CNWC Electrification Policy Series 4

Electric transport, updated August 11, 2022

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Summary

GASOLINE POWERED PERSONAL MOTOR TRANSPORT is among the largest energy use categories of greenhouse gas (GHG) emissions in Canada. Decarbonizing this activity requires electrifying it. At the current usage level, this would require upward of 12,000 megawatts of new non-emitting electricity generating capacity across the country. This has the potential to eliminate some 85 million tons of GHGs annually from Canada's national inventory. Electrifying all road and rail transport could eliminate a further 60 million tons.[1]

The CNWC supports the current governmental support for electric transport infrastructure, though with some shift in focus. While direct subsidies for vehi-

[1] Environment & Climate Change Canada, *National Inventory Report 1990–2020*, Table 2–3, p. 38.

cle purchases may serve a useful purpose, the current limitations of electric grids represent serious bottlenecks that impede consumer uptake of electric transport technology. The above-mentioned new generation capacity required to electrify just gasoline-powered transport entails major additional quantities of power at the local level. Moving this amount of power to end users at the right time will require significant additions of capital equipment to urban grids. Timely delivery of such vast quantities will require careful forethought and planning.

Urban grids, in short, will require significant expansion in their capacity to distribute power—their duties will expand to "fuelling" motor vehicle fleets that currently collectively consume hundreds of Terawatt-hours of energy each year. Federal and provincial subsidies should be targeted at least in part to addressing the financial and technological implications of this.

Major electrification projects and efforts with immediate payoffs in economic stimulus, pollution emissions reduction, and general quality of life should include:

1. Electrifying, by overhead wire, most of Metrolinx's GO Train lines in the Greater Toronto and Hamilton area. This should occur in tandem with electrification of the freight rail system in the GTHA, since Canada's Class 1 freight rail carriers own significant parts of the GO systm.

2. Expanding charging infrastructure, focusing on high capacity installations for commercial and public transit vehicle fleets; making these multiple fast-chargers available to personal vehicles.

3. Building new zero-emitting generation capacity.

Rail electrification infrastructure boom Because of the infrastructure implications of electrifying road and rail transport, this activity is the critical leading edge that will spur the full electrification of the economy. Electric transport facilitates massive new electrical capacities in urban areas, preparing them physically and technologically for full electrification and full decarbonization.

CNWC similarly is encouraged by government investments in charging infrastructure, and the charging industry value chain. The federal and Ontario provincial investment in Umicore's EV battery manufacturing in Kingston[2] signals long-term confidence in this growth industry, and positions Canada as an integral part of the international value chain in this new segment.

Government support for electric rail transit should be expanded to include freight rail, on a regional basis. The Greater Toronto and Hamilton Area (GTHA) is a prime candidate for a comprehensive regional rail electrification that includes freight lines.

Items 1, 2, and 3 in the list above would, collectively, if undertaken concurrently, represent the largest infrastructure project in Canada's history, and the fastest and most dramatic GHG reductions—provided the electricity to supply the massive new end uses is zero-emitting. The number of jobs alone would be

[2] see https://electricautonomy.ca/2022/07/13/umicore-electric-vehicle-battery-factory-ontario/

economy-changing, and would put Ontario and Canada on an upward trajectory for the foreseeable future.

Government stimulus The CNWC reiterates its position that a significant portion of government stimulus support in the area of a green recovery should focus on electrification of commercial vehicles, including rail locomotives.[3] In addition to immediate improvements in air quality and quality of life, this would spur wider and faster electrification of all road vehicles. Moreover it would dovetail with increased "urban electrification" developments, such as construction site power from the grid, recreational events both recurring and one-off, and innumerable applications currently served with gasoline- and diesel-powered portable generators.

See CNWC's Urban Electrification Policy Position for details on the latter.

Electric road freight Road freight logistics, as an economic category, has grown in recent years, was stimulated by the pandemic, and is likely to continue growing. Freight truck fleet owners continue to unanimously indicate interest in electrifying. Canadian National ordered a battery locomotive for delivery in 2023. Project 2 in the list above involves major transit fleet owners (TTC and OC Transpo, among others) that have either already invested substantially in BEVs or plan to invest. Targeted government-supported stimulus in this area should continue, as it will achieve important and fast results, not only in battery-electric mass transit, but also with commercial and personal vehicles.

Commercial and personal vehicle uptake could also benefit from concurrent marketing focusing on the very real but often overlooked societal, organizational, and personal advantages of the drastically reduced maintenance workload of BEVs relative to conventional vehicles. Countless hours and dollar expenditures related to this maintenance are eliminated with BEVs. Together with generally lower fuel costs, this dimension accelerates the already significant market uptake of these vehicles.

