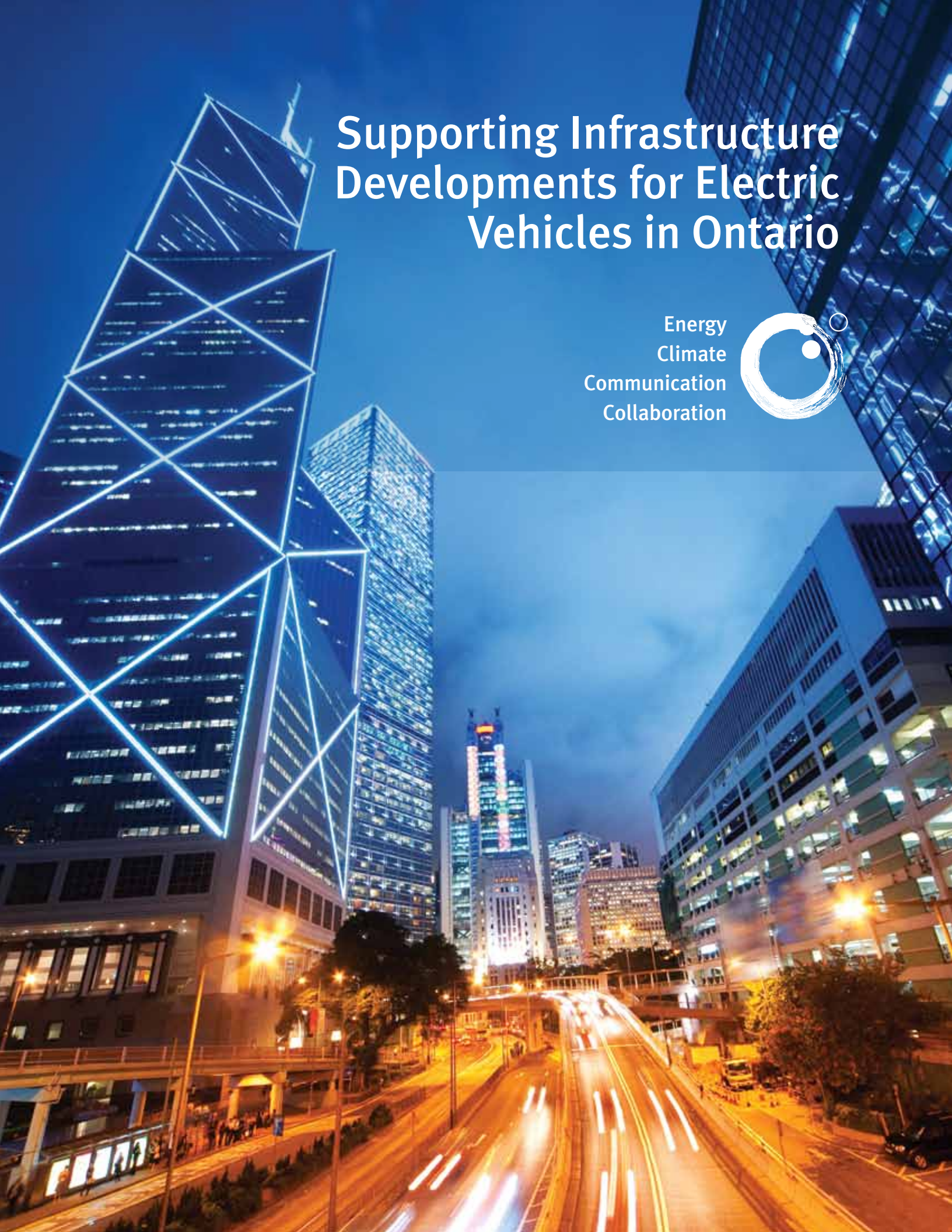
Supporting Infrastructure Developments for Electric Vehicles in Ontario

Energy
Climate
Communication
Collaboration



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Key Terms

The following terms and acronyms are used throughout this report. These definitions provide context for how they are used in this document.

Electric Vehicles (EVs) A ground vehicle propelled by a motor that is powered by electrical energy from rechargeable batteries or other source onboard the vehicle, or from an external source in, on, or above the road-way. For the purposes of this report, Electric Vehicles will only refer to developments in the automobile.

EV Infrastructure Refers to the charging stations that will interface with EVs, structural design of the spaces dedicated to EV, the application of renewable energy technology where appropriate and electric grid interface.

EC3 The concept of organizing around Energy, Climate, Communication and Collaboration. This is the working title of an industry leadership initiative to facilitate information transfer and dialogue around strategies for sustainability.

EC3 EV Infrastructure Workshop The Event on March 10, 2010 in Toronto Canada hosted by the EC3 Initiative where over 90 leaders from the automotive, home building, utility, and government sectors came together to review EV developments and consider infrastructure requirements for Ontario.

Smart Grid An upgraded version of the electrical grid that is internet-enabled to be communicative and responsive, maximize efficiency and optimize demand and supply, while lightening the environmental impact of electricity production and transmission.

Acknowledgements

This report would not have been possible without the dedicated focus of Anna Palamarchuk of Waterfront Toronto. Anna's efforts to compile the research referenced in this report, organize the notes from the EC3 Electric Vehicle Infrastructure Workshop (March 10, 2010), and work with me to coordinate the writing is very much appreciated.

Leadership support from Debbie Baxter, VP at Loyalty One has been a crucial factor in EC3 success to date. Debbie's dedication to environmental initiatives is to be commended and I appreciate her continued efforts to establish a green economy for Canada.

Thanks to Anthony Watanabe and his team at Innovolve for their partnership in hosting the EC3 Workshop and to Bernard Hellen of traffic marketing + design for the continued professionalism and quality of graphic design displayed throughout this document.

I would also like to take this opportunity to dedicate this report to my good friend Patrick Guran, Chief Conservation Officer, PowerStream. Patrick's direct support for my activities over the years has had a lasting, positive impact on my career and I have thoroughly enjoyed our efforts to advance Energy Conservation and Demand Side Management in Ontario.

Andrew Bowerbank

Design: traffic marketing + design inc., www.trafficdesign.ca
Photographs: John Pepelnak, iStockphoto.com, Toronto Archives

Executive Summary

Only 2 to 5 percent of vehicles being designed and built today are currently taking advantage of alternative fuels and new plug-in electric technologies. Although these percentages are increasing rapidly, particularly with the rising interest in fuel efficiency following the economic downturn, there is much to be done to encourage the uptake of this under-used technology. For a start, we must begin to break down occupational "silos" and learn to communicate across sectors to achieve true market transformation.

The EC3 Initiative recently hosted the Electric Vehicle Infrastructure Workshop on March 10, 2010 with a primary objective to do just that – facilitate cross sector engagement. Industry leaders representing automotive, construction, and utility sectors came together through the EC3 Workshop to review the advancements in plug-in electric vehicle technology and consider strategies for market adoption through buildings and infrastructure. Discussions led to the conclusion that pilot projects designed to test electric vehicle technology and improve market awareness and confidence in Ontario would be needed before infrastructure commitments could be established.

This Report will provide a synopsis of the main issues raised by industry leaders at the EC3 Workshop; case studies to reference as we consider strategies for public integration; and an overview of pilot projects under consideration to promote consumer confidence and spur market uptake. Preceding the review of Workshop discussions, the Report will provide a brief overview of electric vehicles, including the benefits, challenges, and a review of the current marketplace.

Ontario's target is to have electric vehicles make up 5% of all cars in the province by 2020.[25]

The rate of development of electric vehicles and associated technologies, including battery technology, is enormously exciting. I have no doubt that as we develop the necessary supporting infrastructure, and as carbon comes to be priced properly into the global economy, the advantages of electric vehicles are going to become more and more apparent.

