Migration to Electric Vehicles

Submission to
New Brunswick Select Committee on Climate Change

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Foreword

Green house gases (GHG), mainly carbon dioxide from the burning of fossil fuels, are causing the heating of the planet at an alarming rate. At the current atmospheric concentration of over 400 parts per million the global average temperature may well exceed 1.5C above pre-industrial times even if we stopped burning fossil fuels today. The effects of global warming (aka “climate change”) are now obvious to even the layperson as increasingly severe storms, droughts, and heat waves pound us. If the Arctic permafrost starts to release its huge stores of methane, then the resulting feedback loop may cause us to lose any control of the global warming process. There is no question that climate change is threatening the lives of our children, our grandchildren and the generations to follow.

A problem as complex as global warming needs a multi-faceted approach for reducing GHG including renewable power generation, better building heating efficiency, urban design which supports walking/biking over driving, improved public transit, electrification of transportation and more. In this paper the focus is on supporting the electrification of transportation by switching to electric vehicles. Many sources have been drawn upon in the preparation of this document including those listed in the references section plus the personal experience of driving a fully electric Nissan Leaf in New Brunswick for the last two years.

Introduction

In 2014 New Brunswick produced 14.9 Mt (CO_2 equivalent) of green house gases. Of those, 13% (1,870,000 tonnes) came just from the exhausts of light-duty on-road vehicles. This is due, at least in part, to the fact that New Brunswick has the the highest dependence on personal vehicles in Canada at over 1.6 vehicles per household, That dependence has resulted in over 1/2 million light-duty vehicles in New Brunswick which are driven, on average, over 16,000 km each year.

Transitioning to electric vehicle (EV) technology can be used to eliminate most of those emissions from light-duty on-road vehicles. This paper examines the current state of EV technology, its ability to reduce GHG emissions in N.B., the actions needed to support a transition to EVs in N.B. and how the transition would benefit the N.B. economy.

Electric Vehicles

In the context of this paper, “electric vehicle” or “EV” describes a vehicle which is propelled, at least part of the time, by an electric motor and can be registered for normal use on public roadways. The most common types of EVs include hybrid electric vehicles, plug-in hybrid electric vehicles, and battery electric vehicles.

The *hybrid electric vehicle* (HEV) has been on the road for many years The best selling model in this group is the Toyota Prius of which over 9 million have been sold during the last 20 years. This type of EV reduces emissions by capturing energy normally thrown away during braking. The energy is stored in a small lithium-ion battery for later use by an electric drive motor. All of the power still ultimately comes from burning gasoline or diesel in an internal combustion engine so this is, at best, a weak stop-gap measure on the road to low-carbon.

The *plug-in hybrid electric vehicle* (PHEV) adds the ability to charge the hybrid's battery from the electric grid. The ability to charge from an external source plus a bigger battery means that the driver can take short trips completely or almost completely using electricity only. The internal combustion engine automatically takes over when the battery is exhausted giving the vehicle a range similar to a typical gasoline/diesel vehicle. The GM Volt is one of the most popular PHEVs on the North American market today with over 100,000 sold.

The ultimate EV is the *battery electric vehicle* (BEV). It contains no internal combustion engine but relies solely on an electric motor and battery. The cradle-to-grave GHG emissions of a BEV are the best of any motorized vehicle. The maintenance costs are much lower since electric drive trains are much simpler and have none of the service items required by an internal combustion engine. Many drivers appreciate the quiet superior performance of the electric motor as well.

BEVs are the best choice (see *Electric Vehicle Comparison* table below) to reduce GHG. Examples include the Nissan Leaf with a range of up to 170 km with over 220,000 in global sales and the highly

regarded luxury Tesla Model S with a 350-470 km range. While their adoption has been limited by a high purchase price and a limited range on non-luxury models, large improvements in both price and range are on the way in the form of 320+ km range non-luxury vehicles like the GM Bolt (late 2016), Tesla Model 3 (2017) and Nissan Leaf (2nd gen, 2018). (see Appendix A – Falling Cost of Battery Electric Vehicles)

