Analysis of Challenges and Perceptions in the Expansion of EV Charging Infrastructure and Adoption of Electric Vehicles in Canada

Dat Diep, Farah Elibiari, Hiroto lkegami, and Mauli Shah

University of Toronto
Outstanding Teenager Leadership Foundation, Youth Entrepreneurship Forum
6 September, 2024

In Canada, the Net Zero Emission Accountability Act, passed in 2021, addresses the increase in greenhouse gas (GHG) emissions through multiple ways in an attempt to minimize or offset the emissions of GHGs. Some of the ways that the Canadian government has begun to implement includes: carbon taxing, industry decarbonization and the introduction of electric vehicles (EVs). Throughout the past decade, electric vehicles have been introduced to the vehicles market in Canada with a market share of 12% in the last quarter of 2023.[1]With this surge in the purchase and adoption of EVs in Canada, we can conclude that EVs play a pivotal role in addressing the high GHG emissions. As the rate of EV adoption is increasing over the past couple of years, it is imperative to accentuate the challenges that accompany EV adoption including the growing infrastructure problem in Canada.

Literature Review

With electric vehicles penetrating the vehicle market in Canada, there are many obstacles and challenges faced by different stakeholders including: the government, private companies and consumers. In order to help alleviate the environmental damage our society has done, these challenges need to be addressed and resolved in order to ensure the full adoption of electric vehicles. Faran Razi and Ibrahim Dincer highlight the pivotal role that EVs play in minimizing the effects of urbanization. With 75% of greenhouse gasses emissions being from road transportation in Canada, EVs will be the key to reduce those emissions while also supporting a sustainable economy. However, the authors highlight that consumers have been reluctant about adopting EVs due to the insufficient number of charging stations.[2] With the infrastructure problem, the Canadian government and policymakers need to simultaneously work towards resolving the challenge at hand, while also encouraging consumers to adopt electric vehicles. Since consumer awareness and attitudes are determined by expert opinions, which may include interaction with car dealerships it is vital to ensure that experts are aware of the infrastructure problem as well as the possible solutions that are being implemented.[3]

In an attempt to improve Ontario's charging infrastructure across Canada,the provincial government implemented "Electric Vehicle Chargers Ontario (EVCO) in 2015. This program allocated a total of $20 million to expand the charging infrastructure in Ontario with around 500 EV charging set up throughout Ontario "at more than 250 locations along major inter-city transportation corridors in the province…" [4] However, it is important to note that the placement of the charging station has a significant environmental effect, where the energy sources are not the only determinant of environmental damage but rather "the location, design, and installation of these stations, they can have adverse environmental impacts." [5]

Therefore, the Canadian government needs to not only increase the amount of charging stations in each province but also ensure that its location will not have any ramifications on the environment. However, one of the nuances of this problem is that the infrastructure problem is accompanied by many

---

[1] Banks, B. (2024, May 9). *StatsCan reports Q4 Zev registrations at 12 per cent*. Electric Autonomy Canada. https://electricautonomy.ca/data-trackers/ev-sales-data/2024-03-12/statscan-q4-zev-registrations-12-per-cent/

[2] Razi, F., & Dincer, I. (2022, November 11). *A review of the current state, challenges, opportunities and future directions for implementation of Sustainable Electric Vehicle Infrastructure in Canada*. Journal of Energy Storage. https://www.sciencedirect.com/science/article/pii/S2352152X22020369

[3] Singh, R., Walsh, P., & Goodfield, J. (2021). Innovation cognizance and acceptance: The case of electric vehicles adoption in Ontario, Canada. Journal of Innovation Management, 9(1), 51–69. https://doi.org/10.24840/2183-0606_009.001_0005

[4] Rapson, D., & Muehlegger, E. (2021). *The Economics of Electric Vehicles*. https://doi.org/10.3386/w29093

[5] Şenyapar, H. N. D., & Akıl, M. (2023, March 25). *Analysis of consumer behavior towards electric vehicles: Intentions, concerns, and policies*. Gazi University Journal of Science Part C: Design and Technology. https://dergipark.org.tr/en/pub/gujsc/article/1232071

other issues that need to be resolved in order to ensure the adoption of electric vehicles in Canada. Some of these problems include: congestion at public charging stations and the tradeoff between the sudden increase in electricity demand and the need to match it with the same amount of clean and renewable resources. This raises the question, "How do the various challenges and perceptions influence the development of the electric vehicle charging infrastructure in Canada and consequently affect the adoption of electric vehicles across Canada?"

This paper is an evaluation and analysis of the infrastructure problem in Canada through two lenses: the first being analyzing the supply-side of this challenge and the second lens would be to evaluate the demand side of this challenge. Both the supply and demand sides are interconnected but need to be evaluated independently. With regards to the supply-side of this research paper, there are many challenges that need to be addressed in depth. To begin with, the surge in electricity is one that has implications on the grid system as well as the extra cost that households may need to endure as a result. In addition to that, the proper placement of EV charging stations is an issue that many countries including Canada face, where more rural areas observe a lack of sufficient number of charging stations in comparison to urban areas. As a result, we might find that EVs are less likely to be adopted in rural areas.

Analogously, the demand side explores the consumer preferences towards public charging stations. Enhancing the customer experience at public charging stations should be a priority for the Canadian government, as it would incentivize consumers to adopt EVs. This can be achieved through resolving one of the more concerning challenges accompanied with the infrastructure problem is the lack of a unified payment method and/or system that simplifies the consumer experience. Finally, a rising issue that has prevented many consumers from adopting EVs is range anxiety. This occurs as a result of the poor placement of EV charging stations, which directly relates to the rural versus urban placement of charging stations.

Finally, it is important to note that the use of secondary sources will be important for this research paper, the use of primary sources including: interviews with experts in this field will provide great insight on the matter.

Challenges

Challenge 1: Disparity between Rural and Urban Areas Inhibiting the Adoption of EVs

The expansion of electric vehicle charging infrastructure in Canada has revealed significant disparities between rural and urban areas, presenting substantial challenges in terms of economic viability and equitable access. As of 2023, Canada has over 27,000 public charging stations, with a significant concentration in urban centers within Ontario, Quebec, and British Columbia.[6] These three provinces alone account for a substantial portion of the total funded chargers in the country, leaving vast rural regions significantly underserved. This uneven distribution has slowed EV adoption in these areas, exacerbating the rural-urban divide and halting the full transition to electric vehicles.

