Provincial perspectives on electric traction

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This paper discusses how Canada's provinces are placed with regard to electric traction in general and to ways of powering electric traction in particular. Several factors are considered. They include amounts and sources of electricity generation, degree of dependence on imported oil, extent of investment in automotive industries, provincial policy context, and climate. Two types of powering are emphasized: powering by on-board storage devices (as in battery-electric and plug-in hybrid vehicles) and powering from the grid while in motion (as in streetcars, trolley buses and electric trains).

Production, source, and use of electricity

Provinces may be hospitable to electric traction to the extent they produce a surplus of electricity, especially if it is renewable.

Figure 1 shows the production of electrical energy in each province during 2009, and the sources of the electricity. [1] In Figure 1, and throughout this paper, aggregated data are provided for the three maritime provinces, New Brunswick, Nova Scotia, and Prince Edward Island, which are mostly similar in respect of the matters discussed.

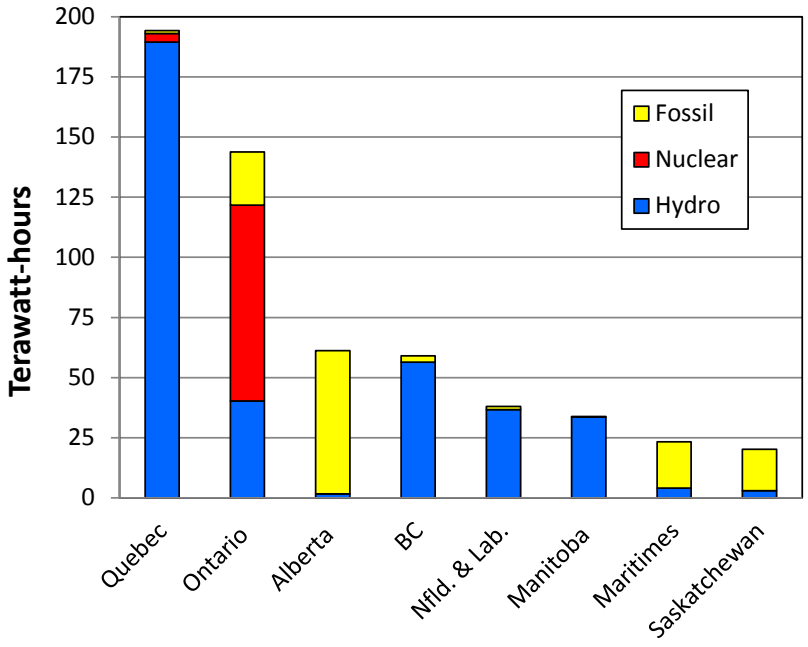

Figure 1: Production and source of electrical energy in 2009

Four provinces – Quebec, British Columbia (BC), Newfoundland and Labrador, and Manitoba – produce almost all their electricity from hydraulic sources. Together with that of Ontario, this hydraulic generation puts Canada in the position of having a relatively large share of renewably produced electricity. In this respect, Canada at 62 percent renewable was is fifth in 2010 among members of the Organization for Economic Cooperation and Development (OECD), behind Iceland, Norway, Austria, and New Zealand. Canada was 29th among the 137 countries and economies for which the International Energy Agency provides such information. [2]

Figure 1 shows too that in five provinces – Alberta, Saskatchewan, and the three maritime provinces – most electricity is produced from fossil fuels.

Figure 2 shows total production of electrical energy, as in Figure 1, and also consumption. [3] Of note is Quebec's higher consumption than production. The difference mostly comprises imports from Newfoundland and Labrador pursuant to a 65-year contract expiring in 2034. Indeed, with these imports Quebec has a surplus, much of which is exported to the United States.

