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A BUMPY ROAD AHEAD

A critical assessment of Canada's **Electric Vehicle Availability Standard**

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TRUE NORTH IN CANADIAN PUBLIC POLICY

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This paper examines Canada's plan to mandate that by 2035 100 percent of new vehicles sold will be zero-emission vehicles under the federal government's *Electric Vehicle Availability Standard*. While electric vehicles (EVs) offer advantages over internal combustion engine (ICE) vehicles, concerns persist over cost, driving range, charging options, and carbon emissions during battery cell manufacturing, making mandated goals uncertain.

Geopolitical and economic implications arise from EV mandates in the US and Canada, particularly as they relate to the dominance of Chinese EV manufacturers. There are security risks associated with Chinese control of critical minerals essential for EV production, economic threats to the North American auto sector, and hurdles faced by local automakers in competing with their Chinese counterparts.

The paper notes aluminum's increased use in EVs to lower overall weight and increase efficiency and driving range. However, aluminum production is carbon-intensive, and increased usage raises an EV's GHG emissions life cycle. A recent study forecasts a substantial increase in aluminum usage in new EV construction, significantly adding to an EV's carbon footprint.

In the event of a critical mineral shortage, prioritizing small battery packs for compact and midsize EVs could maximize GHG emissions reductions. However, automakers profit more from SUVs, and consumer preferences lean heavily towards SUVs. Thus, if automakers prioritize fewer of the larger battery packs that large electric SUVs use over many smaller battery packs, the expected reduction in GHG emissions may not materialize as forecasted.

Norway has the most EVs per capita. Its approach to reducing GHG emissions through EV subsidies has been very expensive. It offered extensive tax (and non-tax) incentives for EV purchases; its EV tax incentives alone cost over $1,800 per tonne of GHGs mitigated. This contrasts starkly with Canada's estimate of $266 of social costs incurred from generating one tonne of GHG.

The paper also discusses potential disruptions in the market due to the prescriptive nature of the *Electric Vehicle Availability Standard*, which mandates that EVs comprise a specific minimum proportion of sales. If there is a misalignment among government, consumers, and auto dealers with these targets it could lead to elevated prices, vehicle shortages, and unmet consumer demands.

Additionally, the paper addresses the impact of non-exhaust particulate matter (PM) emissions from EVs, which may surpass those of ICE vehicles. These emissions, which contain heavy metals, microplastics, and micro rubber, create substantial risks for adverse health effects and premature fatalities.

Since EVs are relatively new in Canada, there is limited data on collision-related insurance claims, leading to uncertainty about future EV insurance costs. In contrast, the UK, where EVs are more established, saw dramatic increases in insurance rates in 2023 for EVs compared to conventional vehicles. Statistics also show that EV repair costs are higher than for ICE vehicles, prompting concerns from industry figures like Elon Musk about the need to lower those costs.

Further, maintenance and general repairs for EVs differ from those for conventional vehicles. While electric drivetrains have fewer moving parts, potentially simplifying maintenance and repairs, EVs use sophisticated technologies that may raise repair costs. A large survey revealed that EVs encounter more problems than gas-powered vehicles, particularly with their electric motors, batteries, and charging systems, highlighting their complexities.

EVs offer lower refuelling or charging costs compared to gas-powered vehicles. According to the federal government, driving a midsize car for 400 kilometres costs approximately $10 in electricity compared to $50 in gas. However, this comparison may not be entirely fair due to the significant government taxes included in gas prices that are absent from electricity prices. Assuming comparable taxes on electricity as on gas, the cost of the above recharging example could rise significantly from $10 to $25.62, still cheaper than gas, but less so than without the taxes.

As of 2023, Canada had 26,500 public charging ports. Projections indicate that the country will need about 455,500 public ports by 2035. This requires adding about 98 new ports every day over 12 years. These estimates do not include private charging ports.

Electrical utilities in Canada will face significant hurdles in ensuring distribution grids can handle the substantial demand for EV charging capacity. Upgrading and expanding various grid components will be necessary, but the compressed timeframe imposed by the regulations raises uncertainty about timely completion.

Overall, the government's ambitious timeframe is unrealistic, risky, and potentially ineffective in achieving significant emissions reductions. Concerns also arise regarding threats to Canada's auto sector, its nascent EV supply chain, and the substantial investments needed for charging infrastructure and grid enhancements. Additionally, potentially higher EV ownership costs would disproportionately affect lower- and middle-income individuals, with accelerated adoption timelines exacerbating these issues.

Canada needs a more flexible approach to light-duty vehicle emissions reductions. This includes rescinding the current mandated zero-emission vehicle sales minimums and replacing them with increasingly stringent GHG emission standards. Such a change would enable automakers to adjust their vehicle portfolios to market needs while still meeting emission reduction goals. Additionally, Canada's targeted standards and timelines should align more closely with industry efforts to source critical minerals and develop less costly, yet profitable EVs with superior operating characteristics. **MLI**

Dans le présent document, *nous examinons le plan du Canada visant à faire passer à 100 p. cent la part zéro émission des véhicules neufs vendus en 2035, en vertu de la nouvelle* norme sur la disponibilité des véhicules électriques *fédérale. Si les véhicules électriques (VE) offrent des avantages par rapport aux véhicules à moteur à combustion interne (VCI), en revanche, leur coût, leur autonomie, les capacités de recharge et le carbone émis durant la fabrication d'éléments de batteries inquiètent toujours et rendent les objectifs incertains.*

Les plans du Canada et des États-Unis en matière de VE soulèvent des enjeux géopolitiques et économiques, surtout en ce qui concerne la domination chinoise sur cette industrie : risques de sécurité liés au contrôle chinois des minéraux critiques – essentiels à la production –, menaces économiques pour l'industrie automobile nord-américaine et obstacles à la concurrence des constructeurs locaux face à leurs homologues chinois.

Ce document souligne le recours accru à l'aluminium pour alléger les VE et améliorer leur efficacité et leur autonomie. Toutefois, la production d'aluminium étant intensive en carbone, cet apport additionnel ajoutera des GES tout au long du cycle de vie d'un VE. Une étude récente prévoit une forte hausse de l'apport d'aluminium dans les nouveaux VE, ce qui augmentera considérablement l'empreinte carbone de ce type de véhicule.

En cas de pénurie grave de minéraux critiques, prioriser les blocs-batteries de petite capacité pour les VE compacts et intermédiaires maximiserait les réductions de GES. Toutefois, les VUS sont plus rentables pour les constructeurs et préférés par les consommateurs. Donc, si les constructeurs préfèrent les blocs-batteries de grande capacité en petit nombre pour les gros VUS électriques plutôt que les blocs-batteries de petite capacité, la baisse prévue des GES pourrait ne pas se matérialiser.

La Norvège possède le plus de VE par habitant. La méthode des subventions adoptée lui a coûté cher. Le pays a offert d'importantes incitations fiscales (et non fiscales) à l'achat; ses incitations fiscales ont coûté à elles seules plus de 1 800 dollars par tonne de réduction de GES, un fort contraste avec un coût social estimé à 266 dollars par tonne de GES pour le Canada.

Nous examinons également dans ce document les risques de perturbation du marché en raison de la nature prescriptive de la nouvelle norme sur la disponibilité des véhicules électriques, *qui prévoit une proportion minimale de vente. Si le gouvernement,* *les consommateurs ou les concessionnaires ratent les cibles, des prix élevés, des pénuries de véhicules ou une demande à la consommation non satisfaite pourraient en résulter.*

Enfin, ce document aborde l'impact des VE sur les émissions de matières particulaires (MP) de sources autres que les gaz d'échappement, potentiellement supérieures à celles des VCI : métaux lourds, microplastiques et caoutchouc cellulaire, susceptibles d'importants d'effets néfastes sur la santé et de décès prématurés.