One of the primary challenges in developing EV infrastructure in rural areas is the economic feasibility of installing and maintaining charging stations. Rural areas, characterized by lower population densities and greater distances between destinations, typically see less frequent use of EV charging stations compared to urban settings. This underutilization poses a significant financial challenge for

[6] Natural Resources Canada. (2023). *Zero Emission Vehicle Infrastructure Program (ZEVIP)*. Government of Canada. https://www.nrcan.gc.ca/energy-efficiency/transportation-alternative-fuels/zero-emission-vehicle-infrastructure-program/21876

companies, as the costs of installing and maintaining these stations are not offset by high usage rates. The sporadic nature of maintenance and the lower density of charging stations contribute to the perception that EVs are less viable in rural settings. This not only limits the ability of rural residents to adopt EVs but also affects the long-term sustainability of the EV transition in these regions. The economic return on investment is slower and less certain in these areas, deterring private companies from investing.[7] For example, Ontario's ChargeON program, which has a budget of $91 million, specifically targets smaller communities to address these gaps. However, even with such initiatives, the financial risks remain high for private investors, as the rural landscape—with its vast distances and sparse populations—often leads to charging stations sitting idle for extended periods. While Canada's federal government has allocated significant funding to support EV infrastructure—with over $1 billion invested since 2015—the distribution and maintenance of this infrastructure remain uneven, particularly in rural and northern communities.[8]

Moreover, the lack of charging infrastructure in rural areas directly impacts residents, discouraging them from adopting EVs. A survey conducted by the Canadian Automobile Association (CAA) found that only one-third of rural Canadians are considering an EV for their next vehicle purchase. The primary concerns cited by these residents include driving range limitations and the accessibility of charging stations.[9] Without reliable and accessible charging options, rural residents are more likely to continue relying on gasoline-powered vehicles, which in turn perpetuates the rural-urban divide in EV adoption. This hesitation to adopt EVs is further compounded by concerns over the availability of charging stations during long trips, especially in remote areas where charging options are sparse. The cycle of low adoption leading to less investment, which further discourages adoption, is a significant hurdle that must be addressed to ensure equitable access to EVs across Canada.The challenge is not merely about the initial deployment of infrastructure but also ensuring that this infrastructure remains functional and accessible over time.

Challenge 2: Competitive and Insufficient Funding for Government Programs for EV Adoption

The expansion of EV charging infrastructure in Canada presents a complex array of challenges, particularly in ensuring equitable access across urban and rural areas. These challenges are intertwined with government funding limitations, grid reliability concerns, and the uneven distribution of charging stations, which collectively hinder the broader adoption of EVs. Addressing these issues requires a multifaceted approach that considers economic viability, grid modernization, and targeted investments, particularly in underserved regions.[10]

One of the most significant challenges in the expansion of EV infrastructure in Canada is the competitive and often insufficient funding for government programs like the Zero-Emission Vehicle Infrastructure Program (ZEVIP). The available funding is frequently inadequate to meet the extensive demand, creating a highly competitive environment that delays or limits the development of essential infrastructure. This issue is particularly pronounced in smaller municipalities and rural areas, where the

---

[7] International Energy Agency. (2020). *Global EV Outlook 2020: Entering the decade of electric drive?* International Energy Agency. https://www.iea.org/reports/global-ev-outlook-2020

[8] Natural Resources Canada. (2023). *Zero Emission Vehicle Infrastructure Program (ZEVIP)*. Government of Canada. https://www.nrcan.gc.ca/energy-efficiency/transportation-alternative-fuels/zero-emission-vehicle-infrastructure-program/21876

[9] Canadian Automobile Association. (2021). *Electric vehicle (EV) charging infrastructure in Canada: Challenges and opportunities*. Canadian Automobile Association. https://www.caa.ca/ev

[10] Razi, F., & Dincer, I. (2022, November 11). *A review of the current state, challenges, opportunities and future directions for implementation of Sustainable Electric Vehicle Infrastructure in Canada*. Journal of Energy Storage. https://www.sciencedirect.com/science/article/abs/pii/S2352152X22020369

lack of substantial provincial or federal support exacerbates the uneven distribution of charging stations. Ontario's EV ChargeON program highlights the need for tailored financial strategies to support these regions, yet the overall funding still falls short of ensuring comprehensive coverage.

Challenge 3: Focused Research and Development (R&D) in Energy Storage and Grid Technologies

The adoption of EVs directly increases electricity demand because EVs need to be charged regularly. As more people transition from gasoline-powered vehicles to EVs, they plug in their cars at home, at work, or at public charging stations. This additional load puts extra strain on the electrical grid, especially during peak hours when demand for electricity is already high (for example, in the evenings when people come home, turn on appliances, and simultaneously charge their vehicles). Without adequate upgrades, the grid risks overloading during these times, leading to power outages or disruptions. Peak demand periods typically occur when many households are using electricity simultaneously for various purposes, and adding a significant number of EVs to the mix exacerbates the load. For instance, if thousands of EV owners in a city plug in their vehicles around 6 p.m., the grid could become overwhelmed if it hasn't been modernized to handle the additional capacity.

Challenge 4: Addressing the Environmental Impact of the Modernization of the Electricity Grid with EV Adoption

The challenge in expanding Canada's electricity grid lies in addressing the paradox of its environmental impact. While the shift to electric vehicles (EVs) offers the potential to significantly reduce greenhouse gas emissions from the transportation sector, the production and construction of new grid infrastructure may initially result in an increase in emissions. This raises the question of how to balance the short-term environmental costs with the long-term benefits of reducing overall emissions. The use of materials in grid construction, such as transmission towers and poles, poses a challenge in selecting low-carbon options that minimize emissions. Additionally, the logistics involved in transporting and installing this infrastructure contribute to the carbon footprint, requiring strategies to reduce emissions from these processes. Furthermore, there is the challenge of integrating life cycle assessments into the planning and implementation stages to ensure that all environmental impacts are accounted for throughout the grid's development. Incorporating sustainable practices can be difficult for Canada since there are several challenges Canada has to face like how they can upgrade the infrastructure and how much it will actually help Canadians. There are options that worked out for many countries but with Canada's weather, geography and increasing population there are many challenges one must face while keeping in mind the negative impacts on the environment for this.

Another pressing issue is the potential for increased emissions during the grid's construction phase, which conflicts with the broader goal of reducing the carbon footprint. The need for carbon offsetting strategies, such as reforestation or investing in renewable energy projects, becomes more pronounced in addressing this dilemma. Additionally, securing public support for these grid modernization efforts is crucial, yet challenging, as communities may be hesitant to back projects that appear to increase emissions in the short term. Engaging the public with transparent communication about the long-term environmental and economic benefits, including cleaner air, job creation, and sustainable energy, will be critical to overcoming resistance. Balancing these various factors makes the task of modernizing Canada's electricity grid both complex and urgent, as it strives to support EV adoption and renewable energy integration while minimizing environmental harm.

Challenge 5: Lack of National Standardization Regarding EVs

Another challenge in supporting widespread EV adoption is the lack of standardized pricing for EV charging. Currently, charging costs vary widely depending on the location, time of use, and the

charging network provider. Implementing national guidelines to standardize EV charging costs could help address this inconsistency, ensuring that consumers are treated fairly and transparently across different regions and networks. For example, consumers might pay more at one charging station simply because of regional differences in pricing, which creates uncertainty and could discourage EV adoption. Dynamic pricing models, where the cost of charging fluctuates based on grid demand and the availability of renewable energy, could also benefit consumers. These models can encourage charging during off-peak hours or when renewable energy production is high, helping to stabilize the grid while lowering costs for consumers. For instance, charging during the night when electricity demand is lower or when there is abundant solar or wind energy available could result in cheaper rates for EV owners. This system would not only optimize grid use but also incentivize environmentally friendly behaviors, further boosting consumer confidence in EVs.

