Electric Vehicles in Rural and Remote Communities

Identifying Opportunities, Understanding Challenges

Prepared for Indigenous Clean Energy

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About Dunsky

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Working across the buildings, renewable energy and clean mobility sectors, we support our clients through three key services: we **quantify** opportunities (technical, economic, market); **design** go-to-market strategies (programs, plans, policies); and **evaluate** performance (with a view to continuous improvement).

Executive Summary

Many rural and remote communities are interested in the role that electric vehicles (EVs) can play in reaching their decarbonization goals. The contexts of these communities differ from urban settings, however, where much of the discussion around EVs has focused to-date. This report identifies considerations relevant to EV uptake in rural and remote communities, including isolated grid management and emissions implications, distance from other population centres, and extreme cold conditions. Through general advice regarding EV selection and use and the exploration of hypothetical EV use cases, it provides EV-related insights relevant to rural and remote communities across Canada.

EV Considerations for Rural and Remote Communities

- Grid integration: To successfully integrate EVs into a remote grid, the timing of EV charging should be managed such that it avoids periods of high demand for electricity from other end uses. Charging management can also lead to reduced community emissions and increased renewables integration. Charging can be managed through either low or high technology solutions, which vary in their certainty of outcome.
- Distance from population centres:
    - Vehicle maintenance considerations: EVs require less maintenance overall, and those who adopt EVs will see reduced vehicle maintenance costs compared to combustion engine vehicles. EVs also require *different* maintenance (including different tools and skillsets, such as those related to working safely around high-voltage systems and an increased focus on software tools and diagnostics). Training and investment in equipment for local mechanics will support EV adoption in communities that are far from larger centres.
    - Vehicle economics: EVs today cost more upfront than internal combustion engine vehicles, however this is forecasted to change in the coming years as battery prices decline. EVs *save* on ownership and maintenance costs, however. Generally speaking, the more an EV is used, the more favourable the economics become. For those rural and remote community members with low annual mileage (for example, 5,000 km/year), operations and maintenance savings may not offset higher upfront costs. For those community members with higher annual mileage (for example, over 10,000 km/year), however, there is good news: EVs will likely represent lifetime economic savings, even before factoring in available incentives.

- **Cold climate impacts:** Many rural and remote communities are found further north and experience lower temperatures than Canadian averages. These low temperatures have implications for vehicle range, or the distance an EV can travel on a full battery charge. The optimal temperature for EV range (i.e. when real-world range of EVs most closely matches the manufacturer rated range) is between 10 and 30 degrees Celsius. Below or above these temperatures, range starts to degrade. This has important consequences for those rural and remote communities that experience cold temperatures for large portions of the year. If public charging infrastructure along routes of interest is limited, these range concerns can be avoided through the use of a plug-in hybrid electric vehicles (PHEVs). PHEVs have both electric and internal combustion drive trains, allowing them to switch to the vehicle's internal combustion engine once the electric range runs out. Alternatively, for buses, medium, and heavy-duty vehicles, fossil fuel-fired heaters can avoid range degradation in cold temperatures. Because much of the degradation is a result of using electrical energy to heat the cabin of the vehicle, fossil fuel heaters mean that range is essentially unaffected by cold temperatures.

EV Use Cases

Use case 1: Red Rock Indian Band Member Bus Service

The Red Rock Indian Band is an Ojibwe First Nation in Northwestern Ontario. The Band is interested in establishing a bus service for its members. The use case analysis compared the economic and emissions impacts of using an electric bus for this service as compared to a diesel bus. In the main scenario – where the same bus provides both a local service and a longer-distance service – the electric bus was estimated to provide $257,800 in lifetime economic savings while emitting 913 fewer tonnes of CO_2e. An alternate scenario assesses the economic and emissions savings of a local-route only, which allows for a smaller battery and even greater savings.

Lifetime Electric Bus Savings	
$257,800	913 Tonnes CO_2e

Use case 2: Kuujjuaq Water Truck

Kuujjuaq is a small remote community in the Nunavik region of Quebec. The community has a fleet of medium and heavy-duty diesel vehicles used for snow clearing, garbage collection, sewage removal, water delivery, and various other services. The use case analysis focused on the trucks used for water delivery, comparing the economic and emissions impacts of an electric water truck as compared to a diesel water truck. The electric water truck is estimated to provide $125,200 in savings over the vehicle lifetime. In the main scenario, which assumes the electric water truck is charged using electricity produced by diesel generators, emissions savings are minimal. An alternate scenario assumes that a portion of the electricity used to charge the vehicle comes from renewables leading to greater emissions savings.

Lifetime Electric Water Truck Savings	
$125,200	**80 Tonnes CO_2e**

Use case 3: Rocky Point, Morell, and Scotchford Car Sharing Program

The Abegweit First Nation is a Mi'kmaq Band with roots in Prince Edward Island. Members live in the communities of Rocky Point, Morell, and Scotchford – which are the focus of this analysis - among other locations. The three communities are geographically spread across PEI, and members frequently travel between them. A number of licensed drivers in the communities do not currently own vehicles and have trouble accessing transportation, however. To serve them, the First Nation is interested in establishing a light-duty EV car sharing program. The use case analysis compared the economic and emissions impacts of using an electric car for this service as compared to a gasoline car. In the main scenario – which considers the incentives available for light-duty vehicles in PEI - $23,900 in economic savings per vehicle are expected over the vehicle lifetime, along with 77 fewer Tonnes of CO_2e emissions. In the alternate scenario, which does *not* include electric vehicle purchase incentives, the electric car still shows considerable economic savings.

Lifetime Electric Light-Duty Car Savings	
$23,900	**77 Tonnes CO_2e**

EV Opportunity Identification Checklist

Building on the insights from the EV considerations for rural and remote communities and use case analyses, rural and remote communities should keep the following checklist in mind when assessing opportunities for EVs:

- ✓ **Emissions impacts:** If using a remote grid to charge, will a portion of the energy come from renewables or from excess diesel generation that would otherwise go to waste?
- ✓ **Economics:** Do vehicles have mid-to-high annual kilometers?
- ✓ **Model availability:** Are there electrified models available for the type of vehicle of interest? (*see summary of model availability in Chapter 5)*
- ✓ **Range adequacy:** Will the vehicle range go as far as needed on a single charge (even in cold conditions)? Alternatively, are there fast charging stations along the routes travelled that could be used?

If 'yes' to all, EVs are expected to be beneficial, offering cost and emissions savings while meeting transportation needs. EVs and EV charging infrastructure may be eligible for financial incentives. A summary of current funding available across the country is included in the 'Funding Opportunities' chapter of this report.

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1. Introduction

Introduction

Many rural and remote communities are interested in the role electric vehicles (EVs) can play in reaching their decarbonization goals. The contexts of these communities differ from urban settings, however, where much of the discussion and research around EVs has focused to-date.

There are some common EV-related concerns that are cited by consumers everywhere – including those in urban, rural, or remote settings. Some of the most often discussed include upfront costs, range adequacy and charging infrastructure, and vehicle model availability. Many of these concerns have been addressed through numerous studies, forecasts and reports. A summary of common responses to these concerns is included here:

- **Upfront costs:** EVs do continue to have higher upfront costs than internal combustion engine vehicles[1], however these costs are forecasted to decrease considerably over time as batteries prices decline. In addition, there are a number of incentives available to Canadians (touched on more in the Funding Opportunities Chapter of this report) that can help reduce these costs. As illustrated throughout this report, these higher upfront costs can often be offset through operations and maintenance savings.

- **Range and Charging Infrastructure:** All levels of government are working to establish a national network of electric vehicle charging infrastructure. Many EV drivers find that they do most of their charging at home rather than at public charging stations, however, and that their vehicle range is sufficient for many day-to-day activities. Chargers are increasingly located on major routes travelled by Canadians, which is useful for those occasions when longer distances are driven. Gaps in infrastructure remain on less travelled corridors, however, presenting a problem that will need to be addressed across the country in coming years.