Les VE étant relativement nouveaux au Canada, peu de données existent sur les réclamations liées aux collisions et, donc, nul ne sait ce qu'il adviendra des futures primes applicables. Par contre, au RoyaumeUni, là où les VE sont plus courants, ces primes ont connu une hausse spectaculaire en 2023, par rapport aux véhicules traditionnels. Les statistiques montrent également qu'il en coûte plus cher de faire réparer un VE qu'un VCI, ce qui amène de grandes figures de l'industrie comme Elon Musk à reconnaître la nécessité de – réduire ces coûts.

Par ailleurs, selon qu'il s'agit d'un VE ou d'un véhicule traditionnel, l'entretien et les réparations générales diffèrent. Bien que le groupe motopropulseur d'un VE comprenne moins de pièces mobiles et offre ainsi la possibilité de simplifier les mises au point, le VE fait usage de technologies sophistiquées qui peuvent accroître les coûts de réparation. Une vaste enquête a révélé que les VE comportent plus de défectuosités que les véhicules à essence, en particulier pour la catégorie moteur-batterie-système de recharge, ce qui témoigne de leur complexité.

Les VE offrent des coûts de ravitaillement et de recharge plus bas. Selon le gouvernement fédéral, un modèle intermédiaire peut parcourir 400 km pour environ 10 $ de courant contre 50 $ d'essence. Toutefois, ce rapprochement n'est sans doute pas très juste en raison des taxes importantes sur l'essence par comparaison avec l'électricité. Si les taxes sur l'électricité et sur l'essence étaient comparables, le coût de recharge dans l'exemple cidessus augmenterait considérablement pour passer de 10 à 25,62 $. C'est toujours meilleur marché que l'essence, mais pas autant que sans les taxes.

En 2023, le Canada comptait 26 500 bornes de recharge publiques. Selon les projections, le pays aura besoin d'environ 455 500 bornes publiques d'ici 2035. Il faudra donc ajouter environ 98 nouvelles bornes chaque jour pendant 12 ans. Ces estimations ne tiennent pas compte des bornes privées.

Les services d'électricité canadiens auront du mal à assurer une distribution d'énergie suffisante pour répondre à l'importante demande de capacité de recharge des VE. Il faudra moderniser et développer divers composants du réseau, alors même que les délais imposés par les réglementations soulèvent des doutes quant à leur construction rapide.

Globalement, l'ambitieux calendrier gouvernemental est irréaliste, risqué et potentiellement inefficace pour parvenir à des réductions d'émissions d'importance. Les menaces pesant sur le secteur automobile canadien, sa chaîne d'approvisionnement naissante en VE et les investissements substantiels nécessaires pour l'infrastructure *de recharge et l'amélioration du réseau posent aussi problème. En outre, les coûts d'acquisition et d'exploitation, potentiellement plus élevés, toucheront de manière disproportionnée les personnes à revenu faible ou moyen, et les délais d'adoption accélérés exacerberont ces difficultés.*

Le Canada requiert une approche plus souple pour réduire les émissions des véhicules légers. Il doit annuler les minima de vente actuels pour les véhicules zéro émission et les remplacer par des normes GES de plus en plus renforcées. Ce changement permettrait aux constructeurs d'adapter leurs flottes aux besoins du marché tout en respectant les objectifs de réduction des émissions. En outre, les normes et les échéanciers du Canada doivent s'aligner plus étroitement sur les efforts déployés par l'industrie pour s'approvisionner en minéraux critiques et fabriquer des VE moins coûteux, mais encore rentables grâce à des caractéristiques de fonctionnement supérieures. **MLI**

Introduction

> *"The most basic question is not what is best, but who shall decide what is best."*
> – Thomas Sowell

Canada has set ambitious greenhouse gas emission (GHG) climate targets, aiming to reduce national GHGs by 40 to 45 percent by 2030 compared to 2005 levels. This translates to a 310 megatonne (Mt) reduction in GHGs. Over the longer term, Canada has a national objective to achieve net-zero GHGs by 2050. To achieve these goals, the federal government has mandated a significant shift in the automotive sector with the goal of having 100 percent of new vehicles sold being zero-emission vehicles. To meet this goal, the government has introduced substantial subsidies to both automotive suppliers and purchasers.

The transportation sector is responsible for 22 percent of Canada's total GHG emissions (ECCC 2023a). Within this sector, light-duty vehicles, including cars, SUVs, vans, and light trucks, constitute 51 percent of the sector's total emissions. Recognizing the need to address these emission sources, the federal government announced its Electric Vehicle Availability Standard in December 2023. The standard mandates escalating percentages of new vehicle sales be zero-emission vehicles, culminating in a requirement that by 2035, 100 percent of new vehicles sold be zero-emission vehicles. The government has set the following sales targets (Table 1, page 10).

As of the third quarter of 2023, zero-emission vehicles accounted for just over 13 percent of total new vehicle sales in Canada (ECCC 2023b). The government estimates that reaching its zero-emissions vehicle sales goal could mitigate 360 Mt of GHGs cumulatively by 2050 (ECCC 2023b).

TABLE 1: Mandated sales of new zero-emission vehicles

Year	Percent of passenger vehicle sales that must be zero-emission vehicles
2026	20%
2030	60%
2035	100%

Source: ECCC 2023b.

Achieving these objectives will necessitate transforming the auto sector, addressing both the demand (the market for zero-emission vehicles) and supply (battery production, vehicle assembly, and raw material sourcing). Remaking Canada's auto sector will also entail mining critical minerals such as lithium, cobalt, manganese, nickel, and graphite within Canada. These raw materials must be processed to create essential inputs for battery production (Carreon 2023). Electric vehicle assembly involves manufacturing components like electric motors and power electronics alongside traditional elements found in internal combustion engine vehicles. The size of this transformation has led governments to subsidize both vehicle purchases and manufacturers to the tune of tens of billions of dollars.

Purpose of this paper

This paper will examine Canada's ability to meet the Electric Vehicle Availability Standard's target of 100 percent zero-emission vehicle sales by 2035. It will assess electric vehicle suitability, costs, challenges to the auto sector, and potential externalities. Additionally, the paper will discuss risks and uncertainties linked to the standard's timeline, irrespective of the level of ease or difficulty in meeting it.

Acronyms and terminology

See Table 2, page 11.

Electric vehicle characteristics

Battery electric vehicles (BEVs) are highly efficient, converting 77 percent of energy to power, in contrast to ICE vehicles which are 12 to 30 percent

TABLE 2: Acronyms and terms used in this paper

Battery electric vehicle (BEV)	A fully electric battery vehicle
Hybrid electric vehicle (HEV)	Non-plug-in dual electric and gas-powered engine
Hydrogen fuel cell vehicle (FCV)	Compressed hydrogen and a fuel cell power an electric motor
Internal combustion engine (ICE)	Vehicle running solely on gas or diesel fuel
Plug-in hybrid electric vehicle (PHEV)	Vehicle with a dual electric and gas-powered engine with electric plug-in charging capability
Zero-emission vehicle (ZEV)	A technology-neutral vehicle with the potential for zero or non-harmful tailpipe emissions. Includes BEVs, PHEVs, and FCVs. In this paper zero-emission vehicles are *de facto* BEVs and PHEVs, since Hydrogen FCVs have an inconsequential market share.

efficient (US Dept. of Energy Undated). BEVs have fewer parts, require less maintenance (no oil changes, spark plugs, coolant flushes, muffler/exhaust systems), offer better torque and acceleration, enhanced driving experience, operate quietly and smoothly, and can provide more interior cabin room than their ICE counterparts (Scherr 2021).

