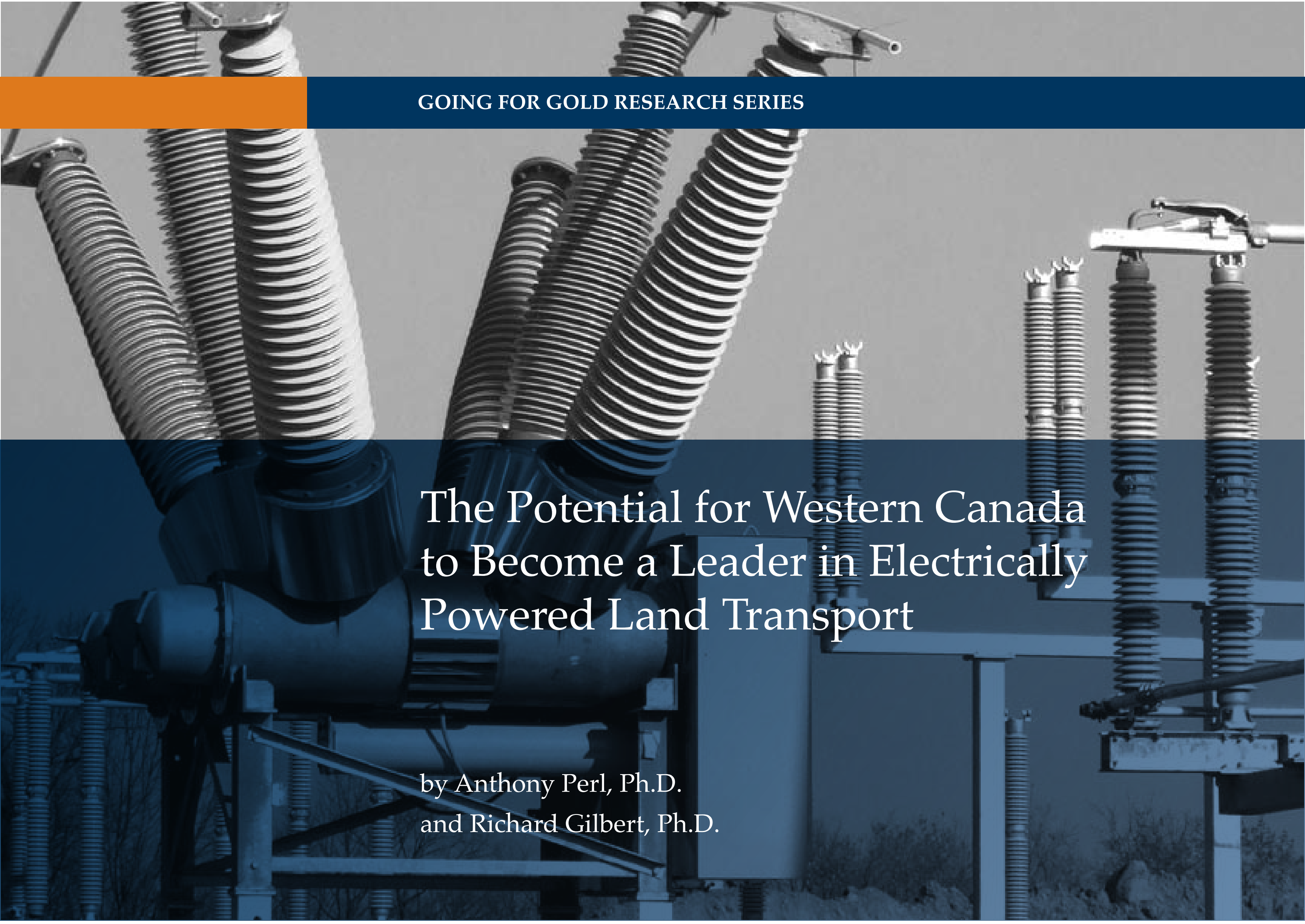

GOING FOR GOLD RESEARCH SERIES

The Potential for Western Canada to Become a Leader in Electrically Powered Land Transport

by Anthony Perl, Ph.D.
and Richard Gilbert, Ph.D.

Contents

Canada West Foundation
CANADA IS STRONGER WHEN THE WEST IS THRIVING!

GOING FOR GOLD

The Western Canadian Economy in the International Arena

The Going for Gold Project is focused on options for improving western Canada's, and by extension, Canada's international economic competitiveness. Work-to-date includes a survey of economic experts, a public opinion survey and a series of papers on key aspects of international economic competitiveness.

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SUMMARY

World oil production will soon enter an inexorable decline. Western Canada is likely to benefit from the resulting high prices, presenting a unique opportunity to invest a share of that surplus in infrastructure that opens the door to a post-carbon economy.

Transport is the major user of oil and is likely to undergo dramatic changes over the coming decades. Land transport will become increasingly powered by electricity because it offers the most advantageous way to blend energy inputs to power the mobility levels desired by modern societies. This paper presents the case for western Canada positioning itself at the leading edge of such a transition to electric land transport, as both user and manufacturer of electric propulsion technology. It sets out a process for developing and implementing an economic development strategy that would guide western Canada to a leading position in electric transport.

ABBREVIATIONS USED IN THIS PAPER

ART	Advanced Rapid Transit (system of Bombardier Corporation)
BC	British Columbia
BEV	Battery Electric Vehicles
CEV	Canadian Electric Vehicles Ltd.
EM	Electric Motor
EPRI	Electric Power Research Institute (US organization)
EESU	Electrical Energy Storage Unit (device of the EESTOR company)
EV	Electric Vehicle
ICE	Internal Combustion Engine
NAFTA	North American Free Trade Agreement
PRT	Personal Rapid Transit (or Transport, or Transportation)
UEL	United Electrical Engineering Ltd. (subsidiary of Wismer & Rawlings Electric Ltd.)
US	United States of America

1. WESTERN CANADA COULD USE LESS OIL

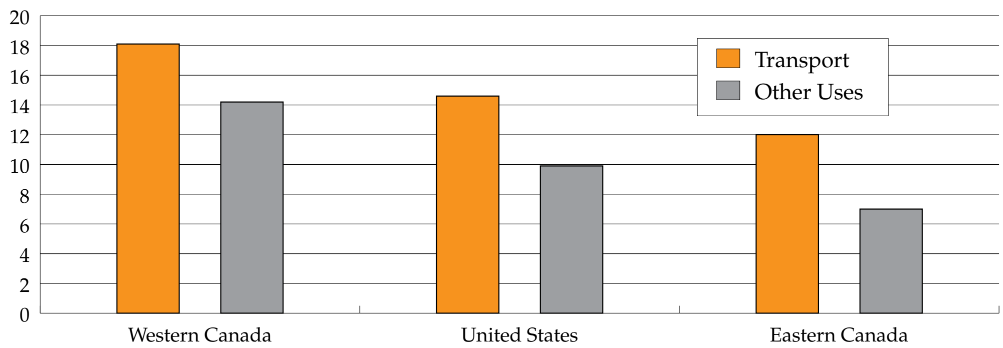
We must leave oil, before it leaves us.[1]

Fatih Birol, chief economist of the
International Energy Agency

The four provinces of western Canada are among the most oil intensive jurisdictions in the world. Figure 1 shows that per-capita consumption in 2007 was 70 per cent higher than that of Eastern Canada and 30 per cent higher than that of the United States. Figure 2 shows that western Canada also produces well over three times more oil than it consumes. Moreover, this production is increasingly from oil sands, which seem effectively limitless.[2] Thus, in spite of heavy consumption, western Canadians may

Figure 1

Estimated per-capita end-use consumption of oil products in western Canada, the US, and eastern Canada, 2007



Source: *Canada's Energy Future: Reference Case and Scenarios to 2030*, National Energy Board, Ottawa, 2007 and Davis SC, Diegel SW, and Boundy RG, *Transportation Energy Data Book*, Edition 27, 2008.

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1 This statement has been often attributed to Dr. Birol. It appears to have been made first, at least in English, in Birol F, 'Outside View: We can't cling to crude: we should leave oil before it leaves us,' The Independent, March 2, 2008, at http://www.independent.co.uk/news/business/comment/outside-view-we-cant-cling-to-crude-we-should-leave-oil-before-it-leaves-us-790178.html.

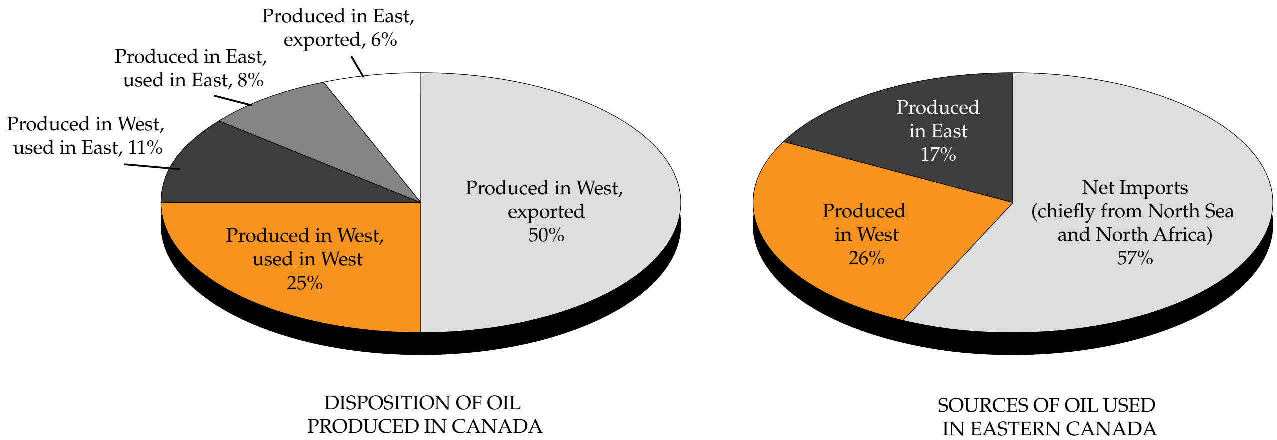
2 According to one authoritative source, the *Oil & Gas Journal*, Canadian reserves of oil—chiefly in Alberta's oil sands—are the second largest in the world after those of Saudi Arabia. Other sources do not recognize the oil sands as a 'proved reserve' and set Canada's reserves at only a small fraction of the first source. Canada's total reserves in 2006 have been given as 12.0, 16.5 and 178.8 billion barrels, respectively, in the trade journal *World Oil*, in BP's *Statistical Review of World Energy 2007*, and in *Oil & Gas Journal.* These estimates of reserves are as listed, with others, in a table at the Web site of the US Energy Information Administration entitled 'World proved reserves of oil and natural gas, most recent estimates', at http://www.eia.doe.gov/international/reserves.html.

have less reason to be concerned about potential limits to oil production than most people in the world.