The CNWC strongly supports the recently announced multilevel government support for a first-of-a-kind battery manufacturing facility in Windsor. Together with the above-mentioned Kingston plant, this should be part of an integrated Canadian electrification value chain that includes the labour force. Electrification offers major growth potential for high skilled well paying jobs.

Skilled trades transformation to electrical Electrification on the scale recommended here—at least 12,000 MW of new non-emitting generating capacity, substantial numbers of new transformers, some of them high capacity, and innumerable lower-voltage ones—will require essentially a new workforce. There

[3] Canada's federal government in early July 2022 announced purchase incentives for a range of heavier electric vehicles; see https://tc.canada.ca/en/road-transportation/innovative-technologies/zero-emission-vehicles/medium-heavy-duty-zero-emission-vehicles/incentives-medium-heavy-duty-zero-emission-vehicles. While CNWC supports this, we feel that commercial fleet charging support should be targeted to local electric distribution infrastructure.

will be a permanent workforce that builds nuclear plants. Auto-mechanics will become primarily auto-electricians. Residential electricians will be employed for decades upgrading homes to 200+ amp service.

Prove to the public that electricity is ready for prime time energy replacement At the same time, recent major prolonged electrical outages in the nation's capital and throughout eastern Ontario illustrate the need to reinforce grids for reliability. In the "electrical future," most energy will be delivered through the wires, including many thousands of megawatts, at all hours, for transport. Outages like those resulting from the storms in eastern Ontario and west Quebec on May 21 2022, which threw thousands of customers out of power for days and in some cases weeks, are highly problematic any time of the year, and absolutely must not happen in the dead of winter.

In light of this, the CNWC applauds the Ontario Energy Board's Reliability and Power Quality Review (RPQR)[4]. We hope OEB will in the current and next Phase of this process incorporate Ontario's experience with these recent events, as we believe they represent a qualitative departure from normal storm-related outages and hence a possible early hint of the outage scenarios we may expect when we are relying on the electric grid not just for the things we rely on it for today, but transport and heating energy as well.

Zero-emitting electricity: the linchpin Most commercial vehicles are diesel-powered. Because of this, it is imperative that the electricity that charges commercial vehicle batteries be zero-emitting. If these batteries were charged with electricity from gas-fired power plants, the GHG emissions related to vehicle operation would be roughly the same as diesel, and nitrogen oxides would be comparable. Much of the gains from electrification at the operational end would be eliminated at the energy production end.

Fleet owners must consider the origin of the electricity that charges their batteries—they would be as responsible for the CO_2 involved in generation as they are today for diesel.

It is therefore imperative that the federal government encourage the addition of zero emitting generation capacity when provinces seek to make electricity available for BEV battery charging. With direct-from-grid electrification of rail, it is vital to not just "hold the line" on but dramatically reduce CO_2 emissions from electricity generation.

Equally important is to preserve existing zero-emitting generation. The Pickering nuclear plant in Ontario is scheduled to leave service in 2025, and there is no plan to replace it with new zero-emitting capacity. Moreover, Pickering could be refurbished, which would keep more than 3,000 MW of capacity in service and available to help meet the demands of an electrified, decarbonized, and growing economy. CNWC urges the federal and Ontario provincial government to acknowledge the importance of keeping the plant online, either via refurbishment or building a new plant.

[4] See https://engagewithus.oeb.ca/rpqr

How to pay for it The CNWC believes that government support for the above could be very effective, and recommends a combination of direct subsidy (to overcome the significant costs of charging infrastructure) and market financing. Canada's federal government recently launched a direct subsidy for commercial electric trucks, which covers part of the purchase cost. The CNWC believes subsidies should help defray the infrastructure cost to ready local grids for the bulk charging that would characterize an e-truck fleet.

The federal government's green bond framework, announced in March 2022, makes nuclear power, the largest expandable bulk power technology that is available today, ineligible. The Ontario provincial green bond framework similarly denies eligibility to nuclear. This is a step backwards. The CNWC strongly urges the federal and Ontario governments to reconsider this unfortunate and incorrect categorization, and include nuclear in the list of eligible technologies.

Another method of financing could involve developing some form of zero emission credits, with a financial value, based on the principle that if carbon dioxide (CO_2) from energy usage is a pollutant to be taxed, then fungible energy that does not involve CO_2 should receive a credit. So if CO_2 from, say, gas-fired generation were taxed to the fullest extent,[5] then *avoided* CO_2 from nuclear generation on the same grid should receive credits equivalent in value to the tax (in Canada, currently $50 per metric ton)—since nuclear electricity is perfectly fungible with gas-fired electricity.