- **Vehicle Model Availability:** In recent years, almost all major auto manufacturers have made commitments to producing electric vehicles in the coming years, ranging from snowmobiles to heavy-duty freight trucks. There are already many electrified light-duty cars and SUVs on the market, and pick-up trucks should be available as soon as next year. Vehicle model availability is changing rapidly – we provide a summary of current and forecasted available by vehicle type in the Vehicle Availability Chapter.

This report goes beyond these commonly addressed areas. Instead, it focuses on additional considerations relevant to EV uptake and use that are expected to apply to many rural and remote communities. These include isolated grid management and emissions implications, distance from other population centres, and extreme cold conditions. Through general advice regarding EV selection and use and the exploration of hypothetical EV use cases, this report provides insights relevant to rural and remote communities across Canada.

[1] Internal Combustion Engine vehicles ignite and combust fuel (e.g. gasoline, diesel) within the engine to power the vehicle.

1.1 – Defining Rural and Remote Communities

For the purpose of this report, remote communities are defined as having isolated electricity grids. The federal government estimates there are close to 300 remote communities across Canada[2]. The federal government defines rural areas as all territories lying outside population centres[3]. They are typically characterized as having low population densities, increased presence of agricultural and remote or wilderness lands, and – for some – are located far from other communities. For the purpose of this report, we also consider rural communities to be connected to the regional grid.

We have included both rural and remote communities in this report because many share key characteristics relevant to EVs that *differ* from urban contexts. Rural and remote communities are diverse, however, and not all considerations will apply to all communities.

1.2 – Defining EVs

Throughout this report, electric vehicle (EV) refers to both battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs). BEVs are vehicles with only an electric drivetrain, while PHEVs are vehicles with both electric and internal combustion drivetrains. PHEVs can be plugged in to charge and are supplemented by their internal combustion engine when low on charge. This is contrasted with hybrid electric vehicles that cannot be plugged in but rather charge through the use of regenerative braking (and are excluded from this report).

1.3 – How to Use this Report

The goal of this report is to inform rural and remote community members about EV considerations specific to their community contexts. It can also be used to help identify opportunities for EVs, with a goal of selecting those opportunities that will lead to emissions and economic savings while meeting transportation needs. While reviewing this report the reader can:

1) Learn about unique factors that will influence EV adoption and benefits in rural and remote communities (Chapter 2)

2) Review economic and emissions impact analyses for three specific EV use cases while taking in the general 'Learnings for Other Communities' included alongside each example (Chapter 3)

3) Review funding available to identify potential financial support for EV-related projects (Chapter 4)

4) Review vehicle availability timelines to understand current and near-term availability of electrified models by vehicle type (Chapter 5)

5) Reference a checklist that can be used to identify promising EV opportunities (Chapter 6)

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[2] Government of Canada. (2011). Status of Remote/Off-Grid Communities in Canada. Available online.

[3] Statistics Canada. (2018). Rural Area: Detailed Definition. Available online.

2. EV Considerations for Rural and Remote Communities

Although rural and remote community residents will experience many of the same barriers to and benefits from adopting EVs as those in urban settings, there are unique factors to consider in these settings, highlighted below.

2.1 – Grid Integration

Our energy systems are increasingly distributed, with growing sophistication of end user energy production and consumption. A growing number of consumer devices can produce energy or consume energy in a way that can be controlled to provide electrical system benefits. EVs primarily fall into the latter category - the timing and amount of power they draw from the grid is flexible and can be adjusted using a variety of strategies and devices. In some cases, EV charging can be detrimental to the grid, however. The timing and amount of power required for charging can also impact economic and emissions savings from EVs. Large EV projects are likely best evaluated alongside those responsible for operating the electrical system in order to maximize benefits.

EVs on the Grid: Opportunities and Challenges

EV charging can be managed to provide benefits to communities. Unmanaged, however, EVs can be detrimental to the grid.

Opportunities	Challenges
• Can increase utilization of energy produced from renewables *or* energy from generators that would otherwise be wasted (for example, due to artificial loading to maintain optimal off-peak generator performance)	• Unmanaged, can provide little emissions benefit or actually increase community emissions
• Can minimize peak impacts or help balance loads, reducing the need to invest in large, centralized energy system infrastructure (for example, diesel generators or feeder upgrades) as demand grows	• Unmanaged, can result in peak load growth and the need for large investments in additional grid infrastructure

There are many options for controlling EV charging, with varying degrees of technological requirements and certainty of outcome. Low technology options (with lower degrees of certainty of outcome) include time-of-use pricing (which encourages consumers to charge when grid demand is low using electricity rates that vary by time of day) or text alerts (which notify consumers when it's a good time to plug in). A higher technology option (with greater certainty of outcome) is direct load control through smart EV chargers by the grid system operator. The operator has the ability to communicate with EV charging equipment and can time vehicle charging such that it aligns with the needs of the grid. If EV charging is managed correctly, peak demand impact (or the maximum instantaneous electricity use on a given grid) can be minimized, community emissions reduced, and renewables integration increased.

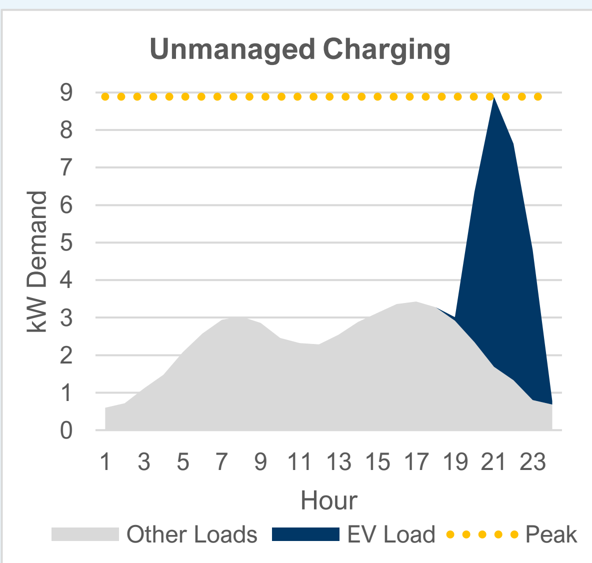
2.1.1 – Minimizing Peak Impacts

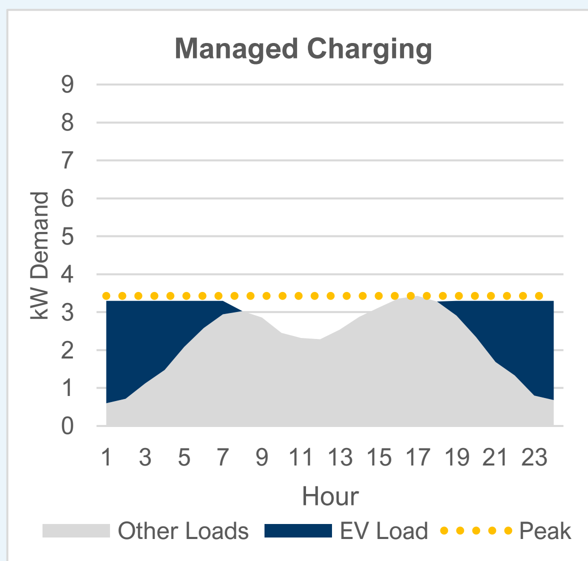
EV charging can represent a considerable increase in electrical demand on the grid. Demand from an electric light-duty vehicle being charged with a level two charger can potentially *double* the peak load of a household if EVs are charged at the same time as other electrical loads. At a community-wide scale, this can represent a large incremental increase in load for some rural or remote feeders. As EVs are being adopted in communities, managing charging loads will help mitigate potential impacts, such as the need to upgrade distribution infrastructure. Whether through low-tech or high-tech solutions, charging should be managed such that it happens at times of low demand (off-peak) to minimize impacts on the grid (see figure below).