Oil scarcity is nevertheless on the horizon. Soon, many experts believe, world supply oil will no longer keep up with world demand, even if demand does not rise. Some—including the International Energy Agency's chief economist, quoted above—believe this will happen during the next decade because there has not been enough investment in new supply capacity to offset inevitably declining production from long-exploited oil fields. Even with much more investment, world oil supply will soon begin to fall for geological reasons as there are geological limits to how much oil can be extracted in any year.[3] Such limits appear to have been reached for the US in 1970, for North Sea oil fields in 1999, and for Mexico in 2004.[4] Indeed, production is now declining in most countries that have produced oil.

Figure 2

Oil production, imports, and consumption in Canada, east and west of the Manitoba-Ontario border, 2007



NOTE: No oil was imported into western Canada.
Source: National Energy Board website and *in Supply and Disposition of Re-fined Petroleum Products in Canada*, Statistics Canada.

3 See, for example, Deffeyes KS, *Beyond Oil: The View from Hubbert's Peak*. Hill and Wang, New York, NY, 2006.

4 See *BP Statistical Review of World Energy*, BP plc, London UK, 2009, at http://www.bp.com/statisticalreview.

We must be careful, of course, not to overstate the consensus on an imminent oil supply problem. For example, Leonard Maugeri, an economist who is senior executive vice president of the Italian oil company Eni, has written, "advanced exploration and extraction methods can keep oil production growing for decades to come."[5] Daniel Yergin, chair of IHS Cambridge Energy Research Associates, has written, "… careful examination of the world's resource base—including my own firm's analysis of more than 800 of the largest oil fields—indicates that the resource endowment of the planet is sufficient to keep up with demand for decades to come."[6]

Others contend that supply challenges have already arrived.[7] Supply constraints, they argue, doubled the price of a barrel of oil between mid-2007 and mid-2008 to above US$145. Although an economic recession then curbed demand for oil dramatically (pushing the oil price down below US$35 per barrel), demand for oil has increased again as economies have recovered. By the early fall of 2009, the price was back around $80 per barrel, where it had been two years earlier.[8]

In any case, recessions are a socially destructive means of reducing oil consumption. Systematic conservation and planned fuel switching would be a much less traumatic transition strategy to the post-carbon era, an argument that applies with particular force to western Canada.

The idea that jurisdictions with abundant energy resources will have a smooth ride in the energy transition to the post-carbon era is as unrealistic as it is appealing. Western Canada will be buffeted both as a producer of oil and a consumer. Wild swings in oil price, such as happened during

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5 Maugeri L, 'Squeezing more oil from the ground,' *Scientific American*, October 2009. See also, Maugeri, L (2009) 'Understanding Oil Price Behavior through an Analysis of a Crisis,' in *Review of Environmental Economics and Policy*, vol 3, pp147-166.

6 Yergin D, 'It's still the one,' *Foreign Policy*, September-October 2009, at http://www.foreignpolicy.com/articles/2009/08/17/its_still_the_one. See also, Lynch M, 'Peak oil is a waste of energy.' *New York Times*, August 24, 2009, at http://www.nytimes.com/2009/08/25/opinion/25lynch.html?bl&ex=1251345600&en=f0a941c577e3a21f&ei=5087%0A . Lynch argued that "Oil remains abundant, and the price will likely come down closer to the historical level of $30 a barrel as new supplies come forward in the deep waters off West Africa and Latin America, in East Africa, and perhaps in the Bakken oil shale fields of Montana and North Dakota."

7 See, for example, Hamilton J, *Causes and consequences of the oil shock of 2007-2008* (conference draft). Brookings Institution, Washington DC, 2009, at http://www.brookings.edu/economics/bpea/~/media/Files/Programs/ES/BPEA/2009_spring_bpea_papers/2009_spring_bpea_hamilton.pdf. See also, Rubin J, *Why your world is about to get a whole lot smaller*. Random House Canada: Toronto, Ontario, 2009.

8 In October 2009, the spot price of a barrel of oil at the New York Mercantile Exchange rose above $80. This had last happened in October 2007.

2007-2009, can play havoc with the fiscal capacity of producer provinces. Western Canadians are also exposed to oil price volatility as consumers. Prices for gasoline and diesel fuel throughout western Canada hit all-time highs during the summer of 2008, with potentially severe impacts on the budgets of households and businesses.[9]

Western Canadians paid record prices for gasoline and diesel fuel because the price of crude oil used in western Canada is essentially the price established on world markets. Government could subsidize the price of oil products, as is done in many producer countries, but this is rarely suggested.[10] Subsidies would cause taxes to increase. More importantly, they could help raise local consumption, reducing the amount available for export and thus the flows of income to governments and businesses in producing provinces.

Ensuring that as much as possible of what is produced can be exported could provide a powerful rationale for western Canadians to reduce their oil consumption. A second reason for anticipating post-carbon energy options is to help avoid the destructive price swings, noted above, that can result when demand pushes against supply. A third reason is to contribute to a global quest to find substitutes for oil. A fourth reason is to profit from the worldwide departure from oil at the same as gaining revenues from its ongoing use. **This paper seeks to examine some of the opportunities for western Canada to take advantage of the move away from oil by becoming a leader in electric traction.**

In this paper we use the term **oil depletion** to refer to the decline in the worldwide capacity for oil production that could become evident during the next decade, whether for reasons of lack of investment or geology, or both. Oil depletion will impel a reduction in oil consumption. Anticipatory reductions in oil consumption could result in a 'soft landing' into a post carbon energy regime, if oil consumption is kept below declining supply. Lack of preparation for oil depletion could result in a disastrous 'hard

9 Data do not seem to be available for Canada on the impacts on households of these changes in oil prices. There are suggestions that in the US high oil prices contributed to problems in the housing sector by making suburban homes less affordable. See Cortright J, *Driven to the Brink: How the Gas Price Spike Popped the Housing Bubble and Devalued the Suburbs.* CEOs for Cities, Chicago IL, at http://www.brokersinsider.com/pdf/driventothebrinkfinal.pdf.

10 Subsidies could also be contrary to NAFTA. See Holden, M, *Canadian Oil Exports to the United States Under NAFTA.* Information and Research Service, Library of the Parliament of Canada, PRB 06-33E, November 16, 2006, at http://www.parl.gc.ca/information/library/PRBpubs/prb0633-e.htm.

landing' characterized by destructive cycles of high prices and their disruptive consequences.

Transport—including air, marine, off-road, and rail transport—is the main use of oil, as is evident from Figure 1. (Other uses include lubrication, industrial processes, space heating, and as a feedstock for the production of fertilizers, pesticides, pharmaceuticals, and plastics.) In considering how to reduce oil consumption, moving people and freight without oil must play an important role. In Canada, about 80 per cent of the oil used for transport is for road transport.[11] Thus, reducing consumption of oil products for road transport should be a priority.

11 For data on oil use for transport in Canada, see Table 7 of 'Comprehensive Energy End Use Database Tables,' Office of Energy Efficiency, Natural Resources Canada, at http://www.oee.nrcan.gc.ca/corporate/statistics/neud/dpa/trends_tran_ca.cfm.

2. ELECTRIC TRACTION COULD REPLACE THE MAIN USE OF OIL

Transport's high share of all oil consumption is one of three reasons why transport will be the sector most strongly affected by oil depletion. Another reason is that this share has been increasing.[12] The third and perhaps most important reason is that motorized transport is almost entirely—about 95 per cent—fuelled by oil. Thus, there is relatively little experience with other transport fuels and little available capacity to use them for moving additional volumes of people and goods.

There are three ways by which conservation of oil used for transport can be achieved. One is to perform less of the activity, to travel less or move less freight. Another is to perform the same amount of activity but more efficiently, so that less oil is used for each unit of the activity. This would mean, for example, using 20 litres of fuel rather than 30 to move a loaded truck through 100 kilometres, or moving the freight instead by diesel-powered train. The third way is to use another fuel, as in using an electric bus rather than a diesel bus. Each means of reducing oil consumption has merit, but only the last may yield reductions that can outpace oil depletion while maintaining the necessary and desired transport services that underpin societies around the world.

Several other transport fuels are being considered as future substitutes for oil. Most attention is given to fuels that allow continued use of internal combustion engines (ICEs[13]), including synthetic oil made by processing bitumen extracted from oil sands. Production of synthetic oil will be significant for North America but will likely remain a relatively small part of world supply, perhaps rising to five per cent of the total (rather than the present one to two per cent). More rapid exploitation is limited by environmental and resource constraints.[14] Biofuels can sustain use of ICEs,

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12 For oil products' share of all transport fuels, transport's share of all oil use, and the rates of growth of oil use for transport and for other uses, see the 2008 edition and earlier editions of the International Energy Agency's *World Energy Outlook*, IEA, Paris.

