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1. Introduction

In 2019, emissions from transportation represented 34% of Saskatoon's community greenhouse gas (GHG) emissions; a 6.9% increase from 2014. The Low Emissions Community (LEC) Plan actions include electrification of private vehicles with a milestone target that 30% of all new vehicle sales are electric by 2030, and 90% by 2050, for a total projected savings in emissions of 2,756,000 tonnes CO_2e. Further, the Government of Canada has set a mandatory target for all new light-duty cars and passenger trucks sales to be zero-emission by 2035, accelerating Canada's previous goal of 100 percent sales by 2040.[1]

In the 2020/2021 Multi-year budget, a community electric vehicle charging infrastructure pilot received $100,000 funding to begin piloting charging stations and start addressing barriers to adoption such as inadequate infrastructure. In conjunction with that project, a high-level scan of readily available research and best practises was completed to understand trends in electric vehicle adoption and availability of charging infrastructure, explore barriers to EV adoption, and understand how other Canadian municipalities are facilitating the adoption of EV's.

The research is not comprehensive, but instead provides an overview that can help inform why Saskatoon is investing in public charging stations, whether the electricity at these stations should be subsidized, and what other areas of EV adoption the City can explore in the future.

2. Current Rate of Electric Vehicle Adoption

Near the end of 2018, electric vehicle (EV) market share in Canada was around 2.2% which increased from 0.9% market share in 2017.[2] However, the national sale of electric vehicles has been growing rapidly in the last five years, with sales increasing 75% from 2016 to 2017 and increasing an additional 79% from 2017 to 2018.[3] The graph below shows the stable increase of Canadian EV sales since 2013.

[1] https://www.canada.ca/en/transport-canada/news/2021/06/building-a-green-economy-government-of-canada-to-require-100-of-car-and-passenger-truck-sales-be-zero-emission-by-2035-in-canada.html
[2] City of Toronto Electric Mobility Strategy Assessment Phase, Pollution Probe & The Delphi Group, 2018
[3] Electric Vehicle Outlook 2019, FleetCarma, 2019

Figure 1. Annual Plug-in Hybrid EV and EV Sales in Canada. FleetCarma.

EV sales were the highest in the following provinces at the end of 2018:

- Ontario 45% of national EV sales;
- Quebec 34% of national EV sales; and
- British Columbia 18% of national EV sales.

The widespread adoption of EVs in these provinces is largely due to comprehensive municipal and provincial EV strategies and incentives for the purchase of EVs.[4] EV sales in the rest of Canada were only 3% overall.

In Saskatoon, EV adoption has grown substantially. For example, in 2016 there were 41 plug-in and hybrid EV's registered in Saskatoon growing to 477 in 2021, an average of 65% increase per year (shown in Figure 2). The adoption of electric vehicles in Canada is expected to continue; a recent survey by KPMG[5] found that 71% of Canadians would consider purchasing an EV the next time they buy a vehicle and 49% are more likely to buy an EV today compared to a year ago, or even pre-pandemic.

[4] City of Toronto Electric Mobility Strategy Assessment Phase, Pollution Probe & The Delphi Group, 2018
[5] https://home.kpmg/ca/en/home/insights/2022/01/kpmg-2022-auto-poll.html