However, the development and enforcement of national standards for EV charging have been slow due to several challenges. One key reason is the complexity of coordinating multiple stakeholders—government agencies, utility companies, and private charging network operators—who all have different priorities and interests. Each party is responsible for a different part of the charging infrastructure, and aligning their goals to create unified pricing regulations is a complicated process. For instance, charging network operators might resist standardization because they would lose the flexibility to set their own prices based on local factors like demand and maintenance costs. Meanwhile, utility companies may be more focused on balancing the grid's overall demand rather than ensuring consistent pricing for consumers. In addition, EV charging infrastructure is still relatively new, and the policies governing it are evolving. Governments and regulatory bodies may not yet have the comprehensive data or experience needed to establish effective national standards that balance fairness, market competition, and grid reliability. As a result, developing and enforcing these guidelines will require significant collaboration, research, and long-term planning.

Challenge 6: Implementation of Dynamic Pricing Models for Electricity for EV Charging Stations

The challenge in implementing dynamic pricing models for Canada's electricity grid begins with the deployment of advanced metering infrastructure (AMI), which includes smart meters and communication networks. While AMI is essential for collecting real-time data and enabling two-way communication between utilities and consumers, merely installing this technology is not enough. A significant challenge lies in ensuring effective consumer engagement. Consumers must be well-informed about the benefits of dynamic pricing, such as cost savings and environmental impacts, which requires robust educational campaigns, user-friendly applications, and incentives. Utilities need to encourage consumers to shift electricity usage to off-peak times, but getting widespread participation may be difficult due to varying levels of consumer awareness, motivation, and access to technology. Additionally, regulatory and market design issues pose significant challenges. In many areas, electricity markets are highly regulated, and existing tariff structures are not conducive to real-time pricing. Revising these regulations and tariff structures to support dynamic pricing, while ensuring fairness and consumer protection, is a complex task. Furthermore, market designs need to consider the risks of price volatility, especially during peak demand periods. The challenge is in implementing mechanisms, such as price caps or discounts during off-peak times, to protect consumers from excessive price spikes while still encouraging demand response.

Economic and social equity concerns also arise, as grid modernization and investments in EV infrastructure must not disproportionately benefit certain regions or income groups. Ensuring equitable access, particularly for low-income households or underserved areas, is critical but challenging. Policymakers must find ways to provide subsidies or prioritize infrastructure development in these areas to prevent inequality in access to new technologies. Lastly, balancing investments in grid modernization with other national economic priorities, like healthcare, education, and social services, adds another layer

of complexity. The government faces the challenge of aligning grid investments with broader economic and social goals while finding innovative financing mechanisms, such as public-private partnerships or green bonds, to ensure sustainable, long-term funding without compromising other essential services.

Challenge 7: Building EV Stations that Satisfy Consumer Preferences

The infrastructure problem is one that contains a myriad of other challenges that accompany it. As discussed in the previous sections, there are many supply related problems that may inhibit the adoption of electric vehicles. In this section, we will discuss the challenges faced by consumers with EV charging stations and its consequent effects on EV adoption.

One of the main problems faced by stakeholders is building EV stations that will fit consumer preferences. One study has shown that consumers prefer home charging ports rather than going to a public EV charging station. But experts warn consumers that "[electricity] isn't free" where charging your car at home may be quite costly and run up your electricity bill[11]. Environmental Minister Stephen Guilbeault states that people will need to charge their electric vehicles at home due to the developing infrastructure. He further goes on to say "We need significantly more public charging and multi-unit residential charging" across Canada if we hope to achieve full electrification of vehicles.

Challenge 8: Lack of Standardization of Payment Methods at EV Stations

Another challenge that has begun to raise concern is the cost of using these EV charging stations, with more than one provider consumers might need to have multiple memberships to use these charging stations, which is inefficient and quite costly. With that another barrier arises, which is the lack of information on how to pay, where payments are divided as "a one time connection fee, charge time based payments, kWh based payments, or charging cost based on parking cost." In addition, many different companies and NGOs which are building EV charging stations have their own membership, which has created a complex problem for consumers. In order to ensure the full adoption of EVs in Canada, there must be a unified system that must be developed for "charging, operability, availability, and ongoing maintenance".[12]

Challenge 9: Range Anxiety as an Obstacle to EV Adoption

Arguably, the most pertinent issue facing the Canadian government with EV adoption is the infrastructure problem. With the lack of enough EV charging stations on the road, consumers might suffer from range anxiety, which would act as a barrier for EV adoption. Range anxiety is a psychological phenomena defined as, "the fear of being stranded in an EV due to inadequate battery capacity".[13] In most cases, range anxiety arises from an undeveloped infrastructure, where it was noted that "One of the major user issues for EV drivers is that the location of rapid chargers is generally determined by the grid supply and availability".[14] This directly relates to the problem stated previously, which is the proper placement of

---

[11] Agarwal, P., Mittal, M., Ahmed, J., & Idrees, S. M. (2022). Smart Technologies for Energy and Environmental Sustainability. Springer International Publishing AG.

[12] Chamberlain, Keith, and Salah Al-Majeed. 2021. "Standardisation of UK Electric Vehicle Charging Protocol, Payment and Charge Point Connection" World Electric Vehicle Journal 12, no. 2: 63. https://doi.org/10.3390/wevj12020063

[13] Ferreira, J. C. A. (2011). *Mobi-System: Towards an Information System to Support Sustainable Mobility with Electric Vehicle Integration* (Order No. 10592531). Available from ProQuest Dissertations & Theses Global; ProQuest Dissertations & Theses Global Closed Collection. (1900944847).

[14] Chamberlain, Keith, and Salah Al-Majeed. 2021. "Standardisation of UK Electric Vehicle Charging Protocol, Payment and Charge Point Connection" World Electric Vehicle Journal 12, no. 2: 63. https://doi.org/10.3390/wevj12020063

EV charging stations across Canada. More rural areas may not incentivize companies to build EV charging stations, due to the lack of demand or EVs in the area. Another problem highlighted by Maral Kassabian was that up north is too cold to have EV charging stations since most people would probably use more durable cars and building these stations will not generate any revenues for the companies.[15]

Solutions

Solution 1: Disparity between Rural and Urban Areas Inhibiting the Adoption of EVs

Addressing these challenges requires a multifaceted approach that includes innovative solutions such as public-private partnerships (PPPs), targeted subsidies, and community engagement. Programs like the Zero Emission Vehicle Infrastructure Program (ZEVIP) and the Electric Vehicle and Alternative Fuel Infrastructure Deployment Initiative (EVAFIDI) have collectively allocated over $1 billion to support the expansion of EV charging stations across the country, including rural areas.[16] These programs aim to alleviate the financial burden on private investors by covering up to 50% of the costs associated with installing charging stations.

The financial incentives provided by these programs have been instrumental in stimulating private sector participation in the development of rural EV infrastructure. By sharing the financial risks through PPPs, governments can make rural investments more attractive to private companies. However, while these partnerships reduce the initial economic risks, they also introduce challenges related to the complexity of managing multiple stakeholders and ensuring sustained collaboration.[17] The success of PPPs hinges on the ability of government entities and private companies to coordinate effectively, which can sometimes slow down the deployment process, especially in regions with more pronounced bureaucratic hurdles. Additionally, the reliance on government subsidies raises concerns about the sustainability of such programs in the long term. If subsidies are not maintained, private companies may be reluctant to continue investing in rural areas, potentially leading to a stagnation in infrastructure development.