The CNWC recommends that nuclear generators should receive clean energy credits up to the value of the tax on gas-fired generation had the latter been supplying electrical energy in place of nuclear on the same grid. That value can easily be determined simply from recent records of power generation at the individual unit level, exports and imports, and demand, such as are published minutely by the Alberta Electricity System Operator (AESO) and hourly by the IESO.[6]

Further to this, CNWC recommends that because the carbon tax is mandatory, any clean energy credits registry should also be mandatory. In fact, carbon tax proceeds should explicitly be tied to clean credits. This is the only way to make both the tax and the credits meaningful. It follows from this that claims on the part of the issuing jurisdiction, electricity generators, end users, or purchasers of credits must be verifiable according to some rigorous and agreed methodology. Such a methodology could only be related to the actual operation of the electricity system in question. Again, reliable data in sufficient detail and

[5] This is recommended in the Power Workers' Union's submission to the Independent Electricity System Operator's request for feedback on its proposed Clean Energy Credit Regristry; see https://www.pwu.ca/submissions/submission-on-the-iesos-clean-energy-credit-registry/

[6] It is important to acknowledge the implicit value of avoided CO_2 as the result of the "clean" electrical energy from solar and wind installations in Ontario that were contracted under the *Green Energy Act* of 2010. Ontarians have been paying these amounts, via their electricity bills, since the *GEA* renewable energy contracts came into effect. While the financial value of avoided CO_2 emissions was never explicitly quantified in terms of dollars per ton CO_2, it was implicit in the elevated contract prices paid to *GEA* wind and solar. While the precise value of avoided CO_2 depends on the *GEA* contracted rate of whichever renewable generation is replacing the main emitting generation (natural gas combined cycle), the range of values is $300 to $900 per ton.

frequency is indispensable.

Tying the tax to credits may help to address the persistent problem of how to deal with Scope 3 emissions in the *GHG Protocol* in the case of replacing polluting energy with fungible non-emitting (electrical) energy. In the case of a new EV owner, where the original seller is a gasoline retailer and the new seller is an electricity retailer, the seller and consumer of the replacement energy would report Scope 3 and Scope 1 emissions, respectively. Prior to the replacement, the seller would report positive emissions from the use of sold products (gasoline) while the user would report direct emissions from the car that burned the gasoline. After the replacement the seller reports the amount of electrical energy sold, as well as the CIPK of the grid at the time of sale. The user reports use of that electricity—at that CIPK—at the next charging session. Total CO_2, reported as Scope 3 by the seller and Scope 1 by the user, is the same figure. The value of the credit is the difference between the CO_2 that would have been emitted by a gasoline car and that that was actually emitted based on the electricity used at the given CIPK, multiplied by the per-ton carbon tax.

Passenger rail

Electrifying current diesel

Developments with electrification are fast moving. CNWC applauds current government support for passenger rail, and encourages governments to continue supporting it. We also encourage expanding support to include freight rail at urban-area hubs and terminals. Emphasis must be on infrastructure planning: in generation, transmission, and distribution. The workforce and labour implications of this are significant and far reaching. Careful integrated planning is required.

The country's largest rail commuter network, Metrolinx's GO system, is currently diesel powered. Metrolinx has abandoned hydrogen, likely due to the cost barrier of hydrogen electrolyzed with expensive Ontario grid electricity. CNWC supports replacing diesel commuter rail with electric, and on the question of overhead catenary vs battery believes the former is more advantageous, for the following reasons:

1. It uses electricity much more efficiently.
2. It uses locomotive space much more efficiently.
3. It is in commercial use all over the world, including in heavy freight applications, and the time has come to expand it in North America.

Either overhead wire or battery electric would require electricity in bulk, at scales of up to 5 MW per locomotive, at the locomotive. Electricity, either for direct use or charging batteries, must be zero-emitting, otherwise greenhouse gas and nitrogen air pollution reductions due to eliminating diesel will be simply front loaded at the generation end.

Cost considerations Electricity also must be cost-competitive with diesel. Ontario's electricity pricing policies in previous years have made cost-competitiveness difficult. At current diesel pump prices ($2 per litre in Canada in late July 2022[7]), diesel at mean efficiency in terms of engine torque and speed costs roughly 68 cents per kWh, while the Ontario electricity all-in price for Class B users is roughly 26 cents.

Ontario electricity used in a BEV application would cost roughly 41 cents per kWh in shoulder season conditions. That could more than double at low temperatures. Diesel cost would remain largely unaffected; in fact might see marginal improvements in cold temperatures. This would narrow the price difference between electricity and diesel in transport applications, thereby also reducing the financial attractiveness of electricity. Unless there is a clear cost advantage to electricity, voluntary uptake of electrification will be disappointing. Figure 1 shows that this price difference has so far in 2022 been steadily increasing in electricity's favour.