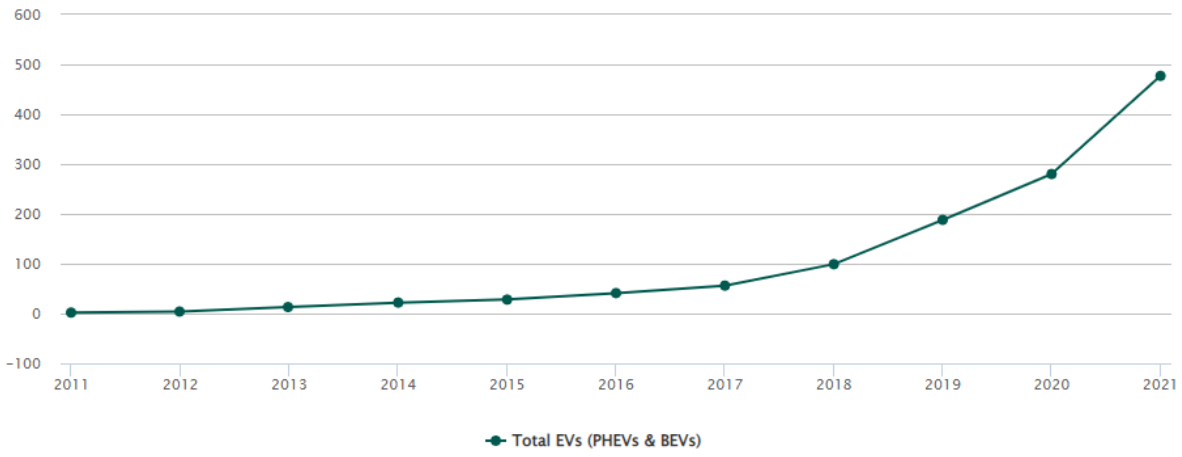

Figure 2. Electric Vehicles (EVs) registered in Saskatoon. Source: Saskatoon Government Insurance.

3. Charging Infrastructure

EV charging is typically supplied through Electric Vehicle Supply Equipment (EVSE) commonly referred as an EV charger. There are three different levels of charging infrastructure currently available in the market: Level 1, Level 2, and Level 3.

Level 1 charging connects directly to any household plug. Level 1 charging can provide a 15 to 24 km range per hour of charge, meaning completely charging a vehicle will take more than 8 hours. However, this type of charging may be suitable for many users that can plug-in their vehicle every night and not fully deplete it during the day. Especially if they can top up at Level 2 chargers during the day.

Plugshare is a web- and mobile- app that provides crowd-sourced data on the availability of charging infrastructure (including who might be using a charger). As of February 2022, Plugshare showed 14 locations with Level 1 charging stations with a total of 75 charging ports in Saskatoon. Eight locations are available for public use, while the others are reserved for guests or employees at the business (for example, hotels) or are currently restricted. Of those 8 locations, 7 are free for use (regular parking rates apply) and 1, an electrified campsite, charges $46/day. There are also numerous outdoor outlets that may be used for charging that are not tracked through Plugshare. Table 1 summarizes these findings.

Table 1: Level 1 Charging Stations in Saskatoon

Row Labels	Count of Location	Sum of ports
Free	12	59
Public	7	30
Limited	5	29
Pay-per-use	2	16

Public	1	15
Limited	1	1
Grand Total	**14**	**75**

Level 2 charging is the most common charging method for public charging and can also be installed at home. It reduces the charging time by more than half and provides a range of 30 to 40 km per hour of charge. The purchase price for Level 2 chargers typically costs $1,000 to $12,000 plus installation costs. Public chargers will often be a smart charger, meaning they are networked with other chargers and provide functionality such as data collection, revenue collection, and can stop charging once a full charge is reached.

As of February 2022, Plugshare showed 39 Level 2 charging station locations in Saskatoon, with a total of 95 ports. Of these, 25 locations (45 ports) are available for public use, while others are reserved for guests or employees at the business (for example, hotels) or are otherwise restricted. Of those 25 public locations, 21 are free for use (regular parking rates apply) and four charge $0.75/hour or more. Table 2 summarizes these findings.

Table 2: Level 2 Charging Stations in Saskatoon

Row Labels	Count of Location	Sum of ports
Free	28	50
Public	21	35
Limited	7	15
Pay-per-use	11	45
Public	4	10
Limited	7	35
Grand Total	**39**	**95**

Level 3 charging is the fastest charging method currently available. It is typically found at gas stations or other public places. It can provide up to 250 km range per hour of charge. The charger itself costs between $45,000 to $100,000 plus installation costs. Level 3 chargers are typically pay-per-use with charges by the minute.

Most of the chargers along the highways that go through Saskatoon are only Level 2, meaning a user will need to stop for several hours to charge their vehicle during a long-distance road trip. Plugshare showed 7 Level 3 charging station locations in Saskatoon, with a total of 12 ports. Five of these locations are available for public use, while the

others are restricted for guests at their business (in this case, car dealerships). Of those 5, 1 is free for use and 4 charge $15/hour or more. Table 3 summarizes these findings.