Managed Charging: Household Peak Power Demand Example

The graphs below demonstrate the impact that EV charging can have on household peak power demand without and with managed charging. On the left, an EV driver plugs in to a level two charger which draws, at most, 7 kW of demand. This coincides with other large draws of power (for example, use of the stove and hot water tank). The addition of EV load causes the household peak to grow from 3 kW to approximately 9 kW – a large relative increase in demand. Extrapolating to a whole neighbourhood, we can see how EV charging can lead to large increases in demand requirements across a community.

On the right, a smart charger is employed to deliver a lower power, longer duration charge (delivering the same kWh battery charge by the morning). Under this scenario, peak demand remains at below the household peak of 3 kW.



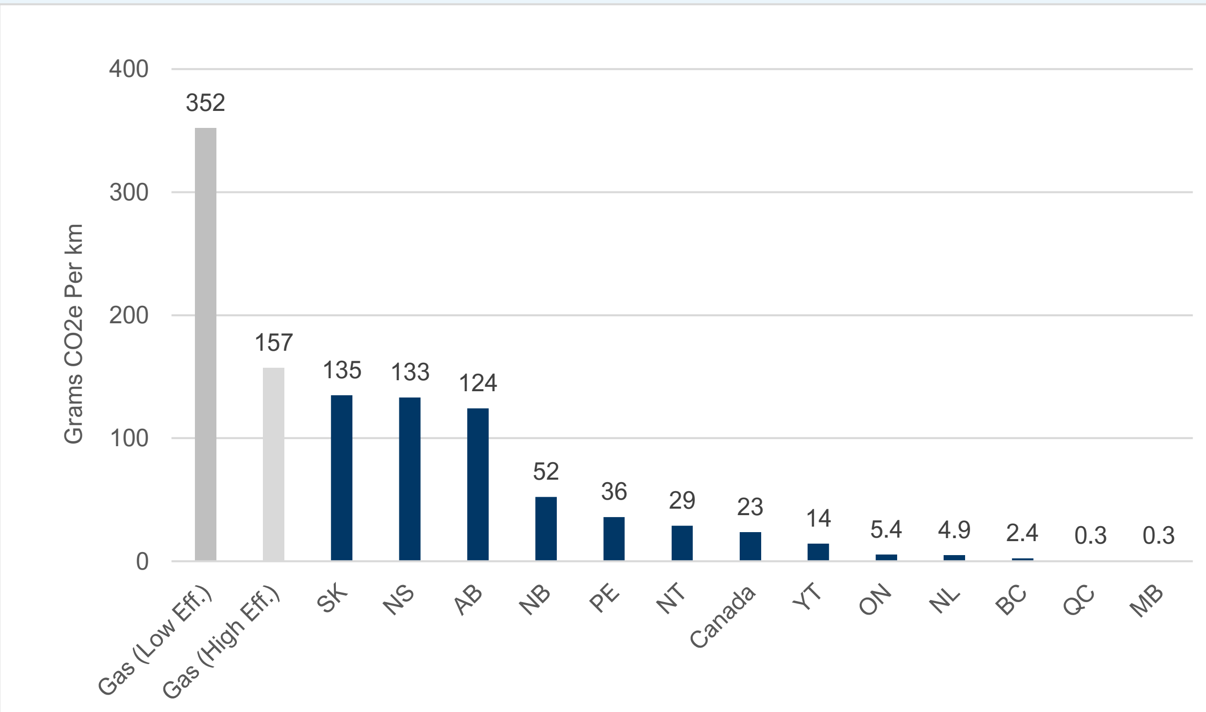


2.1.2 – Reducing Emissions and Integrating Renewables

The emissions generated by EVs depend on the source of electricity used to charge the vehicle. For rural communities, which are considered to be connected to their provincial or territorial grid for the purpose of this study, EVs represent an emissions benefit over gas vehicles in any location across the country. Alongside all other grid-connected Canadians, rural community members can be sure switching to an EV would result in lower operating emissions (see figure below).

Even Canada's Most Emissions-Intensive Regional Grids Result in EV savings

The graph below compares the operating emissions (measured in grams CO_2e per km driven) of two light-duty gas cars - one high efficiency and one low efficiency, shown in grey - to the operating emissions of an EV charged using each of the provincial grids, shown in blue[1,2]. EVs have an emissions benefit in all provinces and territories with a regional grid.



1. Provincial grid emissions data sources from Environment and Climate Change Canada's Greenhouse Gas Inventory with exception of PEI (where no consumption intensity values were available). PEI's grid emissions factor was sourced from a recent publication from the provincial Special Committee on Climate Change.
2. Nunavut is excluded from this graph because it does not have a regional transmission grid – instead each community in the Territory has local diesel generation and electricity distribution systems, as described by the Qulliq Energy Corporation here. For the purpose of this report, these communities would be categorized as remote.

For remote communities with isolated microgrids, the situation is more complex. Many remote communities rely on diesel generators to produce their electricity. Although there is some dependence on the grid and the vehicle in question[4], we would not expect to see a meaningful emissions benefit from EVs in these communities until at least some of energy used to charge the vehicle comes from renewables *or* from diesel generation that is otherwise wasted (for example, due to artificial loading of the generator). EVs can be paired with on-site renewable generation (e.g. solar) and a battery storage system, allowing them to be charged using renewables at any time. Alternatively, EV charging can be actively managed such that it's timed with periods of high renewables production and low community demand – for example, as wind turbines generate electricity during the night - reducing the curtailment of renewable energy, or at times when generators are run beyond the demand needs in order to maintain equipment functioning.

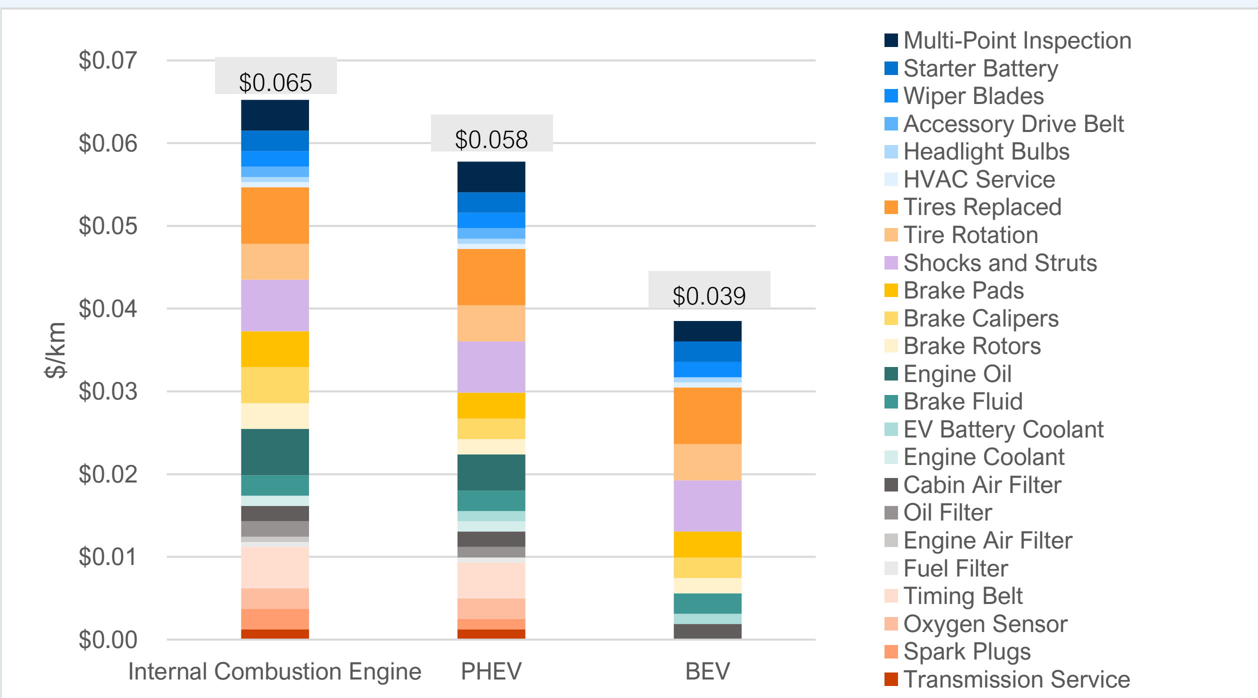
[4] Environment and Climate Change Canada's Greenhouse Gas Inventory includes emissions intensities for isolated diesel grids in Nunavut that range from 740 to 890 grams CO_2e per kWh electricity consumed over the most recent five years that data is available for. This equates to approximately 133 to 160 grams CO_2e per km for an average light-duty electric vehicle.

