EVS-24: ELECTRIC VEHICLE-RELATED OPPORTUNITIES for CANADIAN INDUSTRY & ORGANIZATIONS

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EXECUTIVE SUMMARY

Electric vehicles and related technology are definitely an opportunity for Canadian manufacturers and service providers which will grow as North American (and global) use of electric vehicles grows. The Electric Vehicle Symposium 24 or EVS-24 (Stavanger Norway, May 2009) provided a good snapshot, and global perspective, of the current state of electric vehicle technology and opportunities which will largely be market-driven. For example, the Electric Vehicle Technology Roadmap for Canada forecasts at least one-half million electric vehicles on Canadian roads by 2018. Electric Mobility Canada (EMC) collaborated with the National Research Council Canada's Industrial Research Assistance Program (NRC-IRAP) to create a Canadian presence at EVS-24, with a particular emphasis on Canadian small- and medium-sized enterprises (SMEs). Red River College (RRC) has prepared this report concerning EVS-24, drawing lessons concerning how Canadian SMEs could potentially participate in the provision of electric mobility products and services domestically or for export.

There are technological imperatives with respect to battery technology (related primarily to **improving energy density**) which will be essential to success in North America, i.e. reducing cost, size, weight and volume; increasing reliability and life; and maintaining/increasing performance. However, there are opportunities beyond battery technology, which were identified at EVS-24, i.e.:

- light weighting;
- vehicle components fabricated from composite materials;
- repurposing automotive batteries/technology for stationary applications;
- software for vehicle and infrastructure applications;
- vehicle electrification, scale-up and customization for Canadian conditions;
- advancing electric vehicle technology to enable operation as an every day vehicle;
- electric vehicle charging infrastructure;
- standards and homologation/harmonization ;
- testing for Canadian climatic conditions and extremes;
- RD^3 – Research, Development, Demonstration and Deployment;
- integrated supply chains; and
- vehicle-to-grid integration.

The National Research Council of Canada – from the perspectives of both its national laboratories and the Industrial Research Support Program – is well-positioned to support Canadian organizations, especially SMEs through programs, initiatives and actions such as:

- on-going support – existing programs, NRC Automotive, and the Automotive Partnership Canada;
- Network Membership Agreements to support electric vehicle technology;
- organizing participation in both in-bound and out-bound technology missions; and
- ensuring that NRC's industrial client base and program partners are aware of Canada's Scientific Research & Experimental Development program and incentives (as well as programs by other science-based agencies) which support technological advances and innovation by Canadian industry.

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PREAMBLE

This report is a summary of the Electric Vehicle Symposium 24 (EVS-24) held in Stavenger Norway from May 13 to 16, 2009. The "EVS" has become the premier global event to promote electric drive vehicles in all regions of the globe, and includes a technical/policy forum, trade show and related events such as a "Ride-&-Drive".

Electric Mobility Canada (EMC[1]) collaborated with the National Research Council Canada's Industrial Research Assistance Program (NRC-IRAP[2]) to create a Canadian presence at EVS-24, with a particular emphasis on Canadian small- and medium-sized enterprises (SMEs).

Red River College (RRC[3]), a participant in EVS-24, has prepared this report concerning EVS-24, drawing lessons concerning how Canadian SMEs could potentially participate in the provision of electric mobility products and services domestically or for export. Opportunities have been identified for NRC-IRAP to support Canada's electric vehicle sector and to help SMEs move forward through the development of new technology.

This report is available at www.rrc.mb.ca/appliedresearch.

[1] Electric Mobility Canada (www.emc-mec.ca) is a national membership-based not-for-profit organization dedicated exclusively to the promotion of electric mobility as a readily available and important solution to Canada's emerging energy and environmental issues. EMC's membership includes:

- Private sector companies engaged in the sale or distribution of vehicles or components of the delivery of professional services. These members represent all modes of surface transportation from bicycles to trains.
- Providers of electric energy at the provincial and local levels.
- Managers of fleets from private sector companies, government agencies and others.
- Related associations, societies, research centres and labour organizations.
- Government agencies and individual supporters.

[2] NRC-IRAP (http://irap-pari.nrc-cnrc.gc.ca) provides a range of both technical and business-oriented services along with potential financial support to growth-oriented Canadian small and medium-sized companies. The program is delivered by an extensive network of 240 professionals in 100 communities across the country. Working directly with clients, NRC-IRAP supports their innovative research and development and helps them become commercialization-ready with their new products and services.

[3] Red River College (www.rrc.mb.ca) is Manitoba's largest institute of applied learning with 32,000 students and 110 full-time programs offered at eight campuses. RRC's Applied Research & Commercialization (AR&C) unit provides support for applied research, knowledge transfer, prototyping, product development, testing and commercialization. Applied research interests include sustainable infrastructure and advanced transportation and energy, especially vehicle technology and renewable fuels such as hydrogen, bio-diesel, ethanol and electricity.