Table 3: Level 3 Charging Stations in Saskatoon

	Count of Location	Sum of ports
Free	3	4
Public	1	1
Limited	2	3
Pay-per-use	4	8
Public	4	8
Grand Total	**7**	**12**

Level 3 chargers are available in the following communities in Saskatchewan:

- Whitewood (south of Esterhazy)
- Estevan
- Regina
- Moose jaw
- Swift current
- Maple Creek
- Davidson
- Humboldt
- Saskatoon
- Martensville
- Battleford
- Lloydminster

There are a growing number of Level 3 chargers along major highways across Canada.

4. Barriers and Benefits to EV Adoption

Barriers to EV adoption include the higher up-front cost, range anxiety/lack of infrastructure and concerns with reliability (especially in the winter)[6][7][8]. A 2022 survey

[6] https://globalnews.ca/news/7632277/internal-government-poll-support-electric-vehicle-subsidy/
[7] City of Toronto Electric Mobility Strategy Assessment Phase, Pollution Probe & The Delphi Group, 2018
[8] https://www.cvma.ca/press-release/new-survey-underscores-need-ambitious-government-efforts-convince-canadians-purchase-electric-vehicles/

done by KPMG[9] found that while 71% of Canadians are considering the purchase of an electric vehicle for their next purchase, they have many concerns including:

- 79% won't consider an EV unless it can run for a minimum of 400km on a fully charged battery;
- 64% believe EV's aren't reliable in Canada's cold harsh winters (compared to 67% a year ago); and
- 51% expect public charging stations to work quickly, saying they aren't willing to wait; and 85% believe 'queuing anxiety' will mount with people having to wait in line to use a public charging station.

4.1. Higher Up-Front Cost

EV and PHEV's have a higher price tag than combustion engine vehicles that are similar in type, largely due to the cost of the battery. There are now numerous models of battery electric and plug-in hybrid vehicles in the $32,000 to $55,000 price range with luxury models costing up to $160,000. Comparable ICE models are typically priced $8,000 to $12,000 less than the EV-alternative[10].

This discrepancy in the purchase price can be off set by the lower cost to run the vehicle. In Saskatchewan, for example, savings have been estimated at approximately $2,700 per year[11] with the operation of an EV relative to an ICE model. Moreover, the City of Saskatoon has estimated that its fleet vehicles could save as much as $3,000 per year in fuel costs alone.

Electric vehicles are cheaper to maintain because there are no oil changes or engine maintenance required and because regenerative braking puts a lot less strain on the brakes. Batteries are costly, but should not need replacement before 250,000 or more km's, the typical life of a vehicle. As battery technologies improve and as the EV market becomes more competitive, it is anticipated that the purchase price of EVs will continue to decrease.

Based on examples in other municipalities[12], ownership cost barriers can be overcome through education, such as comparing the life-cycle costs of gas and electric vehicles, and through purchase incentives or more formally, government subsidies. Currently, the federal government offers a point-of-sale incentive of $2,500-$5,000. In other jurisdictions across Canada, provincial governments are also offering EV subsidies including:

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[9] https://home.kpmg/ca/en/home/insights/2022/01/kpmg-2022-auto-poll.html
[10] CAA provides information on the cost of electric and ICE vehicles in Canada at: https://www.caa.ca/sustainability/electric-vehicles/electric-vehicles-available-in-canada/
[11] https://www.2degreesinstitute.org/reports/comparing_fuel_and_maintenance_costs_of_electric_and_gas_powered_vehicles_in_canada.pdf
[12] City of Toronto Electric Mobility Strategy Assessment Phase, Pollution Probe & The Delphi Group, 2018

- British Columbia provides rebates of $3,000 for the purchase or lease of a new electric vehicle, including longer-range plug-in hybrids, and $1,500 for the purchase or lease of a shorter-range plug-in hybrid electric vehicle;
- Quebec offers rebates up to $8,000 for electric vehicles; and
- Nova Scotia provides a rebate of up to $3,000 for the purchase of a new electric vehicle, $2,000 for a used electric vehicle and $500 for an e-bike.

