle.

Economics

What does it cost to purchase an electric vehicle?

From earlier economic assessment of electric vehicles it is known that their economics depend most sensitively on the purchase price.[4] The European-versions of the iMiEV, as tested, are not available here, but, as noted earlier, starting in late 2012, the North American version of the iMiEV became available.

Comparative Current Operating Costs

Vehicle	Fuel Consumption	Operating Cost	Annual Operating Cost
iMiEV (all-electric)	26 kWh/100 km	$2.50 per 100 km	$220
Average conventional car	15 Litres/100 km	$19.50 per 100 km	$2,160
Efficient conventional car	8 Litres/100 km	$10.50 per 100 km	$1,150

Assumptions: gasoline price of $1.20 per Litre; electricity price of 7¢ per kWh; and annual travel of 12,000 km

[4] http://www.rrc.mb.ca/files/file/appliedresearch/preliminaryeconomicreport.pdf

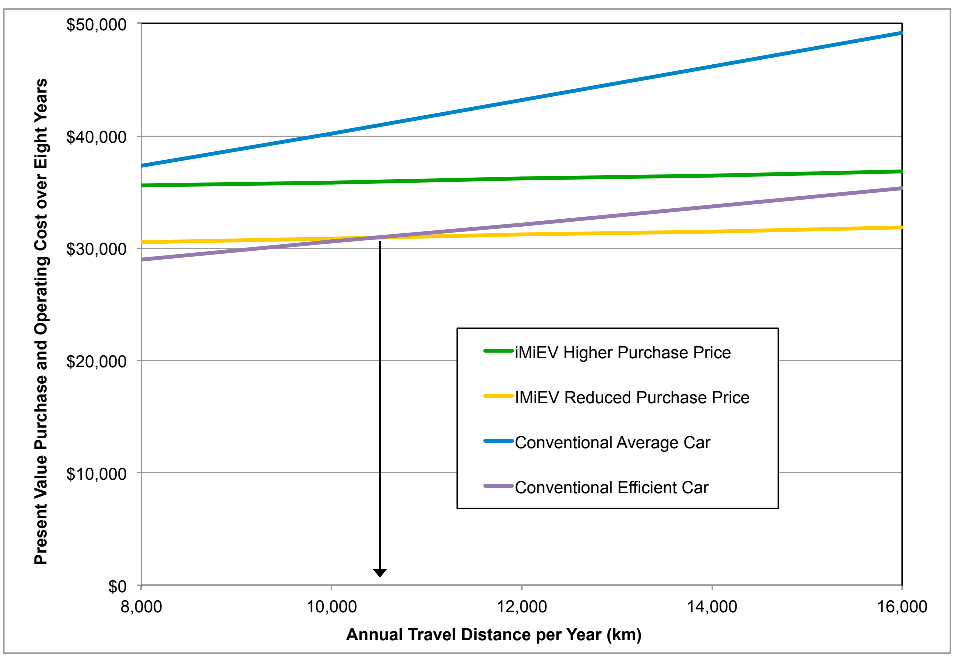
Economic Feasibility Assessment Assumptions	
Mitsubishi iMiEV	**Conventional Cars**
Higher purchase price $33,000 Reduced purchase price $28,000	Conventional average car price $26,000 Conventional efficient car price $22,000
Annual maintenance cost $200	Annual maintenance cost $400
Energy consumption 26 kWh/100 km	Conventional average car: 15 L/100 km Conventional efficient car: 8 L/100 km
Longer term average electricity price 10¢ per kWh	Longer term average liquid fuel price $1.60 per Litre
After eight years, effectively no resale value	After eight years, higher resale values: Conventional average car: $5,000 Conventional efficient car: $3,000
Cost of money of 6%, and assumed vehicle life of 8 years. Annual travel distance treated as independent variable as presented.	

When initially released, the North American iMiEV was relatively expensive, around $33,000. At the same time, in response to changing market conditions, reductions in purchase price have occurred, in the case of these vehicles typically by around $5,000. As such, more recently the 2012-model iMiEV could be purchased for a price of around $28,000.

What does it cost to operate an electric vehicle?

The use of electricity as the "fuel" for the iMiEV results in a dramatically lower operating cost compared to a conventional vehicle. Representative operating costs are presented in the table below, comparing the iMiEV to both an average conventional vehicle and an efficient vehicle, like a conventional hybrid. Values are presented both in term of "per 100 km" basis and "annual" basis, the latter assuming 12,000 km travel per year (noting that an average Manitoba vehicle travels roughly 16,000 km, which includes a portion of longer distance trips).