HYBRID and ELECTRIC VEHICLE INDUSTRY

The International Energy Agency Implementing Agreement for co-operation on Hybrid and Electric Vehicle Technologies and Programmes (IA-HEV[4]) published, in February 2009, its 2008 Annual Report entitled *Hybrid and electric vehicles, The electric drive establishes a market foothold, Progress towards sustainable transportation*. The following quotes (essentially the balance of this section) have been excerpted from the Chairman's message in the report:

> **The future will be electric and renewable.** The strong interest for hybrid and electric vehicles as one of the future mobility solutions had a great impact on the work for the IEA Implementing Agreement for co-operation on Hybrid and Electric Vehicle Technologies and Programmes (IA-HEV). It inspired the planning of the 4th phase of the Implementing Agreement that will start in December 2009.
>
> **Hybrid and electric vehicles and the role of the IA-HEV. The technical solution is known: it is electric and renewable!** The best solution and therefore the future for transportation will be electric and renewable. Why is this so obvious? Basic physics and nature tell us why:
>
> - The electric drive is at least 3 times more efficient than combustion processes.
> - Many options for the clean and renewable production of the electricity already exist, ranging from hydro- and wind power, locally produced biomass power plants to decentralized solar power stations, photovoltaics, etc.
>
> Within the framework of the "Large scale test with lightweight electric vehicles" in Mendrisio (Switzerland), test bench measurements .... compared the energy consumption of the Volkswagen Gold and Peugeot 106 with electric-, diesel- and gasoline drivetrains .... have substantiated this result.
>
> The IEA report "Towards a sustainable energy future" mentions "there is no intrinsic ceiling to variable renewables' potential". The integration of renewable electricity into the transport sector can be supported by the use of the vehicle-to-grid (V2G) concept. Our position in the actual debate of the use of biofuels is important – also because hybrid and plug-in hybrid electric vehicles can and will use biofuels in addition to electricity. So the conclusion that alternative motor fuels are obsolete is being rash in judgement.
>
> Future transportation may show the following portfolio:
>
> - Go by foot and use bicycles – for longer distances use electric assist bicycles.
> - Use clean electricity for means of mass transportation (railways, ...) as much as possible.

[4] IA-HEV member countries are Austria, Belgium, Canada, Denmark, Finland, France, Italy, the Netherlands, Sweden, Switzerland, Turkey and the United States of America.

- Replace passenger vehicles and buses as much as possible by trams and electric trolley buses in densely populated areas.
- Replace diesel buses, diesel trucks etc. by hybrid vehicles with alternative motor fuels (later perhaps by hydrogen) as much as possible.
- Replace short distance trips with internal combustion engine vehicles as much as possible by electric vehicles, starting with electric 2-wheelers and small lightweight electric vehicles, and gradually introducing four-wheeled electric vehicles.
- Replace mid- and long distance trips by hybrid electric-and plug-in hybrid electric vehicles as much as possible.
- Start using alternative motor fuels for selected applications and perhaps start using hydrogen to fuel airplanes.

The development of such a "sustainable mobility portfolio" is just at a starting point. Many R&D efforts, demonstration projects and applications are needed to give a detailed picture. The optimum picture may differ from country to country, from region to region and from town to town. But first pieces of the puzzle can already be used today with benefits for the users. As members of the various IEA Implementing Agreements in the transport sector, countries can share these results and learn from each other. This will speed up the development and it saves taxpayers' money.

The way to electric mobility is a marathon ... there is common agreement on one lesson: a technological change needs time, especially if the previous technology is so dominant. The culture of thinking in short or even mid-term payback periods in company boards clashes with the time needed for the developments of components and system integration. And even if all homework is done by the manufacturers, there is a market outside the factory building that asks which advantages consumers may have by driving an electric vehicle. ... You need good preparations, a trained team, good know-how and a roadmap. ... Quick success will not happen. This is a critical situation in a world where media and politics look for quick solutions.

The pathway to the electric and renewable mobility has many milestones ... High oil prices and the current economical crisis lead to much attention for electric vehicle technologies in all the media. It is obvious that gas-guzzlers are outdated. But I am critical about today's "EV hype". Electric propulsion will be the dominant drivetrain of future vehicles but this needs time.

The first milestone that has to be reached is ramping up production figures, starting with basic components like power electronic parts, batteries and their components, even power contacts, rare materials for motors, and DC- and AC-motors. This is only part of the whole chain that has to be built up. ... We assume that the time to market is a critical factor ... **but there is a window of opportunity for vehicle developments** ... It is very well possible that new types of entrepreneurs enter this field with new products and offers. Mastering the technology of hybrid and electric vehicles provides perfect opportunities for new competitors. They could arise outside of today's industrialized part of the world, in regions

like China and India, or in new industries like IT technologies. Actually we have an exciting time for new entries – and a frightening one for "veteran" car producers, their employees and their hometowns.

IEA report "Towards a sustainable energy future" ... The transportation segment has been identified as one of the most important, but also as one of the most difficult fields decisive for sustainability of the future global energy supply. The most important facts are:

- Transport remains a challenge. 60% of all the oil is consumed by the transport sector.
- There is a need to de-carbonize transport energy.
- To lower CO_2 by 50%, new transport technologies e.g. EVs and PHEVs are needed.
- EVs and PHEVs are mentioned among the 17 key technologies in the "energy technology perspectives" report of the IEA.
- Research development, demonstration and deployment of advanced vehicle technologies (like fuel cell vehicles and EVs) must be doubled if these are to play a major (and sustainable)role by 2030 and beyond.
- Funding should be increased in the next 5-10 years, to increase the probability of successful development.
- Electricity grid integrity: there is no intrinsic "ceiling" to variable renewables' potential.

The automotive industry will change ... The winners will be those companies that can align advanced clean vehicle technology and consumer demands.