GHG emissions benefit

BEVs produce no tailpipe carbon emissions. However, they do generate significantly more carbon emissions during manufacturing, primarily due to the carbon-intensive process of battery cell manufacturing. Despite this, their overall life cycle emissions are potentially much lower than traditional ICE vehicles. The extent of the reduction depends on the electricity source. Hydro, nuclear, and renewables substantially cut BEV GHGs. Transport and Environment, a prominent European decarbonization organization, suggests that BEVs offer a 37 to 83 percent GHG reduction (Gimbert 2022).

Determining the GHG reduction from plug-in hybrid electric vehicles (PHEVs) poses challenges and their effectiveness in reducing emissions is a topic of debate. PHEV emissions intensity depends on how regularly they are recharged and operated solely on their electrical powertrain. The International Council on Clean Transportation (ICCT) estimates that PHEVs lower GHG emissions on average by 34 percent. However, the models reviewed showed a wide range, from 10 to 52 percent (Bieker et al. 2022).

Another ICCT study measured real-life PHEV tailpipe emissions. It found actual GHG emissions were three to five times higher than the official values. Real-life emissions ranged from 90 to 195g CO_2/km compared to official values of 37 to 39g CO_2/km (Plötz et al. 2022).

Market realities clash with government and institutional climate ambition

Auto manufacturers are currently in a challenging operating environment. Long-term market sustainability for the supply and demand for EVs hinges on several factors. For one, the success of EVs relies on their ability to perform at least as well as ICE vehicles; they must be competitively priced, and they must be produced at costs that can generate profits sufficient to cover the auto sector's cost of capital.

In a typical competitive market without active government intervention, price signals play a crucial role in guiding suppliers and manufacturers on how to efficiently allocate resources for producing vehicles most in demand. However, the industry is being buffeted by government and institutional environmental pressures that, while well-intentioned, are not aligned with market realities.

How heavy will the thumb on the scale be?

The auto industry is grappling with reconciling government and institutional climate ambition pressures that are incongruent with market realities. A mandate that 100 percent of new vehicle sales by 2035 be EVs will exacerbate the consequences of this incongruity. The federal and provincial governments are putting their thumbs on the scale, so to speak. Through mandates, timelines, and subsidies for manufacturing and purchasing, government policies are pushing for rapid EV adoption.

With the stakes being so high, many actors are seeking to influence outcomes.

Stellantis CEO Carlos Tavares has noted that when governments push unaffordable EVs on consumers, it leads to people keeping their gas-powered vehicles longer, which is a "disaster" for the climate (Krisher 2024).

International organizations such as the International Energy Agency and non-governmental entities such as the Sierra Club and the Glasgow Financial Alliance for Net Zero also advocate for replacing conventional vehicles with EVs (UN Environment Programme 2024; European Environment Agency 2024; IEA 2021; Sierra Club Undated; GFANZ 2023).

In parallel, institutional investors such as BlackRock, Vanguard, and State Street, which manage trillions of dollars in investment capital, advocate for strong climate policies and lower emissions from their investment portfolio of companies (Sharfman 2021; Fink 2022; Vanguard Undated; Funk and Shah 2022).

The problem for manufacturers is when market realities, such as the market's reluctance to buy EVs (because of their high costs, limited driving range, and undeveloped charging network shortcomings) are not in sync with the institutional demands for lower carbon products.

Auto manufacturers initially embraced ambitious electrification plans but have scaled back due to financial and market considerations. Examples of these changes include:

- GM's response to market demands and production problems was to announce the reintroduction of PHEVs for certain models. This marked a reversal of its decision to discontinue plug-in hybrid vehicles three years earlier.
- Volvo decided to sell off its electric car subsidiary, Polestar. The day it made the announcement Volvo's stock price rose by 26 percent (Smith 2024).
- Renault abandoned plans to carve out its EV and software company into a public company due to a lack of investor support (Guillaume and Van Campenhout 2024).
- Stellantis embedded manufacturing flexibility so it can produce EVs, HEVs, or ICE vehicles as dictated by market demand. It sees such flexibility as vital given upcoming elections in the US and Europe which may change government policies towards EVs, including purchase subsidies. Stellantis' strategy recognizes that EVs are still too costly for widespread adoption and if governments end their purchase subsidies, demand will fall significantly (Krisher 2024).

- Ford is delaying the start of EV production in its Oakville plant by 2 years. It is now scheduled to start in 2027 (Canadian Press 2024).
- Hertz Car Rentals is selling a third of its EV fleet due to a lack of rental demand and unexpectedly high collision repair costs (McIntosh 2024).

Toyota has purposely resisted aggressive electrification plans for its product portfolio. The company still believes electric vehicles are important and is investing tens of billions of dollars in their development. And though Toyota forecasts EV unit sales of 3.5 million in 2030, the company believes EVs will make up no more than 30 percent of the overall car market. The remaining market will be HEVs, PHEVs, FCEVs, and ICE vehicles (Takahashi 2024).

Toyota's chief scientist, Gill Platt, argues that there is not enough lithium for BEVs to replace ICE vehicles. Toyota forecasts a shortage of lithium, potentially out to 2040. Platt has said, "What has to change is that we have to mature a little bit, and we have to stop doing wishful thinking." Rather, he says, to minimize GHG emissions, it will be more effective to spread the lithium over the greatest number of vehicles possible. And that would be accomplished by making many hybrid EVs with small electric batteries, as opposed to many fewer full electric vehicles with much larger battery packs (Greimel 2023).

Geopolitical and economic concerns arising from an EV mandate

Chinese auto manufacturers produce electric vehicles that are technologically competitive and much more affordable than their North American counterparts. Chinese firms also dominate critical resource supply chains essential for EV production. Mandated accelerated timelines for EV adoption in Canada and the US intensify the economic threat, posing challenges for Western automakers trying to catch up.

Security issues over Chinese control of critical minerals

A group of 17 retired US military officials, including one-, two-, and three-star generals recently wrote a letter to President Joe Biden expressing their concern about the national security implications tied to the United States' policy of rapidly adopting EVs. While acknowledging the significance of the Environmental Protection Agency's (EPA) fuel economy standards in advancing climate objectives, the letter raises concerns about those standards, deeming them so stringent that they are a *de facto* mandate compelling the sales of EVs (Marks et al. 2024).

The letter highlights a critical point – that in the absence of a sustainable EV production supply chain, the accelerated transition to EVs would render the United States increasingly dependent on China for critical minerals and manufacturing. The officials write that:

> even more concerning is the fact that this reliance hinges upon China's goodwill to export those minerals and manufactured goods to the U.S. This will undoubtedly open the U.S. up to economic manipulations by China, identical to what Russia is doing with Ukrainian grain exports, and a major threat to our national security (Marks et al. 2024).

The military officials' concerns are valid given some Chinese actions. China has recently tightened its regulations on rare earth exports, necessitating government approval for Chinese companies to export gallium and germanium, which are crucial for chip-making (Nguyen and Onstad 2023). Moreover, in 2023 China banned export of the technology that is essential for extracting and separating rare earths. Earlier, in 2010, China banned rare earth exports to Japan during political disputes over the ownership of the Japanese Senkaku Islands (Shunsuke 2023).

The economic threat to the auto sector

The federal government's Electric Vehicle Availability Standard poses a threat to Canada's auto industry. The sector contributes $16 billion to Canada's economy and supports 500,000 direct and indirect jobs (Mai 2023). It also plays an important role in fostering new product development and sales in the tech sector in areas such as AI, cybersecurity, and data analytics. For example, BlackBerry's software is used in over 230 million vehicles built by most of the major auto manufacturers (Sanchez 2024).