[7] see GlobalPetrolPrices.com

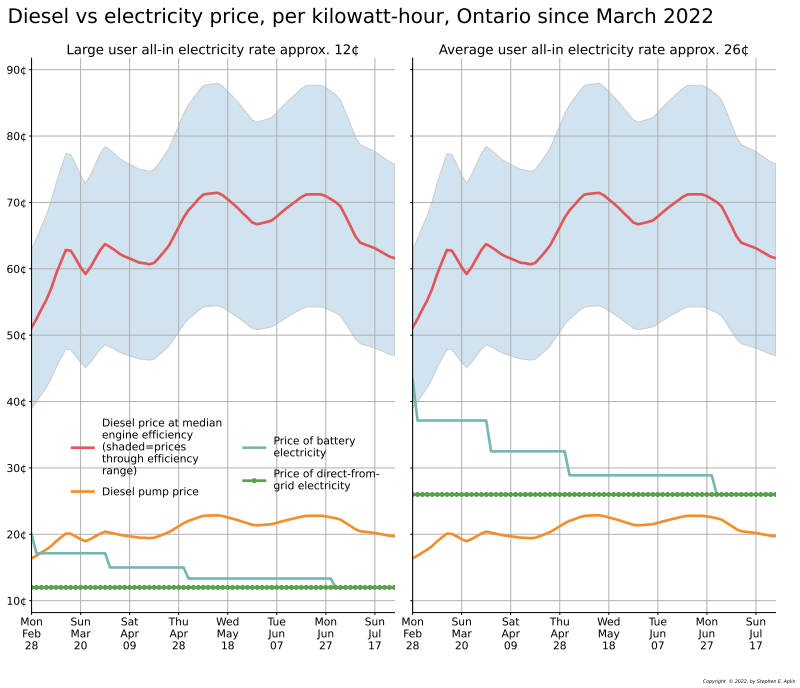

Figure 1: Diesel driving costs, Ontario. Data sources: GlobalPetrolPrices.com; Association of Major Power Consumers in Ontario, 2019 Forecast; personal electricity bills.

New and expanded LRT

The CNWC supports all electric light rail projects, applauds all levels of government supporting these projects, and hopes this clean, quiet, and energy efficient mode of transportation becomes more integrated into Canadian cities.

In particular, CNWC supports the extensive and ambitious Metrolinx projects throughout the Greater Toronto and Hamilton Area. Collectively, these are the largest and most complex transit projects in North America, and their electrification components the most significant in the Western Hemisphere. Electrification will expand from these projects, possibly to the two Class 1 freight rail lines in the region, which opens further very exciting possibilities—see "Freight rail," below.

Metrolinx's decision to provide battery power at the new backup power facility in Mount Dennis (to serve the new Eglinton LRT) rather than gas-fired power illustrates one avenue of possibility. The company could, where appropriate, offer charging services from these facilities. This could introduce interesting new services in urban area, expanding the ubiquity of energy storage opportunities.

The energy storage implications of electric transport are widely discussed, but are still unclear. Locomotive-scale storage is likely to be more valuable as

transport-related “off-grid” mobile energy stored at convenient times than as a frequency control ancillary service. The facilities and infrastructure to charge this size of battery are suitable for multi-unit charging, whether EVs or stationary devices. This could allow owners of this infrastructure to become power providers and re-sellers.

Freight rail

ELECTRIFYING FREIGHT RAIL OVER LONG LINES is impractical at this time. However, in urban areas where shunting/switching operations consume large amounts of diesel fuel and contribute significantly to air pollution and noise, the CNWC believes this activity should be electrified. In Canada, the largest rail electrification effort is occurring in the Greater Toronto and Hamilton Area, with the above-mentioned Metrolinx projects in the area.

The CNWC believes the electrification of Metrolinx's currently diesel-powered GO system should occur concurrently with a similar effort in the freight system in the GTHA and contiguous areas in Southern Ontario.

As mentioned above, direct to grid electrification would be the most efficient use of electricity. It is proven, in widespread use all over the world, and is the most straightforward approach to electrification in heavy applications like rail.

Passenger rail electrification decision drives freight While not advocating across the board electrification of the national rail system, CNWC supports a piecemeal approach: exploring specific routes and areas on a case-by-case basis. In the September 2021 version of this Policy Position, we identified the proposed CN Milton Logistics Hub as a promising case, especially in light of Metrolinx's decision to electrify with overhead catenary (see the Passenger rail section, above). The latter will see a "transport electrification economy" centred in the GTHA, based on overhead catenary with large locomotives, with established procurement and supply systems, and a skilled workforce. That may serve to ease the way for Canada's two Class 1 freight rail carriers, which both have large scale operations in the GTHA, to adopt the same technology in the region.