Electric Vehicle Comparison

	Hybrid (HEV)	***Plug-in Hybrid (PHEV)***	***Battery EV (BEV)***
GHG Reduction	Fair	Good (driver dependent)	Excellent
Fuel Cost	Good	Better	Best
Maintenance Costs	Good	Good	Excellent
Affordable Long Range Ability	Yes	Yes	Coming in 2016

Owning a Battery Electric Vehicle (BEV) in New Brunswick

Two years ago my wife and I purchased a new Nissan Leaf. The 2014 Leaf has a range of 100-140 km on a single charge. Over the past two years we've driven our Leaf year-round including many trips from New Maryland to Saint John and some longer trips to Charlottetown PEI and Halifax NS. Here are some of the things we learned:

1. We both love driving the Leaf. Our gasoline car is known for being quiet reliable, and comfortable, but the Leaf quickly became the preferred car for us both.
2. The quietness of the Leaf was initially surprising and quickly spoiled us for cars with an internal combustion engine.
3. Knowing that the Leaf does not produce a toxic exhaust is uplifting especially while driving or stuck in traffic.
4. The Leaf is cheap to drive. In 2015 we travelled over 16,000 km which required 2,900 kWh of electricity. Thanks to some free public chargers we didn't have to pay for it all. Even if we had, the power for whole year would have still only cost $350, about a $1,000 savings over gasoline.
5. We no longer have to spend time to drive to a gasoline station, to wait for our turn at the pump, to fill the tank and to make our payment. Now we take a few seconds to plug in when we park at home. The Leaf automatically charges while we sleep.
6. Trips longer than travelling from Fredericton to Saint John (100 km) are excessively time consuming since there are no high-speed chargers in the province.
7. On winter mornings we can remotely preheat the Leaf while it's sitting in the garage with the door closed since there is no exhaust. In the summer we can pre-cool it.
8. Many times while travelling, we charged the Leaf by simply plugging it into a regular household outlet overnight.
9. The more we drive an electric car the less we want to drive a gasoline car.

GHG Reduction

A battery electric vehicle is a zero-emission vehicle. If the electricity used to charge the battery is generated solely from clean sources, such as photovoltaic solar panels, then total ongoing GHG emissions are essentially zero. The only indirect emissions caused by a BEV are those produced when generating electricity needed to charge its battery.

Even though NB Power still generates some power using coal and oil, driving a BEV using the New Brunswick power grid can greatly reduce total GHG emissions. NB Power's (2014-2015) power generation produces about 360 grams of GHG for each kWh produced. Driving a Nissan Leaf 16,000 km would generate 0.96 tonnes of GHG.

The average annual distance driven by drivers in New Brunswick is 16,000 km. The average fuel efficiency achieved by New Brunswick drivers in 2014 was 10.6 L/100km. A litre of E10 gasoline produces 2.12 kg of GHG from its fossil fuel content. So the average driver in New Brunswick annually produces 3.6 tonnes of GHG. **That means that currently a BEV provides, on average, an annual GHG reduction of 2.6 tonnes per vehicle.** This amount will continue to improve as NB Power shifts power generation to renewable sources.

GHG savings are likely to be initially better than average because a battery electric vehicle is so inexpensive to drive. It is quite likely that high (double N.B. average) mileage drivers will make up a large portion of the early BEV drivers. **In this case, replacing 10,000 vehicles with BEVs would reduce carbon emissions in New Brunswick by over 52 kt (52,000 tonnes) annually**. If early adopters drive 3 times the N.B. average then over 78 kt of GHG savings would be realized each year.

Other Environmental Benefits

In addition to being an excellent way to reduce GHG emissions, battery electric vehicles provide some other very nice environmental benefits such as zero local air pollution, and reduced noise pollution.

Replacing cars with BEVs reduces air pollution. The exhaust of both gasoline and diesel engines has been linked to health problems including lung disease and cancer. According to Health Canada, “in 2007, transportation sector emissions represented about 27% of Canada's total emissions inventory. Pollutants caused by fuel combustion include particulate matter, nitrogen oxides, volatile organic compounds, benzene, metals and sulphur dioxide, among others; many of these contribute to the creation of smog.” A BEV emits none of these. Also, as BEVs proliferate, the possibility of being stuck behind an exhaust belching black/blue/white smoke will disappear.