13 Abbreviations used in this paper are listed on Page 1.

14 See Hargreaves S, Curing oil sands fever: Despite wide-eyed predictions, serious constraints remain in developing Alberta's heavy oil. *CNNmoney.com*, October 7, 2006, at http://money.cnn.com/2006/10/04/news/economy/oil_sands/?postversion=2006100700.

but competition with food production or soil nourishment, or both, limits the extent of their use.[15] Natural gas can fuel ICEs, but prospects for its continued availability may also be limited.[16] Hydrogen too can fuel ICEs, but this light gas is difficult to store and to transport, and today almost all of it is made from natural gas.[17] Each of these alternatives for the oil products now fuelling ICEs can at best fill a relatively small niche, falling far short of providing the energy needed to maintain today's mobility levels and requiring a complex and costly overlay of multiple energy production and distribution systems to provide these oil substitutes.

The Electric Motor

The only realistic alternative to the petroleum-liquid-fuelled internal combustion engine for land transport is the electric motor (EM), for which there are three types of configuration. They differ according to where the electricity is produced and how it gets to the EM.

In the first case, the electric vehicle (EV) is fuelled from the electricity grid while the vehicle is in motion, as are Vancouver's Skytrain, Calgary's C-Train, Edmonton's light rail system, and Vancouver's trolley buses (and as were the trolley buses that once operated in Calgary, Edmonton, Regina, Saskatoon, and Winnipeg[18]). In the second case, electricity is stored on board, usually in a battery, with the storage being replenished from the grid while the EV is stationary (golf carts are the best known example of a battery-electric vehicle [BEV]). In the third case, electricity is produced on board, in most cases by an ICE. Hybrid cars and diesel-

15 For biofuels' impacts on soil nourishment, see particularly Patzek TW, Pimentel D, Thermodynamics of energy production from biomass, *Critical Reviews in Plant Sciences,* September, vol 24, no 5–6, pp327–364, 2005.

16 According to one source, worldwide there is about a third more natural gas than oil in relation to current levels of production: if current levels were to continue, natural gas would last for 60.4 years and oil (including Canadian oil sands) for 47.0 years. See *BP Statistical Review of World Energy*, BP plc, London UK, 2009, at http://www.bp.com/statisticalreview. There is considerable excitement about natural gas in North America, where production has increased recently after reaching an apparent peak in 2001 and then declining until 2005, the result of new techniques for extracting gas from shale. Some industry analysts say the boom in US natural gas production is a mirage resulting from faulty representation of production data by US Energy Information Administration. See, for example, Slide 17 of the presentation by Matthew Simmons to the Offshore Technology Conference, May 6, 2009, at http://www.simmonsco-intl.com/files/OTC%20Topical%20Luncheon.pdf.

17 Hydrogen can be made by electrolyzing water, even using renewably generated electricity, but this process can be part of a remarkably *inefficient* process for fuelling transport, as discussed later in this paper.

18 For previous Canadian trolley bus systems, see Wyatt D, *All-time list of Canadian Transit Systems*, at http://home.cc.umanitoba.ca/~wyatt/alltime/other-modes.html.

electric trains are of this type. Combinations of the three types of EV exist. For example, Rome, Italy, has trolley buses with batteries large enough to allow up to ten kilometres of off-wire movement with a full load.

EMs have numerous advantages over ICEs. Indeed, they are superior to ICEs in nearly every respect except one. EM's advantages in relation to ICEs include:

- Highest torque at low speeds, allowing rapid acceleration.
- Reversible polarity during deceleration, allowing conversion of otherwise-wasted kinetic energy into usable electricity through 'regenerative braking.'
- Efficient conversion of applied energy: about 95 per cent compared with ICEs' 30-40 per cent.
- Much higher power per unit of weight or volume, reducing space and energy needs.
- Little or no pollution at the vehicle, including air and noise pollution.
- Few moving parts, making for simplicity, durability, and ease of maintenance.
- Flexibility as to ultimate energy source, allowing for ready transition to renewable powering. (Electric transport systems can remain unchanged while generation of electricity changes, say, from coal-powered to wind-powered.)

EMs' one major disadvantage when compared with ICEs lies in the energy density of their fuel, as stored on the vehicle. Per kilogram, gasoline and diesel fuel contain many times more usable energy as the best available (lithium ion) batteries,[19] leaving BEVs with limited ranges.

19 The most ambitious projection of energy density for a storage system for electric vehicles may be that for the Electrical Energy Storage Units (EESUs) under development by the EEStor company. These capacitor-based units are projected to have an energy density of about 1.2 MJ/kg, i.e..., about twice that of current lithium-ion batteries. (See the EESU patent at http://www.patentstorm.us/patents/7033406/fulltext.html.) If EEStor's projection is realized, the effective energy density of an ESSU will be one tenth that of gasoline, taking into account the greatly superior efficiency of EMs when compared with ICEs. The Canadian company ZENN has a major stake in EEStor and the right to deploy EESUs in most light-duty vehicles. See Hamilton T, 'Race is on to build a better car battery,' *Toronto Star*, October 19, 2009, at http://www.thestar.com/business/cleanbreak/article/712133.

Delivering electricity while in motion (grid-connection) and on-board production are well established strategies for overcoming the challenges of storing electricity. Grid-connection requires supporting infrastructure—e.g., overhead wires—that constrains operation. On-board production today is mostly achieved from generators powered by ICEs fuelled by oil products. Such hybrid ICE-electric vehicles can use less fuel than comparable pure ICEs, but perhaps not enough to meet the constraints of oil depletion.[20]

Another means of on-board electricity production has found favour: fuel cells making use of hydrogen. Indeed, a vision held by many seeking a replacement for the ICE is that of fuel-cell EVs using hydrogen generated by electrolysis achieved with renewably generated energy.[21] Figure 3 suggests that this vision is not realistic for an energy-constrained world because of the additional energy required to produce, transport, store and then use hydrogen in a fuel cell.[22]

Figure 3 shows the energy transitions from a renewable source of electricity such as a wind turbine, through production of hydrogen from the electricity and then production of electricity from the hydrogen, to the EM in the fuel-cell vehicle. The cumulative efficiency of going through the numerous steps is 20 or 25 per cent according to whether or not the hydrogen is liquefied.[23]

For comparison, at the top of Figure 3 the efficiency of direct use of the electricity from the renewable source is noted, as for example in the case

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20 The fuel use ratings of the US Environmental Protection Agency suggest that the hybrid version of the Toyota Camry achieves 40% lower fuel consumption than the regular version in urban driving and 13% lower fuel consumption when on the highway. See http://www.fueleconomy.gov.

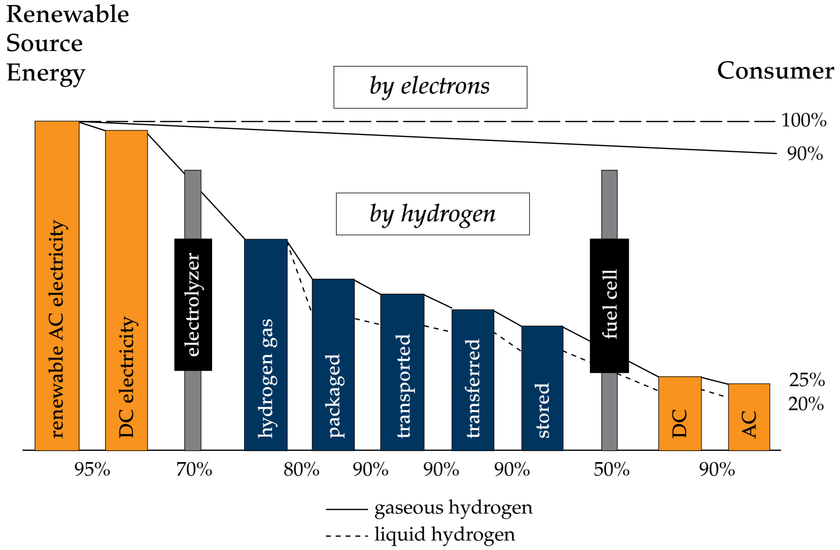
21 For an enthusiastic elaboration of a version of the hydrogen fuel-cell transport vision, see Clark WW, The green hydrogen paradigm shift: Energy generation for stations to vehicles. *Utilities Policy*, 16, 117-129, 2008.

22 Figure 3 is based on Figure 9 of Bossel U, *Does a Hydrogen Economy Make Sense?* European Fuel Cell forum, Oberoohrdorf, Switzerland, 2005, at http://www.efcf.com/reports/E13.pdf. The numbers under the bars show the conversion efficiencies of the processes represented by the bars.

23 The cumulative efficiency of the total process is the product of the individual efficiencies of the individual processes. The low cumulative efficiency may have in part been what caused US Energy Secretary Steven Chu to propose withdrawing most research funding from fuel-cell vehicles, an action that was reversed by the US Congress. See Ohnsman, 'GM, Toyota fuel-cell plans clash with US battery car push,' October 9, 2009, at http://www.bloomberg.com/apps/news?pid=20601087&sid=az48qD9Cl_kQ.

Figure 3

Movement of energy from generator to motor directly (upper two lines) and by making hydrogen that is used to make electricity (bars)



NOTE: The numbers under the bars show the conversion efficiencies of the processes represented by the bars.

Source: Bossel U, *Does a Hydrogen Economy Make Sense?* European Fuel Cell Forum, 2005.

of Calgary's C-Train.[24] The efficiency of direct use is typically 90 per cent, representing losses during distribution and voltage conversion. Thus, energy losses in the case of the fuel-cell vehicle are seven to eight *times* those of the grid-connected vehicle. Corresponding losses for a BEV would be in the order of 40 per cent: 10 per cent as for the grid-connected vehicle plus 15 per cent each for charging the battery from the grid and discharging it to the EM.