The electricity consumption value of 26 kWh per 100 km was calculated as the average of seasonal values based on actual experience so far. The current cost of electricity is about 7¢ per kWh, versus about $1.20 per Litre of liquid fuel used in conventional vehicles. Even with relatively high annual electricity consumption, the iMiEV's operating cost is only about 1/10th that of an average Manitoba vehicle, and 1/5th that of an efficient vehicle. Recharging the iMiEV from a



fully-depleted condition to completely full works out to cost about $1.40. In contrast, one individual visit to a gasoline refuelling station today for a conventional vehicle typically costs more than $25. These price advantages make a compelling case for electric vehicles within Manitoba.

What is the payback compared to a conventional vehicle?

The overall economic feasibility of the iMiEV was considered based on a series of assumptions, compared to two alternatives: an average conventional vehicle powered by an internal combustion engine (ICE), and an efficient conventional vehicle (i.e., a smaller more efficient vehicle or a hybrid). Assumptions are presented in the table above. The results are presented in the figure below, in terms of the present value of total vehicle costs (i.e., purchase and operating) over an eight-year period. The iMiEV could be expected to operate much longer, but eight years was selected for analysis given it corresponds to the typical battery warranty period, including that provided by Mitsubishi.

There is still some uncertainty as to the life and costs of batteries for electric vehicles, so for this analysis, the conventional car models assumed to have a higher resale value than the iMiEV at the end of life. This is a highly conservative assumption.

It is known that the economic feasibility of electric vehicles is most sensitive to purchase price. Two cases were included: "higher purchase price" of $33,000, which reflects the initial cost of the iMiEV as announced by MMSCan; and "reduced purchase price" of $28,000, which reflects price reductions.

In earlier economic analysis on electric vehicles, the price of gasoline was used as the major independent variable. Although the economics of electric vehicles are known to be much more sensitive to changes in gasoline price versus electricity price, gasoline price has continued to increase more or less steadily, and a single average future price of $1.60 per Litre was assumed in this case covering the eight year period. The corresponding future average price of electricity was assumed as 10¢ per kWh. For analysis of the iMiEV, the major independent variable was assumed as the annual travel distance by the vehicle, ranging from 8,000 km annually, reflecting basic commuting only, to 16,000 km annually, which is the average travel distance for all cars within Manitoba.

As illustrated in the figure on page 9, the iMiEV has a lower total cost over eight years than a conventional average vehicle at any travel distance and even with the higher purchase price. More relevant is the comparison to a lower cost, more efficient conventional vehicle. As illustrated, with the higher purchase price, the iMiEV is overall more costly for any travel distance, but when the reduced purchase price is considered, the iMiEV has a lower cost for annual travel distances exceeding about 10,500 km. As such, for many prospective vehicle purchasers today, depending on user characteristics, the iMiEV represents a good choice economically, not even considering any of its environmental benefits.

Overall Suitability

What are the most suitable users for this type of vehicle?

The iMiEV is essentially an urban commuting vehicle. The suitable annual travel distance would involve urban driving in the range of 10,000 km to 12,000 km annual, sufficient to economically attractive, but not to push the limits of the vehicle.

How does one determine if a particular operation or style of use is suitable for an electric vehicle?

In order to help evaluate suitability of the iMiEV, a series of relevant user characteristics are provided as a guideline in the table below.

Suitable User Characteristics for the iMiEV All-Electric Vehicle
Need to carry up to only four passengers at a time.
Limited luggage or cargo hauling requirements.
Drive roughly 200 km per week on a regular basis throughout year, including daily commuting and additional use.
Little if any highway travel (vehicle can travel on highway but not extensively).
Available dedicated driveway, garage, carport, or parking spot with at least Level 1 plug-in point available.

Electric Vehicle Technology & Education Centre (EVTEC)

EVTEC at Red River College is responsible for applied research and innovation projects concerning ground transportation electric and hybrid vehicles that utilize renewable fuels, including bio-diesel (used for auxiliary systems, such as on-board heating, ventilation and air conditioning). EVTEC has a mission to: support electric vehicle (EV) innovation amongst Manitoba's transportation sector; enhance electric vehicle education at the College and in the region; and increase public awareness of electric vehicle technology.

Contacts

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