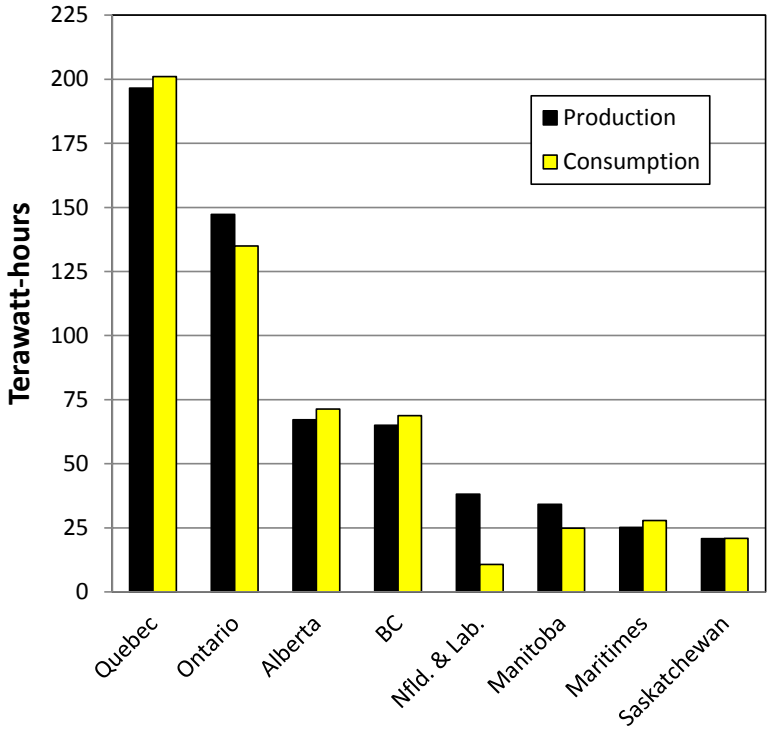

Figure 2. Production and consumption of electricity in 2009

Dependence on oil imports

Oil fuels almost all transportation today. Provinces may be hospitable to electric traction to the extent they are reliant on oil imports, especially from unstable sources.

Table 1 ranks the provinces according to their reliance on oil imports. [4] The range is large. Quebec is the most dependent. Its high degree of dependence may be regarded as even more extraordinary when two further factors are taken into account. One is that a substantial share of Quebec's imports comes from countries that are potentially unstable (Algeria is the main supplier). [5] The other factor is that no reserve of crude oil or oil products is evidently available for use if supplies are interrupted. [6] Alberta is at the other extreme. This province uses only about 13 percent of what it produces, as oil or oil products, exporting the balance to other provinces or to the US. [5]

Table 1 – The oil dependence of Canada's provinces

Canada's provinces ranked from most to least dependent on oil imports

Province(s)	Comments
Quebec	Imports about 90 percent of consumption from outside Canada; almost all the balance is imported from Eastern Canada
Ontario	Imports about 25 percent of consumption from outside Canada; almost all the balance is imported from Western Canada – sent via the U.S.
Maritimes	Imports about 75 percent of oil consumption; but much consumption is exported as fuels
Manitoba	Produces some oil, but mostly relies on imports from Alberta and Saskatchewan; there is a massive flow-through for export
BC	Produces some oil, but mostly relies on imports from Alberta
Nfld. & Lab.	Produces more oil than is consumed, but imports oil for other provinces and for processing
Saskatchewan	Produces about three times more oil than is consumed; the balance is mostly exported to other provinces and to the U.S.
Alberta	Produces about seven times more oil than is consumed; the balance is mostly exported to other provinces and to the U.S.

Manufacturing base

Provinces may be interested in and suitable for the production of goods associated with electric traction to the extent they have an existing manufacturing base concerned with the production of transportation equipment.

Table 2 shows how the provinces vary in this respect. [7] Ontario has by far the largest transportation manufacturing base. In 2010, shipments of transportation equipment from Ontario manufacturers totaled $68 billion, compared with Quebec's corresponding total of $13 billion. An important difference between the two is that motor vehicle goods comprised almost two thirds of Ontario's total, whereas aerospace-related products comprised just over two thirds of Quebec's total. Thus, Quebec may be relatively more

hospitable to transportation technologies that are more compatible with aerospace production, including some innovative public transit. Ontario may be relatively more hospitable to production of vehicles similar to those used today except they are propelled by electric traction motors rather than by internal combustion engines.

Table 2 – The provinces' transportation manufacturing bases

Annual value of shipments of manufactured transportation equipment in 2010

Billions of dollars	Province(s)
>50	Ontario
5-50	Quebec
0.5-5	Alberta, BC, Manitoba, Maritimes
<0.5	Newfoundland and Labrador, Saskatchewan

Automobile use

Provinces may be open to innovative transportation technology to the extent they are not dependent on existing technology. Dependence on existing transportation technology may be reflected in per-capita automobile use. Thus openness to change may be associated with relatively low levels of car use.