Despite Tesla's existence for two decades and electric models coming out of China, legacy companies like GM, Ford, Stellantis, and Volkswagen have mostly overlooked their advancements (Reid 2023). Traditional automakers are now trailing behind innovators such as Tesla, BYD Auto, SAIC Motor, and NIO (the latter three Chinese companies) in electric vehicle development (CJO Global 2023).

Under a normal competitive environment, the legacy automakers would be in a difficult position. But with the Canadian government forcing all vehicles sales to be EVs by 2035, the threat to the industry's competitive viability has increased. The Stellantis CEO views Chinese competition as an "existential threat" (Muller 2024).

Elon Musk recently asserted that without import restrictions, Chinese EVs could "demolish" global competitors (Muller 2024). Former GM, Ford, and Chrysler executive Bob Lutz also expressed skepticism from a consumer perspective about the US government's similar goal – ensuring that 50 percent of new cars sold by 2030 are electric. He said that Americans are not prepared for such broad EV adoption. "If it's an authoritarian government like China, they'll just say: 'You either buy an electric vehicle or you buy no vehicle at all.' Well, that may work in China but it's not going to work in the United States. Or Europe" (Moorcraft 2023). One could presumably add Canada too.

Canada presently does not impose the same high tariff levels on imported Chinese autos as the United States.

Currently, the United States has a 27.5 percent tariff on Chinese autos exported to North America (Cutler, 2023). The Biden administration's $7,500 tax credit to Americans buying EVs only extends to those vehicles produced under the Canadian-US-Mexico Free Trade Agreement (CUSMA). Interestingly, Canada presently does not impose the same high tariff levels on imported Chinese autos as the United States. Canadians can also use the federal government's $5,000 purchase subsidy to buy specific Tesla models manufactured in Shanghai and imported, providing a unique dynamic regarding tariffs and subsidies within the North American automotive market. From January to October 2023, the value of Chinese-made EVs imported into Canada soared 2,700 percent, from $66 million to $1.8 billon (Chase and Kirby 2023).

Four Chinese companies are currently looking to establish auto manufacturing facilities in Mexico. Given that Mexico is a signatory to the CUSMA free trade pact, Chinese-made vehicles produced in Mexico could potentially bypass the high US tariffs (Murray, Chu, and White 2023). Of those four companies, BYD Auto, now the world's largest EV manufacturer by sales, has recently announced negotiations with Mexican officials to build an electric vehicle production facility in Mexico, strategically intended for exporting EVs into the United States and, possibly, Canada (Reuters 2024). Although establishing a manufacturing plant in Mexico does not in itself give BYD tariff-free access to the US market, it does lower export costs, and it is a first step to introducing a Chinese car manufacturing presence into North America.

Finally, irrespective of the above, assuming North American automakers can offer competitive products, auto sector representatives for Canada claim that those automakers will not have the capacity to supply all the zero-emission new cars that Canada needs to meet demand. One industry expert said, "If the Canadian government is absolutely committed to that [100 percent EV sales by 2035] target, it is not going to come through any domestic base production" (Gollom 2024).

The government's policy response should not necessarily keep all Chinese EVs out of Canada. Competition is vital to ensure that North American automakers innovate and price vehicles competitively. It is essential for a healthy and robust auto sector. The challenge is to let the industry continue to develop its EV supply chain and to innovate and ensure its product offerings meet Canadian needs. This includes EV operating characteristics on par with or better than ICE vehicles, sufficient charging infrastructure, and models that all Canadians can afford. It is highly unlikely all this can be accomplished by 2035.

EV adoption scenarios with unfavourable GHG mitigation outcomes

How well EV adoption can achieve significant GHG reductions is premised on two factors. The first is how well EVs will reduce emissions. The second is the feasibility of quickly and completely replacing ICE vehicles with EVs. The previous section dealt with the second factor. However, while the initial factor is commonly assumed to hold given that EVs generate no tailpipe emissions and Canada presently generates clean electricity, there are scenarios where widespread EV adoption may not result in GHG reductions as initially thought.

These scenarios revolve around supply constraints, including for lithium and other critical minerals used in battery production, and for aluminum which is increasingly used in EV production. Related issues are the time required to obtain permits to establish new mines and processing facilities, along with the increasing market demand for larger SUV-type vehicles. One or more of these constraints, when interwoven into various scenarios, gives pause to mainstream thought that rapid EV adoption will yield large environmental benefits.

Increased aluminum use and emissions

Aluminum has become an increasingly integral material in the production of EVs. It is used for battery casings and is increasingly relied on in the construction of EV bodies. Its lightweight and sturdy nature helps manage the weight of EVs, a critical factor in maximizing efficiency, extending range, and meeting consumer preferences for larger vehicles (Dey 2023).

Producing primary aluminum relies heavily on electricity, which means the carbon intensity of aluminum production is sensitive to the type of fuel used for generating electricity. While the global average GHG emissions for every tonne of aluminum produced is 11 Mt, this figure can vary significantly, as depicted in table 3. In contrast, producing one tonne of steel generates approximately 1.85 tonnes of GHGs on average (UK Steel 2020). Therefore, although aluminum offers significant advantages over steel in EV manufacturing, increased use will raise an EV's lifecycle GHG emissions (Table 3).

A recent study forecasts a substantial rise in aluminum usage in new vehicle construction from 2020 to 2050, estimated at 3.75 to 5 times current

TABLE 3: GHG produced in aluminium production by energy source (megatonnes of GHG per tonne of aluminum)

Coal	18
Natural gas	3 – 5
Hydro	2
World average	11

Source: Matthews 2020.

levels (Billy and Muller 2023). Unlike other studies, this one more thoroughly examined aluminum's impact on emissions intensity in EVs. It concluded that the increased use of aluminum in EV production will significantly contribute to an EV's carbon footprint, even after factoring in recycling efforts (Billy and Muller 2023).

Commonly used metrics for measuring vehicle GHG reductions, such as grams of CO_2 emitted per kilometre, concentrate on usage emissions. Usage metrics encourage practices like light-weighting and increased aluminum use, which themselves contribute to a materially greater environmental footprint.

The study's authors conclude that there is a paradox. While a rapid shift to EVs will curb the GHG emissions that result from driving, that rapid shift will create more emissions from aluminium production. Even using optimistic projections, the declining GHG intensity in producing aluminum will not likely offset the additional emissions created by its increased use.

Some may note that Canada produces low-carbon-intensity aluminum. However, our country's aluminum production facilities already operate at 95 percent capacity, limiting their ability to increase production in the short-to-medium term (Congressional Research Service 2022). Moreover, many vehicles sold in Canada are built elsewhere where aluminum production has higher carbon intensity. Billy and Muller (2023) state that "if current trends continue, the contribution of aluminum to the carbon footprint of EVs will largely exceed the one from battery materials… and assembly." In the rush to rid ourselves of ICE vehicles, we may be simply exporting some of our carbon emissions elsewhere.

Demand for electric SUVs and resource constraints

The SUV market is forecast to grow 6.6 percent compounded annually between 2022 and 2027 (Markets and Markets 2024). Currently, SUVs are the most popular vehicles sold in Canada and the United States, making up approximately 73 percent of auto sales in the US and 85 percent in Canada (Munoz 2022; Statistics Canada 2024).[1] Automakers also have a financial incentive to produce conventional and electric SUVs as they are significantly more profitable than compact and midsize automobiles.