Electric motors produce very little noise, especially compared to gasoline engines which are designed to create thousands of explosions per minute. That said, a BEV is especially quiet when stopped (BEVs do not idle) and when accelerating. Also, BEVs have no exhaust to break or customize so the

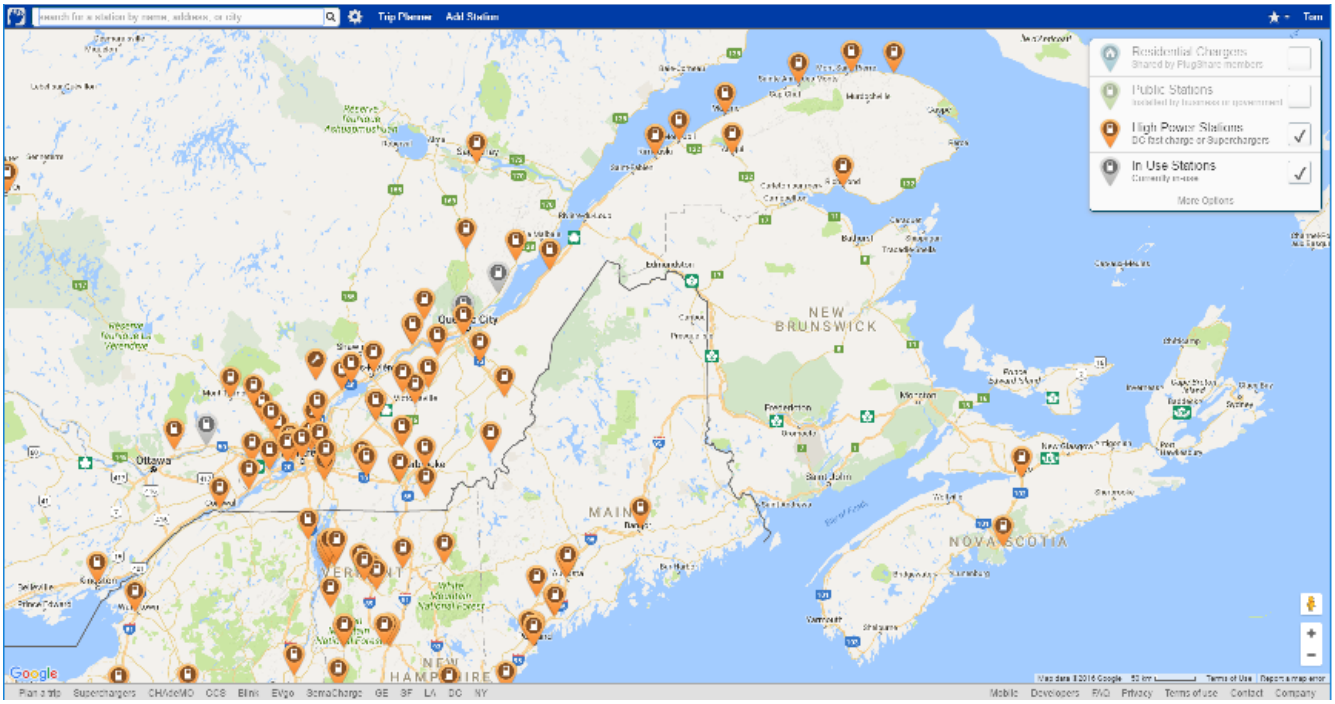
exceptionally noisy vehicles will disappear as gasoline/diesel vehicles become obsolete.

Economic benefits

The early adoption of battery electric vehicles will position New Brunswick to benefit both economically and environmentally. BEVs are far more efficient and inexpensive to run than their internal combustion engine counterparts. That means any business which migrates from gasoline/diesel to BEV transportation will become more efficient, more profitable, and better positioned to create more growth and jobs. Taxis, delivery services, travelling sales people, entrepreneurs and any businesses with employees who frequently drive represent some of the likely early adopters.