Working fields for the future ... IA-HEV has identified the following factors that are important to influence the future market share of electric, hybrid and plug-in hybrid electric vehicles:

- Regulatory and other governmental measures to overcome the barriers for large deployment of EVs, HEVs and PHEVs.
- Advances in battery technology.
- Application of HEV technology in high-volume vehicle models.
- The difference in purchase price between EVs, HEVs, PHEVs and conventional vehicles.
- The availability of components for EV, HEV and PHEV drivelines.
- The quantity of EVs, HEVs and PHEVs that manufacturers will be able to supply.

The better will win – join the group! ... the electric vehicle *is* at least 3 times more energy efficient than all internal combustion engine technologies. ... not all framework conditions that are necessary for the electric vehicle are in place. Production facilities are not yet ready and there is a lack of specialists. The automotive industry has to learn how to produce this new product and how to bring it to the marketplace. The electric power industry and the utilities must realize how important this technology will be for their businesses. Governmental authorities must adapt their regulations. Car retailers have to learn how these new vehicles have to be marketed and how maintenance and service have to be organized. And consumers have to learn how to use these new technologies.

NRC AUTOMOTIVE

NRC Automotive is an initiative of the National Research Council to turn the challenges facing the automotive sector into opportunities (http://www.nrc-cnrc.gc.ca/eng/sectors/automotive.html).

NRC Automotive's factsheet states that the automotive industry is Canada's largest manufacturing sector, accounting for 12% of the manufacturing GDP and 24% of manufacturing trade, employing 158,302 in automotive assembly and component manufacturing and another 336,212 in distribution and aftermarket sales and service. In 2006, industry shipments amounted to $59.8 billion in vehicles and $28.5 billion in parts.

Industry challenges include the need to be globally competitive and develop unique solutions and capabilities, while working with a lack of resources for conducting R&D activities. Green engineering is becoming more pervasive, with the benefit of reducing fuel consumption and costs.

Key technology platforms, as identified by NRC Automotive, are:

- Lightweight Materials (aluminum and magnesium, polymer composites and nano-composites, hybrid materials – metal and polymers, recycling and waste management);
- Alternative Propulsion/Plug-In Hybrid Electric Vehicle –with focus on components (batteries, capacitors, sensors); and
- Testing Centre for Manufacturing Processes (scaling up and prototyping, low cost manufacturing, bonding and joining technologies, surface coatings).

NRC Automotive will support innovation by providing automotive firms coordinated access to NRC's research leaders and state-of-the-art facilities and expertise across science and engineering disciplines, industry advice and support through NRC-IRAP and competitive intelligence by NRC-CISTI. Through consultation, NRC has identified needs which are key to the industry's future competitiveness and NRC is in a position to contribute:

- Lightweight vehicles
    - Light metals
    - Polymer composites
    - Hybrid structures
    - Biomaterials, biocomposites
- Alternative propulsion
    - Plug-in hybrids and electric vehicles
    - Fuel cells
    - Biofuels
- The "Connected Car"
    - Sensors and sensor networks
    - Telematics
    - Robust software engineering

These factors are the driving force behind NRC-IRAP's support for EMC's participation in EVS-24.

EVS-24 OVERVIEW

EVS is organized by the World Electric Vehicle Association (WEVA) and is THE global electric vehicle technology conference for academic, government and industry professional involved in electric drive technologies. WEVA brings together the European Association for Battery, Hybrid and Fuelcell Electric Vehicles (AVERE), the Electric Drive Transportation Association (EDTA) and the Electric Vehicle Association of Asia Pacific (EVAAP).

EVS began in 1969 as an academic forum for global networking and technical information exchange, but as electric drive technologies have moved from the classroom and laboratory to the marketplace, EVS has become oriented to both the academic and business worlds. Due to the membership in WEVA of three regionally focussed associations, EVS rotates annually between Asia, Europe and North America. EVS-24 was held in Stavenger Norway, from May 13 to 16, 2009 (www.evs24.org).

The three themes of EVS-24 – in addition to a broad view of the real cost of energy use, were:

1. **Towards Zero Emission** – based on a sector-by-sector analysis focused on nations, cities and building transportation systems while considering current and future directions, limitations, challenges and possibilities;
2. **Youth** – looking towards creating interest for youth in this field; and
3. **Health** – with emphasis on the link between Health and Transportation.

Key event statistics were as follows:

- 45 countries represented
- Total registrations – 2958
    - Public Exhibition – 1,320
    - Delegates – 1,069 (with 67% from Europe, and 32 individuals from Canada)
    - Exhibition staff – 446
    - Press – 120
- Abstracts received - 449
- Presentations (lectures and posters) - 370 (including 9 from Canada and 63 from the USA)
- Topics (papers/topic)
    - Vehicles (81)
    - Batteries (64)
    - Drive systems (56)
    - Energy & environment (50)
    - Simulation (47)
    - Market issues (31)
    - Policy issues (26)
    - Fuel cells (15)
- EVS Viking Rally
    - 20 cars on the 570 km Hydrogen Road
    - 7 cars on the 70 km Electric Road
- Ride & Drive
- Exhibition
    - over 5,000 m^2
    - 100 organizations in 70 booths
    - 40 countries represented

The Exhibition featured exhibitors ranging from public, non-profits to multi-nationals.

While numerous OEMs (Original Equipment Manufacturers, such as A123 Hymotion and Magna) were in attendance; established (eg. Mitsubishi, Toyota) and emerging electric (eg. Bright, Think) vehicle manufacturers were the highlight of the Exhibition – attracting large numbers of visitors, especially the public. The "Big 3" – Daimler-Chrylser, Ford, and General Motors (other than the Volt) – were notable by their absence (attributed to current global economic conditions).