In a January 2022 interview, CN VP of Sustainability Janet Drysdale named a number of potential ways to lower CO_2 per gross ton mile (GTM). Drysdale mentioned electrification via battery and direct catenary as possible technological options. CNWC salutes CN's determination to lower GTM emissions as much as possible. We urge the company to look seriously at catenary. It is the only economical and technologically proven way to take all emissions from all GTM. We urge a targeted hub approach: electrify the shunters/switchers at hubs, like the newly approved intermodal facility at Milton. This could and should include complete truck electrification, one of the criteria on which the federal government approved the hub.

CNWC also urges Canada's other Class 1 rail carrier, Canadian Pacific (which owns Metrolinx's Milton Line), to consider overhead catenary as the technological basis for GTHA line electrification. That would standardize the technology across the region, thereby opening its potential to all area rail lines.

The CNWC believes such an effort would represent the simplest and most popular way to address the environmental impacts of surface transport in Canada. It would also be the lowest-cost. If pursued concurrently with efforts to electrify passenger rail, it would be a major and unique infrastructure undertaking, un-

like anything in Canada's history. Job creation potential, across all the skillsets required for electrification generally, would be enormous. Environmental, air quality, and quality-of-life payoffs would be equally enormous.

Public communication and branding A public-facing electrification effort like the above would showcase the instant benefits of electrification. The famous "Live Better Electrically" campaign of the late 1950s, a joint venture between General Electric and Westinghouse which was intended to complement numerous similar drives by local electrical utilities across the U.S., at one point had as a goal to sell 20,000 all-electric homes.[8] A similar effort today could capitalize on the general elite consensus that electrification is the route to decarbonization.

Spectacular projects such as rail electrification across a significant urban area are one public-facing way to showcase the benefits of electrification.

[8] See https://dahp.wa.gov/historic-preservation/historic-buildings/historic-building-survey-and-inventory/live-better-electrically-the-gold-medallion-electric-home-campaign. Ontario Hydro, the predecessor to OPG, Bruce Power, the IESO, Kinectrics, and Hydro One, ran a short-lived version of 'Live Better Electrically" in the late 1970s.

Commercial trucks and vans

E-COMMERCE HAS EXPLODED IN THE PANDEMIC, and was growing strongly before the pandemic. This trend will continue. Delivery of ordered items is performed today almost entirely by petroleum-powered trucks and vans. These are a significant source of air pollution, greenhouse gases, and noise. Because they operate in urban areas, their effect on human health is of concern.

To address these problems, the CNWC recommends a parallel, concurrent focus on enabling the rapid uptake of battery-electric commercial trucks and other large vehicles such as buses. These are likeliest to require charging for multiple vehicles, therefore higher rates of charging power, therefore more robust electrical distribution equipment than that required for residential feeders that might serve several personal BEVs at most.

This enables multi-vehicle charge centres similar to the large multi-vehicle gasoline service stations that are common today. In the area of personal BEVs, this "refueling" model is more likely to prevail over one in which the majority of BEVs are charged at owners' residences.

Such service offerings are a natural next step for new-energy-economy entities like OPG's PowerOn, which is bringing large-scale charging capability to the Toronto Transit Commission's new electric bus charging yards. CNWC would encourage commercial fleet-level services along the same lines, and hopes these are introduced to the commercial delivery industry in Toronto. Fig. 1 (page 8) shows the price spread between diesel and electric in Ontario has recently become unequivocally favourable to electric.

The CNWC believes that focusing on commercial applications, where infrastructure upgrades represent capital investment instead of consumer spending and therefore are open to capital market financing and prime-rate borrowing, will spur faster "gateway" growth of personal vehicle electrification than focusing on residential charging.

All major road freight carriers have indicated interest in and intent to electrify their transport operations to some extent. Growth in this area is physically constrained by electricity transmission, distribution, and of course generation.

The CNWC recommends targeted investments to address transmission and distribution constraints that could impede projects. Commercial-scale charging infrastructure would involve higher rates of electrical power than individual residential. The factors that constrain commercial BEV uptake are those that if effectively overcome could enable faster personal BEV uptake.

These investments could facilitate new equipment purchases on the part of utilities and/or commercial operators who have identified specific locations for fleet-level charging. We feel such measures would spur charging capacity additions, and thereby advance BEV uptake, much faster than the current focus on personal vehicles, important though that is.

All new generation must be zero emitting

Most commercial transport in Canada is diesel powered.[9] Diesel usage in Ontario was 5.5 billion litres in 2019, and we can assume that most of those were used commercially.[10] Converted to grid electricity for the purpose of commercial transport, these 5.5 billion litres of diesel would be roughly 39 billion kilowatt-hours, roughly the annual production of a 5,000 MW power plant.[11]

The efficiency characteristics of diesel engines are such that electrifying diesel-powered transport equipment in order to decarbonize can result in significant emission reductions *only if the electricity that charges the batteries is zero-emitting*. This means:

1. If electric trucks are charged with electricity generated by natural gas, emissions would be not much lower than those of the original diesel-powered equipment operating at its optimal range. Using gas-power-recharged electric trucks would thereby mostly undo whatever progress was made by displacing diesel.