2.2 – Vehicle Maintenance Considerations

Although EVs require less maintenance overall, they also require *different* maintenance (including different tools and skillsets, such as those related to working safely around high-voltage systems and an increased focus on software tools and diagnostics). For rural and remote communities, long distances from major centres may make maintenance challenging. Automakers may also have reservations about selling to drivers who are far from properly trained technicians who can safely diagnose and repair EVs. Training and investment in equipment for local mechanics can help mitigate these concerns and support EV adoption. In all settings – rural, remote, or urban - those who do adopt EVs will see reduced vehicle maintenance compared to gas or diesel vehicles. These reductions are a result of EVs not having many of the parts that require frequent maintenance in combustion vehicles (see figure below).

Real-World Data Shows Considerable EV Maintenance Savings

A recent study included a comprehensive analysis of maintenance costs for a typical light-duty for internal combustion engine (ICE) vehicle, PHEV, and BEV[1]. The results of this analysis are summarized in the graph below, which includes schedule maintenance costs for each drivetrain type on a dollar per kilometer basis. Compared to internal combustion engine vehicles, PHEVs were found to have an 11% reduction in maintenance costs (namely due to reduced maintenance related to brakes and powertrains). BEVs were found to have a 41% reduction in maintenance costs thanks to savings related to powertrains, filters, fluids, and brake maintenance.



1. Argonne National Laboratory. (2021). Comprehensive Total Cost of Ownership Quantification for Vehicles with Different Size Classes and Powertrains. Available online.

2.3 – Vehicle Economics

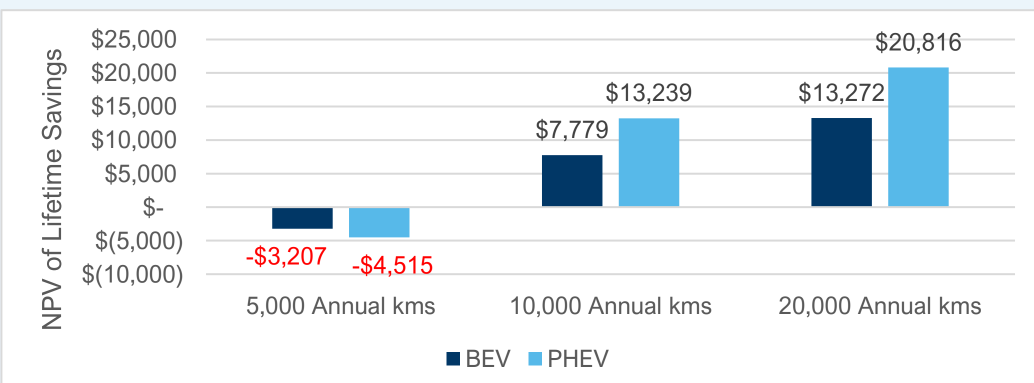
Although today EVs cost more upfront than internal combustion engine vehicles, this is forecasted to change in the coming years as battery prices decline[5]. EVs save on ownership costs, however – EV maintenance costs are less than internal combustion engine vehicles (as outlined in the previous section) as are fuel costs (the degree to which varies by gas and electricity prices in a given location). Generally speaking, the more an EV is used, the more favourable the economics become.

For those rural and remote community members with low annual mileage, operations and maintenance savings may not offset higher upfront costs. For those community members with higher annual mileage, however, there is good news: EVs will likely represent lifetime economic savings.

It should be noted that if EVs are required to drive far distances between charges, however, the vehicle's battery capacity must be large enough to cover a roundtrip, or the route must include public chargers. Cold climate impacts on range should be considered when assessing if a battery is large enough to cover a given route, as outlined in the next section.

Total Cost of Ownership

In the example below we illustrate how the total cost of ownership of EVs (considering both upfront and operations and maintenances costs) varies depending on kilometers driven for a small light-duty car. For this example, we calculated the net present value (NPV) of lifetime EV savings over gas vehicle savings for three scenarios that vary by annual kilometers driven[1]. For the 5,000 km scenario, EVs actually represent a loss – the higher upfront cost is not covered by operations and maintenance costs given low distances driven, and a gas or diesel vehicle makes more economic sense. The story quickly changes as annual kilometers increase, however, with considerable lifetime savings for the 10,000 and 20,000 annual kilometer scenarios. PHEVs show greater savings under these scenarios due to their lower upfront costs today.



1. Average Canada-wide electricity and gas prices were used, and the vehicle is expected to be owned for 10 years.

[5] Today EVs cost somewhere in the order of $15,000-20,000 more than internal combustion engine vehicles before incentives. This difference in upfront cost will shrink over time as battery costs decline, however, with many industry experts predicting that light-duty EVs and light-duty internal combustion engine vehicles will cost the same the mid to late 2020s.

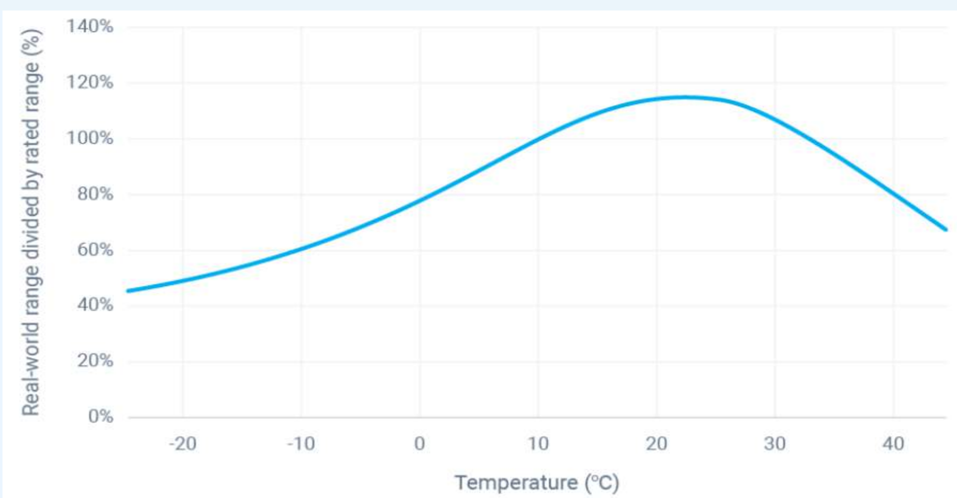
2.4 – Cold Climate Impacts

Many rural and remote communities are found further north and consequently experience lower temperatures than Canadian averages. These low temperatures have implications for vehicle range, or the distance an EV can travel on a full battery charge. The optimal temperature for EV range (i.e. when real-world range of EVs most closely matches the manufacturer rated range) is between 10 and 30 degrees Celsius. Below or above these temperatures, range starts to degrade. As temperatures drop to -20 or below, some studies estimate that an EV may only be able to travel ~50% of rated range. In other words, a battery rated to travel 300 km on a full charge will only be able to travel 150 km in extreme cold conditions. This has important consequences for those rural and remote communities that experience cold temperatures for large portions of the year. If public charging infrastructure along routes of interest is limited, these range concerns can be avoided through the use of PHEVs. PHEVs have both electric and internal combustion drive trains, allowing them to switch to the vehicle's internal combustion engine once the electric range runs out. PHEVs do not see the same level of lifetime O&M benefits as battery electric vehicles (BEVs), however, which only have an electric drivetrain, as highlighted in the Vehicle Maintenance Considerations section.