There has been a recent resurgence of interest in EVs—mostly light-duty BEVs and hybrid vehicles with EMs and ICEs—for three reasons. Foremost is heightened concern about the security of oil supplies. Second is the continuing concern about emissions from ICE vehicles, notwithstanding a substantial decline in these emissions over the last few decades, at least from light-duty vehicles. The third reason is technological improvements in EVs, particularly in batteries and other storage devices.

24 Further information about Calgary's C-train is provided later in the text in Chapter 4.

Evidence for the resurgence is easy to find. In March 2009 the federal government in the United States allocated $2.4 billion to its electric vehicle industry, and coupled this with enhanced incentives to purchase electric vehicles and measures to strengthen the electrical grid to accommodate much more electric traction.[25] Governments in other countries are also investing heavily in EV research and development or consumer subsidies, or both. For example:

- The government of South Korea is to invest $340 million in electric vehicle research by 2014, chiefly in the development of high-performance batteries. The government's goal is to "grab 10 per cent of the global electric car market by 2015."[26]
- The German government is to invest $705 million in electric vehicle research by 2012. Its target is "to make Germany the leading market for electric mobility."[27]
- In October 2009, the French government announced a 14-point action plan to support EV research, create a battery production supply chain, stimulate demand for EVs, and develop recharging infrastructure, representing investment of about US$1.5 billion.[28]
- In Japan, which has been overwhelmingly the leader in the production of hybrid automobiles, government subsidies per EV can amount to as much as $10,000.[29]

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25 See the source in Note 24 and also Siry D, 'Federal EV tax credit must be changed,' October 13, 2009, at http://www.wired.com/autopia/2009/10/ev-tax-credit/. The $2.4 billion investment in EV research and development was part of the *American Recovery and Reinvestment Act of 2009*, at http://www.gpo.gov/fdsys/pkg/PLAW-111publ5/content-detail.html, explained at http://www.recovery.gov/. Also provided for in the *Act* are investments of $9.0 billion for intercity rail, with priority for electrically powered high-speed rail and $18.8 billion for improvement of the electrical grid.

26 See 'South Korea targets world electric car market,' Agency France-Press, October 7, 2009, at http://www.mnn.com/transportation/cars/stories/skorea-targets-world-electric-car-market.

27 See Block B, 'Germany Boosts Electric Vehicle Development,' World Watch Institute, Washington DC, September 19, 2009, at http://www.greenandsave.com/green_news/green-blog/germany-boosts-electric-vehicle-development-4997.

28 See *La lettre du réseau EDF Transports et véhicules électriques, No. 148* : 'Un plan national pour accélérer le développement du véhicule électrique en France,' October 2009, at http://transports.edf.fr/edf-fr-accueil/transport/documentation-54010.html. The recent announcement may be in addition to a US$550 million investment into 'carbon-free vehicles' made in 2008. See the source in Note 27.

29 See Moffett S, Shirouzu N, 'More governments power electric-car development,' *Wall Street Journal*, October 21, 2009, at http://online.wsj.com/article/SB125606654494097035.html.

- China has the most ambitious program of all concerning electric traction, with major thrusts on three fronts. Regarding road vehicles, "Chinese leaders have adopted a plan aimed at turning the country into one of the leading producers of hybrid and all-electric vehicles within three years, and making it the world leader in electric cars and buses after that."[30] Regarding intercity electric rail, China has embarked on what has been described as the "largest railway expansion in history,"[31] committing more than US$1 trillion to expand the rail network from 78,000 to 120,000 kilometres of which 18,000 km is to be capable of supporting high-speed passenger service (200-350 km/h). Much of this is to be completed by 2012. Almost all the new service will be electrified. The longer term plan is to provide high-speed rail service to all 300 or so cities with a population of more than 200,000.[32] The third front is urban public transport. New subway lines or major extensions to existing lines are under construction in at least 15 cities, and 12 more are planning them.[33]

In most cases, governments' support for electric traction has been matched or exceeded by private-sector and other investments.

During the next several decades, what appears likely to occur is a widespread shift to electrified land transport, with deployment of all three types of EV noted above, and combinations thereof, including familiar types of EV and unfamiliar types. What remains unclear is how fast that transition will occur, and what the balance among grid-connected, battery powered and hybrid electric vehicles will be. In our

30 The quotation is from Bradsher K, 'China vies to be world's leader in electric cars,' *New York Times*, April 2, 2009, at http://www.nytimes.com/2009/04/02/business/global/02electric.html.

31 The quotation is from Wong J, Light A, *China Begins Its Transition to a Clean-Energy Economy*, Center for American Progress, Washington DC, June 4, 2008, at http://www.americanprogress.org/issues/2009/06/china_energy_numbers.html.

32 Information about China's rail expansion comes chiefly from an interview with Zheng Jian, chief planner with China's Ministry of Railways, in 'High-speed trains to take the strain,' *China Daily*, June 24, 2008, at http://chinadaily.cn/cndy/2009-06/24/content_8315454.htm.

33 See Bradsher K, 'Clash of subways and car culture in Chinese cities,' New York Times, March 26, 2009, at http://www.nytimes.com/2009/03/27/business/worldbusiness/27transit.html. Bradsher suggested, "The question is whether the burrowing machines [that are digging the subway tunnels] can outrace China's growing love affair with the automobile … ."

analysis of future US transport revolutions,[34] we concluded that by 2025 it would be reasonable—and desirable—that 30 per cent of the movement of people by land and 55 per cent of the movement of freight by land could be powered by electric traction. Present shares of electric traction are less than 0.2 per cent in each case.

What also remains unclear is the role Canada will play in this shift, whether as a producer of the means of electric traction or as a user of electric traction. Until recently, Canada might be said to have been 'punching above its weight' on electric traction but efforts elsewhere, touched on above, have put Canada firmly in the shade. The federal government and the electric vehicle industry have recently completed the *Electric Vehicle Technology Roadmap for Canada*,[35] which seeks to move Canada forward on these matters. If Canada's national government invests heavily in this area, as other national governments are doing, western Canada should be a recipient of this investment.

We also see revolutions in aviation and marine transport. For aviation, there is essentially no alternative to liquid fuels. Flying will consequently contract from being a mode of mass transport to serving a narrower travel niche, eventually used only occasionally by most people when making urgent trips over long distances and more frequently by the few who can afford the high cost of remaining commercial services of the private or fractionally owned aircraft that could be cost-competitive with sky-high air fares. Marine transport is already a highly efficient user of energy at low speeds. Its efficiency can and will be enhanced by extensive exploitation of wind power, particularly through the use of towing kites, as illustrated on the cover of the first edition of our book, *Transport Revolutions: Moving People and Freight without Oil*.[36] Marine transport's share of both freight and passenger mobility is thus likely to increase.

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34 For the suggestion as to how much of the transport system of the US (and that of China) could be and should be electrified by 2025, see Chapter 5 of Gilbert R, Perl A, *Transport Revolutions: Moving People and Freight Without Oil*. Earthscan, London (UK), 2008. For information about this book, visit http://www.transportrevolutions.info.

35 At the time of writing only the summary of the *Roadmap* was available, at http://www.evtrm.gc.ca/pdfs/E-design_09_0581_electric_vehicle_e.pdf *or at http://www.emc-mec.ca/content/technology-roadmap.*

36 Details of *Transport Revolutions* are given in Note 35.

3. WESTERN CANADA COULD PRODUCE ENOUGH ELECTRICITY, MUCH OF IT RENEWABLE

In our book *Transport Revolutions*, which focussed on China and the US, we estimated that operation of US transport that had been electrified to the extent indicated above would require only six to seven per cent of the expected US electricity supply in 2025. We also suggested that it would be feasible to provide as much as 25 per cent of the 2025 US electrical supply from renewable sources, including hydraulic, solar thermal, photovoltaic, wind, geothermal, and marine. The current share is about 10 per cent. Moreover, there is scope for improving the efficiency of electricity use that could obviate any increase in generating capacity for the purpose of electrifying transport.[37] We believe the percentage of extra electricity that would be required in Canada for a similar degree of electrification would be similar.

The sources of western Canada's electricity are shown in Figure 4. About 55 per cent of it in 2007 was produced from renewable sources (mostly hydraulic, but also wind and biomass). The remaining 45 per cent was

Figure 4

Sources of electricity generation in western Canada, 2007

	British Columbia	Alberta	Saskatchewan	Manitoba	West
Hydraulic	89.1%	2.9%	14.5%	95.7%	51.0%
Wind	0.2%	1.4%	0.7%	0.5%	0.7%
Biomass	5.5%	4.1%	1.3%	0.4%	3.7%
Total Renewable Sources	**94.9%**	**8.3%**	**16.6%**	**96.7%**	**55.5%**
Coal	0.0%	60.3%	64.5%	2.7%	29.2%
Natural Gas	5.0%	29.2%	18.9%	0.6%	14.5%
Oil	0.1%	2.2%	0.1%	0.0%	0.8%
Total Non-Renewable Sources	**5.1%**	**91.7%**	**83.4%**	**3.3%**	**44.5%**

Source: Canada's Energy Future, National Energy Board, Ottawa, 2007

37 On the scope for efficiencies in electricity generation and use see, for example, McKinsey & Company, *Curbing Global Energy Demand Growth: The Energy Productivity Opportunity*. McKinsey Global Institute, San Francisco, Ca, 2007, at http://www.mckinsey.com/mgi/publications/Curbing_Global_Energy/index.asp.

produced from fossil fuels, chiefly coal. As for oil production, there are considerable differences among the four western provinces. The two that produce little oil[38] happen to be the two whose electricity is generated almost entirely from renewable sources. Renewable sources provided 95 and 97 per cent of the generation of electricity in BC and Manitoba in 2007. Such sources provided only 8 and 17 per cent of the electricity generated in Alberta and Saskatchewan, where coal and then natural gas were the main fuels used for generating electricity.[39]

Could Alberta and Saskatchewan expand their generation of renewably produced electricity?