The UK is strongly committed to this emerging technology, which is one reason, no doubt, why Nissan plans to produce 50,000 electric cars a year at its British plant from 2013.

ANTHONY CARY, *BRITISH HIGH COMMISSIONER FOR CANADA*

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Introduction

I find historical developments in the automotive sector fascinating to study. Lessons learned through this dynamic sector can be an effective mechanism to support efforts for market transformation towards a low-carbon economy. At the turn of the 20th century, the electric vehicle (EV) was about equal in quantity on the roadway to vehicles driven by the internal combustion (IC) engine. The problem for EVs at the time was the limited range of the battery but it was a quiet vehicle, simple to start and easy to operate.

IC engine vehicles on the other hand were noisy and smelly but the range allowed people the freedom to travel great distances. Vehicles driven by IC engines were also very difficult to start; in fact, it was this difficulty that held back the technology. As an example, doctors were wary of the "kick-back" produced by the external hand crank starter; it had a reputation of breaking thumbs due to this kick-back, something physicians could not tolerate in their profession. Women at the time were also leery of the difficulties in starting IC engines since fashion and social etiquette restricted their ability to apply the physical effort required.

Then a gentleman by the name of Charles Kettering invented the electric ignition system in 1911 for the IC engine, eliminating starting concerns. Add to this breakthrough technology the fact that Texas crude oil was inexpensive and the improvements in roadway development made automotive transportation comfortable. Each of these improvements contributed to the market shift that led to the IC engine dominance we identify with today.

We are now beginning to revisit the benefits of electric motors in our vehicles and not just by independent product developers but by the leading car manufacturers around the world. This renewed interest towards electric vehicles is also bringing about a market shift that affects multiple sectors. In the near future, a car will be able to plug into a house and draw energy from the grid. The days of industry developing products within independent sectors are evolving to consider strategies that can bridge cross-sector opportunities (in this case, transportation, buildings, energy) in support of new technology applications.

This Report reviews an example of how industry leaders in Ontario, Canada are beginning to collaborate in support of electric vehicle development. Next step objectives are to establish a number of Pilot Projects that can demonstrate the interaction of electric vehicles through urban, suburban, and transit corridor applications. How quickly we establish these Pilot Projects will depend on the leadership interest to support innovation. If we work together we can use these opportunities to advance the Province's smart grid and clean technology objectives, build consumer confidence to support market adoption, and provide home builders & property developers with the tools needed to incorporate EV technology into new community development strategies.

Andrew Bowerbank

Founder and Chief Strategy Officer, EC3 Initiative
Founding Executive Director, World Green Building Council Secretariat (2007-9)
Hon. Board Member, Canada Green Building Council GTA Chapter (2006-10)
Board Member, EcoSmart Foundation

Background on Electric Vehicles

The internal combustion engine was widely adopted in the late 1850s when engineering advances in commercial drilling and production of petroleum began. Presently, petroleum products powering internal combustion engines provide 95% of the world's motorized movement.[1]

Although this technology has served us well until now, concern about climate change, poor air quality, and the rising cost & importing of oil, has shifted our thinking to new ways of moving people and goods.

Electric vehicles have become part of this new shift, gaining increasing popularity over the years as manufacturers develop vehicles ready for the market. Electric vehicles represent a step towards sustainability, using less energy, and causing less pollution, noise, and emissions overall.

Although there are no tailpipe emissions from electric vehicles, there can be emissions resulting from the generation of electricity itself. In Ontario, the energy supply is generated from both non-emitting sources such as hydro, nuclear, and wind, as well as sources challenged by carbon emissions, such as natural gas and coal. Adding renewable energy sources to the supply mix is a great opportunity to achieve significant emission reductions associated with EVs, and address the potential increased energy demand EV technology could place on the electricity grid. It should also be noted however, even if initially the electricity is not sustainably produced, the generation can become sustainable... without the need for changes in the transport system. Electric mobility is inherently sustainability ready.[2]

Shell expects electricity-powered vehicles to account for as much as 40% of the worldwide car market by 2050.[3]

PETER VOSER, *CHIEF EXECUTIVE OFFICER, ROYAL DUTCH/SHELL*

FleetWise EV300 Project

The Toronto Atmospheric Fund (TAF) is the City of Toronto's climate change agency dedicated to greenhouse gas emission reduction. Toward this goal, the FleetWise EV300 project was developed, which aims to position Toronto and the GTA as a leading adopter of electric vehicle technology by accelerating hybrid and electric vehicle solutions for public and private fleets. The program facilitates standardized data collection and information sharing with respect to cost and performance issues for fleet managers. FleetWise EV300 also works with municipalities, utilities, the Province of Ontario, public and private fleets, non-profit organizations and technology manufacturers to develop a local plan for deploying EV charging infrastructure in homes, offices and public areas.[4]

The first FleetWise project, the Plug-in Hybrid Electric Vehicle Pilot was designed to test the performance of these vehicles in fleet use. The Pilot Project found that overall vehicles produced only a marginal increase in fuel efficiency (10%), which resulted in greenhouse gas emissions being reduced by 6%. However, when there was sufficient charge in the battery to run on the electric motor, vehicle fuel efficiency jumped to a 35% improvement with a 20% reduction in greenhouse gas emissions. This result "speaks volumes about the need for better access to charging infrastructure".[5]

CASE STUDY

Washington State

Washington State recently signed into law the Green Highways bill which will help accelerate the development of electric vehicle infrastructure and the use of electric vehicles. The bill requires certain regional and state agencies to seek funding to establish electric vehicle infrastructure in publically available off-street parking lots. The bill also calls for recharging outlets in each state-operated highway rest stop by the end of 2015. Specific provisions are also made to encourage the development of electric vehicle infrastructure not only on, but adjacent to major highways, as well as to compel state and local governments to convert their fleets to either electric fuel or bio-fuel by June 2015.[6] These aggressive efforts demonstrate the type of leadership required to promote the development of electric vehicles. This bill provides great momentum and inspiration for other jurisdictions like Ontario to follow.

CASE STUDY

Infrastructure

Electric vehicles have the added benefit of being largely "*infrastructure ready*" with the majority of charging done at night in residential garages. This provides a unique opportunity that surpasses experiments such as ethanol fuel which requires an elaborate system of resources and infrastructure for growing, collecting, drying, fermenting and burning. Ethanol fuel has also been criticized for issues related to increased food prices, land use impacts, water and fertilizer use, and the energy and pollution balance of the cycle of production. Converting ethanol into electricity for charging electric cars however, is a more effective strategy than transforming the biomass into biofuel. In fact, it would be 80 percent more efficient and twice as effective at reducing greenhouse gas emissions, according to a study published in *Science*.[7]

Hydrogen fuel cell technology is equally challenged in terms of infrastructure readiness. Although hydrogen facilities exist close to population centres, access to hydrogen is not widely available for purposes other than commercial use. The California Hydrogen Highway is one example of an initiative designed to offer refuelling stations across the state. Although several stations are in operation, three have already been decommissioned, putting into question the viability of the technology long-term.[8]

Furthermore, it is often argued that hydrogen fuel cell vehicles are inherently inefficient. This is due to the fuelling process, which consists of generating hydrogen, transporting it long distances, getting the hydrogen into the vehicle, and running it through a fuel cell – all for the purpose of converting the hydrogen back into electricity to drive the same motor that would be found in an electric vehicle. "Thermodynamically, each additional step in the conversion process decreases the overall efficiency of the process".[9] In addition to these inefficiencies, hydrogen fuel cells are not yet cost effective. "As of October 2009, *Fortune* magazine estimated the cost of producing the Honda Clarity at $300,000 per car".[10]

In addition to being "*infrastructure ready*", the Canadian marketplace is "*socially ready*" for the infrastructure requirements of electric vehicles. This is because much of the population is already familiar with plugging in block heaters overnight or before driving to help start engines in cold weather. Recharging electric vehicles, especially in a residential setting requires a similar process, making Canadians a great market for mass acceptance.