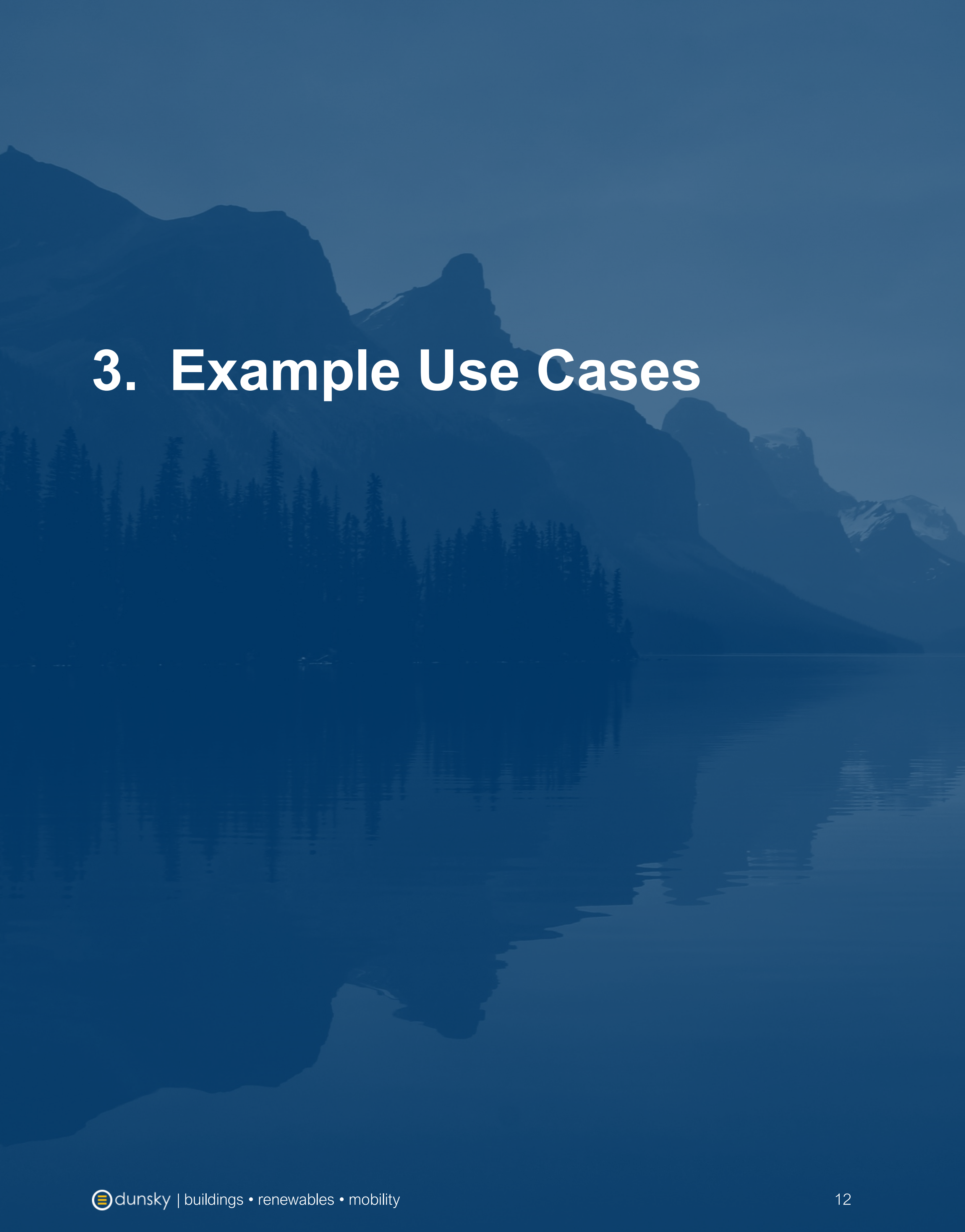
At cold temperatures, much of this range degradation is a result of using electrical energy used to heat the cabin of the vehicle. To address this, some manufacturers of buses and medium and heavy-duty vehicles have included fossil fuel-fired heaters in vehicles. By using fossil fuels to heat the vehicle, range is essentially unaffected by cold temperatures, eliminating the need to purchase large (and expensive) batteries to meet range requirements on the coldest days, and instead right-sizing batteries to match the majority of use required. Two of the case studies included in this report include vehicles that use fossil fuel heaters for this reason.

Real-World Range Varies with Temperature

The graph below illustrates how real-world range (as a percent of rated range) varies with time[1].



1. Geotab. (2020). To what degree does temperature impact EV range? Available online.



3. Example Use Cases

Example Use Cases

In this section, we explore three hypothetical use cases for EVs – a bus service in Northern Ontario, a water truck in Northern Quebec, and a car sharing service in PEI.

Through coverage of a variety of vehicle types, a mix of rural and remote settings, and inclusion of cold climate considerations, we aim to provide insights about just a few of the many types of opportunities that exist for EVs, including economic and emissions impacts and strategies for mitigating potential challenges. Although the examples focus on community-owned vehicles, some of the learnings are also relevant for personal vehicles.

Figure 1. Communities and Use Cases Included in the Study

3.1 – Red Rock Indian Band Member Bus Service (ON)

The Red Rock Indian Band is an Ojibwe First Nation in Northwestern Ontario. The Band is interested in establishing a bus service that would provide local and longer distance transportation for its members. All communities on the proposed bus route are rural, with the exception of Thunder Bay, and all are connected to the Ontario provincial grid.

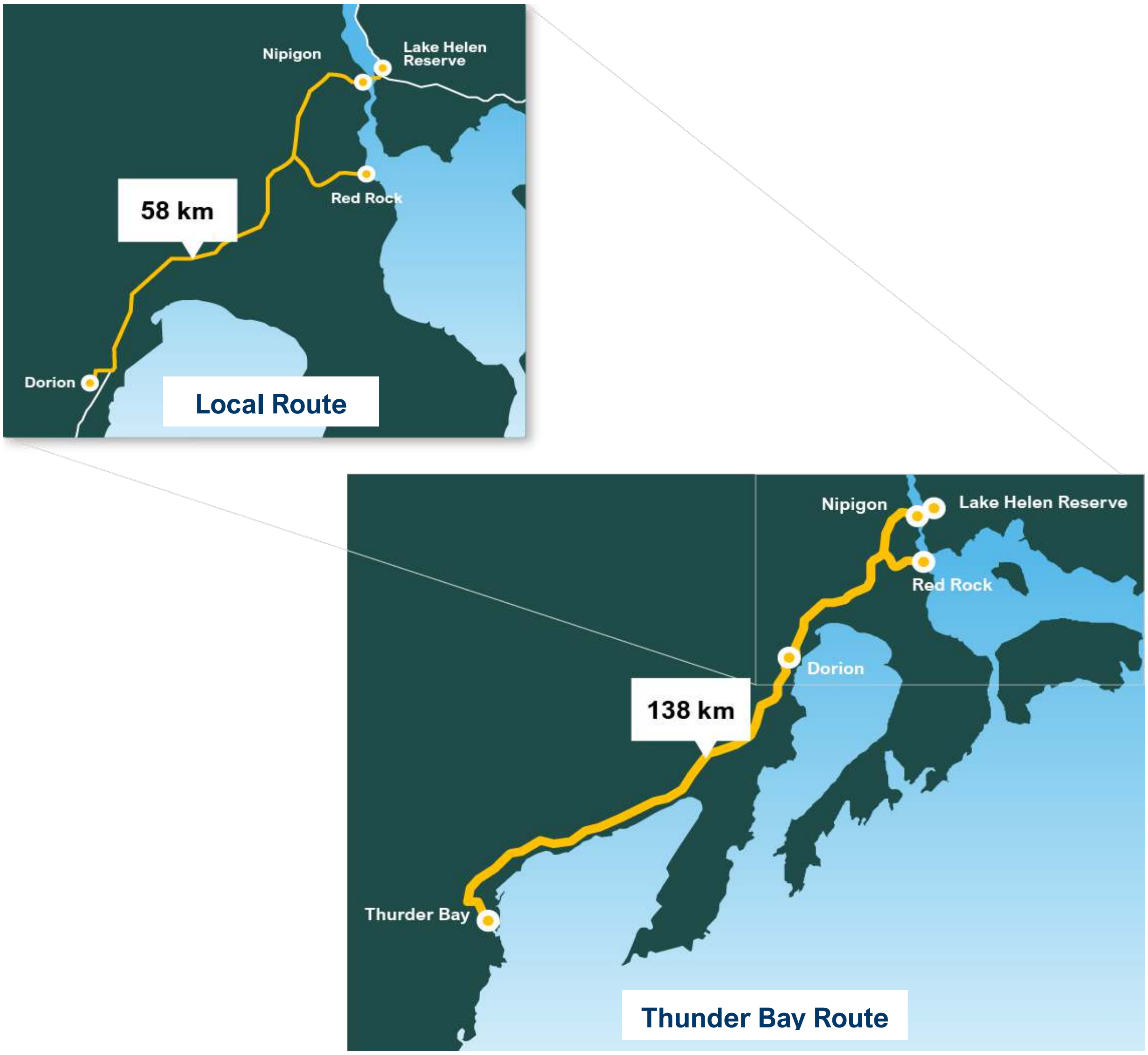
Most buses are used for a very specific purpose with little variation in driving patterns (drive cycle) over time. Transit buses have many stops and starts and typically do not travel far from their home base parking depots. Conversely, coach buses are primarily used on highways, reaching higher speeds, doing fewer stops and starts, and going greater distances from parking depots.