Figure 3 shows per-capita automobile use in the provinces in 2009. Residents of BC appear to be the least automobile dependent and residents of Alberta the most – the latter registered 51 percent more vehicle-kilometres per person than the former. [8, 9]

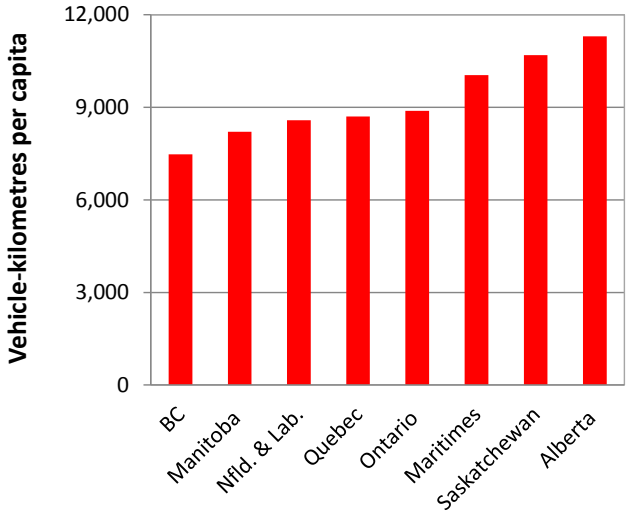

Figure 3 – Per-capita automobile use in 2009

Thus, changing the transportation habits of residents of BC may be easier than those of other provinces, and changing those of Alberta may be especially difficult. (Alternatively, although not pursued here, a province's high level of automobile use may mean that its residents may be more interested in battery-dependent vehicles than in grid-connected vehicles.)

Transit use

Today, most electric traction is found in urban transit. Higher levels of transit use may be associated with greater willingness to use at least some forms of electric traction.

Figure 4 shows the wide range of transit trips per capita across the provinces. [10, 9] On average, each Quebec resident makes more than 11 *times* as many transit trips as each resident of Newfoundland and Labrador.

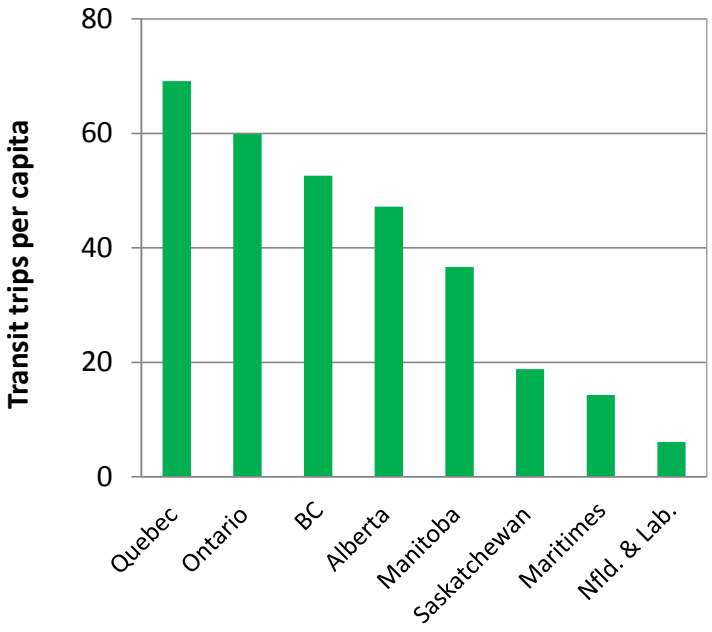

Figure 4 – Trips by urban transit made per capita in 2009

As the heaviest users of transit in Canada, Quebec residents may be the most agreeable to the introduction of innovative means of transportation that use electric traction.