Part of that economic benefit comes from the work of creating of a comprehensive charging infrastructure which encourages and supports the use of BEVs. As shown on the following map, neighbouring jurisdictions are already investing in high-speed chargers. High-speed charger facilitate long-distance travel so are a key part of a charging infrastructure.

High-Speed EV Charger Locations



Starting the adoption of BEVs now will position businesses to benefit from the advantages of the reduced fuel and service costs of electric transports. BEV technology is already being deployed in heavy duty transport applications. BYD (China) produces BEV buses which have been chosen by Washington State (USA) for both highway and intra-city use. Nikola Motor Company (USA) plans to start production of big rig transports this year.

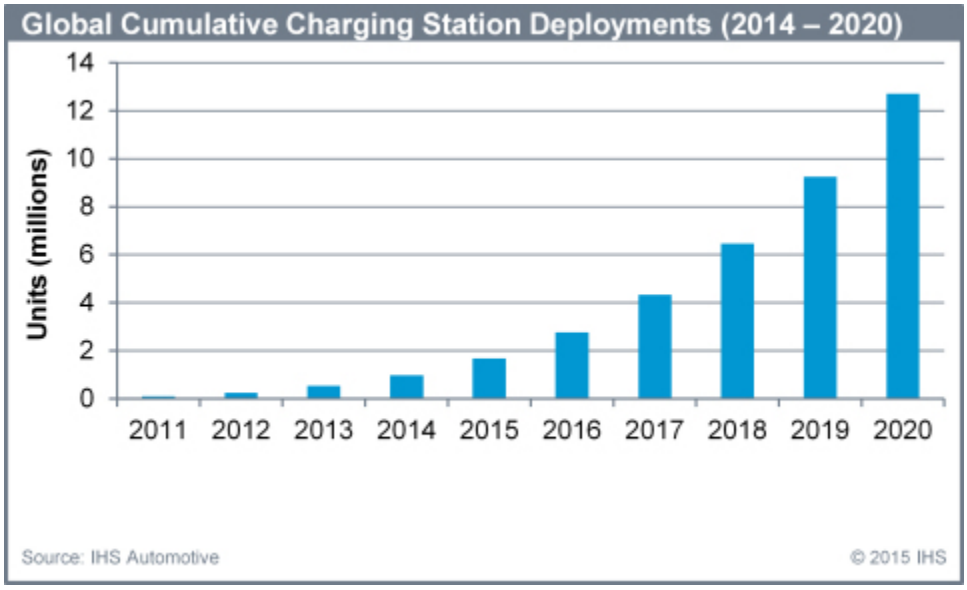
The Opportunities Summits Summary Report (July 2016) by the New Brunswick Jobs Board Secretariat contains several references to required improvements to the transportation infrastructure. Supporting the electrification of the N.B. transportation sector may provide both cost relief and improvements related to those requirements.

The use of BEVs would give NB Power a boost in revenue even while reducing costs for drivers. This new revenue is likely to precipitate little incremental cost in power generation for the utility since BEVs are designed to be able to automatically charge during off-peak periods. New Brunswick drivers, on average, drive their personal vehicles about 16,000 km per year. Early adopters of BEVs will likely be high mileage drivers so the first 10,000 BEV may generate more than $6 million in additional revenue. Also, the smart grid technology currently being researched by NB Power could reduce power generation costs by using BEVs to reduce peak power demands. Of course, these benefits will only be realized if there is a sufficient uptake in BEVs.

The reduction in air pollution is likely to also have a positive effect on healthcare costs. Health Canada reports that "As a fuel, gasoline can negatively affect our health both before and after combustion." The NB Lung Association, Health Canada, Canadian Medical Association (CMA), Environment and Climate Change Canada and the OECD are just a few of the organization which warn about the impact to health effects of air pollution. A 2008 study produced by the CMA reported that air pollution in N.B. caused 54 acute premature deaths, 4,392 emergency room (ER) visits, and 24,312 doctor's office visits in 2008.