There are a relatively large number of electrified bus options currently on the market. Buses are promising applications of EVs given their predictable use and therefore the ability to right-size battery and charger sizes, often leading to clear-cut economic savings. Those vehicles that do more transit bus style driving can often be outfitted with relatively smaller batteries, reducing vehicle upfront cost. These buses will likely need to travel back to depots to quickly charge up between routes, however, requiring greater investment in higher power (faster) charging infrastructure in some cases. For vehicles with drive cycles more similar to coach buses (farther distances, continuous driving), larger batteries are required to cover longer ranges. These vehicles may have more time between routes however, and potentially can require less expensive, lower-power, charging infrastructure, allowing them to charge up over the course of 7-12 hours.

Due to low population densities in the communities included in this example (with the exception of Thunder Bay), multiple buses for different drive cycles – one local route and one longer distance route – was not considered feasible. Instead, for the purpose of this analysis, the same bus is assumed to do a frequent local route between the communities of Lake Helen Reserve, Nipigon, Red Rock, and Dorion and a less frequent route between these communities and Thunder Bay (see route map on following page). This assumes that the same bus is used to do two very different routes: one more transit-style, one more coach style. It is challenging to right-size a bus to fit both use cases, and as such this use case analysis assumes investment in both a more-expensive large battery as well as a more expensive high-power charging infrastructure. To understand the economic impact of this, we also present an alternate scenario where the bus is only used for a local transit-style route, and consequently outfitted with a smaller (less expensive) battery *and* only requires a single charger.

Throughout the winter, the communities that would be served by this bus route routinely have cold temperatures that would greatly reduce the range of the electric bus batteries. As outlined in the Cold Climate Impacts section, this range reduction can be mitigated through the use of a fossil fuel-fired heater. For this use case, we assume the bus includes a diesel-powered heater. The fuel cost and emissions of running this heater are also included in this analysis.

Figure 2. Local and Thunder Bay Bus Routes, Including One-Way Distance in Kilometers



Vehicle and Charger Assumptions

Key assumptions for the electric bus and diesel bus are included below.

Table 1. Bus Vehicle and Charger Assumptions: Main Scenario

Vehicle Type	Metric Type	Metric	Assumption
Electric bus	**Technical specification**	Battery Size (kWh)	160
		Approximate Range (km)	335
		Charger power (kW)	100
		Number of chargers per bus	2
	Cost	Upfront cost (vehicle)	$395,000
		Upfront cost incentive	$0
		Upfront and installation cost (2 chargers)	$150,000[6]
		Total electric bus upfront cost (vehicle and chargers)	**$545,000**
Diesel bus	**Cost**	Upfront cost (vehicle)	$280,000
All	**Other**	Years of ownership	10

A charger that delivers 100 kW of power can fully charge the bus' 160 kWh battery in approximately an hour and a half. This analysis assumes that two high power chargers are required – one in Thunder Bay and another in Lake Helen Reserve, where the bus is assumed to be parked when off-shift. Using these chargers, the bus driver would be able to fill the battery in Thunder Bay and in Lake Helen Reserve between trips to and from the local communities and Thunder Bay.

Other Assumptions

The local route – travelling between the communities of Lake Helen Reserve, Nipigon, Red Rock, and Dorion – is assumed to be completed four times per day Monday through Friday. This frequency would allow community members to move back-and-forth between communities to reach jobs or other commitments in the morning then return home during the late afternoon or evening. The Thunder Bay route is assumed to be completed two times per weekend (on the same day). This route would allow members to reach shops and services on a weekly basis, spending the day in Thunder Bay then travelling back to their community in the late afternoon or evening, and would also allow those living in Thunder Bay to visit the communities then return home in the same day.

[6] The fast charger uses a connection type which is compatible with all vehicles that accept direct current charging (including light, medium, and heavy-duty vehicles as well as buses). The full installed cost of a 100 kW charger is estimated to be $100,000, however for the purpose of this assessment it is expected that the cost of the fast charger in Thunder Bay could be shared with another user, reducing upfront costs for the Band.

Bus service feasibility assessment requires a greater degree of planning than the scope of this study allows, including an assessment of expected ridership, detailed route planning, and an analysis of the ability of the service to provide attractive employment opportunities. The analysis in this use case provides an illustrative comparison of the economic and emissions differences between meeting the routes outlined above with a diesel bus as compared to an electric bus, but more analysis is required to demonstrate the real-world feasibility of these routes.

Table 2. Bus Route, Fuel Price, and Emissions Factor Assumptions

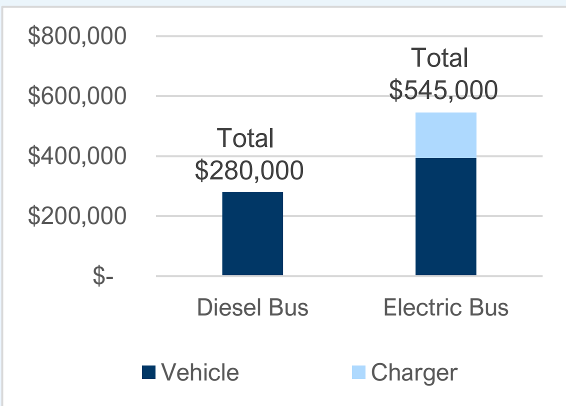
Metric	Assumption
Local route roundtrip distance (km)	116
Thunder bay route roundtrip distance (km)	276
Annual distance driven (km)	149,300
Diesel price ($/L)	See appendix (varies by study year)
Electricity price ($/kWh)	See appendix (varies by study year)
Emissions factor	See appendix (varies by study year)

Results

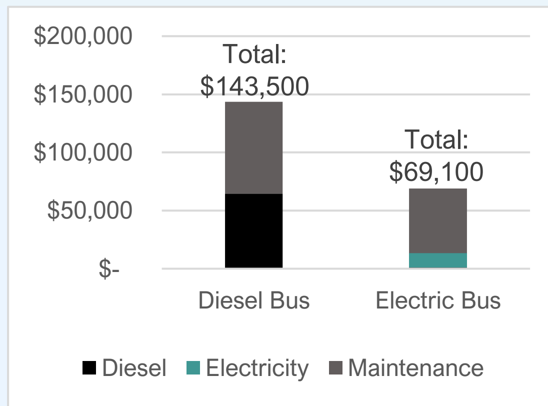
Economic Analysis

Although the upfront cost of the electric bus and charging infrastructure are considerably higher than the upfront investment of the diesel bus, the electric bus is estimated to save $257,800 over the assumed ten years of ownership on a total cost of ownership basis (accounting for upfront, fuel, and maintenance costs). Financing could help to offset initial capital requirements, and incentives or government funding may be available to reduce overall community investment.