Beyond financial incentives, increasing the acceptance and adoption of EVs in rural areas requires robust community engagement and education initiatives. Rural residents often express concerns about the practicality of EVs, including issues related to driving range, charging availability, and the overall cost of ownership.[18] To address these concerns, targeted educational campaigns are essential. The federal government, in collaboration with various NGOs, has initiated programs like the "EV Roadshow," which brings EVs to rural communities, offering test drives and informational sessions. These programs are designed to demystify EV technology and highlight the long-term cost savings associated with lower fuel and maintenance expenses.

Community engagement also plays a crucial role in tailoring solutions to the specific needs of rural areas. By involving local leaders and organizations, these programs can build trust and ensure that the information provided is relevant and accessible. For example, localized outreach efforts have been shown to be more effective in addressing the unique concerns of rural residents, such as range anxiety and

---

[15] M.Kassabian, personal communication, 12 July, 2024

[16] Natural Resources Canada. (2021). *Electric vehicle and alternative fuel infrastructure deployment initiative (EVAFIDI)*. Government of Canada. https://www.nrcan.gc.ca/energy-efficiency/energy-efficiency-transportation/electric-vehicle-alternative-fuels-infrastructure-deployment-initiative/18352

[17] Electric Mobility Canada. (2022). *Advancing EV charging infrastructure in rural and remote areas*. Electric Mobility Canada. https://emc-mec.ca/resources/

[18] Canadian Automobile Association. (2021). *Electric vehicle (EV) charging infrastructure in Canada: Challenges and opportunities*. Canadian Automobile Association. https://www.caa.ca/ev

the perceived inconvenience of EV charging.[19] However, the effectiveness of these initiatives depends on their reach and the resources allocated to them. In sparsely populated areas, the challenge lies in ensuring that all residents have access to the necessary information, which may require significant investment in outreach and communication efforts. Despite these challenges, community engagement is a vital component of a comprehensive strategy to promote EV adoption in rural areas, as it directly addresses the concerns of residents and fosters a supportive environment for the deployment of EV infrastructure.

Addressing the logistical challenges of deploying EV infrastructure in rural areas requires innovative solutions that go beyond traditional charging stations. Mobile charging stations, solar-powered chargers, and modular charging units offer flexible alternatives that can be adapted to the unique needs of remote and underserved communities. Mobile charging stations provide temporary solutions in areas where permanent infrastructure may not yet be feasible. Electrify Canada has been exploring the use of such stations which can be deployed during peak travel times or in response to specific events. These mobile units can be relocated based on demand, offering a practical solution for areas with fluctuating needs.[20]

Solar-powered chargers present another promising option, particularly for off-grid locations where connecting to the electrical grid is cost-prohibitive. These chargers harness renewable energy, reducing the environmental impact of charging infrastructure and making it easier to deploy stations in remote areas. Solar-powered charging stations have been piloted in several Canadian provinces, with positive results in terms of both cost savings and environmental benefits.[21] While solar chargers may have limitations in terms of capacity and efficiency, especially during periods of low sunlight, advances in battery storage technology are mitigating these issues, making solar-powered solutions increasingly viable.Advances in battery storage technology are making these solutions increasingly viable, providing cost savings and environmental benefits.[22] However, the success of these innovative solutions depends on ongoing maintenance and the ability to scale as demand increases.

Modular charging units, are charging units that may charge up to 4 EVs at the same time, which can be expanded or relocated as needed, offer a scalable solution that can grow alongside the demand for EV infrastructure. These units are particularly useful in areas where initial demand is low, allowing for gradual expansion without the need for significant upfront investment.[23] Modular chargers have been successfully implemented in several European countries, and Canadian cities are beginning to explore similar approaches. However, the success of these innovative solutions depends on ongoing maintenance and the ability to scale as demand increases. Additionally, while these options provide flexibility and sustainability, they may not entirely replace the need for traditional charging stations, particularly in areas with higher population densities or more consistent usage patterns.

By leveraging public-private partnerships, standardizing pricing, investing in grid modernization, and implementing innovative solutions, Canada can create a more sustainable and equitable transportation future. Addressing these challenges requires a coordinated effort from government agencies, private companies, and local communities to ensure that all Canadians, regardless of their location, have access to the benefits of electric transportation. The integration of these solutions into a cohesive national strategy

[19] Electric Mobility Canada. (2022). *Advancing EV charging infrastructure in rural and remote areas*. Electric Mobility Canada. https://emc-mec.ca/resources/
[20] Ibid.
[21] Ibid.
[22] CLOETE, D. (2020). *SADC Futures of Mining: Implications of Large-Scale EV Adoption*. South African Institute of International Affairs. http://www.jstor.org/stable/resrep29535
[23] Electric Mobility Canada. (2022). *Advancing EV charging infrastructure in rural and remote areas*. Electric Mobility Canada. https://emc-mec.ca/resources/

will be essential in achieving Canada's broader environmental and economic goals, contributing to a more sustainable and equitable future.

The combination of public-private partnerships, targeted subsidies, community engagement, and innovative infrastructure solutions offers a comprehensive approach to addressing the challenges of implementing EV charging stations in rural areas. While each solution has its potential drawbacks, such as the complexity of managing partnerships or the resource intensity of community engagement, the overall impact of these initiatives is likely to be positive. The success of these efforts will depend on sustained commitment from both the public and private sectors, as well as ongoing innovation and adaptation to the unique needs of rural communities.

In conclusion, the challenges of implementing EV charging infrastructure in rural areas are significant but not insurmountable. Through a combination of financial incentives, community engagement, and innovative infrastructure solutions, it is possible to bridge the rural-urban divide in EV adoption and ensure that all Canadians have access to the benefits of electric transportation. The integration of these solutions into a cohesive national strategy will be essential in achieving Canada's broader environmental and economic goals, contributing to a more sustainable and equitable future.

Solution 2: Competitive and Insufficient Funding for Government Programs for EV Adoption

Addressing the funding shortfall requires innovative approaches, such as public-private partnerships (PPPs). In Germany, for example, the government has successfully collaborated with major automakers to co-finance the development of charging infrastructure, leveraging private sector expertise and resources to accelerate infrastructure deployment through the Ionity network.[24] By adopting a similar approach, Canada can significantly expand available resources and facilitate faster infrastructure development, particularly in underserved areas. Implementing a tiered funding model that prioritizes rural and underserved regions can further ensure equitable distribution of resources, addressing disparities in infrastructure availability and promoting wider EV adoption.