Lastly, New Brunswick has both the telecommunications capability and the skills to grow a industry of companies which monitor and manage charger networks. The increase in BEVs in North America has pushed the growth of EV charger networks. The number of public chargers in the USA jumped from 541 in 2010 to 30,945 in 2016. Chargers are often installed on a communications network so they can be monitored for usage, payments, patron assistance and problem detection. Examples include FLO (flo.ca), ChargePoint (chargepoint.com) and Blink (blinknetwork.com). Some studies suggest the size of the EV charger industry will be $8-12 billion by 2022.

Global Projected Growth in EV Chargers



Migration Action Plan

So if battery electric vehicles are so great, why are there so few of them in New Brunswick? There are three main barriers: unfamiliarity, lack of chargers, and an above average purchase price. The solutions for overcoming these barriers are not overly complicated but they do require a concerted effort.

1) Educate

New Brunswickers are highly dependant on personal transportation. Independence, security, and economic well-being often revolve around having access to a personal vehicle, especially for people in rural areas. It's no surprise that people will only switch to a new type of vehicle when they are comfortable, confident, and secure in its success.

People need to feel confident about making a dramatic change like switching to electric vehicles. Their confidence will be boosted by increasing their understanding of how an electric car would work for them, test driving an electric vehicle in a non-sales environment, and talking to others in their community driving BEVs. Demonstrations, presentations, and information booths at malls, public events, local markets, on-line, etc. are some of the ways to deliver on these needs. The education effort should initially focus on high-mileage drivers such as rural or inter-city commuters, who would see the highest economic return from driving a BEV. Lastly, the education process itself must be regularly updated since improvements in EV technology are happening very quickly.

2) Deploy Both High Speed and Destination Chargers

On most days the vast majority of people drive within a very small area. They commute to work, pick up groceries, run errands, etc. within the same region, town, or city. Many studies (USA based) have concluded that the vast majority (~90-95%) of people's driving needs can be handled by a BEV with a 100 km range. The problem is the other 5-10%. People want a car that can be taken on a 1,000 km road trip even though such a trip may only happen once a year. New Brunswickers are also very social folks who like to regularly visit friends and family who live more than 100 km away.

Long-distance travel with gasoline cars requires a big enough gas tank and plentiful gas stations along the way. In a similar fashion, long-distance travel with battery electric cars need a battery with sufficient capacity and plentiful high-speed charging stations. Today's non-luxury BEVs have a 100-170 km range. Any travel beyond that range means stopping for a charge or charging at the destination before the return trip. Currently all of the public chargers in New Brunswick only support normal speed charging which can take a hour and a half to complete a 50 km charge.

The soon to be released GM Bolt, Tesla Model 3, and Nissan Leaf (2nd gen) will all have a range of 320 km or more. They are expected to start production during the next two years. That range supports convenient long distance travel if high-speed charging, that is, fast-chargers and/or super-chargers, is

available. High-speed chargers need to be deployed throughout the province to allow residents and tourists to charge at convenient locations along the way. Locating high-speed chargers conveniently near coffee shops, restaurants, etc. gives drivers and their passengers a place to have a quick break and give the local economy a boost.

A charger is referred to as a *destination charger* when it charges at a normal speed which requires hours rather than minutes. This speed is usually quite sufficient when the driver has reached their destination rather than stopping along the way just to charge. Examples of good places for destination chargers include employee parking, shopping malls, restaurants, hotels, and public parking. Access to this type of charger can be quite useful for supporting BEV drivers who regularly drive to a location, such as work, which is outside of their round-trip range. Even a regular household 110 volt outlet can be useful for destination charging, especially if the car is parked overnight or for a full work shift.

Destination chargers make travel even more convenient for BEV drivers. Forward-thinking retail businesses are installing destination chargers to attract customers. For example, Amsterdam Inn and Suites has installed a charger at each of their locations in Fredericton, Sussex, Moncton and Quispamsis. Amsterdam Inn and Suites, like many businesses, do not even charge for the service since the cost is minimal. Installing destination chargers at work provides employers with an inexpensive way to support green transportation. Educating businesses and providing incentives for charger installations would support the convenience and adoption of BEVs.