The Exhibition also featured a number of transportation infrastructure suppliers – especially for charging infrastructure.

EMC organized a booth (Stand 373) in the Exhibition which showcased a number of Canadian organizations and technologies. Support for this activity was provided by NRC-IRAP. The booth was staffed by Al Cormier (EMC), Ray Hoemsen (RRC), and Peter Maurmann (Westward Industries). Canadian organizations represented (i.e. literature distributed) in the EMC booth were:

- Cantec – PQ;
- Delaware Power Solutions – BC;
- Delta Q – BC;
- Electrocraft – ON;
- Isaac Instruments – PQ;
- Motive Industries – AB;
- National Research Council Canada's Industrial Research Assistance Program;
- Plastik M.P. – PQ;
- Red River College – MB;
- Smart e Bikes – ON;
- Thumbprint Solutions – ON;
- TM4 – QC; and
- Westward Industries - MB.

Advanced Lithium Power (energy management and battery technology – Stand 288), Electrovaya (battery technology – Stand 321) andTM4 (a subsidiary of Hydro-Québec, high-performance electrodynamic conversion and power control systems - Stand 323) were the only other Canadian exhibitors.

OPPORTUNITIES

The opportunities concerning electric vehicle technology for Canadian SMEs and organizations will largely be market-driven. For example, the Electric Vehicle Technology Roadmap for Canada forecasts at least one-half million electric vehicles on Canadian roads by 2018. At EVS-24, the United States of America was predicted to have one million PHEVs by 2015, with 10% of the electricity to be generated from renewable sources by 2012.

Some of the evident contrasts between North American and other global regions are:

1. all purpose versus speciality/dedicated applications;
2. grid capacity is not an issue;
3. fleet (versus individual) focus, at least initially;
4. need to increase federal electric vehicle initiatives (and in Canada's case, also with respect to the United States); and
5. charging infrastructure is not well developed, yet – and will be impacted by whatever standards are finally agreed upon.

Still, there are technological imperatives with respect to battery technology (related primarily to **improving energy density**) which will be essential to success in North America, i.e. reducing cost, size, weight and volume; increasing reliability and life; and maintaining/increasing performance.

However, there are opportunities (for not only global EV industries, but also Canadian organizations – including SMEs) beyond battery technology, which were identified at EVS-24.

1. **Light weighting** – reducing the weight of components, and ultimately vehicles, is essential to improving the range of electric vehicles.

2. The development of vehicle components, such as body panels, fabricated from **composite materials** will facilitate light weighting. Work already underway to develop composites which can be produced from biomass (agricultural and forestry wastes) will complement this opportunity.

3. Developments in automotive batteries/technology will present opportunities for **repurposing** in stationary applications (such as backup power supplies).

4. **Software** for applications such as battery power management, vehicle system monitoring and control, and operator displays will be required – and present multiple opportunities as the supplier and manufacturer base is established and grows. Smart meters/grid and related applications – e.g. to monitor usage, will also require software development.

5. The need for **efficient low carbon transportation technology**, especially through development of applications related to vehicle electrification, scale-up and customization for Canadian conditions, will increase with consumer demand and expectations.

6. Advancing electric vehicle technology to the point where an electric vehicle will be able to be an owner's **primary every day vehicle** (i.e. not just a commuter vehicle used) will be necessary to gain

North American consumer acceptance. **Upsizing** (especially range and carrying capacity) will be required in not only the vehicles themselves, but also the charging infrastructure.

7. Easy and convenient electric vehicle **charging infrastructure** – especially in urban areas - is essential to the wide-spread use of electric vehicle technology. Not only will it be necessary to recharge vehicles in the work place, in the community and at home; it will also be necessary to track the related cost of charging so that the cost can be passed along to the individual vehicle owner/operator. For example, this may require the application of a technology, such as RFID, to identify a vehicle using electricity (which will need to be metered) in a public parking facility.

8. **Standards and homologation/harmonization** – will affect vehicle performance and service requirements. Industry involvement is essential to advance knowledge of how emerging and new electric vehicle technology standards will impact component and vehicle development and application. This should also lead to a need for testing and certification support by service providers.

9. **Testing**, for **Canadian climatic conditions and extremes**, will be necessary to ensure electric vehicles will be able to properly function and be maintained (and repaired). **Electric vehicle test/facilities centres** will be needed to study consumption, performance, safety, use/misuse and integration by component and vehicle manufacturers, and to help gain consumer acceptance. This will also enable development of new **training programs** for those who maintain and service vehicles and their components.

10. **RD^3 – Research, Development, Demonstration and Deployment** – including leasing and financing strategies to encourage adoption and use (especially if the financial cost is high in comparison to current passenger automobiles) will be necessary. New technologies always take time to be adopted, and demonstrations will be necessary to help roll out electric vehicle technologies. To help drive consumer acceptance, reduced costs will be required – this can be addressed by increasing volume to reduce costs, but financial incentives and awareness initiatives – as have been done in other jurisdictions – will likely be necessary.

11. Development of an **integrated supply chain**, e.g. from materials to cells to batteries to users, will provide opportunities for organizations involved in distribution and logistics. Electric vehicles should be developed with a systems point-of-view which will need to account for component and sub-system **integration and optimization**.