Bridging Technology

Beyond the advantages previously noted, electric vehicles also make a very good bridging technology. As the range and composition of electric batteries improve over the coming years and market leaders strive to build consumer confidence, market uptake will support further technology advancements to offset the transportation sector's dependence on oil.

> Once we get to the electric car, we can then make truly big gains with the environment by improving how the electricity is generated.[11]
>
> DENNY MOONEY, *SENIOR EXECUTIVE AND ENGINEER, GENERAL MOTORS*

The *Electric Vehicle Technology Roadmap for Canada* identifies the following three types of highway-capable vehicles that are part of this new shift in mobility.[12] These vehicles represent a transition in technology with an ultimate goal of the all-electric vehicle.

Hybrid-Electric Vehicles

These vehicles rely primarily on an internal combustion engine supported by electric power. Referring to the hybrid vehicles currently produced by most major automotive manufacturers, these cars reduce fuel consumption by allowing the IC engine to shut off at low speeds or when idling and by capturing energy through braking.

Plug-in Hybrid Electric Vehicles

There are two versions of PHEVs. One is labelled "Plug-in Hybrid" and the other is "Extended-Range Electric". Both versions have an electric-drive with an IC engine for traction or generation and, when stationary, can accept electric power from the grid.

- **Plug-in Hybrid**

  This is a conventional hybrid vehicle with a large battery pack. For heavy acceleration and high speed, the gasoline engine kicks in to provide added power. Their large battery packs allow them to rely more on electricity than conventional hybrids do.

- **Extended-Range Electric**

  This vehicle represents a radical departure from conventional hybrids. The wheels in these cars are turned only by a large electric motor. The electric motor also provides enough power during heavy acceleration and high speeds. For short trips, the motor runs on battery power alone, with a gasoline powered generator that kicks in to supply electricity (specifically to charge the battery) for longer trips.

Plug-in Electric Vehicles

These vehicles are electric-drive vehicles that do not have an on-board IC engine and can accept electric power from the grid. Typically, batteries are used to store electricity on board, although they can do so by other means.

Battery Development

The cost and limitations of batteries, which historically have been large, expensive and heavy, are seen as the major obstacles to broad scale acceptance of electric vehicles. In fact, it is noted in the *Electric Vehicle Technology Roadmap for Canada* that improved and advanced battery technology is the key element in the viability of the EV industry. Currently, the main challenges with batteries include energy storage and range, weight, service life, and cost.

Energy Storage and Range

Electric vehicles have the disadvantage of low energy density, meaning that batteries provide less energy than their gasoline counterpart, often resulting in shorter vehicle range, higher battery cost, and an increase in weight. For example, the energy density of gasoline fuel is approximately 45 mega-joules per kilogram, compared to the density of a nickel metal hydride battery (the type most commonly used in HEVs) at about 0.25 mega-joules per kilogram. As a result, conventional vehicles are able to travel further on a full tank of gas than electric vehicles can on a fully charged battery. Increasing battery size to off-set this shortcoming results in increased battery cost and weight and decreased energy efficiency. However, lithium-based batteries, which are presently undergoing development for use on a large scale, have twice the energy density as nickel metal hydride batteries. Lithium batteries are currently the technology of choice, representing great potential for improved energy storage performance in future electric vehicles.[13]

Weight

Concern over the weight of current battery technology is a major issue that engineers are striving to address. If batteries can be made lighter, the higher energy density would improve design options and increase range between charges. As mentioned above, lithium-based batteries offer a substantial upgrade over current battery options. In particular, lithium-air and zinc-air batteries (as detailed below), are undergoing extensive research, suggest strong potential in the realm of energy density and weight.

Service Life

The lifetime of a battery is one of the most important features of its performance. This includes both calendar life, which refers to the operating lifetime of a battery, and cycle life, which refers to charge-discharge cycles.

In terms of calendar life, preliminary measurements of lithium batteries suggest that a 10-15 year calendar life can be met; however, this will need to be demonstrated in real-world applications. The same life span of nickel-metal hydride batteries may also be achieved based on anecdotal evidence that many 10 year old Toyota Rav4-EVs are performing well on their original batteries. In terms of cycle life for hybrid vehicles, the battery is recharged each time it is activated via the generator, which is driven by the IC engine. EVs and PHEVs however, are subject to fewer, but deeper, charge-discharge cycles.[14] Optimizing both calendar and cycle life of batteries will be required to create consumer confidence and ensure that electric vehicles capture a significant share of the automotive market.

Cost

Batteries can cost up to 50 percent of the total vehicle cost. This cost, in addition to the cost of electricity over the life of an EV, is higher than the current lifetime gasoline costs. Lithium batteries, which are only now emerging from the prototype stage of development, have not yet experienced cost reductions from economies of scale. Currently, the cost is approximately $800 - $1200 per kilowatt hour, in contrast to the target for a mass-produced and cost-effective battery of $400 - $500 per kilowatt hour. In line with the anticipated cost reductions over time, it is suggested that the cycle life of batteries will also improve. As this happens and as gasoline prices increase, it is estimated that "the break even point" for EVs could occur between 2012 and 2018. In addition to battery costs, EV components must also decrease (by a factor of two or three) to be competitive with conventional vehicles.[15]

Battery Options

As batteries evolve to meet the consumer demand for electric vehicles, their improved efficiencies will become a key factor in the uptake of this growing market. An overview of the key battery technologies for electric vehicles follows.

Nickel-Metal Hydride (NiMH)

This battery has commonly been used in the first generation of hybrid electric vehicles. It offers a number of advantages over the nickel cadmium battery, including higher energy density, less memory effect (which reduces a battery's ability to hold charge), and contains materials of lower toxicity.[16]

Lithium

Lasting longer and weighing less than the NiMH battery, lithium batteries are widely believed to be the technology most likely to power EVs in the near future. There are two common types of lithium batteries. The first is the lithium-ion battery, which can store more energy and generate more power per unit volume than that NiMH battery. The second is the lithium-ion polymer battery, which is cheaper to produce and more durable than the lithium-ion battery. However, it operates at a higher temperature, causing potential safety issues.[17]

According to research cited in the *Technology Review* from Stanford University and Hanyang University in Korea, silicon nanotube electrodes, which have a higher energy storage capacity than conventional materials used, may enable lithium-ion batteries to store 10 times more charge, allowing electric vehicles to run three to four hours without recharging.[18]

Lithium Air

In addition to the technologies noted above, the lithium air batteries offer a further improvement over the lithium-ion battery in terms of energy density and weight. Currently, there is ongoing research to develop a rechargeable version of the battery and test the technology to evaluate its performance under practical scenarios. If successful, the lithium air battery could replace zinc air, lithium, and lithium-ion batteries for electric vehicles.[19]

Silver Zinc

This battery has the benefit of a water based core with no heavy metals, avoiding toxic chemicals and the potential for flammability. In addition, 95% of the battery can be recycled and reused. In fact, ZPower, a California-based company promises to buy back the batteries after they've been depleted to recycle the silver. The battery can also produce 40% more power than traditional batteries, which reduces size and weight. The cost of silver however, is the major hurdle of this technology.[20]

Zinc Air

With some concern over lithium, which, like petroleum, is a limited resource that could be depleted, the zinc air battery has attracted considerable interest. As one of the most abundant metals produced, zinc offers a cheap alternative that is able to sustain large battery production. These batteries have the "highest practical Energy Storage per Unit Weight at the lowest cost of any known battery technology", making zinc air well suited for mass market introduction. It can also be recycled and is non toxic.[21]

CASE STUDY

Burlington Hydro

Burlington Hydro, in partnership with the University of Waterloo and Transport Canada, recently announced a demonstration project of Canada's first all-electric vehicle to be used in a commercial fleet application. The pilot project will study the operating characteristics in practical, real-world working conditions, including its recharging patterns and requirements, its optimization of recharging cycles, battery state-of-health, electricity grid impacts, and overall performance.