Types of EV Chargers

Type	50 km Charge (Hours)	270 km Charge (Hours)	Example Locations	Costs
Regular 110 Volt Outlet	8	N/R	Houses, apartment parkades, employers, tourist accommodations	Cheap
Normal Charger (6 kW)	1 1/2	9	House, apartment parkades Employers, tourist accommodations, public parking, retail	$1,000+ $6,000+
Normal Charger (16 kW)	1.5	3	Tourist accommodations, public parking, retail	N/A (Tesla installed only)
Fast Charger (40-100 kW)	< 1/4	1/2 – 1 1/2	Public parking, retail centres, highway rest stops	$30,000+
Super Charger (120-145 kW)	< 1/4	1/2	Public parking, retail centres, highway rest stops	N/A (Tesla installed only)

3) Offer Purchase Incentives

Financial incentives have been shown to be an effective tool to help people move to battery electric vehicles. Incentives which have been successful in other jurisdictions include a one-time cash amount to reduce the purchase price, a tax-free purchase, a low-cost lease, a reduced registration fee, car pool lane access, and free access to toll roads. Maximum incentives should apply for non-luxury vehicles with features and utility similar to or close to that of the average vehicle. BEVs close to the luxury market should attract less incentives while luxury BEVs should attract none at all. The Ontario EV incentive program uses this strategy by adjusting the amount of incentives based on the manufacturer list price (see References).

The average price of a new car in New Brunswick is $25,000 (2014 data). The average price of new light-weight vehicles (cars, SUVs, & light trucks) in N.B. is $34,000. At $37,000 the purchase price of a new 2016 Nissan Leaf SV with a 170 km range exceeds the average price of a new vehicle by $3,000 and the average price of a new car by $12,000. The higher purchase price prevents many people from being able to make the purchase even though it is offset by the low fuel (electricity) and maintenance costs. BEV owners can experience fuel savings of up to $1,000-3,000 annually so incentives only need to make up a portion of this difference.

Incentives are only required to start the migration. Familiarity with battery electric vehicles and access to a comprehensive charging infrastructure will decrease the need for incentives over time. In addition, the difference in price between BEVs and gasoline cars will eventually disappear. Some market analysts predict that within the next 7-10 years the purchase price of BEVs will become directly competitive with comparable gasoline vehicles. Even before that happens, the need for incentives will disappear. (see Appendix A – Falling Cost of Battery Electric Vehicles)

Summary

Faster and faster global warming is stealing our planet and our children's future. The electrification of the New Brunswick road transportation sector can play a major role in reducing GHG as well as positioning the New Brunswick economy for the future.

Electric vehicles are available now and work well in New Brunswick. Affordable 320+ km range battery electric vehicles will be introduced to the market this year and more are expected to follow quickly in 2017 and the year after that. They will provide businesses with a new tool for increasing efficiency and reducing costs while helping to safeguard the New Brunswick environment.

Action is needed now to prepare New Brunswick to take full advantage of electric vehicles including education, deployment of chargers and the provision of purchase incentives. Electric vehicles will help fight global warming, improve N.B. competitiveness, and make N.B. an even healthier place to live.

Appendix A – Falling Cost of Battery Electric Vehicles

Two car manufacturers, Tesla and Nissan, are currently leading the BEV market. Their success is causing many others to scrambling to catch up. Many long range BEVs, for both luxury and mid-level markets, have now been announced by manufacturers such as GM, Ford, VW, BMW, Mercedes-Benz, Kia, Hyundai, Audi, and others.