12. **Vehicle-to-grid integration**, especially long-term considerations with respect to the impact of increased electric vehicle use on electric power generation and distribution systems, needs to be taken into account from a planning and utilization perspective. For example, there will likely be a need for more transformers in residential areas to handle the increased load due to electric vehicle charging requirements. Bi-directional flow (e.g. use of the batteries in the electric vehicle by the power utility to store electricity until the grid needs it, and then recharging the battery in off-peak periods) is another opportunity which should not be overlooked, especially when power is generated using hydro-electricity (i.e. from water).

SUMMARY

Global markets for electric vehicle technology are increasing with demand, especially in North America.

Electric vehicles and related technology are definitely an opportunity for Canadian manufacturers and service providers which will grow as North American (and global) use of electric vehicles grows.

EVS-24 (Stavanger Norway, May 2009) provided a good snapshot, and global perspective, of the current state of electric vehicle technology and opportunities.

The Electric Vehicle Technology Roadmap (2009) for Canada addresses topics such as energy storage, component for electric vehicles, vehicle integration, business models and opportunities for electric vehicles, government policies, regulatory and human resources issues and public awareness and education which need to be considered as electric vehicles in Canada are anticipated to reach one-half million by 2018.

The National Research Council of Canada – from the perspectives of both its national laboratories and the Industrial Research Support Program – is well-positioned to support Canadian organizations, especially SMEs.

This can be achieved by:

1. On-going program support – through initiatives such as
    a. existing technology and market support programs,
    b. NRC Automotive, and
    c. the Automotive Partnership Canada (www.apc-pac.ca);

2. Network Membership Agreements with appropriate third-party organizations which would support electric vehicle technology through
    a. cluster development,
    b. seminars, workshops, webinars, and other awareness activities,
    c. technology commercialization and diffusion support activities, and
    d. facilitating access to knowledge infrastructure;

3. organizing participation in both in-bound and out-bound technology missions to raise global awareness of Canadian technologies and organizations, and providing Canadian organizations to showcase their technologies and capabilities to others outside of Canada; and

4. ensuring that NRC's industrial client base and program partners are aware of Canada's Scientific Research & Experimental Development program and incentives (www.cra-arc.gc.ca), as well as programs from other science-based agencies, which support technological advances and innovation by Canadian industry.

Appendix A - ELECTRIC VEHICLE TECHNOLOGY ROADMAP for CANADA

Electric Mobility Canada, in July 2009, submitted the Electric Vehicle Technology Roadmap for Canada (evTRM) to the Government of Canada. The complete Executive Summary of the evTRM follows.

ELECTRIC VEHICLE TECHNOLOGY ROADMAP FOR CANADA

August 2009

A strategic vision for highway-capable battery-electric, plug-in and other hybrid-electric vehicles

Executive Summary

The Electric Vehicle Technology Roadmap for Canada (the Roadmap) provides the perspective of numerous stakeholders, chiefly industry, as to how electric vehicles (EVs) for highway use should evolve in Canada over the next nine years, and what should be done to secure this evolution.

The Roadmap focuses on personal and commercial vehicles that rely exclusively or primarily on electric traction. Battery EVs have only electric traction. Their batteries are almost always charged from the electricity grid. The other type of EV covered by this Roadmap has an internal combustion engine (ICE) as well as an electric traction motor. The ICE, by powering a generator, can charge the vehicle's battery, although most charging occurs when plugged into the electricity grid while stationary. The ICE may also provide traction.

The Roadmap envisions at least 500,000 of these vehicles on Canadian roads by 2018, as well as what may be a larger number of hybrid ICE-electric vehicles that have smaller batteries not usually chargeable from the electricity grid. All these vehicles will have more Canadian content than vehicles on the road in 2008.
Other EVs are not considered in the Roadmap. They include fuel-cell-based vehicles, vehicles with two or three wheels, low-speed and off-road vehicles, military vehicles, and vehicles such as trolley buses that are powered from the grid while in motion.

The Roadmap focuses on EVs that rely exclusively or heavily on connection to the electricity grid for recharging their batteries. Part of Canada's potential strength as a focus for EV production and use is the sophistication of the grid and the electrical generation that feeds it. A higher share of this generation is from renewable sources than in almost any other country, meaning that conversion of the Canadian on-road fleet to EVs would result in large reductions in the fleet's carbon emissions. Moreover, several of the provincially and locally owned utilities that provide electrical energy in Canada have a strong interest in electric traction.

The Roadmap covers a wide range of topics related to the production and deployment of 500,000 or more EVs in Canada by 2018. They include energy storage, components for EVs, vehicle integration, business models and opportunities for EVs, government policies, regulatory and human resource issues, and public awareness and education.

The most important of these topics is energy storage. Progress towards widespread use of the vehicles covered by the Roadmap depends above all on one factor: Increasing the amount of electrical energy that can be stored in a given volume or weight on board a vehicle, thereby extending electric traction's range. Canada has many resources in energy storage, but they will be of value only if they are properly nurtured.
The Roadmap makes three recommendations towards securing the vision for EVs in 2018. It also identifies numerous matters requiring action – strategic initiatives – that complement the recommendations. **If the**

recommendations are adopted and the strategic initiatives are implemented, Canada will likely retain its vibrant and growing EV industry and play a full role in the transition away from dependence on fossil fuels.

The recommendations, addressed to governments, industry, and other stakeholders, are these:

1. Reconstitute the Steering Committee as a Roadmap Implementation Committee charged with ensuring that the strategic initiatives identified in the Roadmap are addressed.
2. Make timely and substantial investments in Canadian development and manufacture of EVs and energy storage devices to build on Canada's already strong presence in these industries.
3. Consider supplementing federal and provincial mechanisms to promote the development, public acceptance, and procurement of personal and commercial EVs, and also the installation of charging infrastructure.