With thousands of fleets in Ontario alone, including couriers, as well as mail, delivery and municipal vehicles, it represents a significant proportion of vehicles on the road, most of which are in daily and constant use. Therefore, using electric vehicles in this capacity could deliver major environmental benefits, cutting greenhouse gas emissions and reducing smog. Burlington Hydro's demonstration project is an important first step in highlighting this potential.[22]

Current EV Marketplace

The recent instability in the automobile industry, along with rising public desire to reduce carbon emissions, and the USA and European efforts to reduce dependency on imported fuels, has prompted a renewed interest in alternatives to oil.

As such, most automobile companies are now either producing or plan to produce some version of an electric vehicle to feed this growing market. The following section provides a brief review of recognized automotive manufacturers around the world that are developing electric vehicles, demonstrating the surge in activity in this emerging sector.

It is important to recognize that the number of manufacturers committing to electric vehicles continues to grow at a rapid pace. The EC3 Initiative will continue to work with stakeholder organizations and industry leaders to support EV technology and charging infrastructure developments.

Supporting organizations include:

- Automotive Partnerships Canada
- Clinton Climate Initiative
- Electric Mobility Canada
- Ontario Centres of Excellence
- Sustainable Development Technology Canada
- Toronto Atmospheric Fund
- Ontario Power Authority

CASE STUDY

Hawaii

The Hawaii Center for Advanced Transportation Technologies (HCATT), an agency of the State of Hawaii, organizes partnerships between the federal government and private industry to develop advanced low emission and zero emission vehicles centered on electric drive technology. Over the years, HCATT has developed and demonstrated electric vehicles and charging infrastructure. For example, the agency has entered into a partnership with the Hawaii Natural Energy Institute and Hawaii Volcanoes National Park to introduce hybrid electric buses into the park to support environmentally friendly tours for the millions of tourists that visit the park each year.[23] This is a promising step in deploying electric vehicles in heavily used areas such as national parks.

Automobiles

BYD F3DM

Chinese automobile manufacturer BYD has unveiled the world's first mass produced plug-in hybrid compact sedan that features an electric motor powered by a lithium-ion battery and a one litre Internal combustion (IC) engine. The vehicle (F3DM) can recharge the battery by braking, in line with conventional hybrids, as well as be plugged in overnight, meaning that the IC engine may seldom be used. The car went on sale to government agencies and corporations on December 15, 2008 in China and to the general public in March 2010. The company was able to sell the car for almost 50% less than the price of Toyota's Prius in the Chinese market. The F3DM is slated to go on sale in Europe and the US in 2011.[24]

GM Volt

In November 2010, General Motors is expected to debut its plug-in hybrid Volt, with 40 miles of battery travel, compared to 13 for the Prius, and a gasoline-assisted range of more than 300 miles. The Volt uses a lithium-ion battery which can be fully charged by plugging the car into a residential electrical outlet. The car is expected to be priced around $40,000 USD with a $7,500 US federal tax credit. The Volt is being endorsed by the Ontario government. The province will purchase 500 Volts for the Ontario Public Service fleet and provide a $10,000 subsidy. This works towards Ontario's target to have electric vehicles make up 5% of all cars in the province by 2020.[25]

Mitsubishi i MiEV

Mitsubishi's new i MiEV all-electric vehicle, which uses a lithium-ion battery, was launched for fleet customers in Japan in July 2009 and for the public in April 2010 for a price of 4 million yen ($43,000 USD). After government incentives, the sale price drops to 2.8 million yen ($30,500 USD). Sales in other countries are expected to begin in October 2010.[26] The auto maker has established partnerships with officials in British Columbia for feasibility testing of the car. Under the terms of the agreement, one car would be added to BC Hydro's fleet of vehicles and one to the City of Vancouver's fleet for demonstration and evaluation purposes. The project will contribute to BC's goal of reducing greenhouse gas emissions by 33% by 2020 and becoming a leader in green technology.[27]

Daimler ED Smart Car

Daimler has been testing versions of their new Electric Drive (ED) Smart Car since 2007 featuring a range of 71 miles using a Tesla provided 14 Kwh lithium-ion battery. They have been leasing over 100 vehicles across Europe to gain real world experience. Daimler President Dieter Zetsche has stated the company has big plans for their ED Smart Car.[32]

Tesla Roadster

For those with deeper pockets, Silicon Valley-based Tesla Motors has an all-electric roadster that sells for about $102,500 after the US federal tax credit.[28] The Roadster, which is one of the few highway-capable electric automobiles available in 2010, can accelerate from 0-60 mph in 3.7 seconds and has 200 miles of battery travel. It's not only the first vehicle capable of traveling such distances per charge, but it is also the first production automobile to use the lithium-ion battery. Tesla delivered around 900 cars to customers in the United States and Europe by December 2009, with production reaching 1,000 cars in January 2010.[29]

Fisker Karma

A direct competitor to the Tesla Roadster, the Karma uses Q-DRIVE plug-in hybrid technology, developed exclusively for Fisker Automotive by Quantum Technologies. A fully-charged Karma burns no fuel for the first 50 miles. Venture further and the gasoline engine turns a generator to charge the lithium-ion battery. Once the 50 mile electric range has been exceeded, the car operates as a normal hybrid vehicle. This balance of electric and gas range makes it entirely possible that Karma drivers who charge their car overnight and commute less than 50 miles a day will achieve an average fuel economy of 100 mpg (2.4L/100km) per year.[30]

As a factory option, the Karma can be fitted with a solar paneled roof not only to aid in the recharging of its lithium-ion batteries but also to aid the cabin climate control system. The solar roof is capable of generating a half kilowatt-hour a day and is estimated to provide up to 4 to 5 miles (6.4–8.0 km) of additional range a week assuming continuously sunny days. Additionally, the car will offer a set of solar panels for the garage/house which may charge the Karma entirely 'off the grid'.[31]

> Zero-emission electric cars could shape the image of environmentally aware cities because zero local emission motoring is no longer science fiction.[32]
>
> DIETER ZETSCHE, *PRESIDENT, DAIMLER*

Audi E-Tron

The next phase of technology Audi is developing is the E-Tron electric drive powertrain system. Three concept cars exist as of March 2010 each with differing size and performance. The original E-Tron concept, first displayed at the '09 Frankfurt Auto Show is called the 'Frankfurt Showcar E-Tron'. Based on the platform of the R8, it has been scheduled for limited production. Power is provided by electric motors at all four wheels. The 2nd concept is the 'Detroit Showcar E-Tron'. Power is provided by two electric motors at the rear axle. This concept is also considered to be the direction for the R4 mid-engined, gas powered 2 seat performance coupe. The 3rd is the 'Audi A1 E-Tron' concept. Based on the new A1, it looks production ready. It is unique in that it has a range extending wankel rotory engine to provide power after the initial charge of the battery is depleted. It is the only concept of the 3 to have range extending capability. Power is sent to the road through the front wheels always using electric power.

Ford Focus RV

A prototype all-electric Ford Focus was demonstrated in August '08. Known as the Focus RV, it's planned for commercial launch in 2011 when Ford plans to have 10,000 of these cars on the road in partnership with Magna International. The Focus RV will be a global vehicle that will be sold in the three key markets of North America, Europe, and Asia-Pacific. The car can travel about 160 km on a single charge. A prototype of this car was featured on some episodes of The Jay Leno Show in the Green Car Challenge segment.