In Ontario, drivers are eligible for two incentives including $1,000 toward the purchase of used electric vehicles and $500 towards the purchase of a used-plugin hybrid, the incentives are provided by private donation and are administered by Plug N' Drive.[13]

On the other hand, the Government of Saskatchewan does not offer any specific EV purchase subsidies. As announced in the 2021/22 budget, the Saskatchewan government charges an $150 per year to register an EV compared to a gas vehicle because EVs do not have to pay the Saskatchewan fuel tax like ICE vehicles do.[14]

4.2. Range Anxiety/Lack of Infrastructure

Another major barrier to EV adoption is a lack of access to charging infrastructure that is convenient for everyday use and sufficient to meet community demand.[15] Currently, the battery range for electric vehicles is approximately 200-400 km for cars under $55,000 and up to 663 km for higher priced vehicles. Plug-in hybrids have low battery ranges (40-50 km) with the ability to switch to gas for longer distances, offering flexibility for the user (but likely less savings in terms of fuel, maintenance, and greenhouse gas emissions).

While most EV owners will charge at home, having a robust network for Level 2 and Level 3 chargers provides additional charging opportunities. For short-distance commuters, it can be convenient and ease range anxiety when the ability to top-up at workplaces or commercial/recreational areas during the day is available. For rural commuters travelling slightly longer distances, the ability to charge while at work or running errands becomes essential. Finally, for longer distance road trips, fast chargers are necessary so that cars can be charged in less than an hour. Thus, building a network of chargers is critical to encouraging EV adoption and is expected to be a joint effort between private businesses, municipalities, utilities, provinces, and the federal government.

Charging at multi-unit dwellings can have additional barriers. For example, the condominium board or property owner may not be willing to install chargers or there may be electrical capacity issues. Municipalities can play an important role in both new and existing multi-unit buildings to reduce charging infrastructure barriers for EV owners

[13] https://www.plugndrive.ca/wp-content/uploads/2021/04/Used-EV-Incentive-FAQ-March-16-2021.pdf
[14] https://www.saskatchewan.ca/government/news-and-media/2021/april/20/new-annual-fee-of-$150-on-electric-vehicles
[15] Ibid

who reside at them. One part of this is to provide chargers at other locations in the community in the interim while charging capacity at the buildings themselves is inadequate.

4.3. Concerns About Reliability

A third barrier to EV adoption is concerns about the reliability of EV's, particularly in cold climates. This barrier may be a perception issue as anecdotal evidence indicates that EV's function well, or better, than ICE in cold temperatures[1617]. However, the range of the battery can decrease by up to 50%[18], meaning that robust charging infrastructure becomes even more important. In general, EV users find the driving experience very good and the cars reliable with little need for routine maintenance.

4.4. Perceptions Around the Environmental Footprint of an EV

A recent survey of EV drivers in Saskatchewan done by SaskPower[19] showed that the most common reason for purchasing an Electric Vehicle was for environmental reasons. At the same time, there is sometimes confusion about whether electric vehicles have a lower environmental footprint than internal combustion engines (ICE) when considering that in Saskatchewan most of the electricity comes from coal and natural gas.

Electric vehicles are more efficient than internal combustion engine vehicles and have zero tail pipe emissions. Even with Saskatchewan's current electrical grid where over 70% of the electricity is generated from the burning of fossil fuels, an EV still reduces emissions by 30%. Saskpower is adding more renewable or clean energy to their grid annually and as they shift the grid to cleaner sources, the emissions reduced from an EV can only improve over time.