The strategic initiatives are summarized below in four categories. All are important and all should have the timely attention of the Roadmap Implementation Committee. Where feasible, action with respect to each initiative should begin before mid 2010.

Technology

- Achieve improvements in energy storage through basic and applied research, including improvements in:
  - manufacturing techniques – with the goals of adding scale, improving efficiency, and reducing costs
  - energy density – to reduce costs, increase range, and achieve smaller, lighter systems
  - energy storage management and control electronics – for more efficient use of available energy storage
  - system packaging – to optimize thermal, electrical, mechanical, and safety elements.
- Reduce the cost of EV components by a factor of two to three so they can be commercially competitive with equivalent ICE components, meanwhile reducing the weight of the components.
- Conduct tests of options for charging infrastructure in each major region of Canada, including smart charging and vehicle-to-home and vehicle-to-grid arrangements. Recommend changes and improvements, noting impacts of multiple chargers on power quality.
- Demonstrate vehicle use in real-world operation to assess the reliability and durability of energy storage and other components.

Codes, standards, regulations, and infrastructure readiness

- Review national, provincial/territorial, and municipal regulations that impact the manufacture and use of EVs in Canada. Ensure that the regulations support EV development without compromising safety and other concerns.
- Secure harmonization of North American standards and practices concerning the integration of EV components, including charger interfaces.
- Develop harmonized standards for conversion of used vehicles to electric traction.
- Amend building codes and other regulations to require at least the roughing-in of outlets for charging EVs in all new buildings. Provide model codes and regulations.
- Develop action plans for infrastructure readiness based on best practices.

Studies and assessments

- Assess the merits of and develop a mandate for an Electric Transportation Institute as a Canadian focus of applied EV research and development and other activities required to accelerate widespread use of EVs.
- Assess the potential impacts of incentive programs for the purchase of EVs on EV penetration, and also the impacts of battery warranty and lease programs.
- Estimate EVs' contribution to national and regional electrical energy and power demand over several periods and at several levels of market penetration, taking account of reduced block heater loads and additional battery

conditioning loads. Assess present and expected ability to handle these demands, noting additions that would be required to generation and distribution infrastructure.
- Estimate lifetime savings to purchasers resulting from shifts to EVs from ICE-based vehicles, anticipating changes in electricity rates and fossil fuel prices. Identify corresponding revenue implications for governments.
- Assess whether renewable sources of electricity will be able to support use of the proposed 500,000 or more EVs by 2018.
- Assess the prospects for battery leasing models and the viability of battery 'repurposing' for Canada.
- Compare the social benefits and costs of electric traction and ICE traction that use fossil fuels.
- Identify the feasibility, costs, and benefits of creating a Canadian brand of highway-capable EVs. Also identify new business opportunities for Canadian electrical utilities that could arise from growth in the EV industry.
- Identify and assess the challenges and opportunities for Canada's EV industry posed by the *American Recovery and Reinvestment Act of 2009* and other such measures.
- Identify potential early adopters of EVs, particularly fleets, and how they may be encouraged to become early adopters.

Education and outreach

- Assess the resource requirements for training, education, and certification in skills related to the emerging EV industry. Provide this information to organizations that can develop:
  - technical courses in EV repair, service, and maintenance, and in conversion of ICE-based vehicles to EVs
  - courses to help graduates of universities and colleges secure employment in high-paying jobs in the emerging EV industry in areas such as battery engineering, power systems engineering, power electronics, manufacturing processes, and development of new business models.
- Develop educational and public relations programs designed to increase awareness across Canada of the benefits of EVs and associated technologies.

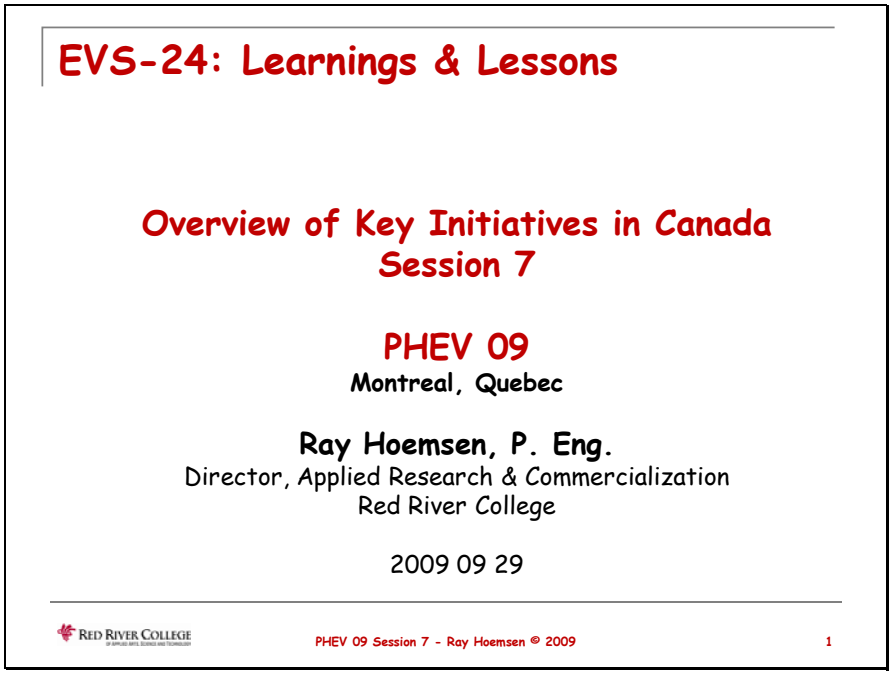
An additional task for the Roadmap Implementation Committee could be to note the limited scope of the present Roadmap and, after appropriate consultation, seek to initiate roadmaps in other areas of electric traction.