According to a recent comprehensive assessment, Alberta has renewable resources sufficient to provide for more than the total present production.[40] They are chiefly geothermal, hydraulic, and biomass energy, but also include wind and solar. Saskatchewan does not appear to be so well endowed, but it is especially endowed with another non-fossil resource used to generate electricity: uranium. Saskatchewan is the world's main producer of uranium and has just about all the known resource of high-grade uranium ore (more than one per cent uranium oxides).[41] If nuclear

38 Although in this paper western Canada is considered as a unit for the production and consumption of oil and oil products, and for other purposes, oil *production* in the four provinces is almost entirely from Alberta (78% of western Canada's total production of crude oil and equivalent in 2007) and Saskatchewan (19% of the 2007 total). BC and Manitoba each contributed 1% of crude oil production. These data are from Statistics Canada's *Energy Statistics Handbook* (4th Quarter, 2007; Catalogue No 57-601-X), at http://dsp-psd.pwgsc.gc.ca/collection_2008/statcan/57-601-X/57-601-XIE2007004.pdf.

39 These breakdowns for the provinces are from Appendix 5 of *Canada's Energy Future*, National Energy Board, Ottawa, 2007, at http://www.neb.gc.ca/clf-nsi/rnrgynfmtn/nrgyrprt/nrgyftr/2007/nrgyftr2007ppndc-eng.pdf.

40 See Kralovic P, Mutysheva D, *The Role of Renewable Energy in Alberta's Energy Future*. Institute for Sustainable, Energy, Environment, and Economy, University of Calgary, 2006, at http://www.iseee.ca/files/iseee/ABEnergyFutures-15.pdf. According to Table 8.4 of the source detailed in Note 39, Alberta's electricity generation in 2007 totalled 60.5 terawatt-hours. The assessment by Kralovic and Mutysheva suggests that each of hydraulic and biomass has the potential to provide this amount, and that high-temperature geothermal energy could provide many times this amount.

41 See Zittel W, Schindler J, *Uranium Resources and Nuclear Energy*, Energy Watch Group, Ottobrun, Germany, 2006, at http://www.lbst.de/publications/studies__e/2006/EWG-paper_1-06_Uranium-Resources-Nuclear-Energy_03DEC2006.pdf.

generation were considered acceptable, Saskatchewan would have the potential to provide all its electricity needs, and more, from this source.[42]

British Columbia and Manitoba also have potential to increase renewable generation of electricity. BC in particular has access to marine energy (from currents, tides, and waves)[43] as well as to the types of renewable source noted above in relation to Alberta and Saskatchewan.

Thus, the potential availability of additional electric power in western Canada to support a transition to electric traction need not be in doubt. As prices of oil and other fossil fuels rise, more types of generation for this purpose will be cost-effective. This paper will not venture into the challenging matter as to exactly when it will be cost-effective to focus on one particular resource rather than another. We note only that generation from several of the noted sources already seems to be close in price to fossil-fuel generation,[44] and will become more competitive if fossil fuels are taxed or their use is otherwise constrained—such as through tradable carbon emissions caps—to address concerns about climate change. In July 2008, BC became the first jurisdiction in North America to impose a carbon tax on consumers.[45]

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42 According to a news report, "The government of Premier Brad Wall has expressed support for nuclear power as a way to wring more value from the province's vast uranium reserves." (Bruce Power eyeing Saskatchewan nuclear plant, *Reuters*, June 18, 2008, at http://uk.reuters.com/article/rbssEnergyNews/idUKN1737917120080617. The same report noted a proposal for the construction of up to four nuclear reactors in Alberta.

43 One report suggests that BC could have access to marine energy that produces similar quantities of electricity to that now produced in the province. See Khan J, Bhuyan G, Moshref A, *An Assessment of Variable Characteristics of the Pacific Northwest Region's Wave and Tidal Current Power Resources, and their Interaction with Electricity Demand & Implications for Large Scale Development Scenarios for the Region - Phase 1.* Powertech Labs Inc, Surrey BC, 2008, at http://www.powertechlabs.com/cfm/index.cfm?It=202&Id=1&Se=2&Lo=2&AF=Download&AA=202,12&AD=DlFile. Figure 11.2 on Page 40 of that document suggests that BC has potential access to 37 GW of wave power and 4 GW of tidal power. Together, this could perhaps result in annual electricity output of about 140 TWh. According to on the source detailed in Note 40, current generating capacity and output are respectively 11 GW and 68 TWh.

44 According to an authoritative source, the following means of generation had an all-in cost in 2003 of less than 10 cents per kilowatt-hour: nuclear, coal, natural gas, biomass, landfill gas, and geothermal. Wind and large hydro were usually below this cost. See Figure 1 of Walden T, *Relative Costs of Electricity Generation Technologies*, Canadian Energy Research Institute, Calgary, Alberta, 2006, at http://www.ceri.ca/documents/CERIComparativeCostsSept2006.pdf.

45 On gasoline, BC's carbon tax amounts initially to 2.4 cents per litre, rising by steps to 7.2 cents per litre in 2012. BC already had the second highest excise duty (flat-rate tax) on gasoline, but because provincial sales tax is not paid on gasoline in BC, but is in some other provinces, BC's total tax on gasoline was sixth highest. If no other changes are made, BC will have the highest taxes on gasoline by 2012.Quebec had imposed a carbon tax on fuels in October 2007. It is paid by distributors and for gasoline amounts to 0.8 cents per litre.

The complementary nature of electricity generation in western Canada—with two provinces mostly using renewable sources and two provinces not—could be reinforced by the development of a common electrical grid. Presently, western Canadian provinces engage in more than three times as much trade in electric power with the US as they do among themselves.[46] Moreover, Manitoba, whose net exports were a third of its production in 2007, is seeking to export more to Ontario rather than to Saskatchewan or Alberta.[47]

Similarly, there would be value in a Canada-wide, high-capacity, direct-current transmission system for electric power. Such a Canadian grid could be a suitable national project for the first third of the 21st century, just as the trans-continental railway was the national project of the last third of the 19th century. Western Canada could lead in such a venture and would be a major beneficiary of it.

46 Data on generation, exports, and imports of electric power are from the source detailed in Note 39.

47 See Manitoba Hydro-Electric Board, 'Exporting Electricity and Enhancing Reliability,' *Annual Report for the Year Ending March 31, 2006*, Winnipeg, Manitoba, pp 31-34.

4: ECONOMIC OPPORTUNITIES IN THE ELECTRIFICATION OF LAND TRANSPORT

We have argued that western Canada has two good reasons to reduce its oil consumption: to protect its consumers from escalating prices and because its per-capita consumption is extraordinarily high. Here, we offer another kind of reason: that there could be substantial opportunities for economic development. Specifically, we propose that western Canada become a leader in what—based on the arguments in Chapters 1-3—we expect will be a major revolution during the coming decades: the electrification of land transport.

Why should a region that is so rich in petroleum sources try to lead in moving its land transport system away from use of oil as a fuel?

Given western Canada's energy abundance and the high probability that oil production will maintain or enhance Canada's position as a major energy exporter well into the future, the **need to lead** in converting land transport systems to electric traction could be seen as an unlikely or even incongruous goal. It might seem paradoxical to rush ahead in advancing alternatives to the main use of oil when so much wealth stands to be generated by extracting and exporting that oil. When alternatives to the internal combustion engine do become available, western Canada would likely be affluent enough to import them. Moreover, concerns that accelerating the transition away from oil as a transport fuel might undermine the West's economic prospects are likely to be raised regarding any attempt to develop electric transport options ahead of the curve.

Nonetheless, there are at least three reasons to aim for leadership in providing alternatives to oil as a transport fuel. First, prices for oil may reach a level where this energy source becomes too profitable to be consumed locally, especially when substitutes such as electric traction can power mobility at a lower cost. The public revenues generated by royalties from producing high-priced oil could well pay for the infrastructure improvements needed to substitute electricity generated by renewable energy sources.

Second, high oil prices will generate inflationary pressure in the Canadian economy to the extent that the economy is dependent on oil. Canada's transport system is the economic sector most dependent on oil, which provides over 95 per cent of the energy used to power mobility. The combination of inflation driven by rising energy prices and declining demand for other goods and services as more spending is devoted to energy yields the 'stagflation' that was prevalent in North America during the 1970s.[48] An even worse fate could be the so-called Dutch Disease that afflicted The Netherlands in the 1970s. This was chiefly a decline in the country's manufacturing sector following the discovery of off-shore natural gas in the 1960s. One remedy for this disease is aggressive diversification of the economic base.[49]

Third, the transition to electric transport systems offers an opportunity for western Canada to move ahead of other North American regions where manufacturing based around the internal combustion engine has flourished.[50] North America's EV manufacturing capacity is in its infancy, yielding a major growth opportunity for EV and propulsion system production. In the event that oil becomes less available and more expensive, electric transport could acquire the trajectory of a leading-edge technology such as the Internet and genomics. Electric transport could thus blossom into an economic driver that provides a major economic stimulus across western Canada in the way that information technology did for the economies of California, Washington, and Oregon in the 1980s and 1990s.

An example of fostering such 'sunrise' industrial development by one of today's major oil producers can be found in the Masdar ecocity initiative being developed by Abu Dhabi, United Arab Emirates (UAE). According to one analyst, the UAE now possesses the world's largest ecological footprint. UAE's per-capita consumption of resources, energy, and water requires natural capital normally associated with 11.9 hectares of land in

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48 See Sachs JD, Stagflation is back; Here's how to beat it. *Fortune*, May 28, 2008, at http://money.cnn.com/2008/05/27/news/economy/sachs_stagflation.fortune/index.htm. See also Rubin J, Buchanan P, A time for caution: Oil set to hit $200 by 2010. *Canadian Portfolio Strategy Outlook*, CIBC World Markets, Toronto, Ontario, July 7,2008, at http://research.cibcwm.com/economic_public/download/psjul08.pdf.