The increasing demand for electric SUVs may pose a challenge for battery production. By 2040, the surge in battery demand for EVs will require a staggering increase in lithium production (40 times what it was in 2020) and 20 times more copper, graphite, and cobalt than in 2020 (Hillberg and Hall 2021).

> *The increasing demand for electric SUVs may pose a challenge for battery production.*

While electric SUVs have lower greenhouse gas emissions per kilometre than conventional gas-powered SUVs, the problem lies in the larger battery packs they require and the resulting higher emissions footprint during manufacturing. The large batteries they need, coupled with a possible shortage of critical minerals, raises questions about automakers' choices in allocating constrained battery supplies. The dilemma is between prioritizing electric SUV production for market and profit reasons at the expense of limiting production of smaller electric vehicles.

The above scenario is the focus of a European study that analyzed the impact on GHG emissions from the increased production of electric SUVs in response to market demand despite the potential critical mineral shortages that could lead to battery rationing. The findings suggest that the high demand for electric SUVs, coupled with supply-constrained batteries, may drive automakers to prioritize the production of more profitable electric SUVs at the expense of producing fewer smaller EVs. In such a scenario, the study concludes that EV adoption may not necessarily lead to significant GHG emission reductions (Vilchez, Pasqualino, and Hernandez 2023).

Toyota's case against full electric vehicle adoption

Toyota has publicly stated that it does not believe wholesale EV adoption is optimal for reducing GHG emissions within the light vehicle transportation sector. The company does think that EVs have an important role to play, but it sees the greatest environmental benefit from a mix of EVs (about 30 percent of the total), along with hybrid, plug-in hybrid, hydrogen fuel-cell, and conventional vehicles (Takahashi 2024). Toyota sees three main barriers to widespread EV adoption including:

- Massive demand for critical minerals coupled with long timelines for mine permitting and construction, resulting in raw material shortages for wholesale EV adoption.
- Inability to build a sufficient EV charging infrastructure in the short-to-medium term.
- The high cost of EVs compared to their conventional vehicle equivalents (McParland 2023).

Toyota's basic argument, based on Table 4, is as follows:[2]

TABLE 4: Variables in the Toyota scenarios

Vehicle type	Size of battery pack	Emission intensity (grams CO_2/km)	Comments
ICE vehicle	None	250	
Hybrid vehicle	1.1 kWh	200	Conventional hybrid vehicle
Electric vehicle	100 kWh	100	Battery pack size for a high-end Tesla model

Source: (Greimel, 2023). The numbers 200- and 100-grams CO_2/km are author calculated.

The argument starts with a limited lithium supply, enough to make 100 kilowatt hours of battery capacity. A company is considering purchasing a fleet of vehicles – initially composed of 100 internal combustion engine (ICE) vehicles with an average emissions intensity of 250g CO_2/km. Greimel (2023) describes two scenarios:

In Scenario One, the entire lithium supply is allocated to produce a single, fully electric vehicle with a 100-kilowatt-hour battery pack. The 100-vehicle fleet is now composed of one fully electric vehicle and 99 ICE vehicles. The average emissions for this fleet, factoring in the weighted emissions of each vehicle type, amount to 248.5g CO_2/km per vehicle. [(1 x 100g CO_2/km) + (99 x 250g CO_2/km)]/100.

Scenario Two takes a different approach, using the lithium to manufacture 90 hybrid vehicles, each with 1.1 kWh battery packs. This results in a fleet of 90 hybrid and 10 ICE vehicles, with an average emissions level of 205g CO_2/km per vehicle. [(90 x 200g CO_2/km) + (10 x 250g CO_2/km)]/100.

Toyota's conclusion, drawn from the above, emphasizes the importance of having a higher number of hybrid vehicles in reducing GHGs. Based on this simple analysis, emissions reductions are 30 times greater using many hybrid vehicles, compared to relying on a smaller number of fully electric vehicles. One may quibble with the numbers, but a reasonable change in values will yield the same overall result.

The case of Norway, the EV capital of the world

Norway has the highest number of electric vehicles per capita globally. EVs now make up 87 percent of all new vehicle sales in that country. A large part of this high EV adoption level is due to the numerous subsidies the government offers its citizens. Norway's government is now reducing some of the incentives based on widespread adoption targets being met, along with some acknowledged negative externalities that have occurred (Aasness and Odeck 2015).

TABLE 5: Norwegian government subsidies on new electric vehicles

Original subsidies for new EV purchases	As of January 31, 2023
Value added tax (VAT) exempt, which is 25 percent of the car's selling price.	Subsidy reduced in 2023
Annual weight fee tax exempt	Taxes are now paid on weights over 500 kg
One-off registration fee exempt	
Purchase/Import tax exempt	Subsidy reduced in 2023
50 percent reduced company car tax	Reduced to 20 percent from 2022 onwards
Exemption from 25 percent VAT on leasing	
Exempt from paying toll roads	Min 30 percent reduction on toll road fees
Exempt from paying ferry charges	50 percent reduction in ferry fares
No annual road tax	Removed in 2022
Free municipal parking	Removed in 2017
Use of bus lanes	Criteria tightened in 2016

Source: Norwegian Electric Vehicle Association 2024

The Norwegian Ministry of Finance estimates that the total cost of the tax benefits for EVs is US$1,400 (or C$1,890) per tonne of GHG mitigated (Camara, Holtsmark, and Misch 2021). To put the GHG mitigation costs in perspective, the government of Canada's social cost of GHGs in 2024 is $266 per tonne (ECCC 2023c).[3] The social cost of GHGs is an estimated cost of the harm incurred to human health, property damage, agricultural output, etc. due to emitting one tonne of GHG. From a benefit-cost perspective, spending $1,890 to save $266 in costs is certainly not a favourable metric.

There are also concerns about the negative impacts the financial incentives have had in Norway. Despite very generous purchase subsidies, incentives have accrued mostly to high-income Norwegians, which contributes to wealth inequalities (Zipper 2023). Increased traffic congestion has occurred because EVs have access to commuter and bus lanes and for that reason public transit commute times have also suffered (Aasness and Odeck 2015). Finally, data has also shown that households purchasing an EV are 24 percent more likely to keep their ICE vehicle than if they purchased a new ICE vehicle instead of an EV, suggesting people may not see EVs as perfect substitutes for ICE vehicles (Fevang et al. 2021).

Electric vehicles are promising but still evolving

Electric vehicles have many positive attributes, and manufacturers are making progress in addressing their shortcomings. Improvements include increased driving range, more models becoming available, and decreased battery production costs. However, when compared to ICE vehicles, EVs still have a few limitations. Some are minor; others are not.

Driving range and recharging in extreme weather

One notable concern is the impact of temperature conditions on EV performance. Studies indicate that the driving range of EVs diminishes in both cold and hot temperatures. Several papers have estimated that between 20 and 60 percent of an EV's range is lost in cold conditions (Zhao et al. 2022; Mimberg and Massonet 2017; Armenta-Deu and Giorgi 2023; Steinstraeter, Heinrich, and Lienkamp 2021). High temperatures have a less pronounced effect, ranging from minimal or no impact to range reductions of up to 32 percent (Park, et al. 2017; Hamwi et al. 2022; AAA 2019; Dhingra 2023).

Also concerning is the impact of low temperatures on EV charging efficiency. While cold temperatures do not pose issues for Level 1 and 2 chargers, they severely affect fast charging (Level 3 chargers) (Senol, Bayram, Naderi et al. 2023). One study has noted that "The charging power dropped drastically from the beginning, prolonging the charging time. In addition, lithium plating was also becoming an important problem due to fast charging under low temperatures, which can cause permanent damage to the battery's electrodes and lead to reduced capacity, shortened lifespan, and even safety concerns" (Senol, Bayram, Naderi et al. 2023)

Insurance premiums

In Canada, it is only recently that EVs have been sold in increasing numbers. Consequently, there is limited data on insurance claims related to repairs stemming from collisions. Reports from countries with more established EV bases suggest that insurance policies for EVs may differ from those for conventional vehicles.