Nissan Leaf

Nissan is expected to release the first 5,000 models of its all-electric car, the Leaf, in late 2010 in five US test markets for a cost of $25,280 USD after a federal tax credit. The battery will have a range of 100 city miles, which is more than the 40 miles that the US Department of Energy estimates is needed for the majority of daily trips. San Diego, with the largest array of chargers available for public use in the US, expects to receive the largest deployment of the car. Furthermore, with the help of a federal loan, Nissan is planning to manufacture up to 150,000 Leafs annually in a new Tennessee plant.[33]

Toyota

Toyota is building on the experiences of their well known Prius hybrid vehicle and is currently undergoing worldwide tests of their plug-in hybrid system. In addition, Toyota and Tesla have teamed up and officially announced the joint development of a new EV prototype based on the Toyota RAV4 cross-over. The two companies plan to have a production version ready by 2012. The new RAV4s will use Tesla's liquid cooled lithium-ion battery configuration that contains thousands of commodity laptop cells. The first prototype is already running and a larger fleet is being prepared for durability testing by Toyota.[34]

Next Steps in EV manufacturing

Additional automotive manufacturers committing to EV development include BMW with their Mini-E, Porsche with their new 918 Spyder, Suzuki, Hyundai, and Honda. It is interesting to note that until very recently Honda was not considering EV development, choosing rather to focus on their hydrogen technology. This all changed following announcements made by Honda in July 2010 to begin production of electric vehicles. Plans include the development of a new plug-in hybrid system to be implemented in mid-size to larger vehicles.[35]

Incentive Programs

In addition to the aggressive pace at which manufacturers are developing electric vehicles, the establishment of incentive programs and EV infrastructure is also an essential step in making this technology successful. The following section demonstrates some government tax programs and infrastructure developments that are making the electric vehicle increasingly a viable option for consumers.

Government of Ontario

As a means of stimulating the automotive sector and making Ontario a leader in the green economy, the province plans to encourage the purchase of electric vehicles by providing rebates between $4,000 and $10,000 after July 1, 2010. EV drivers will be permitted to use High Occupancy Vehicle (HOV) lanes with only one person in the automobile. Public charging facilities will be installed at select government buildings, as well as in some GO Transit parking lots.[36]

United States

The US federal government has loaned Ford Motor Company $5.9 billion and Tesla Motors $465 million to manufacture electric vehicles as part of the stimulus package.[37] The hybrid electric car producer Fisker Automotive has also secured $528.7 million from the US government (Department of Energy), in addition to the $189 million in private equity funding, which they were required to obtain to receive the government grant. The funds will help the company produce a second hybrid electric model in 2012, in addition to its first sports sedan, the Karma, which is scheduled for production this year.[38]

USA Next Steps

The US House and Senate introduced bipartisan legislation titled *The Electric Drive Vehicle Deployment Act of 2010*, which would electrify half of US cars and trucks by 2030. A combination of grants, rebates and other incentives would be provided for the widespread adoption of EVs in selected pilot areas, with the initial goal of deploying 700,000 vehicles over the next six years. *The House Bill* of the Act calls for the US Department of Energy to award $250 million in grants for the pilot communities. Residents could qualify for rebates up to $10,000 on a plug-in vehicle. On a national scale, the existing $7,500 tax credit for EVs would be expanded to include larger vehicles such as commercial trucks. *The Senate Bill* of the Act also includes $1.5 million for research to develop a battery that, on a single charge, would last up to 500 miles. Both versions of the bill also increase incentives for EV manufacturers and supporting infrastructure.[39]

> Our dependence on foreign oil is costing us billions of dollars annually. Electric vehicles have the possibility to transform our economy, revive our car industry, and improve our environment. To make sure electric vehicles succeed this time around we need to invest hundreds of millions of dollars in battery technology and infrastructure.
>
> GAVIN NEWSOM, *MAYOR OF SAN FRANCISCO*

Europe

The European Commission plans to stimulate investment in charging infrastructure and EV services build-up and will issue guidelines on incentives for EV consumer purchase. At the Council meeting, France, Germany, Portugal and Spain presented a joint declaration on electric mobility, seeking to speed up the process to create a "fully inter-operable pan-European charging system". This would see plug-in systems standardized to ensure that EVs can be charged anywhere within the EU. There is also increasing support at the Member State level, with consumer purchase incentives of up to £5000 in UK, €5000 in France and €6000 in Spain being offered.[40]

Spain is also encouraging European Union industry ministers to adopt a statement calling on the European Commission to draft an action plan for electric vehicles. Although met with some opposition by those who wish to maintain a broader approach to sustainable mobility, this represents an important first step in European-wide support of electric vehicles. 15 European Union governments have already introduced incentives for buying electric vehicles, consisting of tax reductions and exemptions, as well as bonus payments. In addition, Britain is discussing opportunities with Nissan to make its Sunderland plant the European base for its new electric car, the Leaf, while London's mayor confirmed up to €17 million for electric vehicle infrastructure. France has also put funds into building a network of charging stations, as well as a plant to produce electric car batteries. Denmark is partnered with Better Place to build nationwide infrastructure and has promised no vehicle registration tax on electric cars until 2012, a tax break for early buyers, and free parking in downtown Copenhagen.[41]

China

Surging past the United States in 2009, China now has the world's largest car market. As a result, the government has begun to promote the development of electric vehicles. The Chinese government has recently unveiled a new subsidy programme which aims to boost the adoption of EVs in the country. The pilot program will initially involve five cities: Shanghai, Changchun, Shenzhen, Hangzhou and Hefei. Consumers of fully electric vehicles will be eligible for subsidies of up to ¥60,000 ($8,783), and subsidies of up to ¥50,000 ($7,320) will be available for buyers of plug-in hybrids.

> Widespread electric vehicle adoption depends on having charging stations that integrate the need for quick charging with the personal need for easy functionality.[42]
>
> STEVE FLUDDER, *VP, GE ECOMAGINATION*

CASE STUDY

Ireland

Consumers who purchase electric vehicles in Ireland will be given a €5,000 grant and will be exempt from the vehicle registration tax. The goal is to make electric vehicles competitive with the petroleum equivalent and to have 2,000 on the road by the end of 2011 and for 10 percent of cars to be electric by 2020. Dublin City Centre has already seen the first charging stations installed and the plan is to have 3,500 in place by December 2011 to make Ireland the first nation to have the whole country covered with charge points.[43]

CASE STUDY

Better Place

Better Place is an electric vehicle services provider, working to accelerate the global transition to sustainable transportation by installing and managing large networks of charging and battery exchange stations (for customers that can't wait to charge up) that give consumers the convenience and services they need to drive electric vehicles. Better Place also sources renewable energy to power the network, creating a zero emission solution. Better Place hopes to use a concept called the "Electric Recharge Grid Operator" where drivers can plug in to a charging system and pay for it through a subscription, similar to a cell phone plan. Customers would pay for unlimited miles or a fixed number of miles, or opt to pay as they go.[44]

Charging Technology

Surveys conducted throughout North America are showing that 78% of round-trip commutes conducted by consumers take place within a 64km range from the home or office.[45] This factor supports the perspectives discussed at the EC3 EV Infrastructure Workshop (March 10, 2010) where participants felt that the majority of EV charging would take place at home. Charging at home could be done through a domestic 110 volt socket but it could take up to 12hrs to fully charge a vehicle's battery. "Level 2" charging stations are now being developed for residential and commercial applications that specify 240 volts, providing a fully charged battery within 6 to 8 hours or better.