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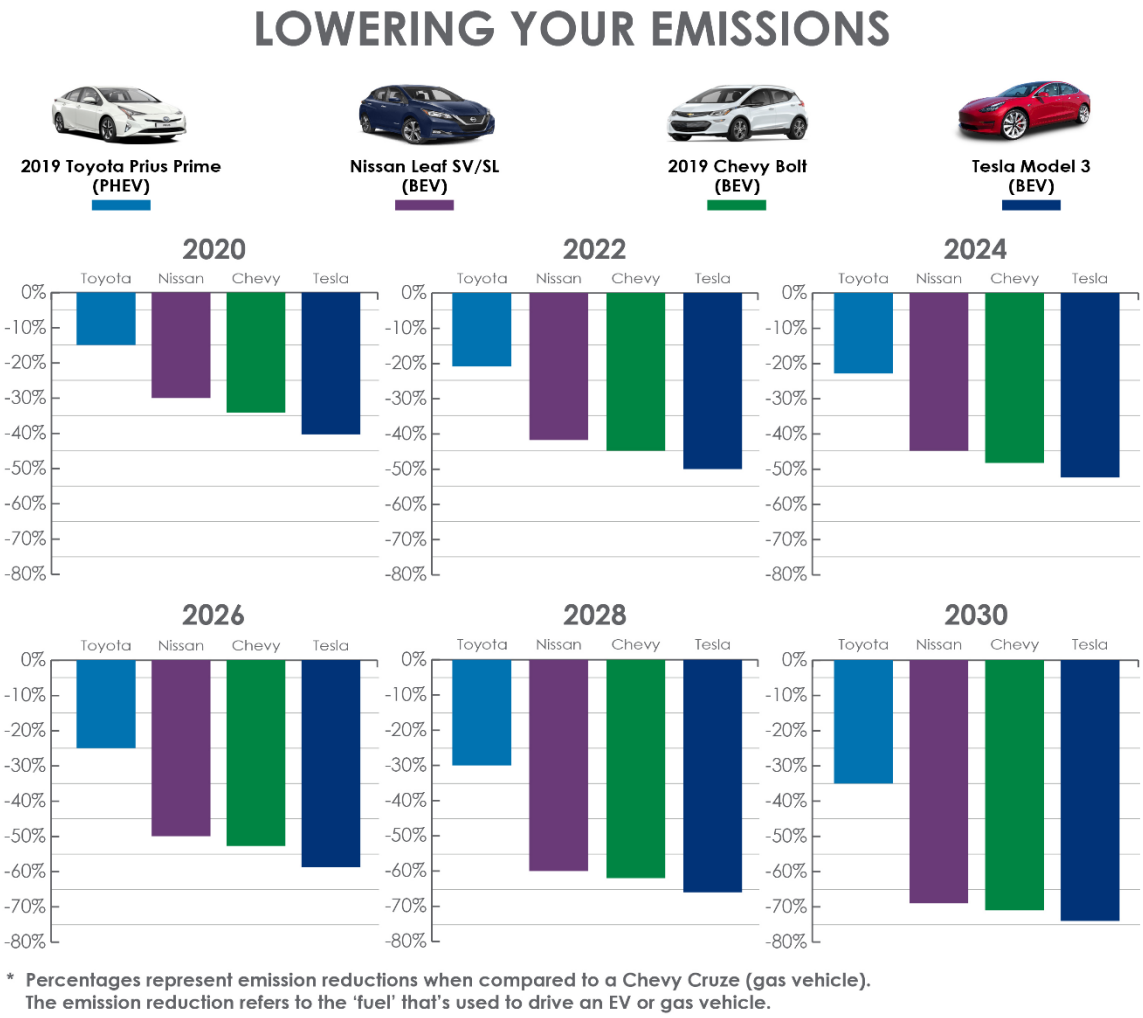
[16] https://www.cbc.ca/news/canada/north/electric-vehicle-yukon-winter-1.4975075
[17] https://www.saskpower.com/about-us/our-company/blog/2021/myth-electric-vehicles-cant-handle-our-cold-saskatchewan-winters
[18] https://www.saskpower.com/Efficiency-Programs-and-Tips/Saving-Power-at-Home/Saving-Tips-and-Programs/Electric-Vehicles/Performance
[19] SaskPower, the Saskatchewan Electric Vehicle Association (SEVA), and the SaskEV Society (Saskatoon) surveyed 121 electric vehicle drivers in Saskatchewan between July 23 to August 4, 2020; results provided to City of Saskatoon.



Source: SaskPower website

5. Municipal Scan of Electric Vehicle Charging Infrastructure

The Administration reviewed charging infrastructure in Canadian municipalities and found 11 of them in British Columbia, Alberta, and Ontario are involved in the install and operations of the charging network in their city.[20] The sample cities, including their populations and the number of stations they have, is shown in Table 1.

Table 1. Canadian Municipalities with municipally owned charging infrastructure.