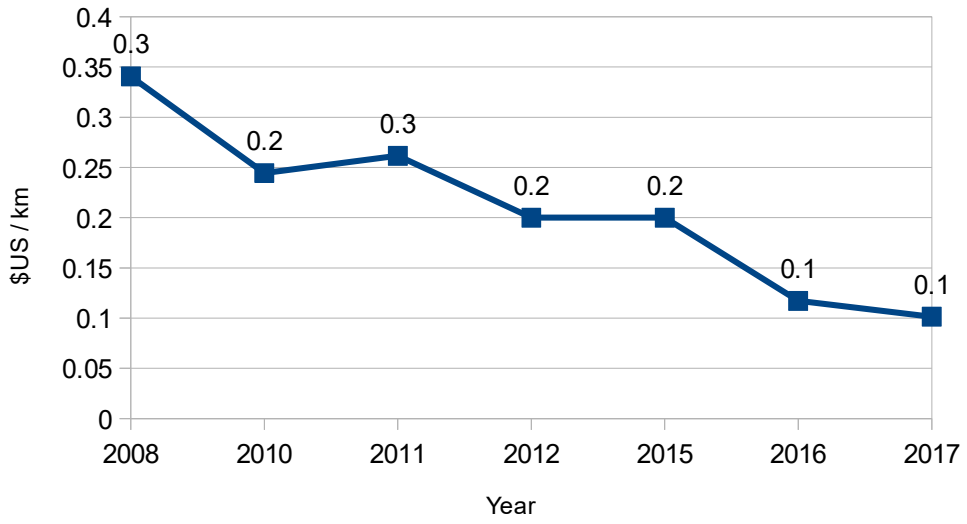
For those drivers not ready to make the transition to a car without a gasoline/diesel tank, many manufacturers have also announced new or improved plug-in hybrids (PHEV). For example, 2016 GM Volt provides up to 85 km of electric range. Most commuters are likely to find this sufficient for their daily travel without burning gasoline. Of course, these cars will continue to need the usual maintenance required by an internal combustion engine such as oil changes, filters, spark plugs, etc. Although PHEVs can reduce GHG, they are a stop gap measure compared to the zero-emissions BEV.

The cost of BEVs is falling and is expected to continue falling because battery costs are falling. The most expensive component of a BEV is the battery so the total price of the vehicle is heavily influenced by battery costs. The International Energy Agency (iea.org), Bloomberg New Energy Finance (bloomberg.com), Nature Climate Change (nature.com), and others have published predictions showing the continued and rapid drop in the price of EV batteries. **Based on falling battery prices and efficiency from large scale production, Bloomberg now expects that BEVs will reach price parity with gasoline/diesel cars within seven years (2023).**

BEV Range vs Price

Year	**Model**	**Price ($US)**	**Range**
2008	Tesla 2-seat Roadster	109,000	320
2010	Nissan Leaf hatchback	33,000	135
2011	Mitsubishi i-Miev hatchback	34,000	130
2012	Tesla Model S hatchback	66,000	330
2015	Nissan Leaf hatchback	34,000	170
2016	GM Bolt hatchback	37,500	320
2017	Tesla Model 3 sedan	35,000	345
2018	models expected from several manufacturers		320+

BEV Range Cost Trend



Appendix B - What about Hydrogen?

Electric vehicles (EV) also include a category of vehicle which uses a tank of compressed hydrogen as the main energy store rather than a battery. These are known as fuel cell vehicles (FCV). The fuel cell component in a FCV uses hydrogen to create electricity which is then used to power an electric motor.

The primary advantage FCV have over BEV is a faster refuelling time. The fastest chargers so far still require 30-60 minutes to fully recharge the battery in a BEV. Refilling the hydrogen tank of a FCV requires about the same amount of time needed to refill the tank of a gasoline/diesel vehicle.

While having the advantage of quicker refuelling, FCVs have a long list of disadvantages:

1. Most hydrogen is produced using a fossil fuel: natural gas.
2. The energy requirements to create, compress, distribute, and convert to electricity make hydrogen 2-3 times more expensive as a fuel source than simply charging a battery.
3. The hydrogen molecule is very small hence difficult to contain.
4. Hydrogen is explosive and burns with an invisible flame.
5. FCVs must fill from a hydrogen filling station. Most of the time, BEVs are charged overnight at home.
6. A FCV must have access to a hydrogen filling station locally and where ever it goes. A BEV can be easily charged at home and, given enough time, anywhere else with a basic electrical outlet.
7. Estimates for installing a hydrogen filling station range in the area of $1–2 million dollars. Estimates for high-speed BEV chargers are roughly in the $30-60 thousand dollar range.

One of the largest proponents of fuel cell vehicles is the automotive giant Toyota. Toyota has worked on the development of FCVs for 23 years and invested several billions of dollars. As of May 2016 only 210 of Toyota's flagship FCV, the Mirai, have been sold in the US and all of those were sold in California, the only state with hydrogen filling stations.

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