Provincial policy context: vehicles with substantial dependence on traction batteries

Table 3 on the next page indicates that the larger provinces are more likely to have policies favouring deployment of plug-in hybrid and battery electric vehicles (known here collectively as EVs). These policies are mostly of four kinds:

- Support for purchases of EVs (Quebec, Ontario, BC, Prince Edward Island)
- Support for use of EVs (Saskatchewan)
- Support for installation of charging stations (Quebec, Ontario, BC)
- Privileging EVs, usually through 'green' licence plates (Quebec, Ontario)
- Support for EV-related research and development (Quebec)

Table 3 – Provincial policies concerning vehicles depending on traction batteries

Provincial policies favouring vehicles with substantial dependence on traction batteries (EVs), in January 2012, ranked from most to least favourable

Province	Policies
Quebec	Pursuant to the *Plan d'action 2011-2020 sur les véhicules électriques*, [11] a purchaser of an EV receives a direct rebate of up to $8,000; a rebate of up to $1,000 is available for installation of a home charging station. Green licence plates for EVsallow parking at public charging stations. Substantial support for EV-related research and development.
Ontario	Rebates for new-vehicle purchases of $4,000-$8,500. [12] EVs are eligible for green licence plates allowing single-person use of high-occupancy vehicle lanes. [13]
BC	There are point-of-sale rebates of $2,500-$5,000 per vehicle for qualifying EVs. Homeowners can secure grants of $500 per qualifying charging station. Funding is available for public charging stations. [14]
Saskatchewan	Rebates on insurance and registration fees for EVs are available. [15]
Maritimes	A sales tax rebate of up to $3,000 ($5,000 for taxis) is available in Prince Edward Island for the purchase of fuel-efficient vehicles, including hybrid vehicles. [16] New Brunswick government officials have a $7,000 higher car allowance if they buy hybrid electric vehicles. [17] Nova Scotia does not appear to have policies favouring EVs.
Alberta	The Green Transit Initiatives Program can support battery-dependent transit vehicles. [18]
Manitoba	Manitoba has an *Electric Vehicle Road Map*, [19] but no current programs favouring battery-dependent vehicles.
Nfld. & Lab.	Newfoundland and Labrador does not have policies favouring EVs.

Table 3 may rapidly become out of date. Moreover, it may not indicate well the overall commitment to EVs. For example, not reflected is Manitoba's sharp analysis of its existing widespread charging infrastructure, used now for serving engine block heaters in winter: "Manitoba already has more than 500,000 plug-points at homes, businesses and parking lots that could be used for Level 1 charging of electric vehicles." [19] (Level 1 charging is relatively slow charging from the regular 110-volt supply.)

Provincial policy context: grid-connected vehicles

Policies favouring grid-connected vehicles are essentially policies that favour electric transit, including subways and other heavy rail, light rail, streetcars, trolleybuses, and rarer systems such as aerial tramways and personal rapid transit. Because of their higher capital cost, electric transit systems are more often found in more populous communities, although one small Swedish community (Landskrona, population about 30,000) has found it expedient to provide service with trolley buses rather than diesel buses. [20]

Table 4 – Existing and planned grid-connected systems

Existing and planned grid-connected transit systems in Canada, January 2012, ranked from most to least extensive

Province	Systems
Quebec	A 2008 *Transportation Plan* proposed major extensions of Montreal's subway system – already Canada's busiest – including further into neighbouring municipalities. Also proposed was an extensive tramway (streetcar) system. [21] Trolleybuses are being considered for Montreal and Laval, [22] and there could be further electrification of the suburban rail system. [23] Laval is also considering an aerial tramway. [24] There is an LRT proposal for Quebec City. [25]
Ontario	Toronto region's transit, most in the City of Toronto, consists of an expanding subway system and an extensive streetcar network. The Ontario government has committed $8.4 billion to Toronto's rapid transit development. [26] There are LRT proposals for Hamilton, the regions of Durham, Halton, and Peel, [27] as well as Kitchener-Waterloo [28] and Ottawa. [29]
BC	Metro Vancouver's light-rail transit (LRT) system has recently been expanded (Canada Line), and the extensive trolley bus system has new, Canadian-made vehicles. [30] A light-rail system is being planned for Victoria. [31]
Alberta	There are plans to expand the LRT systems in Calgary [32] and Edmonton [33]. (Calgary's system is entirely wind-powered. [34]) Edmonton's trolley bus service was terminated in 2009. [35]
Manitoba Maritimes Nfld. & Lab. Saskatchewan	These provinces have no grid-connected transit nor current proposals for it. In Manitoba, there has been discussion of LRT for Winnipeg, but now a diesel bus rapid transit system is under construction. [36]

Table 4 on the previous page summarizes the state of development of electric transit in Canada. The provincial policy context is not elaborated. However, every one of the systems except the original part of Toronto's Yonge subway line was developed using provincial funding. Thus, the list of existing and planned systems implies major provincial policy initiatives.