49 See Mehrara M, The asymmetric relationship between oil revenues and economic activities: The case of oil-exporting countries. *Energy Policy*, 36, 1164-1168, 2008.

50 Major manufacturers may, however, be moving quickly not to manufacture electric vehicles in western Canada but to supply product there. Both BC Hydro and Manitoba Hydro (with Hydro-Québec and several US utilities) are part of a recently established network led by General Motors that seeks to develop a standardized electric fuel infrastructure that can be used easily by drivers. See van Praet N, GM gets plugged in with power companies. *Windsor Star*, July 23, 2008. Also see the present paper's Box 1 above.

comparison to the average global footprint of 1.8 hectares.[51] The secretary general of the Global Wind Energy Council has suggested that Masdar's core goal of eschewing oil use was motivated by the UAE's desire to secure its economic future: "Abu Dhabi's leadership has the foresight to add up the numbers and read the writing on the wall. They see that economic diversification is essential to their future, and where better to start than with the sector that created their wealth in the first place?"[52] Masdar will be powered entirely by renewable energy, using pioneer technologies and designs that reduce the ecological footprint and enhance energy resilience.

By 2015, Masdar's six square kilometres are expected to house 65,000 residents. A Personal Rapid Transit (PRT) system powered by solar energy is to provide the principal means of local motorized mobility. The system is being designed for peak use of 2,000 vehicles operating among 83 stations.[53] This scale of PRT operation, an order of magnitude larger than existing or other planned systems, will provide an opportunity for moving such technology from prototype to commercial production. Reaping benefits from such early adoption of sustainable mobility technology is an explicit strategy. By 2015, Masdar should be "a world-class scientific and research hub … currently non-existent in the Gulf region, [which can] become the core of other knowledge-based activities and industries in addition to clean energy."[54] There is perhaps even greater potential for an analogous industrial development strategy to thrive in western Canada, which has a head start on Masdar and similar 'greenfield' initiatives in launching electric mobility.

Transport Development Strategies for Western Canada

From electric motor manufacturing to vehicle assembly, key components of electric transport production are now a reality in western Canada. Some established suppliers of electric transport technology will be profiled to illustrate current capabilities and identify strategies that led to industrial success, as well as highlight gaps in the spectrum of electric transport

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51 For Masdar, see Raouf MA, *Climate Change Threats, Opportunities and the GCC Countries*. Policy Brief No. 12, Middle East Institute, 17 pp, 2008. Available at http://www.mideasti.org/files/CLIMATE-CHANGE-THREATS-OPPORTUNITIES-GCC-COUNTRIES.pdf.

52 The quotation is from Sawyer S, A Year to Remember. *efocus*, Vol. 9(2), 24-25, 2008.

53 For Masdar's proposed PRT, see Mogge J, Masdar City: Test Site for Living Without Cars. *Quarterly Planet* (C2HMHill), 4, June 2008. At http://www.ch2m.com/corporate/services/sustainable_solutions/assets/quarterly_planet/2008_06_QP.pdf.

54 The quotation is from Page 12 of the source detailed in Note 53.

production. Western Canada's electric transport producers can now be found at each end of the region.

New Flyer Industries

Winnipeg is home to North America's largest bus manufacturer, New Flyer Industries. In 2007, New Flyer earned $96 million on revenues of $887 million and had firm orders for 2,844 buses.[55] More than half of the company's 2,200 employees are employed at its headquarters building that houses two vehicle assembly lines along with corporate offices.

New Flyer produces a range of buses from standard diesel vehicles to articulated electric trolley buses. It recently delivered 188 standard and 40 articulated electric trolley buses to the Greater Vancouver Transit Authority, better known as TransLink. As well, 38 electric trolley buses have been built recently for the Southeastern Pennsylvania Transport Authority to re-equip services in Philadelphia. Electric trolley buses have been a small subset of New Flyer's bus production over the years, but this company is the only North American manufacturer that has delivered grid connected electric road vehicles during the past decade.

New Flyer previously delivered electric trolley bus fleets to Toronto in 1968 and San Francisco in 1992. Other electric models produced in smaller quantities include gasoline-electric and diesel-electric hybrid buses and fuel-cell powered buses. Such a product line offers considerable potential for expanded production as North American cities rediscover the advantages of electric transit and seek to expand such services, replacing vehicles with diesel engines whenever possible. New Flyer has responded to growth in the US by opening assembly plants in St. Cloud and Crookston, Minnesota. Meeting future EV production demand by expanding this capacity in western Canada would provide an opportunity to focus on the vehicles most likely to be the mainstay of public transit in coming decades.

Azure Dynamics

Where New Flyer has built its leading position on a long history of bus manufacturing, with periodic advances in electric trolley bus production, another western Canadian electric transport producer is poised for a burst of growth when local *freight* movement moves to electric traction. In BC,

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55 This information is from New Flyer Industries' 2007 *Annual Report*, available at http://www.newflyer.com/index/financialreport.

Azure Dynamics stands out as a producer of electric and hybrid-electric propulsion systems for road vehicles, operating in "global niche markets including delivery fleets, utility vehicles, [and] shuttle buses."[56]

Launched in 1997 by BC Research Ltd., a publicly sponsored technology incubator, the company secured initial equity financing in early 2000 and was then acquired by Wild Horse Resources Ltd.[57] Deploying electric vehicles that could meet the reliability needs of overnight delivery giants such as Purolator and FedEx has taken several years. Recently, Azure Dynamics was lauded as "a great example of a company that has crossed the chasm from R & D to commerciality."[58] As well as to Purolator and FedEx, Azure has sold electric drive delivery and service trucks to the US Postal Service, Florida Power & Light, and AT&T.

To enhance access to American customers and investors, and lured by a US$1.7-million tax credit from the Michigan Economic Growth Authority, Azure moved its corporate headquarters from Canada to Oak Park, a suburb of Detroit. While some production and most electrical engineering activities remain in Burnaby, Azure has succeeded in growing its U.S. vehicle sales during the challenging market conditions of 2008 and 2009. Azure has signed qualifying sales agreements with the states of Michigan, Oregon, Minnesota, Kentucky, Maryland, and York County in Pennsylvania.[59] This means that Azure's vehicles are eligible for federal government funded public transit initiatives, such as the recent order for 25 CitiBus hybrid electric vehicles that was placed by Howard County, Maryland.[60]

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56 The quotation is from Azure Dynamics' *Investor Fact Sheet*, July 2008. Available at http://www.azuredynamics.com/corporate/investor-relations/press-releases.htm.

57 For the history of Azure Dynamics, see two *Business Wire* items: Immune Networks Ltd., BC Research Announces Equity Financing for Azure Dynamics Inc., September 26, 2000, at http://www.allbusiness.com/automotive/automotive-industry-environment/6505240-1.html; and Immune Networks Ltd., Azure Dynamics Announces Merger, Close of Financing, and Appointment of New CEO, November 28, 2000, at http://findarticles.com/p/articles/mi_m0EIN/is_2000_Nov_28/ai_67398957.

58 The quotation is a statement by J. Marvin Wolff, senior technology analyst at the investment firm Paradigm Capital, reported in Henderson T, Maker of Hybrid Power Trains Moves to Attract Investors. *Crain's Detroit Business*, June 2, 2008, at http://www.crainsdetroit.com/article/20080602/SUB/806020377.

59 Azure Dynamics's pre-qualifying sales agreements as of 2009 are detailed in *Azure Dynamics Wins Michigan Department of Transportation Contract*, at http://www.azuredynamics.com/corporate/investor-relations/documents/PR_September24_2009.pdf.

60 See 'US: Azure Dynamics wins further hybrid CitiBus orders,' in *Automotive World*, October 1, 2009, at http://www.automotiveworld.com/news/environment/78791-us-azure-dynamics-wins-further-hybrid-citibus-orders.

While the financial crisis has certainly impeded Azure's ambitious plans for growth, the company continues to develop its capacity to fulfil US demand for vehicles that can move people and goods with less oil. If electric transport manufacturing is identified as an economic development opportunity for western Canada, the need to convince firms like Azure to site future production on this side of the border will be a high priority.

Wismer & Rawlings Electric Ltd

Another western Canadian firm that has built a niche in electric transport production is privately held Wismer & Rawlings Electric Ltd, of Port Coquitlam, BC. Its wholly owned subsidiary, Unit Electrical Engineering Ltd. (UEL), supplied the linear induction motors that propel Bombardier Corporation's Advanced Rapid Transit (ART) vehicles, best known as the SkyTrain in and around Vancouver. These trains also operate in Toronto, Detroit, Kuala Lumpur, New York, and Beijing with a line under construction linking Yongin with Seoul, Korea. Bombardier has noted that 150 million riders a year make use of ART trains.[61]

Wismer & Rawlings employs 60 staff at its Port Coquitlam headquarters and 85 staff at UEL's production facility in Okanagan Falls, near Penticton. UEL's annual sales were estimated to be $11.1 million in 2007.[62] Wismer & Rawlings' ability to capture this electric production niche was one result—perhaps the most successful outcome—of an economic development strategy that was pursued while expanding Vancouver's electric rail transit services in the late 1990s. Wismer & Rawlings began producing linear induction motors for rail transit vehicles following Bombardier's commitment to locate an electric transit manufacturing facility in BC In 1998, when a $450 million contract was signed for the 21-kilometre, 14-station expansion of Vancouver's SkyTrain system that became known as the Millennium Line.

Beijing's newest rapid transit line, running 28 kilometres to its international airport, operates Bombardier trains propelled by linear induction motors built by UEL. Bombardier has proposals under consideration to supply

61 The information about ART is from Bombardier, *Moving in the Right Direction: Advanced Rapid Transit*, 2008, at http://www.bombardier.fi/en/transportation/products-services/rail-vehicles/advanced-rapid-transit?docID=0901260d8000a648.