Although the home has been identified as the primary location to charge EVs, public charging infrastructure for commuters who travel longer distances than the average commute for work or pleasure will be required. Access to public charging will also be an important factor in developing consumer confidence and market awareness. For commercial and public applications, "Level 3", 600 volt (Canada) charging stations will be available that can provide a much faster charge.

These claims are making the viability of charging in public places much more attractive for the daily commuter. As technologies continue to improve, consumers could have the confidence and the luxury of plugging in their vehicles when they arrive at a local coffee shop or grocery store and return to a fully charged battery. The thought of having to divert your drive to fill up at a gas station could be considered a nuisance in the very near future!

> Product developers are now able to provide Level 3 units that can charge 80% of a battery in about 15 minutes[46] and projects are now under development that are striving to charge 50% of a battery in 3 minutes.[47]

Renewable Charging

Incorporating renewable energy into charging technology is also seen as an important step forward in the mass acceptance and uptake of electric vehicles. In fact, surveys conducted in North America have indicated that public approval and willingness to pay for EVs is closely linked with environmental benefits. "This view leads to the conclusion that if new generating capacity is required for electric vehicles, it should ideally make use of renewable sources of energy".[48] The following provides a few examples of EV charging infrastructure programs that are working with solar energy, striving to provide true zero emissions driving.

Solar Canopies

Solar canopies integrate photovoltaic technology with personal electric vehicles. Using solar panels, a canopy covering a single standard sized parking space is able to generate enough energy to power an electric vehicle for one year.[49]

Chicago was the first city in the USA to incorporate solar-powered electric vehicle charging stations for use in city fleet vehicles. The stations were designed by Adrian Smith + Gordon Gill Architects and manufactured by Carbon Day Construction. Each unit consists of a solar panel and a concealed underground battery pack.[50]

Container-based Charging Station

This is a container-box design concept of a charging station built by "Beautiful Earth Group" in Brooklyn. The solar demonstration unit is made out of decommissioned steel shipping containers and currently provides power for the company's electric vehicle, which takes three hours to charge at their station.[51]

SolarCity and Rabobank

SolarCity and Rabobank have announced a partnership to create the world's first solar-powered electric car charging corridor between San Francisco and Los Angeles. Built in cooperation with Tesla Motors, the corridor will provide a full charge in one-third the amount of time of other charging stations. SolarCity has also installed more than 100 solar home-charging stations for Tesla owners.[52]

CASE STUDY

Japan

Tokyo Electric Power is developing a recharging device that will give small electric cars enough charging during a five minute stop to travel 40 kilometres. Assuming that every 10 minute increment adds approximately 60 kilometres, the new system would be able to deliver a full charge in about one hour, which is a substantial improvement over existing technology. The devices are expected to be installed in public places such as supermarkets and parking lots. The national government of Japan is also pushing electric vehicle roll-out by encouraging cities and towns to become 'model' districts where power outlets would become available for drivers to use free of charge. A region near Tokyo has committed to installing 150 stations and will be offering incentives to EV drivers such as parking, insurance and loan discounts.[53] Japan is also joining Australia, Israel, Denmark, Hawaii and several Northern California locations in signing on with Better Place. The pilot project is currently limited to municipal fleets.[54]

Current EV Infrastructure Developments

The USA is aggressively pursuing the development of EV infrastructure. New York will be joining such cities as San Francisco, Austin, and Detroit in installing battery charging facilities for the public. The US Department of Energy (DOE), as part of the economic stimulus package, is providing much of the funding for many of the new sites.

A new project is currently underway in the USA titled the "EV project". Supported by the US Department of Energy, the goal of the project is to install over 14,000 Level 2 chargers and over 300 Level 3 fast chargers across 16 major cities. The project has over 40 partners including oil companies, utilities, energy organizations, and local governments.[55]

A large charging station is being built in Linyi City in Shandong province, China; one of the country's biggest auto producing provinces that has been developing electric cars since 2004. The charging station will be capable of charging 45 cars at a time. An additional 75 electric vehicle charging stations will be developed in 27 cities across China by the end of the year.[56]

The City of Vancouver, now requires 20% of parking stalls in new multi-family buildings to contain charging receptacles, and requires sufficient space in breaker rooms for additional electrical panels. This provides a baseline level of charging infrastructure now to support early EV adopters, as well as builds in the capacity to support future EV market adoption. Part 13 of the Vancouver Building Bylaw has been updated accordingly. These bylaw changes are intended to be responsive and dynamic and will be reviewed annually.

While changing regulations to support charging for EVs in new buildings is important, the City of Vancouver also recognizes the need to support early adopters of EVs who live or work in existing buildings and have no access to electric outlets. The City, Provincial Government and BC Hydro partnered with the Federal government (NRCAN) to fund the development of new Canadian guidelines for installing EV charging infrastructure. These guidelines offer information on costs and charging technology options, so that developers, building owners, strata councils, and fleet managers can understand their options. The City will also facilitate the development permitting process for retrofitting buildings to include charging infrastructure.[57]

Alternative Developments

Energy Replacement

An energy "replacement" system under development could offer a potential alternative to Level 3 charging. The latest generation of vanadium redox battery has an energy density similar to lead-acid batteries; however, the charge is stored solely in a vanadium-based liquid electrolyte which can be pumped out and replaced with charged fluid. The vanadium battery system is also a potential candidate for intermediate energy storage in ten-minute charging stations because of its high power density and extremely good endurance in daily use. System cost however, is still prohibitive. As vanadium battery systems are estimated to cost between $350–$600 per kW·h, a battery that can service one hundred customers in a 24 hour period at 50 kW·h per charge could cost $1.8-$3 million.[58]

Wireless Transfer

Engineers at Wasada University in Japan are collaborating with Showa Aircraft Industry on a project to replace plug-in charging stations completely. They have adapted an electric city car to charge its batteries wirelessly through inductive charging (electromagnetic fields are used to transfer energy from the base station to the vehicle's battery).

Similar technology is found in small devices like electric toothbrushes. The project envisages that charging plates would be placed in parking bays, or even on buses which could refuel as they allow passengers on and off.[59]

EC3 Electric Vehicle Infrastructure Workshop Objectives

As we strive to transition from the dominance of the internal combustion engine to electric vehicles and other sustainable sources of vehicle propulsion, one of the challenges is to establish new models of cross-sector collaboration and market awareness to advance these opportunities for progressive change.

In December 2009, the EC3 Initiative established the Plug-in Electric Vehicle (EV) Infrastructure Program.[60] This program strives to facilitate the transition to sustainable mobility by organizing innovative thinkers and encouraging new ways of working together to develop programming and market adoption of ground-breaking concepts and technologies.

As part of this program, an EV Infrastructure Workshop was held on March 10, 2010 in association with Waterfront Toronto, Ontario Centres of Excellence, the Building Industry and Land Development Association and other industry leaders to support an in-depth review of infrastructure requirements, market opportunities, and to address challenges. The primary focus however, was to improve cross-sector communication between stakeholders including the automotive sector, home builders, utilities, municipality, and NGOs. Such cross-sector engagement had not yet been established in Ontario, where market leaders typically work within their given fields of expertise to find solutions. The EV Workshop brought leaders together to learn from experiences and discuss concerns in order to make strides for achieving real change. Discussions resulted in valuable insight that lead to the identification of challenges and recommendations to support infrastructure preparedness, as well as strategies to increase market and consumer awareness and confidence. The following section details the outcomes of these discussions.

It was a pleasure to attend the Workshop, as it gave me an opportunity to meet with many key players in the EV and energy sectors. The session also addressed many of the issues and challenges facing EV charging systems.