Grid-connected transportation forms the backbone of urban transit in four of Canada's five major cities. The City of Ottawa, the fourth largest, is the exception. In the City of Toronto in 2010, 50 percent of boardings were on grid-connected vehicles (subway trains and streetcars). The corresponding shares in the City of Montreal (subway), Metro Vancouver (intermediate rail and trolley buses), and the City of Calgary (light rail) were 42 percent, 51 percent and 52 percent. [37]

Climate

Weather extremes are of particular concern for producers and users of electric vehicles because of drain on batteries for heating and cooling cabin interiors. Cold weather is of additional concern because batteries accept less charge as their temperature falls. Several things can be done to meet these challenges. They include deploying efficient heat pumps for heating and cooling, installing electric seat warmers, and pre-warming cabins and batteries using power from the grid especially on very cold mornings. [38]

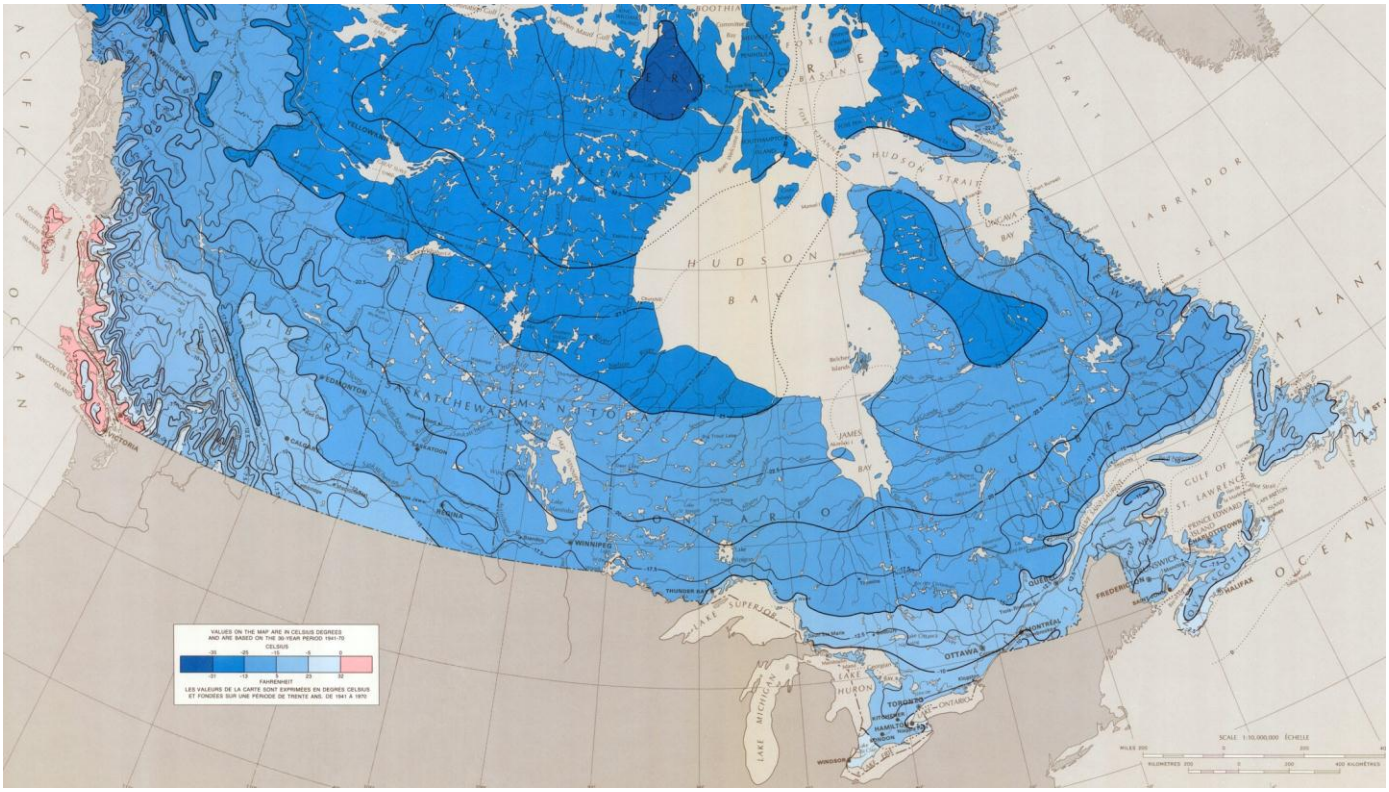

Figure 5 – Mean January temperatures, Canada, 1941-1970

Whatever measures are taken, electric vehicles dependent on traction batteries are likely to pose special challenges when the average daily temperature is below -5°C. Figure 5 on the previous page suggests that this is the case in January for almost all of Canada, excepting coastal British Columbia, the Atlantic coasts of Newfoundland and Nova Scotia, and two parts of south and south-west Ontario. [39]

Figure 5 is the only readily available map. It happens to cover the unusually cold period between 1940 and 1971. Mean temperatures appear to have been higher during the last few decades, but only enough to increase marginally the extent of the above-noted areas (so that, for example, the two Ontario areas may have joined along the north shore of Lake Erie). [40] Cold weather remains a major challenge for battery-based electric vehicle use in most of Canada and much of the United States.

Summary and conclusion

The provinces clearly differ according to the extent to which they are or could be compatible with electric traction, whether for reasons of electricity supply, oil dependence, manufacturing base, automobile and transit use, provincial policies or climate. Table 5 on the next page attempts to summarize these various factors. To provide an overview of much disparate data, an ad hoc, subjective rating system was applied, based on the foregoing. Provinces were scored 1, 2 or 3 on each feature, where 1 represented the least compatibility with electric traction and 3 the most compatibility.