2. Electrifying diesel equipment on the basis of a generation mix of wind and natural gas does reduce CO_2, but only slightly. This would result in continued growth of cumulative CO_2 in the atmosphere, and that growth must stop. Moreover, it would reduce the price spread between diesel and grid electricity in most jurisdictions.[12]

This has profound implications for potential commercial adopters of battery-electric trucks. If new generation supply for e-truck charging is based on natural gas, or even wind and gas, critics of electrification as a decarbonization measure will rightly point to the increased power plant emissions that result from increased fossil fuel use at the power generation end of the BEV truck energy supply chain. These critics, tallying the CO_2 attributable to vehicle use, are unlikely to draw the distinction between the e-truck owner and the government of the jurisdiction where the electricity is generated.

Unless and until it is made explicit that the e-truck adopter is exempt from GHG penalty because the adopter does not control the generation supply mix, potential adopters are likely to simply refrain from converting fleets from diesel to electric.

This means governments of electricity jurisdictions must ensure low carbon supply. It follows from this that in all Canadian provinces and territories, new

[9] The use of diesel as a transportation fuel is predominantly in commercial and industrial transportation. Therefore it is reasonable to estimate that at least 90 percent of diesel sales today are in that category.

[10] Source: Statistics Canada "Sales of fuel used for road motor vehicles, annual (x 1,000)," at https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2310006601

[11] For reference, the Bruce nuclear station on Lake Huron in Ontario is rated at over 6,000 MW. It is one of the largest power plants in the world.

[12] The price spread would reduce ever further if and when carbon taxes are applied to power generation.

supply to ensure that BEVs represent significant CO_2 emission reductions must be zero-emitting.

The CNWC's position is that this new capacity must be nuclear. Nuclear is the only bulk generation type other than large hydro that is proven to have consistently avoided large scale emissions over decades. Most large hydro potential in Canada that can be tapped already has been tapped. Displacing fossil fuel for transportation will require enormous amounts of new electrical generation capacity, and intermittent renewable sources are ill suited to meeting a new demand at this scale.

The latter point is particularly important. There exists today a very large body of evidence that intermittent renewables, while popular, cannot meet existing electrical demand, and we cannot expect they will somehow rise to the challenge when demand has doubled or tripled. Fig 2 shows the potential for electrical demand growth in Ontario just by displacing natural gas. While natural gas is not a transportation fuel, Fig 2 illustrates the magnitude of the electrification challenge. We will not meet that challenge without generation capable of providing power in great bulk, at all times of the day.

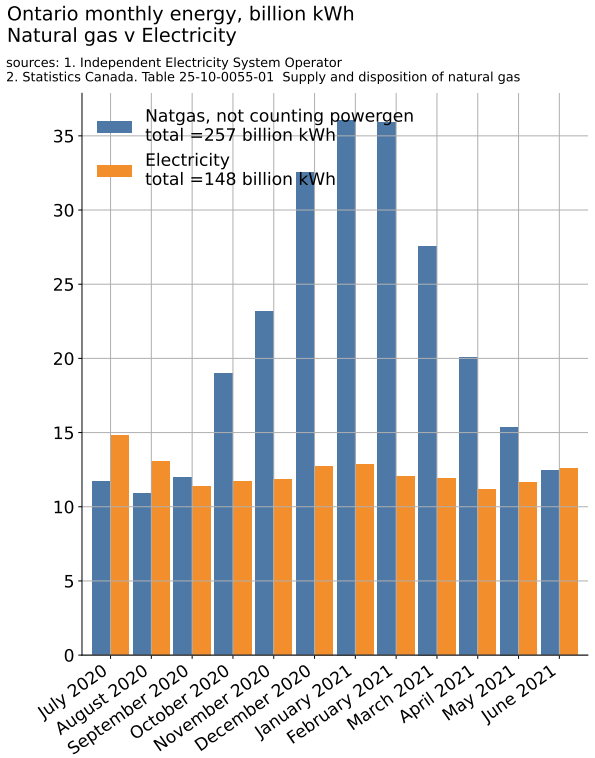

Figure 2: Note that electricity output is highest in summer. That would change if more heating were electrified.

Personal vehicles

PERSONAL MOTOR VEHICLES REPRESENT THE LARGEST and most difficult part of transport electrification. For this reason it is recommended that initial efforts focus on highly targeted specific commercial/industrial applications, in "shovel-ready" projects that are in planning or in progress now.

Personal EV penetration has been slow to proceed, in spite of significant federal and provincial fiscal support spanning the last decade.[13] Instead of continuing this focus, for which there might be diminished federal/provincial capacity given the sharp growth of public debt incurred under the pandemic, we recommend the more targeted approach described in "Commercial trucks and vans."