Working together, I am confident we can propel this technology forward to overcome the various challenges surrounding the widespread deployment of electric vehicles. Ideally I'd like to see one unified strong body coordinating various activities to advance the readiness of the EV.

MR. KOSHI TERAKAWA, *PRESIDENT OF SANYO CANADA INC.*

EC3 EV Workshop Discussions

Smart Grids

During discussions at the Workshop, the topic of smart grid technology and how it can integrate with electric vehicles was raised and debated. Many agreed that the two technologies are complementary and that further research and collaboration was needed to ensure that the two develop in parallel. The following issues pertaining to smart grids were raised:

- The need for communications protocols and meters that provide for energy demand and time-of-use data; facilitation of billing based on peak, mid-peak and off-peak periods; and providing a reference against which consumers can gauge and reduce the cost of their energy use.[61]
- The need for vehicles to communicate with the power grid in response to peak load demands. These vehicles can then be recharged during off-peak hours in the evening at cheaper rates when demand is low.[62]
- The need for in-vehicle communication applications with GPS technology to inform EV users of the closest charging station and best way to get there.

Tax Restructure and Incentive Programs

Although Ontario is providing rebates for electric vehicles and offering perks such as the use of the "High Occupancy Vehicle lanes" on provincial highways, many at the Workshop felt that more can be done with respect to tax restructuring and incentive programs to encourage the development of electric vehicles and infrastructure. Through mechanisms such as the Ontario Green Energy Act, the Province should also be encouraged to continue to attract manufacturing opportunities that support EV technologies as a primary economic objective.

As part of the commitment to helping the provincial government achieve its Conservation and Demand-side Management (CDM) objectives, Utilities need to actively deliver a comprehensive suite of electricity based energy efficiency programs in support of EV infrastructure. These programs should consist of a blend of projects supported by the Ontario Power Authority. Electric vehicle Pilot Projects will also need provincial support to provide opportunities to showcase the existing suite of CDM programs. EVs can be an important visual component in marketing and branding for Local Distribution Companies' CDM efforts in Ontario.

Grid Upgrades to Handle Anticipated Need

Concerns were raised regarding the increase in electricity consumption as a result of large scale EV deployment. Such an increase could have negative environmental impacts if the additional generation derives from coal or natural gas fired power. The Electrification Coalition, a not-for-profit group of business leaders promoting the deployment of EVs envisions that by 2040, 75% of light-duty vehicle miles in the US would be electric.[63] Grid infrastructure will need to be upgraded to the point where enough contingency exists to be able to accommodate this additional demand. Further, maximizing emissions-free electricity supply must also be a priority to ensure that electric vehicles are indeed contributing to positive environmental outcomes, rather than transferring emissions from the tailpipe to the generation site.

New Programs to Support Home Builders and Buyer's Efforts

One of the challenges noted in the Workshop discussions revolved around consumer willingness to pay for green features in their home relative to aesthetic features such as granite counter-tops. Although we are seeing an increase in consumer awareness of the benefits of sustainable living, many at the Workshop were not convinced that it was enough to propel developers to install green features such as electric vehicle plug-in infrastructure.

As electric vehicles begin to penetrate the market, there will be a need for incentives and marketing programs such as the "EV Ready Smart Home". Ideally, this type of program will fit a home with "smart control" options that include the ability to use the EV's stored electricity to sell back to the grid. This brings peak diversification possibilities that are important considerations for Local Distribution Companies (LDCs) as they contemplate peak-load management. With a relatively high proportion of new homes in Ontario, LDCs are well suited to test the concept of the EV Ready Smart Home or neighbourhood.

Sustainable Transportation

Acknowledging that personal vehicles will not go away, electric vehicles are seen as a sustainable alternative to the current IC engine technology. However, many participants at the EV Workshop recognized that personal vehicles should not be the prevalent transportation mode and that a greater focus on providing efficient public transit and sustainable communities with good cycling and pedestrian infrastructure should be prioritized. These transportation modes not only contribute to decreasing air pollution and GHG emissions, but also increase health benefits, build strong community networks, and translate to fewer accidents.

> The EV Workshop provided a great opportunity for cross sector collaboration, bringing together all sectors necessary to make this happen – the housing, transportation, energy, and finance sectors.
>
> Many are new to the topic of electric vehicles so it was a great platform for discussion, learning and collaborating.
>
> COREY MCBURNEY, *PRESIDENT OF ENERQUALITY CORPORATION*

> I found that in general the stakeholders have a better grasp of what's required to prepare for plug-in vehicles.
>
> The discussions are becoming more practical rather than theoretical. That's a good thing.
>
> WYMAN PATTEE, *MANAGER, VEHICLE EMISSIONS AND FUELS, FORD OF CANADA*

EC3 Initiative Next Steps

Discussions from the multi-stakeholder leadership Workshop concluded that Pilot Projects designed to test EV technology would be needed before infrastructure commitments could be established.

As a result, the EC3 Initiative is working to encourage a series of Pilot Projects throughout Ontario that will not only test the technology, but also improve market awareness and confidence. These Pilots could be conducted independently through the support of the Province of Ontario and the electric Utilities or through a combined effort as demonstrated through the USA "EV Project" where by multiple stakeholders and interest groups could be coordinated through a central office.[64]

The following pages review Workshop discussions around potential Pilot Projects for leaders in Ontario to consider. Next steps beyond the Workshop will take the collaboration of industry and government leadership across sectors; however, the chance to develop a better technology and support economic development all while improving the health of the natural environment is an opportunity that only comes around once in a generation...

> We expect electric vehicles to make up a "major portion" of Ford's lineup within a decade. We can now make [EV] cars in the United States and we can do it profitably. The move toward electric cars and hybrids will be sustained and permanent.[65]
>
> ALAN MULALLY, *CEO, FORD*

Transit Corridor Pilot

One way of overcoming the range barrier in electric vehicles is by developing public charging stations at sufficient intervals and appropriate locations, while demonstrating that the same convenience that drivers expect with gasoline powered vehicles are possible.

A Transit Corridor Pilot could make use of Ontario's 400 series of Highways to evaluate infrastructure requirements of EV development, test and verify EV technology, provide an opportunity to showcase vehicles, and generally help understand potential limitations and solutions.

In order for new technology to be successful in the marketplace, people need to hear about it. A demonstration transit corridor electric vehicle program in Ontario can raise awareness in the province and across North America. By empowering automotive manufacturers to test new commercial vehicles, the public will see these new vehicles in action and begin to develop confidence in the technology.

Ontario's 400 series of Highways offers many advantages to test and showcase EV technology. They are major thoroughfares to Ontario's cottage country and other vacation destinations as well as major commuter routes for business professionals, providing the resources required to support an effective market awareness campaign. They also contain a series of public service centres, which can support a high profile EV Pilot. Adding EV charging stations at these locations would ensure vehicles could safely travel longer distances (testing limits of current battery technology), build public confidence, and encourage media opportunities.

Suburban Pilot

A Suburban Pilot would help demonstrate how single family homes can incorporate EV infrastructure to support the feasibility of the technology and contribute to market uptake and consumer confidence. This initiative could have a branding title such as "the Plug-in Ready Home" or the "EV Ready Smart Home" to help builders understand EV requirements and market opportunities to educated buyers.