These ratings are averaged in the two right-hand columns of Table 5, recognizing that comparisons of such subjective ratings have little formal statistical validity. The leftmost of these two columns shows averages of all the ratings. The rightmost shows averages of all the ratings other than that for climate. The averages suggest that three provinces are more compatible with electric traction than the others: Quebec, Ontario, and British Columbia. These happen to be the three most populous provinces and this in itself may be a cause of bias.

Quebec leads slightly if climate is excluded, suggesting that grid-connected electric traction may deserve a stronger emphasis there. British Columbia leads if climate is included, suggesting that battery-dependent electric traction may deserve a stronger emphasis there. In each summary ranking, the other province is second together with Ontario.

These ratings and their summaries, and the analyses on which they depend, may be useful as a stimulus to further work. This work could address, among others, some or all of the following questions. How strong should the relative emphases be on grid-connected and battery-dependent electric traction in the three most populous provinces? What could be done in the other provinces to increase their apparent compatibility with electric traction?

Use of ratings such as those displayed in Table 5 also begs questions about their validity and utility. Are these the most important features on which to assess compatibility with

electric traction? Are the specific allocations of ratings in Table 5 appropriate given the information presented above?

Table 5 – Summary table of ratings of provinces according to compatibility with electric traction

Ratings of provinces based on the foregoing analyses, where 3 is the most compatible with electric traction and 1 is the least compatible

Province(s)	Electricity supply	Electricity source	Oil dependence	Transport manufacturing?	Automobile use?	Transit use?	Policies for BEVs?	Grid-connected transit?	Climate	Average including climate	Average not including climate
Quebec	2	3	3	2	2	3	3	3	1	2.4	2.6
BC	2	3	2	1	3	3	3	3	3	2.6	2.5
Ontario	2	2	2	3	2	3	3	3	2	2.4	2.5
Manitoba	3	3	2	1	2	2	1	1	1	1.8	1.9
Nfld. & Lab.	3	3	1	1	2	1	1	1	2	1.7	1.6
Alberta	2	1	1	1	1	3	1	2	1	1.4	1.5
Maritimes	2	1	2	1	1	1	1	1	2	1.3	1.3
Saskatchewan	2	1	1	1	1	1	2	1	1	1.2	1.3

References

[1] “Report on Energy Supply and Demand in Canada”, Catalogue no. 57-003-X, Statistics Canada, Ottawa, ISSN: 1708-1580, Pages 111-112 (Tables 8-1 and 9), 2011. (Available at http://www.statcan.gc.ca/pub/57-003-x/57-003-x2009000-eng.htm.)

[2] “Electricity Information 2011,” International Energy Agency, Paris, France. ISBN 978-92-64-10191-3, Part III, Pages 8-11 (Table 1.2), 2011.