Mitchell International, a company that handles collision claims in the automotive sector, released statistics showing that, on average, EV repair costs were US$963 higher than those for ICE vehicles. In Canada, this figure was higher: US$1,328 (Mandell 2023). Higher insurance premiums associated with EVs may be due to their higher selling prices and to their more expensive parts.

> *Higher insurance premiums (…) may be due to their higher selling prices and to their more expensive parts.*

An interesting *Road and Track* article argues that although repair costs for EVs are higher, when compared with a similar ICE vehicle model and year, repair costs are roughly equivalent (Ulrich 2023). Whether true or not, Elon Musk remains concerned about repair costs and emphasizes the need to "minimize the cost of repairing a Tesla if it's in a collision" (Ulrich 2023).

A *Financial Times* article reported a much higher rise in 2023 insurance costs for EVs (72 percent) versus ICE vehicles (29 percent) in the UK (Khalaf 2023). The article also stated that EV repair costs are 25 percent higher and take longer to repair. A *Guardian* article provided several anecdotes about major insurers dropping coverage of some EV models (Wood 2023).

Credit ratings agency Morningstar DBRS wrote a commentary "Electrification 2035: Auto Insurance Rates to Increase as the Transition to Electric Vehicles Becomes Law in Canada," indicating that Canadians may see rising costs to insure the EVs over the short to medium term, based on insurance rates in the UK, where EVs are more established (Morningstar DBRS 2024).

It is still premature to predict how high insurance premiums may go. However, the federal government's Electric Vehicle Availability Standard could disproportionately burden lower-income Canadians should higher insurance premiums be the case for EVs in the future.

Maintenance and general repair costs

Electric and conventionally powered vehicles are quite different mechanically. An electric motor has approximately 20 moving parts in contrast to over 200 moving parts in a combustion engine. While fewer moving parts can simplify maintenance and repairs, it is also necessary to recognize that EVs incorporate sophisticated technologies that may raise repair costs.

Consumer Reports conducted a survey that covered more than 330,000 vehicles and found that over the last several model years electric vehicles encountered 79 percent more problems than their gas-powered counterparts. Common problems arose with electric motors, batteries, and the vehicle's charging system (as opposed to the charging station). Interestingly, hybrids emerged as the most reliable option in this survey (Doyle 2023).

In contrast, a US study suggests regular maintenance costs for EVs are approximately 40 percent lower than those for ICE vehicles. This benefit is tempered by the fact that average maintenance costs over a 5-year period are around $200 annually (Rapson and Muehlegger 2022). So, while EVs may have lower maintenance costs, the overall financial picture is a bit more nuanced.

Depreciation

Depreciation is one of the most important costs in vehicle ownership. However, because of a lack of data, researchers have until recently used conventional vehicle depreciation rates on EVs when calculating overall operating costs (Schloter 2022).

A few studies that have been able to use data on residual EV value and depreciation have yielded mixed results. A study by the US Department of Energy concluded that while EVs depreciated faster in the past, newer models are now comparable to ICE vehicles (Rush, Zhou, and Gohike 2022). In contrast, a recent academic study suggested that EVs depreciate at a rate of about 13.9 percent per year, compared to 10.4 percent per year for ICE vehicles (Schloter 2022). This latter finding aligns with results from other academic papers on the subject (Schoettle and Sivak 2018; Propfe et al. 2012). Despite the complexities surrounding EV depreciation, understanding it is crucial to businesses, for leasing calculations, and for individuals wanting to make an informed assessment of total ownership costs.

$10 for an electric vehicle charge vs. $50 refill for the gas equivalent – but for how long?

One often-cited advantage of electric vehicles is their comparatively low cost of refuelling or charging. According to the federal government, driving a midsize car for 400 kilometres would cost Canadians about $10 in electricity, compared to $50 in gas (ECCC 2023b).

Despite the large perceived benefit to consumers, one can question whether the above is a fair comparison. Gas prices contain substantial government levies; electricity prices do not. The federal government currently collects approximately $6 billion in gas and diesel tax revenue annually, with provincial and municipal governments collecting an additional $10 billion through various taxes (see Table 6) such as federal excise tax, provincial excise tax, federal carbon tax, local levies, and federal/provincial sales taxes.

Unlike gasoline, electricity for EV public charging is not subject to federal, provincial, or municipal taxes other than GST, PST, or HST. However, if the government aims to recoup the lost taxes from the gas sector, introducing

TABLE 6: Taxes on gasoline (as of December 2023)

Tax Type	Rate or amount per litre of gas
Federal excise tax	$0.10
Federal/provincial carbon tax	$0.1431 – $0.1920
Provincial/local excise tax	$0.062 – $0.27
Federal/provincial sales taxes	5% – 15%

Source: Natural Resources Canada 2024.

new taxes on electricity or EV usage would increase recharging prices. For instance, assuming that 31.25 percent of the price of gasoline constitutes taxes, a comparable tax on electricity would raise the above recharging cost example from $10 to $25.62, a significant increase.[4]

Another issue relates to electricity rates charged in public stations. In a BC Hydro news release addressing a rate hike application the corporation made for public charging stations, BC Hydro acknowledged that their current rates are lower than the cost of supplying and maintaining the network (BC Hydro 2023). This raises concerns about the unsustainability of current prices and the potential for future increases in electricity rates for EV charging.

Total cost of ownership (TCO)

A University of Michigan paper examined total cost of ownership (TCO) and found that there is a wide range of TCOs, particularly for midsize electric SUVs, with amounts varying by as much as $52,000, depending on the location (Woody et al. 2024). The study also concluded that access to home charging emerged as a significant factor, contributing to an average reduction of $10,000 in TCO. This last point is concerning as EV ownership again disproportionately hurts lower-income families that are not as likely to have a garage or a personal home charging station.

> *The study noted that the lowest EV costs were "in cities with high gas prices, low electricity prices, moderate climates (...).*

The study noted that the lowest EV costs were "in cities with high gas prices, low electricity prices, moderate climates, direct purchase incentives, home charging access, time of use electricity pricing and high demand mileage." It also found that small and low-range EVs are less expensive than gasoline equivalents. Larger, long-range EVs are more expensive than gasoline equivalents. Overall, the paper concludes that the median TCO for EVs is higher than for equivalent ICE vehicles.

Given the above-mentioned issues and challenges, there is uncertainty about whether and when EVs can completely replace conventional vehicles. The federal government's Electric Vehicle Availability Standard puts arbitrary limits on the sale of new ICE vehicles without considering whether EVs will cause problems for Canadians in rural areas, especially those that experience low winter temperatures, or whether higher costs will increase financial burdens on those with low incomes.

A recent study from the University of British Columbia compared the TCO of an EV and an ICE vehicle of the same make. The study concluded that while TCO varied by province, "typical households in Canada generally do not drive enough for lifecycle costs of EVs to be less than ICEVs" (internal combustion engine vehicles) (Javad, Kandikar, and Giang 2024).

Charging stations: does the math work for 2035?

Unlike the market evolution and construction of a gas-fuelling infrastructure in North America around the turn of the 20th century, the current rapid transition from conventional to electric vehicles, as mandated by the government, will require large government expenditures in public charging stations.

As of 2023, there were 26,500 public charging ports across Canada. Each charging port is a unit that an EV plugs into for recharging (Zhang 2023). There can be multiple ports located at a single charging station, providing capacity for supplying electricity to EVs.