The CNWC believes that this represents the fastest way to upgrade local grids so they are capable of delivering the significant amounts of power (10–50 kilowatts per vehicle, or 50–250 kW for a 5-"pump" service station based on DC fast charging technology) required to charge the batteries of a personal BEV fleet of significant size.

When "fueling" concerns have been addressed, i.e., when charging stations are as common as regular filling stations, BEV operational cost advantages over gasoline-powered light vehicles could provide the market impetus that has been missing so far, which converts the personal motor vehicle fleet to electric. The gasoline price in Ottawa, a representative market, rose in January 2022 to a level where it is unequivocally cheaper to operate a BEV in nearly all driving conditions, even at the high Ontario electricity price. If gasoline prices remain at this level, which was unprecedented prior to 2022, then market pressure alone might push more consumers to buy BEVs. In that case, the availability of charging facilities might be the constraining factor in BEV uptake. See Fig. 3.

Another powerful incentive is the drastic advantage of BEVs in terms of maintenance. As Plug 'N Drive emphasizes, BEVs require no oil changes, coolant flushes, or muffler/exhaust system maintenance. These necessities of internal combustion engine (ICE) vehicles consume hundreds and sometimes thousands of dollars a year, and significant amounts of time, always during business hours. With personal vehicles, ICE maintenance is performed by the owner, on the owner's time and dime. Cumulatively, this adds to significant losses through the economy.

[13] The Canadian federal government in late July 2022 reaffirmed subsidies for purchases of passenger cars with retail price of less than $50,000 and station wagons, light trucks, and SUVs less than $60,000; see https://tc.canada.ca/en/road-transportation/innovative-technologies/zero-emission-vehicles/light-duty-zero-emission-vehicles/incentives-purchasing-zero-emission-vehicles.

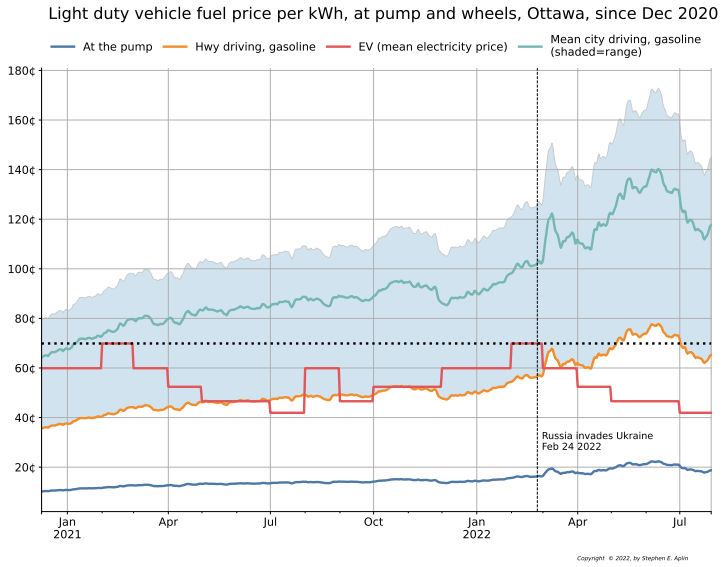

Figure 3: Gasoline driving costs, Ottawa. Data sources: https://www.gasbuddy.com/charts; personal electricity bills.

Market financing vs subsidy

FINANCING OF ALL TRANSPORTATION PROJECTS SHOULD INCLUDE, where appropriate and desired by proponents, some portion of "green" debt financing that incorporates a hard quantified pledge of CO_2 avoidance over a period. Further, the CNWC believes that this explicit promise on the part of the bond issuer that the financed project will result in an explicit amount of avoided CO_2 within a specified time must also specify the penalty the issuer will incur if the CO_2 avoidance promise goes unfulfilled.

Proceeds from the federal CO_2 tax

Proceeds from the carbon tax should be used to increase the coupon rate of green bonds. If the issuer fails to achieve the CO_2 avoidance specified on the coupon, a specified amount must be returned to the government. Alternatively, such funds could be held in abeyance, and released to the issuer or coupon holder when the emissions avoidance has been verified.

The penalty for failing to avoid the pledged amount of CO_2 would be a fixed cost per ton of emissions, payable by the issuer to the underwriter (in this case, the government). The premium accruing to the bondholder should include a certification, by a qualified third party, of the amount of avoided CO_2, based on operating conditions of the grid over the coupon period.[14] The certification set-

[14] Current practice in the case of green bonds claiming specific CO_2 avoidance is to simply project

tles the question of whether the issuer has made good on the "coupon promise." Fulfillment of the pledge becomes a matter of public record.