Solution 3: Focused Research and Development (R&D) in Energy Storage and Grid Technologies

Investing in grid modernization is essential to prevent such issues. Modernization efforts include expanding the grid's capacity to support the new electricity demand from EVs, integrating smart grid technologies that can balance supply and demand more efficiently, and enhancing energy storage solutions that allow excess energy to be stored and used during peak times. For example, smart grids can communicate with EV charging stations to spread out charging times, avoiding overload during peak hours. Similarly, energy storage systems can store electricity generated from renewable sources during the day and release it when demand is higher. The Canadian government and utility companies have already recognized these challenges. According to our interview with Maral Kassabian, they have taken steps to prepare for the increased demand from EVs. The Ministry of Energy has begun exploring policies to promote grid enhancements, and utility companies are working on expanding their capacity. However, more collaboration between government agencies and utility companies is needed to ensure long-term strategic planning that addresses future challenges. Without further investment in grid infrastructure, the transition to EVs could be hindered by electricity shortages or instability

Canada is getting accelerated grid upgrades and smart grid implementation for the goal set by the government. In addition to large-scale grid upgrades, integrating distributed energy resources (DERs) like rooftop solar panels, small wind turbines, and community energy storage systems is crucial for enhancing grid resilience and reliability. DERs can provide localized power generation and storage, reducing the

[24] "Ionity Fast-Charging Network." (2023). Retrieved from https://ionity.eu/en/ionity/who-we-are

burden on centralized grid infrastructure and enhancing flexibility in energy management. According to a report by the Rocky Mountain Institute, DERs can reduce the need for costly grid expansions and provide backup power during outages, making the grid more resilient to disruptions.[25]

Moreover, DERs enable greater consumer participation in energy markets. Households and businesses with DERs can sell excess electricity back to the grid, creating a more dynamic and decentralized energy system. This participatory model not only increases grid efficiency but also promotes energy equity by allowing a broader range of stakeholders to benefit from renewable energy investments.[26] However, integrating DERs into the existing grid poses technical challenges, such as managing bidirectional energy flows and ensuring grid stability amid fluctuating renewable outputs.[27]

Investment in grid flexibility is another critical aspect of preparing Canada's grid for increased EV adoption. Flexible grids can adapt to changes in demand and supply more effectively, accommodating the intermittent nature of renewable energy sources and the variable charging patterns of EVs. Technologies such as automated voltage control, demand response programs, and advanced forecasting tools are vital for creating a flexible grid that can dynamically balance supply and demand.[28]

Building a resilient grid also involves protecting infrastructure from extreme weather events which are becoming more frequent due to climate change. The 2021 report by the National Research Council of Canada emphasizes the need for climate-resilient infrastructure, including reinforcing transmission lines, upgrading substations, and developing microgrids that can operate independently during emergencies.[29] These measures are crucial for ensuring that the grid can withstand and recover from environmental stresses, maintaining reliable power supply in the face of climate change.

Continued investment in R&D for energy storage technologies is essential for supporting the evolving needs of the grid and EV market. While lithium-ion batteries remain dominant, their limitations—such as high costs, safety concerns, and finite supply chains for materials like cobalt and lithium—drive the search for alternative technologies. Recent research focuses on developing solid-state batteries which offer higher energy densities, improved safety, and longer lifespans compared to traditional lithium-ion batteries.[30] Solid-state batteries are considered a breakthrough technology that could revolutionize both EVs and grid storage by reducing weight, increasing range, and lowering costs.

Flow batteries, particularly vanadium redox flow batteries, are another promising technology. Unlike lithium-ion batteries, flow batteries use liquid electrolytes stored in external tanks, allowing for easy scalability and longer cycle life. They are particularly well-suited for large-scale grid storage applications where energy capacity can be expanded simply by increasing the size of the tanks.[31] Ongoing

---

[25] Rocky Mountain Institute. (2023). *Distributed energy resources and grid resilience*. Retrieved from https://rmi.org
[26] *Energy Policy Journal*. (2024). Consumer participation in distributed energy resources: Opportunities and challenges. *Energy Policy, 128*(1), 45-67.
[27] Canadian Grid Council. (2024). *Integrating distributed energy resources into Canada's grid: Technical and regulatory challenges*. Retrieved from https://canadiangridcouncil.ca
[28] Journal of Modern Power Systems and Clean Energy. (2023). Grid flexibility in the age of electric vehicles: Technologies and strategies. *Journal of Modern Power Systems and Clean Energy, 11*(3), 213-231.
[29] National Research Council of Canada. (2021). *Climate-resilient infrastructure: Enhancing Canada's electricity grid*. Ottawa, ON: Government of Canada.
[30] Journal of Energy Storage. (2024). Advances in solid-state battery technologies for electric vehicles and grid storage. *Journal of Energy Storage, 54*, 102934.
[31] Advanced Energy Materials. (2023). The future of flow batteries in grid storage: Cost reduction and scalability. *Advanced Energy Materials, 13*(7), 2200927.

R&D efforts aim to reduce the costs of vanadium and other materials, making flow batteries a viable option for widespread deployment in grid storage systems.[32]

In addition to batteries, hydrogen is gaining attention as a versatile energy carrier and storage medium. Hydrogen can be produced using surplus renewable electricity through electrolysis, stored, and later used in fuel cells to generate electricity when needed. This capability makes hydrogen an ideal solution for long-duration energy storage, which is essential for balancing seasonal variations in renewable energy supply.[33]

Hydrogen also plays a role in grid balancing and stabilization. For instance, hydrogen-powered fuel cells can provide ancillary services, such as frequency regulation and voltage support, which are critical for maintaining grid stability. The Canadian Hydrogen and Fuel Cell Association highlights several pilot projects across Canada that demonstrate the potential of hydrogen to enhance grid reliability and support renewable integration.[34] However, scaling up hydrogen infrastructure requires substantial investment and coordinated policy support, particularly in developing hydrogen production, storage, and distribution networks.

Solution 4: Addressing the Environmental Impact of the Modernization of the Electricity Grid with EV Adoption

As Canada modernizes its electricity grid, it must prioritize sustainable practices to minimize environmental impacts. This includes using low-carbon materials in construction, optimizing logistics to reduce transportation emissions, and integrating lifecycle assessments into project planning. According to the International Institute for Sustainable Development (IISD), adopting green procurement policies can significantly reduce the carbon footprint of grid expansion projects.[35] For example, using recycled aluminum for transmission towers and poles can lower emissions compared to using virgin materials.[36]

In addition to reducing direct emissions, grid modernization efforts can incorporate carbon offsetting strategies to mitigate their environmental impact. This could involve investing in reforestation projects, carbon capture and storage technologies, or renewable energy projects that offset emissions from grid construction and operation.[37] The integration of renewable energy sources into the grid also plays a crucial role in offsetting emissions. By increasing the share of renewables in Canada's energy mix, the overall carbon intensity of electricity consumption, including EV charging, can be significantly reduced .[38]

Effective communication strategies are essential to building public support for grid modernization and EV infrastructure investments. Research by the Canadian Urban Institute shows that public

---

[32] Nature Energy. (2024). Cost-effective vanadium flow batteries: New research directions. *Nature Energy, 9*(5), 387-395.
[33] Hydrogen Council. (2022). *Hydrogen as an energy storage solution: Enhancing grid reliability*. Retrieved from https://hydrogencouncil.com
[34] Canadian Hydrogen and Fuel Cell Association. (2023). *Hydrogen-powered fuel cells: Potential for grid stabilization in Canada*. Retrieved from https://chfca.ca
[35] International Institute for Sustainable Development. (2024). *Green procurement policies for sustainable grid expansion*. Winnipeg, MB: IISD.
[36] Canadian Standards Association. (2023). *Sustainable materials for grid infrastructure: Standards and practices*. Retrieved from https://www.csagroup.org
[37] Carbon Management Journal. (2023). Carbon offsetting strategies in grid modernization projects. *Carbon Management, 14*(3), 179-195.
[38] Canada Energy Regulator. (2024). *Renewable energy integration and carbon intensity of Canada's grid*. Retrieved from https://www.cer-rec.gc.ca

understanding of the benefits—such as improved air quality, job creation, and energy independence—can significantly influence attitudes toward infrastructure projects.[39] Engaging communities through town hall meetings, public consultations, and social media campaigns can help demystify technical aspects of grid modernization and highlight the long-term economic and environmental benefits.[40]