We live in extraordinary times, from a transportation and energy perspective and from many other perspectives. Our times are fraught with challenge, but also brimming with opportunity. The basic message of this Roadmap is that early action, chiefly by government and industry, will not only sustain Canada's strong position in electric transportation but enhance it to the benefit of all Canadians.

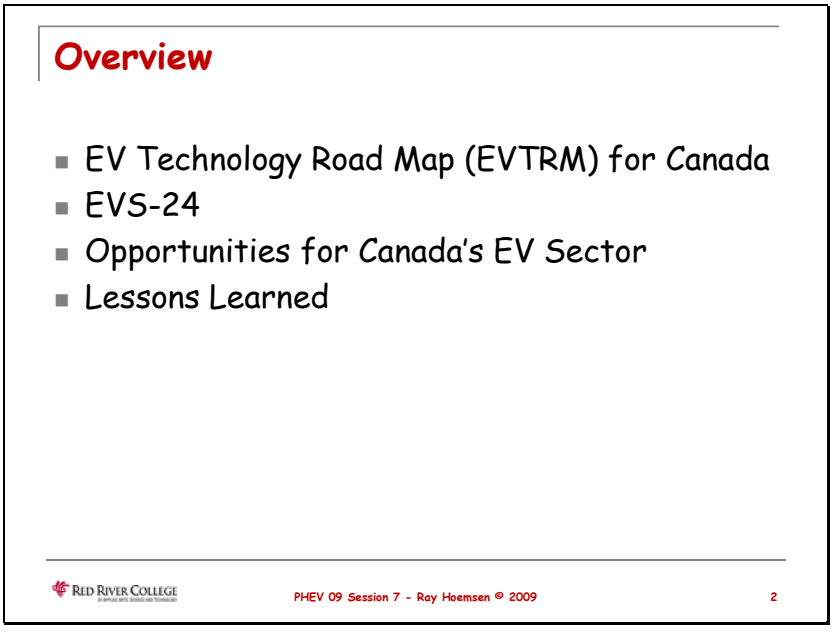
This *Executive Summary* of the Roadmap was prepared under the direction of the Industry Steering Committee. Its contents, conclusions, and recommendations are not necessarily approved by participating organizations and their employees, or by the Government of Canada.

Appendix B – Presentation PHEV Conference 2009, Montreal, Quebec

Slide 1



Slide 2



Slide 3

EV Growth Predictions and Projections

- "The electric car is here" and "The auto industry's e-car push will turbocharge innovation, employment and profits and everyone from the laid-off factory worker in Michigan to Al Gore will approve." Eric Reguly, G&M 20090921, pp B1
- "electric car is at the starting line . . . Automakers must prove that the technology, and the market, are ready . . . Some automobile makers believe the electric vehicle is about to become more than a science experiment" Carter Dougherty, National Post 20090917, pp FP14
- "within 10 years, close to 30% of the car market will be made up with purely electric vehicles, with hybrid and internal combustion engines sharing the rest" Diarmuid O-Connell, Tesla Motors, G&M 20090921, pp B4
- "In 10 years, electric will not be a mass product" Klaus Berning, Porsche, G&M, 20090921, pp B4
- E-cars 0.6% of global industry production by 2020, with hybrids another 0.7% HIS Global Insight per G&M200909, pp B4
- "one-third of the cars made in 2025 will be electrically powered in one way or the other IDTechEX per The Economist, 20090905, pp 75

Slide 4

EV Technology Roadmap for Canada

- Submitted to Government of Canada July 2009
- "Strategic vision for highway-capable battery-electric, plug-in and other hybrid-electric vehicles
- Focus on personal and commercial applications which rely exclusively or primarily on electric traction
- "EVTRM" envisions at least 500,000 EVs on Canadian roads by 2018, **plus** what may be a larger number of hybrid ICE-electric vehicles
  - **with MORE Canadian content than vehicles in 2008**
  - **did NOT consider FC-based, 2- or 3-wheeled, low-speed and off-road, military or grid-powered trolley bus types**

Slide 5

EVTRM for Canada: Overview

- Canada's **potential strength** for EV production and use is the **sophistication of the grid and the electrical generation that feeds it, and high percentage is from renewable sources**: would result in large reductions in carbon emissions
- Several provincially- and local-owned **utilities have a strong interest in electric traction**
- Energy storage is the most important topic considered
  - Progress toward widespread use of EVs depends primarily upon "increasing the amount of electrical energy that can be stored in a given volume or weight on board a vehicle, thereby extending electric traction's range"

Slide 6

EVTRM for Canada: Recommendations

- Implementation (reconstituted Steering Committee)
- Investment (timely and substantial) in development and manufacture of EVs and energy storage devices
- Mechanisms to promote
  - Development
  - Public acceptance
  - Procurement (personal and commercial)
  - Installation of charging infrastructure

Slide 7

EVTRM for Canada: Strategic Initiatives

- Technology
  - **Improve energy storage** – manufacturing techniques, density, management and control electronics, and system packaging
  - **Reduce cost** by a factor two or three
  - **Test charging infrastructure** options, including impact on power quality
  - **EV demonstrations** in real-world operation for reliability and durability
- Codes, standards, regulations and infrastructure readiness
  - Regulations to **support development w/o compromising safety**
  - **Harmonization**, including charger interfaces and used vehicle conversions
  - **Building codes** and regulations amendment **to accommodate charging EVs**
- Studies and assessments
  - R&D, use, impact, social and economic benefits, policy, etc.
- Education and outreach
  - Resource requirements for training, education and certification
  - Educational and public relations programs to increase awareness

Slide 8

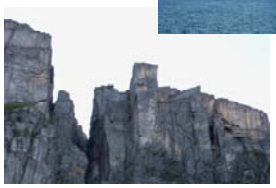
EVS-24: What is it?