KB Homes in the USA should be referenced as a leading example for integrating EV infrastructure into home building. KB Homes is offering an option to pre-wire its new Built to Order™ homes to accommodate charging electric vehicles. This provides a convenient overnight charging option for EV owners, while also putting less strain on the grid than day-time charging at public stations.[66]

CASE STUDY

Massachusetts

The Massachusetts Division of Energy Resources developed the largest electric vehicle demonstration project in the US. The project tested and evaluated the everyday use of EVs for commuting by leasing state-owned EVs to commuters for $249/month. The participants used the vehicles to carpool from home to work or to travel to park-and-ride lots, subways or commuter rail stations where they connect with public transportation to complete their commute. The EVs recharged during the day at outlets that used energy generated from photovoltaic cells. The demonstration project helped to bring EV technology to a broader cross-section of the public. Most of the commuters expressed a desire to continue driving an EV and were frequently asked by other commuters to share information about their experience, providing important word of mouth promotion.[67]

> The housing industry has demonstrated leadership in sustainable development and green building. More and more builders are starting to consider the emerging market for plug-in vehicles in that context.
>
> However, there is still work to be done on this. We need a clearly defined roadmap that outlines how we get from here to there.
>
> STEPHEN DUPUIS, *PRESIDENT AND CEO, BUILDING INDUSTRY AND LAND DEVELOPMENT ASSOCIATION*

Urban Pilot

An Urban Pilot could engage city developers to incorporate EV infrastructure in condominium projects and office buildings. This Pilot may also explore the feasibility of EV infrastructure in the public realm, possibly working in tandem with car sharing programs to provide much needed visibility and promotion of the technology. This Pilot may involve work with Waterfront Toronto developers, providing an opportunity to showcase sustainable transportation initiatives in new downtown Toronto communities.

CASE STUDY

California Hydrogen Highway

A number of years ago, the State of California launched the Hydrogen Highway Pilot Project to test the use of hydrogen as a transportation fuel alternative by constructing a series of hydrogen refuelling station, most of which serve demonstration and research purposes supporting predominately fleet vehicles. To date, nearly 30 stations have been constructed, located in the greater Los Angeles, San Diego, San Francisco, and Sacramento areas. Although the State of California expects 45,000 vehicles and 50-100 hydrogen stations by 2017, other sources report that up to three stations had to close and an additional three stations that California's Air Resources Board had agreed to finance have fallen through due to the lack of hydrogen vehicles.[68]

Nonetheless, this project has been a successful initiative for testing the technology and as a public relations opportunity. Those working on developing electric vehicle infrastructure have a similar vision for establishing pilot programs (to showcase and test new technology) and can look to this initiative to learn from their experiences.

This is an important time in the history of the automobile industry. The world we live and do business in is changing. Automotive technology is clearly changing and the challenges and opportunities faced by our industry continue to evolve.

For these reasons, GM has placed very high priority on vehicle electrification. We believe electric vehicle technology is one of the best long-term solutions to simultaneously increase energy independence and security, remove the automobile as a source of emissions, and enable more sustainable energy pathways.[69]

ALAN TAUB, *HEAD OF RESEARCH AND DEVELOPMENT, GENERAL MOTORS*

Conclusions

In summary, the EV Infrastructure Workshop was hugely successful, resulting in the first step towards market collaboration aimed at supporting the transportation sector's shift to a low-carbon economy.

Discussions that developed between attendees were very enlightening. In many cases, it was the first time industry leaders from across sectors were able to discuss new technology applications, identify challenges, offer recommendations, and inspire action to build market and consumer confidence.

When a leading home builder has an opportunity to forecast market shifts with experts in the automotive sector, new projects can result as an example for others to follow. Many unique factors were discussed that could set the stage for a technology revolution over the coming years including:

- The Canadian marketplace in particular, has a unique cultural perspective that can be a great influence on EV consumer confidence. In many parts of the country, we have experience plugging in our vehicles' block heaters during the winter months. Building on this familiarity would help support market adoption.
- Unlike alternative fuels such as hydrogen, the infrastructure to support electric vehicles is already in place and our electric utilities are already working hard to update supply with smart grid systems and technologies.
- A number of automotive manufactures have been quoted saying EV technology can evolve to be a superior product to current IC engine technology. The last time the automotive sector made a dramatic technology shift to an improved technology was when the direct fuel injection system was introduced in the mid 1980s. EVs have the potential to shift the market to the next level and allow transitional improvements to support market competition and ensure economic success.

Although there is considerable work ahead, Workshop attendees felt a significant step has been established, paving the way for mass electric vehicle deployment. The EC3 Initiative will be working hard in the near future to collaborate with leaders of EV technology and support infrastructure developments in Ontario and across Canada.

List of Workshop Participants

Aspen Ridge Homes

Arista Homes

Aylesworth LLP

BASF Canada

Building Industry and Land Development Association

Bosa Infrastructure

Cda Mortgage and Housing Corporation

City of Hamilton

City of Toronto

Clinton Climate Initiative

Credit Union IC savings

Cross Chasm Technologies

Deloitte

Earth Rangers

Electric Mobility Canada

Empire Communities

Enerquality Corporation

Fleet Challenge Ontario

Ford Canada

Fort Reliance

Great Gulf Group

Green Saver

Homes Publishing Group

Hydro One

Independent Electricity System Operators

Innovolve Group

LoyaltyOne

Magna Advanced Technologies

Marshall Homes

McCarthy Tétrault

MCW Consultants Ltd

Media Profile

Ministry of Energy and Infrastructure

Ministry of Transportation

Ministry of Economic Development & Trade

Mitsui & Co. (Canada) Ltd

Municipality of Meaford

National Bank Financial

Ontario Realty Corporation

Ontario Sustainable Energy Association

PowerStream

PricewaterhouseCoopers LLP

Quadrangle Architects Limited

Robert Hollands Consulting

SANYO Canada

SeeLine Group Ltd

Sheridan Institute of Technology & Advanced Learning

SmartCentres

Sussex Strategy Group

Sustainable Housing Foundation

The Daniels Corporation

The Globe and Mail

Toronto Atmospheric Fund

Toronto Hydro

Town of Markham

Turner Construction

University of Ontario Institute of Technology

University of Waterloo

Urban Capital Property Group

Waterfront Toronto

There is an appetite, there is a spontaneous demand for something that would represent a breakthrough from the past and would ensure for the consumer that when he buys a car and drives a car, the guilt of emitting is completely dissociated from the pleasure of driving.

CARLOS GHOSN, *CEO, NISSAN*

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About the EC3 Initiative

ENERGY CLIMATE
COMMUNICATION
COLLABORATION

Energy, Climate, Communication, and Collaboration make up the elements of the EC3 Initiative. Each element represents core areas of opportunity in support of a low-carbon economy for Canada and across North America.

As economies around the world hit the reset button and societies recalibrate their value systems, we have an unprecedented opportunity to effect positive, enduring change at both the local and global scale.

EC3 Members and Associates

It is important for EC3 to operate as a neutral, non-partisan agency that can communicate across sectors and provide support to leaders in the evolving low-carbon economy. To accomplish this goal, members and associates of EC3 are encouraged to participate in Strategy Sessions to share experiences with their peers. Each Session will be designed to engage participants in strategic discussions based on current trends and develop solutions that will provide results through new project development, investment strategies, and promotional opportunities. Please visit the EC3 website at ec3initiative.com for a current list of members.

EC3 Strategy Sessions: creating new opportunities in a low-carbon economy.

The EC3 Strategy Sessions provide a unique forum for selected executives to convene in a collaborative setting, share new ideas, and effectively establish an implementation strategy across industry sectors to position Canada as a leader in the next stage of the global industrial revolution. Dates and details for each session will be provided through the EC3 website and through direct communication to members.

EC3 Executive Team: providing the tools and resources required to implement new ideas.

Crucial to the development of any project is the knowledge and experience of the leaders that commit to achieving success. The EC3 team is available to support project development or provide complete implementation strategies for projects on behalf of clients. Each team member has been specifically selected based on their proven track records as well as the respect and influence they have established in the industry.

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ANDREW BOWERBANK, *FOUNDER & CHIEF STRATEGY OFFICER*

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