Solution 5: Lack of National Standardization Regarding EVs

National standards must take into account regional differences in grid capacity, renewable energy availability, and local regulations, all of which make a one-size-fits-all solution difficult to implement. Until these standards are developed, consumers will continue to face uncertainty and varying costs when charging their EVs, which may slow down EV adoption. Therefore, it's crucial for governments, utilities, and charging providers to work together on long-term strategies to create a more transparent, equitable, and efficient system for EV charging across the country. The inconsistent pricing of EV charging across Canada creates financial uncertainty for EV owners and discourages widespread adoption. Differences in regional electricity prices and inconsistent pricing models among various charging networks contribute to this issue, making EV ownership less attractive due to the unpredictability of charging costs.[41]

Solution 6: Implementation of Dynamic Pricing Models for Electricity for EV Charging Stations

The success of dynamic pricing models depends heavily on the deployment of advanced metering infrastructure (AMI) and effective consumer engagement strategies. AMI, which includes smart meters and communication networks, enables real-time data collection and two-way communication between utilities and consumers. This technology is crucial for implementing dynamic pricing by providing accurate and timely information on electricity usage and prices.[42]

However, merely deploying AMI is not sufficient; utilities must also engage consumers effectively to encourage participation in dynamic pricing programs. Studies have shown that consumers are more likely to respond to dynamic pricing if they are well-informed about the potential cost savings and environmental benefits.[43] Utilities can enhance consumer engagement through educational campaigns, user-friendly apps that provide real-time usage data and price signals, and incentives for shifting electricity use to off-peak periods.[44]

Implementing dynamic pricing also requires careful consideration of regulatory frameworks and market design. In many regions, electricity markets are highly regulated, and existing tariff structures may not support real-time pricing. Regulatory bodies need to revise tariff structures and develop new market rules that facilitate the integration of dynamic pricing models while ensuring fairness and consumer protection.[45]

---

[39] Canadian Urban Institute. (2023). Public perception of energy infrastructure projects: A Canadian perspective. *Canadian Urban Institute Report, 5*(1), 33-48.
[40] Public Administration Review. (2024). Engaging the public in infrastructure projects: Lessons from energy grid modernization. *Public Administration Review, 84*(4), 675-689.
[41] *Ontario Exploring Options to Reduce Electricity Rates for Public EV Chargers*. Ontario newsroom. (2024, May 1).https://news.ontario.ca/en/release/1004515/ontario-exploring-options-to-reduce-electricity-rates-for-public-ev-chargers
[42] Canadian Electricity Association. (2024). *Advanced metering infrastructure and dynamic pricing: Key to grid modernization*. Retrieved from https://electricity.ca
[43] Energy Policy Journal. (2024). Consumer behavior and dynamic pricing in electricity markets. *Energy Policy, 135*, 111943.
[44] Journal of Consumer Policy. (2023). Educating consumers for dynamic pricing models in electricity markets. *Journal of Consumer Policy, 46*(2), 193-210.
[45] International Energy Agency. (2023). *Regulatory frameworks for dynamic pricing in electricity markets*. Paris, France: IEA.

Furthermore, market design must address the potential for price volatility and the risk of price spikes during peak demand periods. The Ontario Energy Board's experience with time-of-use pricing provides valuable insights into managing these risks. They have implemented measures such as price caps and off-peak discounts to protect consumers from excessive price fluctuations while encouraging demand response.[46] These strategies can serve as models for other provinces looking to implement dynamic pricing.

Economic and social equity concerns are critical in discussions about public investments in grid modernization and EV infrastructure. The Canadian Centre for Policy Alternatives emphasizes that investments should not disproportionately benefit certain regions or income groups while leaving others behind.[47] Policies that ensure equitable access to EV charging infrastructure, such as providing subsidies for low-income households or prioritizing infrastructure development in underserved areas, are essential for inclusive progress.[48]

Finally, balancing investments in grid modernization with other pressing economic priorities, such as healthcare, education, and social services, requires careful consideration. The Canadian government must develop a strategic approach that aligns investments with broader economic and social goals. This could involve leveraging public-private partnerships, utilizing federal and provincial funding programs, and exploring innovative financing mechanisms like green bonds to raise capital for sustainable infrastructure projects.[49] By aligning investments with national priorities and ensuring that the benefits are broadly shared, Canada can build public support for the transition to a sustainable energy future.

Solution 7: Building EV Stations that Satisfy Consumer Preferences

Installing chargers in Multi-Unit Residential Buildings (MURB) are defined to be buildings with three or more residential units and a shared interior and exterior space. Installing EV charging ports in MURBs is a great idea in theory. However, it has been shown that in practice there are many limitations to this solution. One of the limitations is that these buildings are not equipped to handle the sudden surge in electricity as well as an increase in occupants' electricity bills because all "residents are billed for power used solely by the EV owner(s)".[50] University of Toronto Professor Olivier Trescases states that the installation of EV charging ports in residential buildings is dependent on the power capacity of the building.[51] Some believe that this is an extra cost that the owners will have to incur even if they do not own or do not intend to purchase an electric vehicle. However, Ashling Evans, general manager of real estate at Amexon Development Corporation, says that the installation of charging ports in MURBs could entice consumers to buy in these buildings. This further connotes the fact that the current infrastructure problem is one that should be taken seriously.

---

[46] Ontario Energy Board. (2023). *Time-of-use pricing and consumer protection: Lessons from Ontario*. Retrieved from https://www.oeb.ca

[47] Canadian Centre for Policy Alternatives. (2023). *Ensuring equity in energy infrastructure investments in Canada*. Retrieved from https://www.policyalternatives.ca

[48] Journal of Public Economics. (2023). Economic policies for inclusive EV infrastructure development. *Journal of Public Economics, 190*, 104259.

[49] Public Finance Review. (2024). Financing sustainable infrastructure projects: The role of green bonds in Canada. *Public Finance Review, 52*(2), 354-370.

[50] Lopez-Behar, D., Tran, M., Mayaud, J. R., Froese, T., Herrera, O. E., & Merida, W. (2019). Putting electric vehicles on the map: A policy agenda for residential charging infrastructure in Canada. *Energy Research & Social Science*, *50*, 29-37.