- 24th annual event
  - Rotates between Americas and Asia and Europe
  - AVERE (European Association for Battery, Hybrid and Fuel Cell Electric Vehicles)
  - WEVA (World Electric Vehicle Association)
- International Battery, Hybrid and Fuel Cell Electric Vehicle Symposium & Exhibition
- Stavanger Norway
- Towards Zero Emission: Nations-Cities-Vehicles
- www.evs24.org

Slide 9

EVS-24: Stats-n-Facts

- 45 countries represented
- Total registrations: 2958
  - Public Exhibition: 1,320
  - Delegates: 1,069
    - 67% from Europe
    - 32 individuals from Canada
  - Exhibition staff: 446
  - Press: 120
- EVS Viking Rally: both Hydrogen and Electric
- Ride & Drive



Slide 10

EVS-24: Stats-n-Facts

- Presentations: 370
  - Canada: 9
  - United States: 63
- Topics
  - Vehicles (81)
  - Batteries (64)
  - Drive systems (56)
  - Energy & environment (50)
  - Simulation (47)
  - Market issues (31)
  - Policy issues (26)
  - Fuel cells (15)

Slide 11

EVS-24: Stats-n-Facts

- Exhibition
  - Over 5,000 m^2
  - 100+ organizations
  - 70 booths
  - 40 countries represented
  - ~450 exhibition staff

- Canadian Presence
  - Advanced Lithium Power (energy management and battery technology)
  - Electrovaya (battery technology)
  - TM4 (high-performance electrodynamic conversion and power control systems)
  - Electric Mobility Canada (showcase for Canadian organizations)

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EVS-24: Stats-n-Facts

- Electric Mobility Canada
  - Cantec (PQ)
  - Delaware Power Solutions (BC)
  - Delta Q (BC)
  - Electrocraft (ON)
  - Isaac Instruments (PQ)
  - Motive Industries (AB)
  - Plastik M.P. (PQ)
  - National Research Council Canada's Industrial Research Assistance Program
  - Red River College (MB)
  - Smart e Bikes (ON)
  - Thumbprint Solutions (ON)
  - TM4 (QC)
  - Westward Industries (MB)

Slide 13

EVS-24: Learnings

- Contrasts: North America vs rest of World
  - All purpose versus speciality/dedicated applications
  - Grid capacity is not an issue
  - Fleet (versus individual) focus, at least initially
  - Need to increase federal electric vehicles incentives
    - And in Canada's case, also w.r.t. the USA
  - Charging infrastructure is not well-developed - yet
    - And will be impacted by whatever standards are finally adopted

Slide 14

EVS-24: Opportunities

- Improving energy density of battery technology will be essential to success in North America
  - Reducing cost
  - Reducing size, weight and volume
  - Increasing reliability and life
  - Maintaining and increasing performance
- However, numerous opportunities beyond battery technology

Slide 15

EVS-24: Opportunities

- Light weighting
  - Lighter components will reduce vehicle weight, increasing range
- Vehicle components from composite materials
  - Biomass (ag and forestry wastes) as an input
- Testing for Canadian climatic conditions and extremes
  - Fuel consumption, performance, safety, use/misuse, integration
  - Training programs for vehicle/component maintenance/service
- RD^3 – Research, Development and Deployment
  - Cost reduction can be addressed by increasing volume, but leasing and financing incentives and awareness initiatives help
- Standards and homologation/harmonization
  - Industry involvement to advance knowledge and identify needs

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EVS-24: Opportunities

- Software
  - Battery management, monitoring and control, operator displays
- Repurposing automotive batteries/technologies
  - Stationary applications (backup power supplies)
- Charging infrastructure (especially urban areas)
  - Wired and wireless, will be standards-driven
- Upsizing – to be more than just commuter vehicles
- Efficient low carbon transportation technology
  - Vehicle electrification, scale-up and customization for Canada
- Vehicle-to-grid integration (planning and utilization)
  - Generation/distribution, residential impact, bi-directional flow

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EVS-24 Lessons Learned

- Significant contrasts exist between North America and rest of the world
- Rate of growth of EV use is contradictory
  - Demand and awareness (at least "buzz") is increasing
  - Battery technology (energy density) is the most significant limiting factor to widespread use (and growth)
    - Need to reduce size, weight, volume and cost; while increasing reliability, life and performance
- Charging infrastructure cannot be overlooked
- Policy and program incentives will drive adoption and use
- RD^3 is necessary
- For North America, an EV needs to be capable of being a household's primary vehicle
- Numerous opportunities exist for Canadian organizations

Slide 18

Acknowledgments

EMC MEC
Electric Mobility Canada
Mobilité électrique Canada

Slide 19

Thank You!

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