Looking ahead to 2035, the federal government estimates that the country will need 442,000 to 469,000 public charging ports (Dunsky 2022). An average of these figures suggests a requirement for approximately 455,500 charging ports. This means that Canada needs to build 429,000 new public ports by 2035, or an average of 35,750 new ports per year – approximately 98 new ports every single day for the next 12 years. These numbers do not include the required private charging ports. These numbers show the scale of the infrastructure challenges posed by the 2035 mandate of selling only electric vehicles.

Externalities

Government policies, whether regulating, inhibiting, directing, or mandating action, can frequently result in unintended externalities. An externality occurs when a cost or benefit arises but is not borne or received by the decision-maker who caused it. The severity of these externalities may vary based on the specific policy. Below are a few potential externalities arising from government programs or mandates to foster an accelerated transition from conventional to electric vehicles.

Prescriptive vs. principle-based policies

The federal government's Electric Vehicle Availability Standard is a prescriptive policy that mandates the minimum proportion of zero-emission vehicles that automakers must sell to achieve the government's emission reduction targets. If the automakers fail to meet these targets, they will face significant financial penalties. This approach interferes in the market by dictating the types of vehicles that must be produced and purchased, raising concerns about unintended consequences.

For example, as the 2030 deadline approaches, if automakers find that at least 60 percent of new autos that Canadians are purchasing are not EVs, they may be compelled to reduce or halt sales of new conventional gas-powered vehicles to meet the minimum EV sales targets and avoid penalties. This could lead to vehicle shortages and higher prices for new and used gas-powered vehicles, both of which will have an adverse affect on consumers. Given the significance of cars and trucks in the lives of Canadians, as well as the overall importance of the auto sector, this could have serious implications.

A principles-based policy offers an alternative to mandating specific minimum EV sales. It would set minimum emission standards that automakers would have to meet by a certain deadline without specifying how they must meet these standards. Automakers could then customize their vehicle portfolios according to market needs while still meeting overall government emission standards. However, the timeframe and standards must align with market realities to be effective.

Signals sent to equipment manufacturers to reduce investment in ICE fuel economy

The US EPA has imposed increasingly stringent tailpipe emissions standards, which will require automakers to sell electric vehicles to comply with the strict rules. The EPA forecasts that achieving compliance will lead to 67 percent of new auto sales being zero-emission by 2032.

In a 2023 TV interview, former Ford President and CEO Mark Fields noted that once large automakers declared their intentions to aggressively transition to EVs, it sent a signal to Tier 1 suppliers[5] that any efforts they might have otherwise made to research and develop more emission-efficient internal combustion engine powertrains were going to be irrelevant (CNBC 2023). This shift in focus raises concerns that if the EV transition progress is slower than expected and if it is coupled with no significant advancements in ICE powertrains, meeting higher emission standards will become even more challenging.

Earlier this year, the *New York Times* reported that the US administration was considering easing newly proposed emissions standards. This consideration arose after automakers and unions expressed concerns about the readiness of the marketplace, supply chains, and charging infrastructure to meet the EPA's timelines for these standards (Davenport 2024). In late March 2024, the Biden administration announced that indeed, it would ease its short-term timelines (Joselow 2024).

Non-exhaust particulate matter emissions

The federal government's Electric Vehicle Availability Standard will mandate the sale of only "zero-emission" vehicles by 2035. However, labelling EVs as having zero emissions is inaccurate. While EVs do not emit GHGs or other tailpipe emissions, they do produce non-tailpipe particulate matter emissions, which some studies suggest may surpass those of internal combustion engine vehicles.[6] The term "zero-emission vehicles" should be more accurately be renamed "zero-tailpipe-emission vehicles."

Non-exhaust EV emissions include particulate matter (PM) generated by increased tire wear and braking caused by an EV's greater weight, as well as from road wear and road dust resuspension. These particulate matter emissions, such as heavy metals, microplastics, and micro rubber are known to be a substantial risk factor for adverse health effects and premature fatalities (Raza 2023; Piscitello et al. 2021).

Studies examining the impact of EV adoption on particulate matter emissions are inconclusive. One paper, which focused on reductions of $PM_{2.5}$, suggests significant health benefits from widespread EV adoption (Pan et al. 2023). However, it did not consider larger particulate matter (PM_{10}) and the additional PM generated by EVs from their tires and brakes. Other studies indicate that non-tailpipe PM emissions for EVs are either the same or notably higher than for ICE vehicles (Beddows and Harrison 2021; Timmers and Achten 2018). In a study comparing similar EV and ICE vehicles, the authors found that "non-exhaust particle emissions from the equivalent EVs are likely to be more than all particle emissions from ICE passenger cars, including exhaust particle emissions" (Liu et al. 2021).

Another concern is the level of human toxicity EVs generate due to the higher quantities of metals, chemicals, and energy used in their production process. Human toxicity refers to the harmful materials produced from the mining, refining, and production processes, often associated with battery production. A review of existing research found overall that electric vehicles are associated with greater levels of human toxicity (Verma, Dwivedi, and Verma 2021; Bicer and Dincer 2018).

Congestion and injuries

Governments have incentives to boost EV sales. Direct purchase subsidies are the most widely recognized inducement, but various others have been introduced including free parking, access to high occupancy vehicle (HOV) and bus lanes, and exemptions from road tolls or car ferry usage fees.

Offering single-occupant EVs access to HOV lanes may work against the reason for having such lanes – to reduce traffic congestion. Similarly, allowing EVs to use bus lanes can increase bus commuting times, thus discouraging people from using public transit. Furthermore, allowing free parking might give individuals an incentive to choose their vehicles over public transit, also undermining efforts to promote sustainable modes of transportation. Several of these unintended consequences have been documented in Norway where such incentives were offered (Aasness and Odeck 2015).

EVs are significantly heavier than conventional vehicles due to their heavy battery packs. And vehicle weight affects the chance of injury or death in auto collisions. On the one hand, a heavier vehicle may provide added protection for its occupants. However, for bicyclists, pedestrians, or those in lighter vehicles, it may increase the likelihood of their injury or death. If the heavier weight increases braking stopping distances, that too will contribute to increased cyclist or pedestrian injury or death (Arbelaez 2023). One study estimates a 47 percent increase in the likelihood of a fatal accident when a vehicle weighing an extra 1,000 lbs strikes someone (Anderson and Auffhammer 2011).

Another concerning matter is the behavioural response from households to fuel-efficient vehicles (e.g. electric vehicles). One study finds that households that buy a fuel-efficient vehicle are more likely to make their second purchase a larger vehicle. This is troubling from two perspectives. First, larger (heavier) vehicles can cause greater injury and death if they are involved in an accident. Second, purchases of larger vehicles can substantially undercut the emission savings potential attributed to EVs (Archsmith, Gillingham, and Knittel 2020).

Peak electricity demands

To maximize the GHG emissions reduction benefit of electric vehicles, it is critical that the electricity that powers them be produced cleanly. In Canada, 84 percent of electricity is currently derived from low and non-GHG emitting sources, primarily hydro, nuclear, wind, and solar power. Despite this high percentage, the federal government has set a goal for electricity generation to be net-zero by 2035 (Canada 2023).

Based on the facts that electricity demand is expected to double by 2050 and the goal is to achieve net-zero for its generation, the country will need to make very large investments in renewable energy sources while ensuring that the electrical grid can effectively meet demand 24 hours a day, 7 days a week. Ensuring constant electricity availability, especially during peak demand periods such as from 5:00 p.m. to 7:00 p.m. on weekdays, is crucial.