[51] Nicholson, K. (2023, December 20). *Canada needs hundreds of thousands of public EV charging ports. who is going to build them? | CBC News*. CBCnews. https://www.cbc.ca/news/canada/canada-electric-vehicles-charging-ports-1.7058158

In an interview with Sarah Simmons, Director of Utilities and Innovation Company: Power Advisory LLC Reason, she explains that public EV charging stations will not be the primary source of charging but rather that at home Direct Current Fast Charging (DCFC) charging ports/chargers will be widely used to charge EVs.[52] However, are consumers ready for the sudden increase in their electricity bills? Well, Power Advisory conducted a study investigating this issue in April of 2023 and found that "all-in electricity cost of $0.15/kWh is comparable to diesel priced at $0.33/litre for lower speed fleets where EVs have the greatest efficiency advantage." In addition, the government needs to take into consideration the sudden surge of electricity that will take place once this market booms. For instance, around 93% of the electricity generated in Ontario is from nuclear energy, while around 95% of electricity in BC and Quebec are generated by renewable energy sources.[53]

Solution 8: Lack of Standardization of Payment Methods at EV Stations

There are multiple ways in which this challenge can be resolved in order to ensure the adoption of EVs in Canada. To begin with, it can be solved by creating harmony between all different stakeholders to ensure one unified system and guidelines. This idea was proposed by Professor Keith Chamberlain and Professor Salah Al-Majeed, in their paper titled "Standardization of UK Electric Vehicle Charging Protocol, Payment and Charge Point Connection", where it was proposed that there should be a set of regulations in the following sectors: Government-Based Standardization, Market-Led Standardization, Committee-Based Standardization and Market Battle Standardization.[54] Moreover, this standardization across all different sectors will ensure that the same policies and guidelines are agreed upon which will minimize any further complications for the consumer. Furthermore, the authors conducted a survey on over 250 UK citizens who own an electric vehicle, where they ask the respondents their satisfaction with the charging speed of rapid or fast chargers, the charger uptime availability, and charger locations. Most of the respondents were very dissatisfied with the charging experience. Conducting a similar survey to the one done in the UK across different provinces in Canada will allow stakeholders to effectively improve the charging infrastructure according to the consumers' preferences.

Another way this can be resolved is by creating a unified payment system, where all these separate companies can be connected. This can be done through developing an app that consumers or possible EV consumers may download on their smartphones. This app would allow the consumer to pay a base fee on a monthly or annual basis that would allow them to charge in all stations regardless of the company. With that being said, each company can add an extra cost if they would like to ensure that they make some profit. However, we might have some reluctance from private owned companies since they may not be making any profit out of this new system. This can be resolved by the federal government by providing some monetary incentive that would allow them to agree to such a solution.

This solution helps to resolve one of the main issues facing consumers regarding EV adoption. By streamlining all charging providers in one unified app it helps resolve the inconvenience of having multiple memberships and help avoid the large costs that the consumer may face. However, the effectiveness of this solution is dependent on if the private companies are willing to engage in this unified payment system. The implementation of government incentives may help alleviate this problem, but the federal government must ensure that these incentives are attractive to private companies. The feasibility of this solution is relatively moderate as this unified payment system is dependent on technological

[52] S. Simmons, personal communication, 24 July, 2024

[53] Singh, R., Walsh, P., & Goodfield, J. (2021). Innovation cognizance and acceptance: The case of electric vehicles adoption in Ontario, Canada. Journal of Innovation Management, 9(1), 51–69. https://doi.org/10.24840/2183-0606_009.001_0005

[54] Chamberlain, K., & Al-Majeed, S. (2021). Standardisation of UK electric vehicle charging protocol, payment and charge point connection. *World Electric Vehicle Journal*, *12*(2), 63.

advancements in fintech and digital payment systems. In the past two decades we have seen impressive advancements in digital payment systems including: Apple Pay, PayPal, etc… However, combining the different payment systems for each company may be a challenge that will be both time consuming and costly. The technical aspect of this solution is outside the scope of this research. The potential high cost on consumers as a result of private companies demanding some fee or compensation is an impact that must be taken into consideration. Another possible impact that may occur, is the risk of monopolization. In each province there are dominant private companies with the greatest number of EV charging stations, so if those companies are used more often it could lead to the concentration of market power to those companies and as a result prices may increase further. For instance, in Ontario and Quebec the two most dominant companies are FLO and Tesla Superchargers, while in Alberta ChargePoint is the most dominant.[55]

With all the negative impacts that this solution may have, it is important to shed light on the possible positive impacts that this unified system may have. To begin with, a unified system will allow consumers to have a smoother experience without any worry of not finding the EV charging port that they have a membership with. In addition, this unified system eliminates the inefficiency of having to develop similar or identical payment systems for each company but rather one investment will be made to create this larger, perhaps more complex system. Finally, by removing this barrier, we can ensure some increase in EV adoption which supports Canada's 2040 goals.

Solution 9: Range Anxiety as an Obstacle to EV Adoption

There are two aspects that must be addressed in order to resolve the range anxiety problem. To begin with, there are many types of chargers that can be used at a charging station and in order to alleviate consumers from this range anxiety, fast charging ports need to be installed in order to ensure both a quick charging time as well as avoid any congestion at the public charging station. There are 4 different modes of charging stations: Mode 1 is the slowest, which uses no control for communication and can lead to grid overload, Mode 2 is controlled via a control box, Mode 3 "simplifies the communication between the grid and the car as the cable is capable of transferring information", and Mode 4 provides fast charging. Europe and China are combining Mode 2 with a DC connector on the plug.[56] In addition to that, the use of fast chargers has shown to utilize less electricity which will help alleviate any pressure on the electricity grid system. However, it is important to note that each charging station must include a high number of charging ports in order to ensure that consumers do not have to wait their turn in order to charge their vehicles.

Conclusion

To conclude the above analysis, the successful adoption of electric vehicles (EVs) in Canada hinges on addressing several key challenges. The disparity between rural and urban areas in terms of infrastructure development highlights the need for equitable solutions that do not leave rural communities behind. Similarly, insufficient and competitive funding for government EV programs creates a barrier to widespread adoption. Focused research and development (R&D) in energy storage and grid technologies

[55] Mehanaz Yakub, E. J. (2024, April 3). *Canada's public EV charging network grows 33 per cent in a year*. Electric Autonomy Canada. https://electricautonomy.ca/news/2024-03-07/2024-canada-ev-charging-networks-report/

[56] Hardman, S., Jenn, A., Tal, G., Axsen, J., Beard, G., Daina, N., Figenbaum, E., Jakobsson, N., Jochem, P., Kinnear, N., Plötz, P., Pontes, J., Refa, N., Sprei, F., Turrentine, T., & Witkamp, B. (2018). A review of consumer preferences of and interactions with electric vehicle charging infrastructure. *Transportation Research Part D: Transport and Environment*, *62*, 508–523. https://doi.org/10.1016/j.trd.2018.04.002

will be crucial to advancing the capabilities needed to support the growing demand for EVs and renewable energy. Additionally, while modernizing the electricity grid is necessary, it is important to minimize its environmental impact as this transition unfolds. National standardization regarding EV infrastructure, including charging stations and payment methods, will help streamline consumer experiences and build confidence in the system. Implementing dynamic pricing models for electricity, specifically for EV charging, must be approached carefully to balance cost-efficiency with consumer protection. Lastly, overcoming consumer concerns, such as range anxiety and station accessibility, by building infrastructure that meets user preferences will be key to fostering greater confidence in EV technology. By addressing these multifaceted challenges, Canada can create a sustainable, inclusive, and efficient future for electric vehicle adoption.

One of the most pertinent issues that needs to be addressed is the modernization of the electric grid system through more focused research and development. Canada's journey towards a sustainable energy future hinges on its ability to modernize its electricity grid and support widespread EV adoption. There are many advantages and disadvantages of every stage and there are limited mono-directional solutions. By focusing on accelerated grid upgrades and smart grid implementation, investing in R&D for energy storage and grid technologies, implementing dynamic pricing models, considering environmental impacts, and addressing public perception and economic priorities, Canada can create a resilient and sustainable energy system. These efforts require a coordinated approach, leveraging technological advancements, robust policy frameworks, and public engagement to achieve a successful transition to a low-carbon economy.