[3] “CANSIM Table 127-0008: Supply and disposition of electric power, electric utilities and industry, annual”, Statistics Canada, Ottawa, 2011. (Available at http://www5.statcan.gc.ca/cansim/a05?lang=eng&id=1270008.)

[4] “CANSIM Table 128-0009: Supply and demand of primary and secondary energy in terajoules, annually (Terajoules)”, Statistics Canada, Ottawa, 2011. (Available at http://www5.statcan.gc.ca/cansim/a05?lang=eng&id=1280009.)

[5] “The Supply and Disposition of Refined Petroleum Products in Canada”, Statistics Canada, Ottawa, Page 42 (Table 4-1), 2011. (Available at http://www.statcan.gc.ca/bsolc/olc-cel/olc-cel?catno=45-004-X&chropg=1&lang=eng.)

[6] “Oil & Gas Security: Emergency Response of IEA countries, Canada”, International Energy Agency, Paris, France, 2010. (Available at http://www.iea.org/papers/security/canada_2010.pdf.)

[7] “CANSIM Table 304-0015: Manufacturing sales, by North American Industry Classification System (NAICS) and province, monthly (dollars)”, Statistics Canada, Ottawa, 2011. (At http://www5.statcan.gc.ca/cansim/pick-choisir?lang=eng&p2=33&id=3040015.)

[8] “Canadian Vehicle Survey: Annual, 2009”, Catalogue no. 53-223-X, Statistics Canada, Ottawa, Page 17 (Table 4-1), 2010. (Available at http://www.statcan.gc.ca/bsolc/olc-cel/olc-cel?catno=53-223-X&CHROPG=1&lang=eng.)

[9] “Population projections for Canada, provinces and territories, 2009-2036”, Catalogue no. 91-520-X, Statistics Canada, Ottawa, Page 55 (Table 3.1), 2010. (Available at http://publications.gc.ca/Collection-R/Statcan/91-520-XIB/91-520-XIB-e.html.)
[10] “Recent developments in transit in Canadian cities, 2010”, Report of the Urban Transit Task Force to Ministers Of Transportation, Council of Ministers Responsible for Transportation and Highway Safety, Ottawa, Page 3 (Table 1), 2010. (Available at http://www.comt.ca/english/recent-nov2010.pdf.)
[11] “Québec roule à la puissance verte! Plan d’action 2011-2020 sur les véhicules électriques”, Governement du Québec, 2011. (Available at http://www.vehiculeselectriques.gouv.qc.ca/plan-action.asp, in French only.)
[12] “Electric Vehicles”, Ministry of Transportation, Ontario, December 7, 2011. (Available at http://www.mto.gov.on.ca/english/dandv/vehicle/electric/ev-faq.shtml.)
[13] “Ontario’s Green Plates”, Ministry of Transportation, Ontario, December 7, 2011. (Available at http://www.mto.gov.on.ca/english/dandv/vehicle/electric/ev-green-plates.shtml.)
[14] “New rebates help B.C. drivers plug into clean cars”, BC Government Online News Source, November 5, 2011. (Available at http://www.newsroom.gov.bc.ca/2011/11/new-rebates-help-bc-drivers-plug-into-clean-cars.html.)
[15] “Province rewards *green* vehicle owners”, Saskatchewan Government Insurance, February 11, 2010. (Available at http://www.sgi.sk.ca/about/newsreleases/2010/greenrewards.html.)
[16] “Prince Edward Island and Climate Change: A Strategy for Reducing the Impacts of Global Warming”, Government of Prince Edward Island, undated (probably 2009). (Available at http://www.gov.pe.ca/photos/original/env_globalstr.pdf.)
[17] “Government adopts new ‘green’ vehicle policy”, Government of New Brunswick, November 8, 2006. (Available at http://www.gnb.ca/cnb/news/tran/2006e1379tr.htm.)
[18] “Questions and Answers about the Green Transit Initiatives program (Green TRIP)”, Alberta Transportation, July 8, 2008. (Available at http://www.alberta.ca/acn/200807/23960039FB54D-CC21-7234-31C3E853089A1E6C.html.)
[19] “Electric Vehicle Road Map: Driving Towards Fossil Fuel Freedom”, Government of Manitoba, April 2011. (Available at http://www.gov.mb.ca/iem/energy/transportation/images/elec_vehicle_road_map.pdf.)
[20] Andersson, P, “Trolleybus Lanskrona: The world’s smallest trolleybus system”, Presentation at a workshop of the UITP Trolleybus Group, Salzberg, Austria, April 2006. (Available at http://www.trolleymotion.com/common/files/uitp/Anderson_Landskrona.pdf.)
[21] “Transportation Plan”, City of Montreal, 2008. (Available at http://ville.montreal.qc.ca.)
[22] Riga, A, “Trolley bus study electrifying news for Montreal”, *The Gazette*, November 5, 2011. (Available at http://www.montrealgazette.com/Trolley+study+electrifying+news+Montreal/5661309/story.html.)
[23] Charpentier, P, “Electrification – Feasibility for Montreal Commuter Trains”, Presentation at a Railway Association of Canada conference, October 18, 2011. (Available at https://www.railcan.ca/assets/images/events/AGM_2011/Panel_3/A_Patrick_Charpentier.pdf.)
[24] Barry, MC, “Laval Transit launches study on building aerial tramway”, Laval News, December 5, 2011. (Available at http://lavalnews.ca/article/Laval-Transit-launches-study-on-building-aerial-tramway-192306.)
[25] “Projet de tramway : lancement d’une étude de faisabilité”, Ville de Québec, le 9 novembre, 2011. (Available at http://www.ville.quebec.qc.ca/actualites/fiche_archives_actualites.aspx?id=11291.)
[26] “Eglinton-Scarborough Crosstown Project”, Metrolinx, Toronto, January 2012. (Available at http://www.metrolinx.com.)
[27] “The Big Move: The First 15 Years”, Metrolinx, Toronto, January 2012. (Available at http://metrolinx.com/thebigmove/en/lookingforward/5_2_first15years.aspx.)