Utilities currently use “peaker plants,” often powered by natural gas, to meet these peak power needs. These sources can start up quickly and vary the power they produce to meet demand. Meeting peak power needs can be more challenging when wind or solar contribute significantly to grid electricity generation. Both are weather dependent and, as a result, are considered intermittent power sources. If weather conditions are not appropriate to generate power during peak demand, then the electricity supply can fall short, leading to rolling blackouts. Building large battery storage facilities may address part of the peak power needs, but that is unlikely to be a complete solution.

Integrating electric vehicles into the electrical grid brings additional challenges for meeting peak power needs. One study suggests that EVs could raise peak power demands by 8 percent, making the demand for electricity even harder to manage (Li et al. 2022). Moreover, peak electricity demand tends to rise on cold weather days, which are the same conditions that reduce EV driving range and increase charging needs.

To improve driving range in cold weather, EV owners can preheat the vehicle's cabin using the electrical grid rather than the vehicle's battery. However, doing so places additional pressure on peak demand, with another study suggesting an increase of 0.5 to 2 percent in peak load requirements (Sorensen, Ludvigsen, and Andresen 2023).

The choice of energy sources to meet peak power needs is pivotal. Using natural gas predominantly reduces the marginal benefit of EVs in lowering GHGs. Although EVs may not emit tailpipe GHGs, the source of their electricity matters. For example, in Quebec, where electricity is predominantly hydropower-generated, a Hyundai Ionic emits significantly fewer GHGs (0.3g GHG/km) than in Nova Scotia, which uses coal to generate a considerable portion of its electricity (107g GHG/km) (Canada Energy Regulator 2018).

The need to manage EV charging is evident to avoid straining electrical grids and causing reliability issues that will result from increased peak demand due to widespread EV use. This can involve shifting electricity demand from peak to non-peak hours as well as optimizing the use of intermittent renewable energy sources.

Vehicle-to-grid (V2G) systems are also being developed to give utilities real-time data for making optimal charging decisions. V2G enables bi-directional power flow so utilities can take energy from EVs and feed it back into the grid during peak demand or emergencies. However, before V2G systems can be implemented at scale the technical challenges, standards development, and regulatory policies must be addressed (Hamblin 2022).

The distribution grid

Utilities will face challenges ensuring that electrical distribution grids – the final segment of the electrical system for delivering electricity to homes, businesses, and end-users across Canada – will be able to accommodate the massive demand for charging capacity. This challenge is related but incremental to the hundreds of thousands of charging ports required to support wholesale EV usage.

Natural Resources Canada sought input from industry stakeholders regarding grid readiness for EVs. The respondents said that "the **current grid infrastructure will be unable to meet higher loads**" (emphasis in original) (Natural Resources Canada 2022). In another study on EV charging the authors state that "peak periods are among the most critical factors affecting the sub-transmission grid" (Senol et al. 2023).

The distribution grid encompasses various components including substations, lines, poles, neighbourhood transformers, and related equipment, all of which must be upgraded and expanded to handle the increased demand. While utilities routinely upgrade and expand distribution grids as part of their operations, the scale and complexity of upgrades needed for EVs are much more formidable.

One major complication is the load diversity associated with EV charging. Predicting the times when different customers will use electricity is challenging, especially at the neighbourhood level. This unpredictability can strain the distribution grid, particularly in areas with rapid EV adoption or older neighbourhoods. The strain may lead to power outages or equipment damage, necessitating unplanned replacements and repairs (ICF Canada 2021).

Research at Georgia Tech highlights the impact of multiple Level 2 chargers connected to a single distribution transformer in residential areas. Such setups can drastically reduce the transformer's expected lifespan from 30 to 40 years down to 3 years, showing the strain EV charging can have on grid infrastructure (Charette 2022).

Transformer upgrades to accommodate greater electrical loads, load balancing, and voltage regulation are crucial for utilities to address. Convincing enough drivers to charge their vehicles during off-peak hours will be essential to alleviate grid stress.

While distribution grid challenges may not be immediate, they will grow as EVs become a larger proportion of all vehicles on the road. The compressed timeframe imposed by government regulations due to the Electric Vehicle Availability Standard means less time for grid planning, upgrades, and optimization.

Summary and conclusion

This paper assesses Canada's Electric Vehicle Availability Standard, which requires that by 2035, 100 percent of all new vehicles sold be zero-emission vehicles. While electric vehicles can lower GHG emissions, doubts persist whether they are fully substitutable for conventional, gas-powered vehicles. The government's ambitious timeframe is unrealistic, risky, and potentially ineffective for achieving substantial GHG emission reductions.

Concerns also exist about the threats the standard poses to Canada's auto sector, its nascent EV supply chain, and critical mineral resource development. Building a charging infrastructure will require a large investment and substantial upgrades to the country's electrical grids. EVs also have higher upfront costs, and experience suggests that total ownership costs may be higher than for ICE vehicles, disproportionately affecting lower- and middle-income people. Accelerating adoption timelines could worsen the above issues, uncertainties, and risks.

This paper recommends a more balanced and flexible approach to emissions reductions. Specifically:

- Rescind the current mandated zero-emission vehicle sales minimums. Requiring percentage targets is too prescriptive and can lead to significant market misallocations.
- Replace specific EV sales targets with increasingly stringent GHG emission standards for automakers to meet. This will allow automakers to adjust their vehicle portfolios to market needs while still being required to meet overall emission reduction goals.
- Ensure that targeted emission standards and implementation timelines are realistic and align with industry efforts to source critical minerals and develop cheaper, yet profitable electric vehicles with superior operating characteristics. MLI

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Endnotes

1 These figures also include light-duty trucks.

2 This argument is based on an article in *Automotive News* from Greimel (2023).

3 Estimating the social cost of carbon (SCC) is difficult. Modelling the climate is complex. It involves long time horizons, estimating many variables, and value judgements. Changing the discount rate alone, even by 1 percent, can result in large changes in the SCC.

4 The 31.25 percent is based on calculations from data supplied in a Canadian Taxpayers Federation (2022) report.

5 Tier 1 suppliers include companies such as Magna International, BorgWarner, and Dana Incorporated. These companies design and produce the powertrains the large automakers use.

6 Particulate matter (PM) is often categorized as PM2.5 which refers to fine particles with diameters of 2.5 microns or less. PM10 refers to larger particles with diameters of 10 microns or less.

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WHAT PEOPLE ARE SAYING ABOUT MLI

The Right Honourable
Paul Martin

I want to congratulate the **Macdonald-Laurier Institute** for 10 years of excellent service to Canada. The Institute's commitment to public policy innovation has put them on the cutting edge of many of the country's most pressing policy debates. The Institute works in a persistent and constructive way to present new and insightful ideas about how to best achieve Canada's potential and to produce a better and more just country. Canada is better for the forward-thinking, research-based perspectives that the **Macdonald-Laurier Institute** brings to our most critical issues.

The Honourable
Jody Wilson-Raybould

The **Macdonald-Laurier Institute** has been active in the field of Indigenous public policy, building a fine tradition of working with Indigenous organizations, promoting Indigenous thinkers and encouraging innovative, Indigenous-led solutions to the challenges of 21st century Canada. I congratulate **MLI** on its 10 productive and constructive years and look forward to continuing to learn more about the Institute's fine work in the field.

The Honourable
Irwin Cotler

May I congratulate **MLI** for a decade of exemplary leadership on national and international issues. Through high-quality research and analysis, **MLI** has made a significant contribution to Canadian public discourse and policy development. With the global resurgence of authoritarianism and illiberal populism, such work is as timely as it is important. I wish you continued success in the years to come.

The Honourable
Pierre Poilievre

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