Upfront Costs



Annual Costs

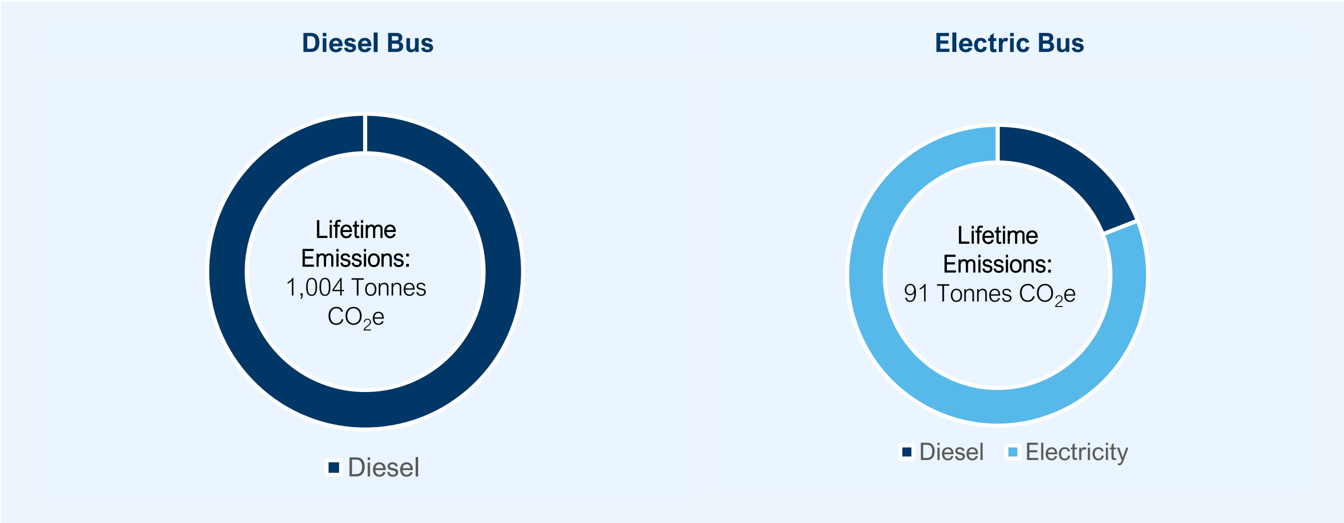


Net Present Value of Lifetime Costs

Diesel Bus	Electric Bus	Electric Bus Savings
$1,288,100	$1,030,300	**$257,800**

Emissions Analysis

The electric bus is estimated to emit approximately 90% fewer emissions of a comparable diesel bus during the assumed years of ownership (a reduction of approximately 913 Tonnes of CO_2e). Of the electric bus emissions, approximately 20% are from the diesel-fired heater, while the remaining 80% are from the electricity used to charge the bus.



Alternate Scenario: Local Route Only

To illustrate the benefits of right sizing a bus for a specific drive cycle, we analyzed an alternate scenario that assumes that the bus only drives the local route. The local route is assumed to be completed four times per day Monday through Saturday (as opposed to Monday through Friday under the main scenario). By eliminating the long-distance trip to Thunder Bay, the bus can be outfitted with a smaller battery, reducing upfront costs. In addition, only a single charger is needed, further reducing upfront costs.

Updated assumptions are outlined below. Assumptions not listed remain the same as the main scenario.

Table 3. Bus Vehicle and Charger Assumptions: Alternate Scenario

<table>
<tr><th>Vehicle Type</th><th>Metric Type</th><th>Metric</th><th>Assumption</th></tr>
<tr><td rowspan="8">Electric bus</td><td rowspan="4">Technical specification</td><td>Battery Size (kWh)</td><td>120</td></tr>
<tr><td>Approximate Range (km)</td><td>250</td></tr>
<tr><td>Charger power (kW)</td><td>100</td></tr>
<tr><td>Number of chargers per bus</td><td>1</td></tr>
<tr><td rowspan="4">Cost</td><td>Upfront cost (vehicle)</td><td>$376,800</td></tr>
<tr><td>Upfront cost incentive</td><td>$0</td></tr>
<tr><td>Upfront and installation cost (2 chargers)</td><td>$100,000</td></tr>
<tr><td>Total electric bus upfront cost (vehicle and chargers)</td><td>$476,800</td></tr>
</table>

In addition to the assumptions above, the bus efficiencies are also adjusted for this scenario. The additional stops and starts along the local route reduce the diesel bus efficiency. The opposite is true for the electric bus, however – the electric bus efficiency actually increases with additional stops and starts thanks to the vehicle's regenerative braking, which recaptures kinetic energy lost from slowing the vehicle and stores it in the vehicle's battery for use (rather than being lost as heat, as is the case for internal combustion engine vehicle friction-based braking systems).

The electric bus becomes more economically favourable under this scenario, realizing $619,600 in lifetime savings. Although the bus drives fewer kilometers, emissions savings are also greater thanks to the increased electric bus efficiency and decreased diesel bus efficiency, reaching 1,557 Tonnes CO_2e over the assumed years of ownership.

Table 4. Bus Economic and Emissions Savings: Alternate Scenario

Scenario	NPV of Electric Bus Savings	Emissions Savings
Main Scenario	$257,800	913 Tonnes CO_2e
Alternate Scenario	$619,600	1,557 Tonnes CO_2e

Next Steps for the Community

- Bus service feasibility study, including an assessment of expected ridership, detailed route planning, and an analysis of the ability of the service to provide attractive employment opportunities.
- Identification of financing and funding opportunities to support the service.
- Vehicle selection and purchase and vehicle charger selection, purchase and install, with bus and charging sizing informed by the results of the feasibility study and available funding.

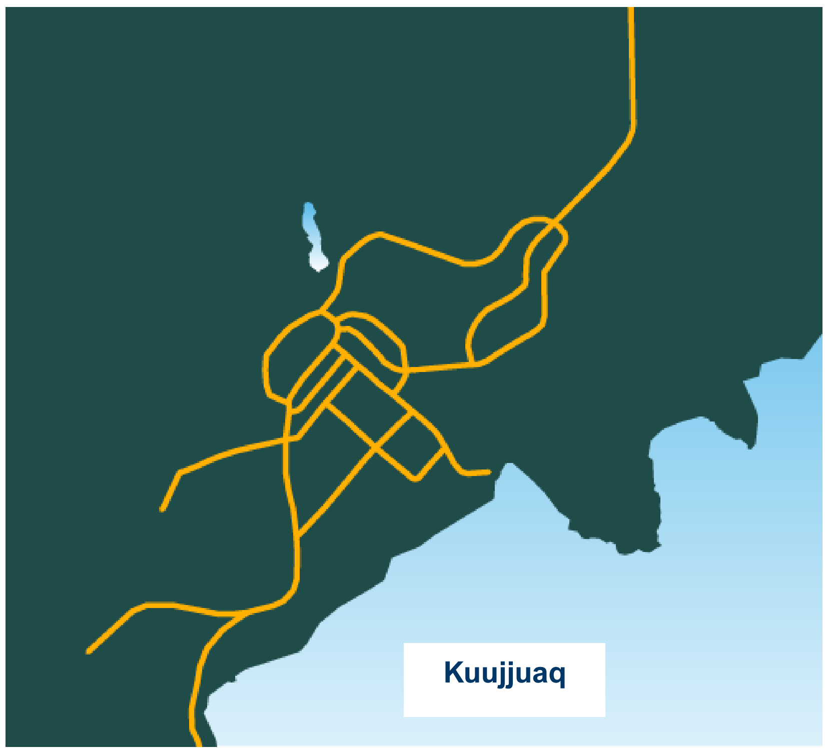
Learnings for Other Communities

- **Buses are promising EV opportunities in many communities** - their frequent use and predictable drive cycles often result in clear economic savings (even without incentives).
- **When possible, right-size battery and charger investments to bus use case,** typically choosing between higher investment in a bus with a larger battery paired with a lower power charger versus a bus with a smaller battery paired with a higher power charger.