[28] “Rapid Transit: Connecting to the Future”, Region of Waterloo, January 2012. (Available at http://rapidtransit.region.waterloo.on.ca/.)
[29] “Ottawa Light Rail”, City of Ottawa, January 2012. (Available at http://www.ottawalightrail.ca/en/project-plan/current-status.)
[30] “Annual Report 2010”, Translink, Vancouver BC, 2010. (Available at http://www.translink.ca/~/media/Documents/about_translink/corporate_overview/annual_reports/2010.ashx.)
[31] “Victoria Regional Rapid Transit”, BC Transit, September 2011. (Available at http://www.busonline.ca/vrrt/.)
[32] ”West LRT”, City of Calgary, January 2012. (Available at http://www.westlrt.ca/.)
[33] “Future LRT”, City of Edmonton, January 2012. (Available at http://www.edmonton.ca/transportation/ets/future-lrt-projects.aspx.)
[34] “Ride the Wind”, Calgary Transit, January 2012. (Available at http://www.calgarytransit.com/environment/ride_the_wind.html.)
[35] “Edmonton Trolley Information”, Edmonton Trolley Coalition, December 2011. (Available at http://www.trolleycoalition.org/trolleyfacts.html.)
[36] “Rapid Transit Backgrounder”, City of Winnipeg, undated (likely 2011). (Available at http://www.winnipeg.ca/cao/pdfs/Winnipeg-BRT-Backgrounder.pdf.)
[37] “Ridership Report Archives”, American Public Transit Association, January 2012. (Available at http://www.apta.com/resources/statistics/Pages/RidershipArchives.aspx.)
[38] Clemens, K, “How plug-in cars can face up to winter’s challenges”, Midwest Energy News, January 18, 2012. (Available at http://www.midwestenergynews.com/2012/01/18/how-plug-in-cars-can-face-up-to-winters-challenges/.)
[39] “The Atlas of Canada: Mean January Daily Temperature”, Natural Resources Canada, August 2009. (Available at http://atlas.nrcan.gc.ca/site/english/maps/archives/hydrological_atlas_1978/water_quantity_temperature_winds/14_Mean_January_Daily_Temperature_1978.)
[40] “The Atlas of Canada: January Mean Daily Minimum and Maximum Temperatures”, Natural Resources Canada, June 2007. (Available at http://atlas.nrcan.gc.ca/site/english/maps/environment/climate/temperature/temp_winter.)