Municipality	Population	City public EV chargers	City EVchargers per Pop (/100,000)
Powell River, BC	13,157	4	30.40
Surrey, BC	500,000	33	6.60
Whistler, BC	11,854	14	118.10
Calgary, AB	1,336,000	68	5.09
Edmonton, AB	981,280	7	0.71
Barrie, ON	153,356	54	35.21
Kingston, ON	136,685	54	39.51
London, ON	404,699	20	4.94
Markham, ON	342,970	17	4.96
Toronto, ON	2,930,000	17	0.58
St. Catharine's, ON	133,113	2	1.50

5.1. Charging Locations

The sample cities suggested that locations should be chosen based on their attractiveness to potential users, and that being close to amenities, especially for level 2 chargers, would increase use. For example, the EV station in Canmore proper is used much more than the PetroCan station on the highway. This is likely because users can plug their vehicle in and access services in the town instead of just waiting for the car to charge.

Popular locations included:

- City Hall or Downtown
- Public Libraries
- Recreation sites and sports arenas
- Wards with significant interest

[20] This research is not exhaustive and there may be other municipalities with EV charging infrastructure, but this offers a sufficient sample size for the purposes of this analysis.

The sample cities also warned about site-specific requirements such as heritage buildings, existing infrastructure, landowners, and permitting that should be considered as they can significantly impact cost and timelines. Some examples included:

- In Surrey, the curbside charging stations planned for 2018 had to be abandoned due to costs more-than-doubling the estimated costs, once updated designs and tender prices came through.
- In Edmonton, the installation process required roadside parking, permits, lane enclosures, and traffic closures; while other sites required removal and replacement of cobblestones that increased expenses and caused delays.
- For the Peaks to Prairies project, ideal sites in Calgary required access to the ring road, but negotiations with potential site owners was challenging. For example, Canadian Tire reserved right to install and host its own charging station infrastructure on their site and would not partner for this project.

A location's grid capacity must also be considered. For example, Edmonton's grid cannot support more than three Level 3 chargers without risk of brownouts. In Surrey, there were neighbourhoods where major building upgrades had been completed that maxed out the area's electricity reserve capacity.

Given that electric vehicle adoption is still quite low in most places, drivers and users of the stations are typically EV enthusiasts so are quite willing to self-educate around where the stations are and how to use them. The sample cities assume that better education will be required as EV's become more mainstream. They have not reported many cases of misuse or abuse of their installed stations. However, parking by non-electric vehicles at the allocated charging spots, has been a problem.

5.2. Workplace Charging

One option for Saskatoon to lead EV adoption by example is to install charging stations for municipal workplace parking lots. A report by the Clean Air Partnership[21], included the following municipal examples of workplace charging policies and implementations:

- Ottawa, ON: Developed a strategy that recommends the requirement of Level 2 charging stations at new and major expansions of City facilities, with Level 1 and DC Fast Chargers considered on a case-by-case basis.
- Markham, ON: Piloted 16 level 2 EV charging stations for employees of the Markham Civic Centre while also allowing Alectra Utilities to explore and demonstrate the value of using "smart" EV charging stations to curtail building energy consumption.
- Kingston, ON: Designed an EV Strategy to be integrated into existing facility policies, bylaws and standards. For example, the policy identifies the need to amend the City's Fees and Charges Bylaw to permit the City (as employer) to collect

[21] https://cleanairpartnership.org/cac/wp-content/uploads/2018/11/Workplace-EV-charging-Policy-V2.pdf

fees for workplace EV charging and to erect appropriate EV charging station and parking bay signage.

All three municipalities charged their users a fee for charging their electric vehicles onsite, with Markham subsidizing the cost for the user through a corporate sponsorship.

The City of Saskatoon currently does not have any Level 2 chargers for employees' personal use.

5.3. User Fees

All but one (Whistler) of the sample cities provided free charging for at least a trial period. Six of these (Powell River, Surrey, Calgary, Kingston, London, and Markham) have since introduced rates of $1.00 to $2.40 per hour for level 2 chargers, and $12 to $24 per hour for level 3 chargers. Edmonton, St. Catharines, London, and Toronto are offering free charge with no apparent plan to introduce fees. The sample cities identified that stations that do not charge a fee for electricity are typically busier. However, as programs grow, charging a cost-recovery user fee becomes more common and important. A summary of the fees charged in other cities is available in Table 2.