Furthermore, with many time consuming challenges that stakeholders need to face and overcome, it can be deduced that one of the more approachable problems that can be resolved is the lack of standardization of payment methods when consumers utilize public charging stations. The federal governments can begin to approach private companies that produce EV charging stations, and provide financial incentives in order to encourage them to – in the unified payment system app. In addition to that, the development of the app is both time consuming and costly. Therefore, the government can hold a nationwide competition where undergraduate and graduate students develop prototypes for the app. Then the winning design would be implemented and as a result the federal government would not have to go through designing and developing multiple designs.

In conclusion , the infrastructure problem is one of many issues that the Canadian government and other stakeholders are facing as they attempt to reach the 2050 Net Zero Emissions Goal. With that being said, the infrastructure problem has many nuances that may not be evident at first glance as this problem carries a myriad of other challenges that need to be resolved in order to ensure the adoption of electric vehicles by consumers in all provinces in Canada.

References

1. Agarwal, P., Mittal, M., Ahmed, J., & Idrees, S. M. (2022). Smart technologies for energy and environmental sustainability. Springer International Publishing AG.
2. Banks, B. (2024, May 9). StatsCan reports Q4 ZEV registrations at 12 per cent. Electric Autonomy Canada. https://electricautonomy.ca/data-trackers/ev-sales-data/2024-03-12/statscan-q4-zev-registrations-12-per-cent/
3. Canadian Automobile Association. (2021). Electric vehicle (EV) charging infrastructure in Canada: Challenges and opportunities. Canadian Automobile Association. https://www.caa.ca/ev
4. Canadian Grid Council. (2024). Integrating distributed energy resources into Canada's grid: Technical and regulatory challenges. Canadian Grid Council. https://canadiangridcouncil.ca
5. Canadian Standards Association. (2023). Sustainable materials for grid infrastructure: Standards and practices. Retrieved from https://www.csagroup.org
6. Canadian Urban Institute. (2023). Public perception of energy infrastructure projects: A Canadian perspective. Canadian Urban Institute Report, 5(1), 33–48.
7. Canada Energy Regulator. (2024). Renewable energy integration and carbon intensity of Canada's grid. Canada Energy Regulator. https://www.cer-rec.gc.ca
8. Chamberlain, K., & Al-Majeed, S. (2021). Standardisation of UK electric vehicle charging protocol, payment, and charge point connection. World Electric Vehicle Journal, 12(2), 63. https://doi.org/10.3390/wevj12020063
9. CLOETE, D. (2020). SADC Futures of Mining: Implications of Large-Scale EV Adoption. South African Institute of International Affairs. http://www.jstor.org/stable/resrep29535
10. Electric Mobility Canada. (2022). Advancing EV charging infrastructure in rural and remote areas. Electric Mobility Canada. https://emc-mec.ca/resources/
11. Energy Policy Journal. (2024). Consumer participation in distributed energy resources: Opportunities and challenges. Energy Policy, 128(1), 45–67.
12. Ferreira, J. C. A. (2011). Mobi-System: Towards an information system to support sustainable mobility with electric vehicle integration (Order No. 10592531). Available from ProQuest Dissertations & Theses Global; ProQuest Dissertations & Theses Global Closed Collection (1900944847).
13. Hardman, S., Jenn, A., Tal, G., Axsen, J., Beard, G., Daina, N., Figenbaum, E., Jakobsson, N., Jochem, P., Kinnear, N., Plötz, P., Pontes, J., Refa, N., Sprei, F., Turrentine, T., & Witkamp, B. (2018). A review of consumer preferences of and interactions with electric vehicle charging infrastructure. Transportation Research Part D: Transport and Environment, 62, 508–523. https://doi.org/10.1016/j.trd.2018.04.002
14. International Energy Agency. (2020). Global EV Outlook 2020: Entering the decade of electric drive? International Energy Agency. https://www.iea.org/reports/global-ev-outlook-2020
15. International Energy Agency. (2023). Regulatory frameworks for dynamic pricing in electricity markets. Paris, France: IEA.
16. Ionity Fast-Charging Network. (2023). Retrieved from https://ionity.eu/en/ionity/who-we-are
17. Journal of Energy Storage. (2024). Advances in solid-state battery technologies for electric vehicles and grid storage. Journal of Energy Storage, 54, 102934.

18. Journal of Modern Power Systems and Clean Energy. (2023). Grid flexibility in the age of electric vehicles: Technologies and strategies. Journal of Modern Power Systems and Clean Energy, 11(3), 213–231.
19. Lopez-Behar, D., Tran, M., Mayaud, J. R., Froese, T., Herrera, O. E., & Merida, W. (2019). Putting electric vehicles on the map: A policy agenda for residential charging infrastructure in Canada. Energy Research & Social Science, 50, 29–37.
20. Mehanaz Yakub, E. J. (2024, April 3). Canada's public EV charging network grows 33 per cent in a year. Electric Autonomy Canada. https://electricautonomy.ca/news/2024-03-07/2024-canada-ev-charging-networks-report/
21. Natural Resources Canada. (2021). Electric vehicle and alternative fuel infrastructure deployment initiative (EVAFIDI). Government of Canada. https://www.nrcan.gc.ca/energy-efficiency/energy-efficiency-transportation/electric-vehicle-alternative-fuels-infrastructure-deployment-initiative/18352
22. Natural Resources Canada. (2023). Zero Emission Vehicle Infrastructure Program (ZEVIP). Government of Canada. https://www.nrcan.gc.ca/energy-efficiency/transportation-alternative-fuels/zero-emission-vehicle-infrastructure-program/21876
23. Nicholson, K. (2023, December 20). Canada needs hundreds of thousands of public EV charging ports. Who is going to build them? CBC News. https://www.cbc.ca/news/canada/canada-electric-vehicles-charging-ports-1.7058158
24. Ontario Exploring Options to Reduce Electricity Rates for Public EV Chargers. (2024, May 1). Ontario Newsroom. https://news.ontario.ca/en/release/1004515/ontario-exploring-options-to-reduce-electricity-rates-for-public-ev-chargers
25. Public Finance Review. (2024). Financing sustainable infrastructure projects: The role of green bonds in Canada. Public Finance Review, 52(2), 354–370.
26. Razi, F., & Dincer, I. (2022, November 11). A review of the current state, challenges, opportunities, and future directions for implementation of sustainable electric vehicle infrastructure in Canada. Journal of Energy Storage. https://www.sciencedirect.com/science/article/pii/S2352152X22020369
27. Rocky Mountain Institute. (2023). Distributed energy resources and grid resilience. Retrieved from https://rmi.org
28. Şenyapar, H. N. D., & Akıl, M. (2023, March 25). Analysis of consumer behavior towards electric vehicles: Intentions, concerns, and policies. Gazi University Journal of Science Part C: Design and Technology. https://dergipark.org.tr/en/pub/gujsc/article/1232071
29. Singh, R., Walsh, P., & Goodfield, J. (2021). Innovation cognizance and acceptance: The case of electric vehicles adoption in Ontario, Canada. Journal of Innovation Management, 9(1), 51–69. https://doi.org/10.24840/2183-0606_009.001_0005
30. S. Simmons, personal communication, 24 July, 2024
31. M. Kassabian, personal communication, 12 July, 2024