62 Information about Wismer & Rawlings and UEL is from *Wismer & Rawlings Electric Ltd.*, ProFile Canada, 2008, at http://www.profilecanada.com/companydetail.cfm?company=140500_Wismer_Rawlings_Electric_Ltd_Port_Coquitlam_BC; and from Unit Electrical Engineering Ltd. *Hoover's Company and Industry Reports*, 2008, accessed through LexisNexis Academic database.

the same ART technology to three Chinese cities, with each proposal specifying the use of the BC-produced linear induction motors.[63] Western Canada's export of this type of electric transit motor is thus poised for further growth around the Pacific Rim, demonstrating the payoff from industrial development initiatives undertaken as part of local electric transit expansion.

Additional Noteworthy Companies[64]

Dynasty Electric Car Corporation, Delta, BC. Dynasty Electric Car Corporation designs, manufactures, and markets zero emission, electric low speed vehicles for urban, recreational and light commercial markets such as planned and gated communities, destination resorts, industrial complexes and universities.

Canadian Electric Vehicles Ltd. (CEV), Errington, BC. CEV was established in 1991 to convert ICE vehicles to clean electric power. Customers have included federal and provincial governments, industrial companies as well as private individuals. CEV has also provided electric power conversion kits to universities, corporations and individuals across Canada, and is currently converting heavy-duty diesel trucks to electric power for the airline industry. CEV sells conversion kits for many vehicles, components for fixing or modifying electric vehicles, and custom-build electronic power-conversion systems for airports.

These vignettes of electric transport manufacturing illustrate how both private and public entrepreneurship have yielded noteworthy production capabilities in western Canada. These and other leading-edge efforts provide part of the nucleus of technical and organizational know-how that western Canada could build upon in maintaining its lead over jurisdictions where established transport equipment manufacturers are closely tied to the ICE. Western Canada is also endowed with considerable academic and other resources that have some focus on electric transport and could be marshalled to support an economic development strategy that focused on electric traction. They include among others the University of Winnipeg's Centre for Sustainable Transportation, the University of

63 See York G, China's newest train has a BC feel. *Globe & Mail*, June 17, 2008, at http://aol.theglobeandmail.com/servlet/ArticleNews/aolstory/TGAM/20080617/RBOMBARDIER17.

64 The information about CEV and Dynasty Electric Car Corporation was taken from their respective Web sites at http://www.canev.com/ and http://www.itiselectric.com/.

British Columbia's Clean Energy Research Centre, and the University of Victoria's Institute for Integrated Energy Systems.[65]

Mention should also be made of western Canada's substantial experience with electric public transit. Of special note are the systems in Calgary and Vancouver. Calgary's C-train is 100-per-cent fuelled by renewably produced electricity purchased from the operator of 12 wind turbines in the Rockies, justifying its slogan 'ride the wind.' Vancouver's SkyTrain and trolley bus systems rely wholly on the regular sources of power for the BC grid, which are 95-per-cent renewable.

Another important electric mobility option that has been receiving attention recently is a high speed train link between Calgary and Edmonton, Alberta.[66] A 2004 study by Calgary's Van Horne Institute concluded that "projected ridership and revenues are able to cover the system's operating costs and, depending on the route / technology chosen, repay all or most of the system's capital cost within 30 years."[67] Among technologies assessed was the kind of high-speed train used in France and elsewhere, electrified and capable of 320 kilometres per hour. This 'Greenfield Electric' system was projected to capture about a quarter of the trips among Calgary, Edmonton, and Red Deer within a decade of implementation. It would generate sufficient revenues to cover about three quarters of capital costs.[68]

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65 The information about the three listed university centres is respectively at http://cst.uwinnipeg.ca/, http://www.cerc.ubc.ca/, and http://www.iesvic.uvic.ca/.

66 See, for example, Kossowan B, 'Political will lags behind train debate,' *Red Deer Advocate*, October 15, 2009, at http://www.albertalocalnews.com/reddeeradvocate/news/local/Political_will_lags_behind_train_debate_64355282.html.

67 The quotation is from Page vi of Shirocca Consulting, *Calgary/Edmonton High Speed Rail: An Integrated Economic Region*, The Van Horne Institute, Calgary, AB, October 2004, at http://www.vanhorne.info/vanhorne/files/vanhorne/HSRFullReport(1062004).pdf.

68 Oil prices were not included in the modelling. Inclusion of recent and expected high oil prices would have suggested an even higher level of feasibility.

A more recent study commissioned by the Alberta government produced similar ridership and revenue estimates.[69] This study justified enhancing mobility between Alberta's two largest cities as a valuable amenity that would help Alberta attract 'footloose' investors and skilled workers who sought easy travel between urban centres and were attracted to jurisdictions that offered such options.

In showing support for a high-speed rail project, Alberta's Minister of Transportation, Luc Ouellette, suggested that government could support part of this infrastructure development by assembling the land needed for the rail right of way, adding that the land assembly could take 'upwards of a couple of decades.'[70] This timing would leave Alberta well behind other jurisdictions that are developing high-speed train networks in anticipation of future energy and environmental challenges.

With China and other nations expanding their capacity to develop and deploy electric mobility, Canada needs to move quickly to fill gaps in manufacturing capability. This expertise could embrace the full spectrum of grid-connected transport opportunities including rail passenger and freight locomotives and rolling stock, light rail transit vehicles, and heavy rail metros (including Advanced Rail Transit). Further analysis will be needed to determine the best strategy for nurturing these different electric transport capabilities. We turn now to how such a strategy could be developed.

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69 This study is TEMS, Inc. and Oliver Wyman, *Market Assessment of High Speed Rail Service In The Calgary-Edmonton Corridor*, February 2008, at http://www.transportation.alberta.ca/Content/publications/production/AIT_Market_Assessment_Full_Rpt_02-2008_FINAL_rev.pdf. This study did take account of the possibility of different oil prices, up to $100/barrel, but in a way that cannot be readily deciphered. For example, $100/barrel oil was said to equate to equate to gasoline at $1.50/litre even though at the time of publication of the report oil was about $90/barrel and the Calgary pump price was about $1.00/litre. The price of a barrel of oil went above $145 later in 2008, the pump price did not rise above $1.35/litre. There are other concerns about the TEMS-Wyman report, including what may be improbable estimates of total trips among the three cities (roughly five times those estimated for the Van Horne report detailed in Note 73).

70 See Fekete, Jason, 'Alberta high-speed line stuck at station,' in *The Calgary Herald*, August 7, 2009, at http://www.calgaryherald.com/news/Alberta+high+speed+line+stuck+station/1864069/story.html.

5: POLICY PROPOSALS AND IMPLICATIONS

Western Canada's diverse and abundant energy resources provide considerable opportunities for developing mobility options that could enrich the region's future. Electric traction offers Canada, and the world, the most efficacious means to help resolve the economic and political challenges that will arise from oil depletion. A judicious mix of proven electric traction technologies offers the most realistic strategy for addressing Canada's energy and environmental challenges. They include EMs, renewable electricity generation, new infrastructure for delivering this power directly to vehicles moving within and between cities, and better batteries and other storage systems. Integrating these energy and transport technologies will yield powerful solutions to the world's oil depletion challenges and provide new opportunities for more sustainable development. During the 20th century, oil products, ICEs, and highway and aviation infrastructure created a framework that powerfully influenced North America's economy and society. This framework shaped industrial development and energy production and use. It transformed the spatial organization of living and working arrangements. The electric trains, trucks, buses, and personal vehicles in our future could well reshape economic and spatial development at least as extensively as did their oil-fuelled predecessors.

Western Canada's role in this transformation remains to be seen. There will be opportunities to extend the gains in energy production being felt across most of the West to include renewable electricity generation. If the transition to electric traction is recognized as an economic development opportunity for western Canada, there could also be a major boost in manufacturing EMs and power distribution infrastructure, and even in electric rail and road vehicles.

Broadening western Canada's participation in the coming transport revolution from a user to a user *and* producer of new electric mobility technology would open up economic opportunities well beyond the extraction of energy-related and other natural resources. By using the coming transport transition as a means to develop vehicle and propulsion system design and manufacturing, western Canada could position itself to profit from both the production of energy and its use in electric transport. Such a trajectory would reap significant benefits for the firms that develop and deploy these transport alternatives, and yield employment opportunities in the communities where these firms are located.

Western Canada Electric Transport Task Force

Achieving this vision will require, among other things, new organizations that can facilitate the expansion of electric transport manufacturing in western Canada. Our proposal is for a two-stage approach to expanding the West's supply of electric transport equipment and vehicles. In the first stage, lasting just over a year, a **Western Canada Electric Transport Task Force** (the Task Force) would assess the energy transition strategy for transport outlined in this paper. If the strategy were found to have merit, the Task Force would then analyze the strengths and weaknesses of policy instruments that governments could use to accelerate this transition in western Canada.

Shifting large volumes of western Canada's mobility from oil to electric power will involve policies that entail controversy, uncertainty, and financial cost. There could be mounting pressure on governments to 'do something' about energy and transport alternatives, even in the relatively near future. The Task Force and those who appoint it will need to signal that its work can lead to prompt action rather than inertia. Ways to send such a message include appointing high-level participants to the Task Force, setting an early deadline for production of its report, and providing the resources needed to bring leading-edge policy research capacity to this effort.

The Task Force could be organized as a Royal Commission, with commissioners drawn from senior executives in government and industry. The Task Force would oversee a research staff composed of leading technical and management authorities who would examine new ways of combining electric power and surface transport. An advisory panel of executives in transport—from railways, trucking, and airlines—and energy could offer focused input to the Task Force's research. The Task Force research staff should be recruited to include global expertise in electric transport design and manufacturing, much of which resides in Europe and Asia in order to comprise an extensive range of expertise.