Table 2. Fees charged at municipally owned Electric Vehicle Charging Stations

Municipality	Fees
Powell River, BC	Initially free. Since April 2020, $2/hour
Surrey, BC	Initially free. Since January 2022, Level 2: $1.98 for first hour, $4.98/hour subsequently Since May 2021, Level 3: $12 for first hour, $24/hour subsequently
Whistler, BC	Level 2: $1/hour Level 3: $0.35 per kWh (minimum $2 charge)
Calgary, AB	Initially all free (paid parking) Since January 2022, Prices vary $0-2/hr
Edmonton, AB	Free (paid parking)
Barrie, ON	Free (paid parking)
Kingston, ON	Initially free (2 years). Since Jan 2020 - $1.50/hour.
London, ON	Initially Free (paid parking) Since October 2021, $2.20-2.40/hour (first 5 minutes free)
Markham, ON	Initially free. Since Jan 1, 2020: Level 2: $1.50/hour (4 hour maximum) Level 3: $15/hour (1 hour maximum)
Toronto, ON	Free
St. Catharine's, ON	Free (paid parking)

5.4. Partnerships and Sponsorships

Municipalities installing public EV stations are often approached for partnerships by:

- Utilities
- Parking authority
- Insurance companies
- Other communities
- Federal government (National Resources Canada)
- Private businesses

Partnerships typically help with:

- Capital Funding for EV stations and installation
- Combining projects to meet requirements for grant applications
- Operating and electricity costs
- Managing the electrical maintenance and grid upgrades

The Saskatchewan Environmental Society previously partnered with Saskatoon Light & Power, the Saskatoon Carshare Co-operative, Affinity Credit Union, the SES Solar Co-operative, Sun Country Highway, Saskatchewan Research Council, Exa Energy, Radiance Co-housing, and Wardell Gillis Law to implement their Renewable Rides project. Renewable Rides brought solar-powered electric vehicles to the Saskatoon CarShare Co-operative's fleet of cars through Virtual Net Metering, as facilitated through Saskatoon Light & Power. Each partner provided various elements to the project, including financial support and in-kind contributions.

Other municipalities, such as Markham, have offered sponsorship branding of their charging stations and on-site signage, as well as online and at civic facilities through advertisements for the charge stations. In return, their sponsor paid for the electricity usage costs from vehicles charging at their stations.

6. Funding Opportunities

Funding for charging infrastructure is available through Natural Resources Canada (NRCan) and SaskPower.

NRCan's Zero Emission Vehicle Infrastructure Program (ZEVIP) is a 5-year $280 million program ending in 2024 and its objective is to address the lack of charging and refueling stations in Canada. It provides 50% matching funding for level 2, fast-charging, and hydrogen refueling stations at workplaces, public, and multi-unit buildings. There is no intake for this program open currently, but the program plans to launch a request for proposals targeting all streams in spring 2022.

SaskPower is currently requesting applications for their Electric Vehicle Infrastructure Program which aims to help fund, develop, and install up to 20 public EV fast-charging (Level 3) stations in high-priority areas in Saskatchewan. Eligible organizations (including municipalities) can request up to $200,000 or 75% of their total project costs.

7. Conclusion

The findings from this research indicate that EV adoption is rising steadily in Saskatchewan and Canada, with variation on the extent to which adoption is being encouraged. Provinces such as Ontario, Quebec, and British Columbia are leading the way in adopting EVs.

There are numerous real and perceived barriers to EV adoption including a higher up-front cost, range anxiety, lack of charging infrastructure, and concerns with cold-weather reliability. Experiences in other municipalities indicate that these barriers can be addressed through improvements to charging infrastructure, incentives to offset purchase prices, and education.

Charging infrastructure, together with education, is likely the biggest role that cities can play in the facilitation of EV adoption. Cities are directly investing in charging infrastructure and several municipalities even offer fully subsidized EV charging during the pilot phases. However, many municipalities introduce usage fees for charging, either right away or later in a post-pilot environment.

Industry and other levels of government also play a crucial role in EV adoption and development of charging infrastructure. This is demonstrated through the growth of the charging network in Saskatoon by private businesses, the province, and the country, as well as the funding offerings from NRCan, and most recently, SaskPower.

The role of the City in demonstrating leadership by electrifying our own fleet, developing a visible, local charging network, and promoting the use of EV's will be important to increasing EV's to the extent seen in other cities and to meet our own targets for EV adoption. The Electric Vehicle Adoption Roadmap, which received funding in the City's 2022/2023 Budget, will provide the City with the action plan to continue this work.