Responsibility of electrical jurisdictions

Authorities in electrical jurisdictions are responsible for those jurisdictions' electricity supply mixes and therefore for the CO_2 those systems emit. Because of this the question is, should an uptaker of BEV technology in a jurisdiction that has implemented a supply mix that emits significant CO_2 be responsible for the generation-to-wheel emissions? The answer could determine whether the decision is made to invest in BEV technology.

For this reason, CNWC recommends that the federal government require electricity system operators to publish generation and demand data at an appropriate (generator-level) detail and frequency. The Alberta Electricity System Operator, which publishes generator-level minutely output—along with demand, exports, and imports—is a good example of this level of detail, and electrical authorities should be required to publish to this standard. This would allow the investing public to make informed decisions about the physical placement of BEV charging infrastructure so as to optimize emissions avoidance. It would also show the public at large the periodic variance in electrical demand and gain an appreciation of the generation required to meet demand.

Canadian federal and Ontario provincial green bonds Unfortunately, the Canadian federal government has gone in exactly the wrong direction concerning which technologies to support with public money. The Green Bond Framework announced in March explicitly rules out nuclear for green funding eligibility. This reflects an ideological bias against nuclear at the ministerial level. This scientifically unfounded bias has no place in a modern democratic government, let alone during a climate crisis in a world where nuclear has proven to be the only technology that can produce zero-carbon power in bulk round the clock. The CNWC strongly urges the federal government to make nuclear eligible in the Green Bond Framework.

an amount of generation based on capacity of the project in question multiplied by an annual capacity factor, and then to assume that that generation displaces an equivalent amount of fossil generation. This rather simplistic methodology was applied in the case of a green bond issued in the Singapore bond market that refinanced a wind project in Quebec. Because Quebec grid-connected generation is virtually CO_2-free to begin with, this particular project cannot be said to have displaced any fossil generation. Nonetheless, the issuer claimed fossil displacement and a specific amount of annual avoided CO_2. As the bond carried no penalty for failing to meet the pledged avoided amount, there is no consequence to the issuer in the event of failing to meet the pledge. But if and when the matter comes to be taken seriously, issuers and certifying authorities whose current practice is described above will have to be more rigorous in quantifying avoided CO_2.

About the Canadian Nuclear Workers' Council

"The collective voice of organized labour in the nuclear industries"

The CNWC has been the collective voice of Unionized Workers across Canada's Nuclear Industry for more than 27 years. Our Member Unions represent Workers in uranium mines and mills, nuclear fuel fabrication, nuclear power plant (NPP) operation and maintenance, NPP construction and refurbishment, medical isotope production, nuclear research and development, nuclear waste management and decommissioning.

The CNWC believes that nuclear power is a proven, reliable and non-GHG emitting source of electricity that will continue to support our clean energy future.

All CNWC policy positions can be found at https://cnwc-cctn.ca/policy-positions/.

Bob Walker,

National Director

Content in this document was prepared for CNWC by S.E. Aplin.

Appendix A

Forecasting EV demand

Will driving habits stay the same?

E-transport impact on demand A driver who drives her gasoline-powered vehicle 15,000 kilometers per year consumes roughly 1,200 litres of fuel. The same driver with an EV and the same driving habits will consume upward of 4,000 kilowatt-hours of electricity ($1,200$ litres $\times$ 9.4 kWh/litre $=$ $11,280$ kWh, of which 20 percent at most goes to the powertrain). *Where* she drives—and recharges—is a critical question distribution utilities must ask and answer. Assuming our "average" driver performs most of her recharging within the service area of her hometown LDC, the LDC should plan to deliver an additional 4,000 kWh per vehicle inside its service area. In a city the size of Toronto, with an estimated 1.1 million vehicles, Toronto Hydro would have to deliver as much as 4.4 billion kWh per year on top of what it does today. In the GTHA, the estimated 6 million cars would require 24 billion from the LDCs that cover the area.

In wintertime, EV charging demand increases because a significant part of battery load is to provide heat to the passenger compartment. Wintertime EV ranges drop, putting demand on fast chargers inside LDCs, assuming driving habits remain constant. Where would most cars recharge? It is commonly assumed this would occur at residences, but it could be dangerous to assume it would occur exclusively there. Multi-vehicle charge stations would likely be scattered through LDCs, mimicking the current filling centres. This would necessitate upgrades to commercial feeders, possibly substations, possibly even a rethink of the voltages in these sectors.

Fleet-level charging, for both light duty cars and trucks and also commercial (delivery) vehicles, underlines the impacts of new, likely substantial, loads inside distribution systems. Together with the likelihood that shopping centres will also offer vehicle charging as an incentive to spend more time and money inside retail centres, the impact on distribution grids is significant. The CNWC recommends more rigorous forecasting than has been performed thus far.