In our estimation, a 15-month time frame for producing recommendations appears both necessary to do sufficient work and desirable in that it will indicate that governments expect to act promptly on the Task Force's findings. A relatively low price of oil might suggest that a longer time frame could be considered. But, even with such a respite in the world's energy transition beyond oil, the need to find solutions will remain pressing. For example, the price of oil could drop sharply following a global financial meltdown triggered by acute 'stagflation'.[71] In this case the 'cure' for reducing global oil demand would be worse than the disease, and a global economic depression caused by dependence on an increasingly scarce oil supply would still call for new energy and transport solutions. Another grim scenario could see world trade sharply curtailed by conflict over oil resources. Here again, the need to come up with mobility alternatives in western Canada would remain urgent.

The Task Force's research goal would be straightforward, yet demanding. After calculating the person- and tonne-kilometres of mobility to be shifted from oil to electric power in the short, medium, and long terms, these aggregate mobility levels would be translated into estimates of new cars, buses, trucks, rail locomotives, and other EVs that could meet such demand. The vehicle volumes could then be translated into a market estimate of the demand for electric vehicle production in North America in particular and also beyond. This demand estimate would be compared with an inventory of the existing production facilities in western Canada that are now producing—or could easily be adapted to producing—EMs, EVs, and power distribution systems. The difference between the potential market demand for EVs and the current production capacity would likely be significant. It would form the subject of the Task Force's subsequent analysis on how to best to grow this capacity in western Canada and how far to grow it.

Possible Policy Instruments

This assessment would form the foundation for evaluating the appropriateness of different policy instruments that could be introduced to facilitate the development of an electric transport manufacturing sector in western Canada. Some of the possible policy instruments are elaborated below in order of increasing levels of government intervention.

The least ambitious intervention that governments could consider for facilitating industrial development would be for governments to offer non-monetary assistance to private firms interested in establishing electric transport production facilities in western Canada. Such support could include identifying suitable production sites (developed or undeveloped), expediting municipal approval of development and construction permits

71 For items on stagflation, see Note 50.

for new industrial facilities, and assisting in the recruitment of skilled workers.

A more engaged intervention would have governments committing to procure their EVs from western Canadian manufacturers, if the proposed products would meet competitive price and performance standards, and if such commitments would be compatible with international and interprovincial trade agreements. Local and provincial governments operate an extensive fleet of cars, trucks, buses and other vehicles. The totality of this fleet would constitute a major market opportunity for electric mobility manufacturers and thus provide an incentive to locate production in western Canada.

Next on the scale of increasing government initiative and intervention would be the establishment of tax and fiscal incentives for private firms that locate or expand electric transport production facilities in western Canada. These could include tax breaks, low-interest loans and outright grants. Incentives would probably be most effective if they were specifically tailored to particular firms following case-by-case negotiations. However, a total envelope for such expenditures should be identified and publicized to actual and prospective producers of electric transport technology who would then be invited to submit proposals for their new facilities and the public support they seek to launch them. The Task Force should evaluate the scale of tax and fiscal incentives needed to make such an industrial development strategy work, and again assess their alignment with trade agreements.

A further step in expanding government's support for electric transport manufacturing ventures based in western Canada would involve public investment into these ventures. Governments could become 'silent partners' by acquiring a minority stake in the equity of producers who locate or expand their presence in western Canada. Governments could also offer reduced-rate or even interest-free loans to provide some of the 'patient capital' needed to build electric transport manufacturing facilities. The appropriate scale for such a public investment program would need to be assessed by the Task Force.

More ambitious public action would see joint ventures established between Crown corporations and electric transport manufacturers to locate equipment and vehicle production in western Canada. With three western provinces' producing electricity through Crown corporations, the potential exists for these entities to form a joint venture with one or more electric transport manufacturers. In Alberta, where electric power is

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generated and transmitted by private companies, the option of engaging municipal public enterprise (e.g., Calgary's ENMAX and Edmonton's EPCOR utility corporations) in these joint ventures could be considered.

A further step could involve creation of a joint venture among western Canadian Crown corporations to produce electric transport technology. This option would be similar to a partnership with private partners, but would shift the balance of effort and responsibility for producing electric transport equipment and vehicles to a public enterprise that would be a jointly owned subsidiary of several western Canadian Crown corporations in the electric power sector. This corporation could license or purchase electric transport technology from one or more private firms to build a line of electric vehicles for sale in Canada, and for export.

The most ambitious public policy instrument available to western Canadian governments desiring to lead in the electric transport transition would be to create a new Crown corporation that would design, develop, and manufacture electric transport equipment and vehicles. This new public enterprise would stand alone from other public and private enterprises and would focus on producing electric transport equipment and vehicles. The western provinces would each take a stake in its capitalization.

These policy instruments may represent the range of actions that governments could consider in guiding the development of electric transport manufacturing in western Canada. They are not mutually exclusive, and the Task Force would consider whether a mix of these instruments or others might be more effective than any one of them. Once the Task Force recommendations are released, a focused opportunity for intergovernmental negotiations on implementing them would need to occur.

Electric Transport Summit

The initial element of the second stage of the two-stage approach we are proposing would be the delivery of the Task Force's findings to an **Electric Transport Summit** of first ministers and selected municipal leaders, where the policies implementing the preferred development strategy could be approved in principle and made public.

The summit would provide a high-profile opportunity to ratify policy arising from the first phase of planning for a shift away from oil-fuelled mobility. The federal government could also be invited to the summit, and would have the opportunity to engage and support the new policies in ways that complemented provincial and municipal initiatives. The summit should be scheduled 18 months from the start of the work of the Task Force to set a clear point at which the policy analysis and political deliberations would begin to yield action.

Additional Entities

Governments ratifying and implementing the new policies could directly or indirectly support two new entities that would play critical roles in implementing these policies. The **Electric Transport Research and Development Centre** would strengthen new and expanding enterprises by helping to bridge the gap between development and commercialization of electric transport technology. The **Electric Transport Asset Partnership** would serve as a banker and broker for financing the establishment and expansion of electric transport producers in western Canada.

The first of these two new organizations would be the analytical heir to the Task Force in that it would continue with charting the most promising pathways to western Canada's new electric transport production. It would need to support and nurture the managerial talent who would establish competitive production facilities for those technologies. It would need to offer objective business-case analyses that provide a measure of confidence for private and public investors in these efforts. We suggest that the Electric Transport Research and Development Centre be modelled on the US Electric Power Research Institute (EPRI).

Founded in 1972, on the cusp of the world's first major oil shock, EPRI is a non-governmental organization whose members generate 90 per cent of the electric power produced in the US. International participation in EPRI is extensive. All four western provinces' major power producers (BC Hydro, TransAlta, Sask Power, and Manitoba Hydro) are members. EPRI "conducts research and development relating to the generation, delivery and use of electricity for the benefit of the public. … EPRI brings together its scientists and engineers as well as experts from academia and industry to help address challenges in electricity, including reliability, efficiency, health, safety and the environment. EPRI also provides technology, policy and economic analyses to drive long-range research and development planning, and supports research in emerging technologies."[72]

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72 The quotation is from the EPRI Web site at http://www.epri.com. EPRI has an electric transport division. It focuses on accelerating the penetration of electric-drive vehicles in order to "increase electricity sales, promote economic development and customer retention, improve customer satisfaction, and contribute to a cleaner environment."

The other new entity, the **Electric Transport Asset Partnership**, would be a banker and broker of new electric transport production capacity. Depending on the policy instruments chosen to facilitate this transition, this entity could be a public enterprise such as the Business Development Bank of Canada or Alberta Treasury Branch Financial, or it could be a private financial entity fostered by favourable tax or fiscal treatment. One possibility would be for the Partnership to grow out of a joint venture among western governments, perhaps through their electric power enterprises.

Much political effort will have be expended to realize the strategy that would exploit the coming paradigm shift toward electric mobility. The proposed timing and level of cooperation required to embrace a new paradigm for transport energy in western Canada might seem incredible in light of the usual experience of government policies and programs, but the circumstances under which these new organizations would be created could be anything but typical. If the price and availability of oil proceed along the trajectory of the last several years, the threat to economic and social stability posed by our present reliance on oil-fuelled transport will have become apparent. Times of crisis not only enable political initiatives that seem unthinkable under ordinary circumstances, they also compel major policy change.

Summary

By anticipating the potential for rapidly changing the energy and technology used to power surface transport across western Canada, governments will be well positioned to make the most of the economic opportunities that accompany such a transformation. Anticipation requires a clear vision for capitalizing on this transport transition as an industrial development opportunity and a policy framework that supports the organization and financing of mass production in electric mobility. Western Canada could join or replace Ontario as a major Canadian producer of rail and road vehicles. Winnipeg could recapture Windsor's glory days of vehicle assembly. Saskatoon could surpass St. Catherines as a producer of vehicle components. Other communities in western Canada could find their chance to contribute to this new wave of transport sector production. All this could happen if the EV industry finds good reason to focus on western Canada as a leader in the first wave of North American movement away from using oil to fuel its mobility. ■

About Canada West Foundation

The Canada West Foundation is the only think tank dedicated to being the objective, nonpartisan voice for issues of vital concern to western Canadians. Through our research and commentary, we contribute to better government decisions and a stronger Canadian economy.

The West is in. And the Canada West Foundation helped put it there. Over the past 40 years, our research and commentary has improved government policy and decision making. Today, the West is on the national agenda and is at the forefront of the most important debates that will shape our country.

We give the people of British Columbia, Alberta, Saskatchewan and Manitoba a voice. A voice for their dreams, interests and concerns. As westerners, we understand the people and the places of the West. We know our history and how it influences our future. Whether it is the economy, energy, environment, education, healthcare, taxes, social services, urban issues, provincial-federal relations or any other policy area of importance to the West, we have researched it, commented on it, stimulated debate about it and recommended practical options for improving the policy response. Democracy lives.

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