3.2 – Kuujjuaq Water Truck (QC)

Kuujjuaq is a small remote community in the Nunavik region of Quebec, situated near Ungava Bay. The municipality has a fleet of medium and heavy-duty diesel vehicles used for snow clearing, garbage collection, sewage removal, water delivery, and various other services. This analysis focuses on trucks used for water delivery. Kuujjuaq does not currently have a centralized underground water distribution system and private water wells are uncommon due to high drilling costs. Instead, potable water is trucked to homes and businesses nearly every day of the week. The trucks travel to and from a nearby water treatment facility and storage tanks in the community's homes and businesses, running for an average of 13 hours each day.

Figure 3. Community of Kuujjuaq



The community has a remote electricity grid, and currently all electricity is produced by diesel generators. As noted in the Reducing Emissions and Integrating Renewables section, we expect little to no emissions benefits from switching to EVs when they are charged using electricity produced by diesel generators like those that power Kuujjuaq. This is demonstrated in our main scenario, which uses an average remote diesel grid emissions factor. In the alternate scenario we assume that some portion of charging is expected to come from renewables.

Although less developed than the bus and light-duty vehicle markets, there are an increasing number of electrified medium and heavy-duty vehicles options. Especially in applications that do not require particularly long driving distances, the efficiency and low operating costs of EV options show promising economics all the way up to heavy duty freight trucks and refuse trucks. Governments around the world are increasingly shifting their focus to reducing GHG emissions from medium- and heavy-duty fleets, which make up a significant portion of overall transportation-related GHG emissions, and are increasingly expected to offer incentives and policies that encourage fleets to electrify.

Similar to buses, electrified heavy-duty vehicle model specifications depend on the vehicle duty-cycle. In this case, the water trucks are assumed to have high annual kilometers due to their frequent use but to stay local (and to drive a limited number of kilometers) on any given day. This duty cycle is well-aligned with a smaller battery size and lower power charger. The range assumed for this use case is thought to be adequate for a single day's use. At the end of the day, it's assumed that the truck returns to the parking depot where it will be charged overnight in preparation for the following day's shift. Although diesel water trucks are currently used in the community, actual use data was limited. Instead, the project team developed assumptions using available data from industry studies along with professional judgement.

Kuujjuaq experiences extreme cold temperatures, which would have the effect of greatly reducing EV range. Using fossil fuel-fired heaters in buses and medium and heavy-duty vehicles in the community will mitigate the range reductions that would result from using an electricity-powered heater to warm the cab. For this use case, we assume the water truck includes a diesel-powered heater. The fuel cost and emissions of running this heater are also included in this analysis.

Vehicle and Charger Specification Assumptions

Assumptions for the electric water truck and diesel water truck are included below. All vehicles must be shipped to the community on a sealift, bearing additional upfront costs. Because these shipping costs are estimated to be the same for both the electric and the diesel truck, they are not included in this analysis.

Table 5. Water Truck Vehicle and Charger Assumptions: Main Scenario

Vehicle Type	Metric Type	Metric	Assumption
Electric water truck	**Technical specification**	Battery Size (kWh)	160
		Approximate Range (km)	155
		Charger power (kW)	50
		Number of chargers per truck	1
	Cost	Upfront cost (vehicle)	$409,300
		Upfront cost incentive	$0[7]
		Upfront and installation cost (1 charger)	$60,000
		Total electric water truck upfront cost (vehicle and chargers)	**$469,300**
Diesel water truck	**Cost**	Upfront cost (vehicle)	$218,500
All	**Other**	Years of ownership	10

A charger that delivers 50 kW of power can fully charge the bus' 160 kWh battery in 3 to 3.5 hours. For the purpose of this analysis, a single charger is required for each electric truck.

[7] In the future, the electric water truck may be eligible for Quebec's *Programme d'aide Écocamionnage*, offered by the Ministry of Transport. The program previously provided rebates of $75,000 or up 50% of the incremental cost of an electric truck compared to a diesel equivalent. The past program concluded in March 2021, but a new version of the program is currently under development. Additional information on current funding available across the country is included in the 'Funding Opportunities' chapter of this report.

Other Assumptions

The water truck travels between the water treatment facility and homes and businesses throughout the community, covering an estimated 100 km per day, approximately 36,000 km per year.

Table 6. Water Truck Route, Fuel Price, and Emissions Factor Assumptions

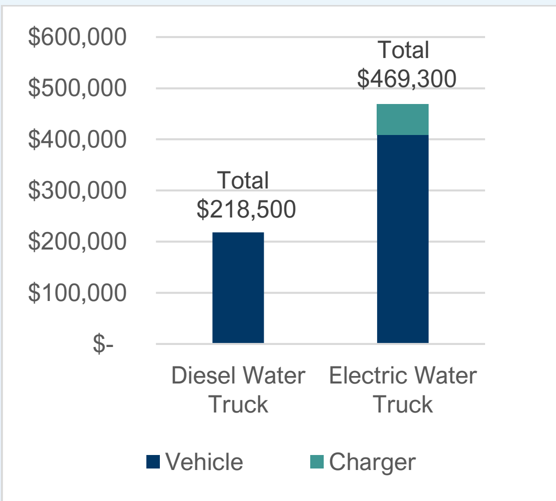
Metric	Assumption
Longest distance driven (km)	100
Annual distance driven (km)	36,000
Diesel price ($/L)	See appendix (varies by study year)
Electricity price ($/kWh)	See appendix (varies by study year)
Emissions factor	See appendix (varies by study year)

Results

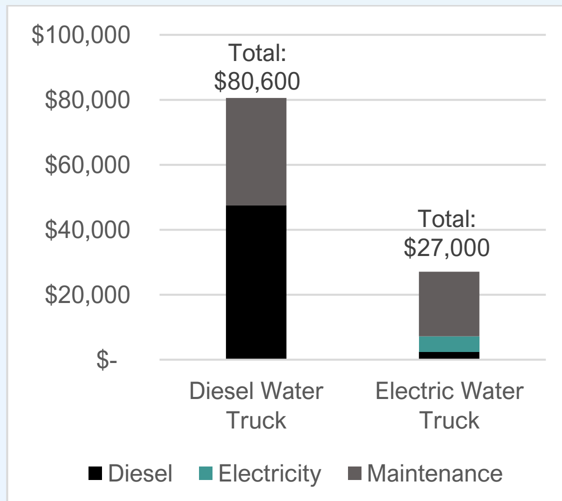
Economic Analysis

Although the upfront cost of the electric water truck and charging infrastructure is close to double that of the diesel water truck, considerable economic savings – $125,200 – are estimated over the lifetime of the vehicle due to reduced maintenance and fuel costs. Financing could help to offset initial capital requirements, and incentives or government funding may be available to reduce overall community investment.

Upfront Costs



Annual Costs



Net Present Value of Lifetime Costs

$784,400 Diesel Water Truck	$659,200 Electric Water Truck	**$125,200 Electric Savings**

Emissions Analysis

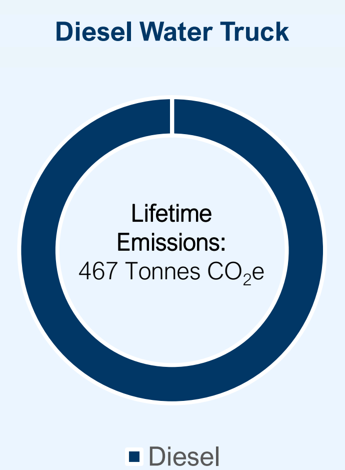
Below, we estimate the emissions savings using an average diesel grid emissions factor (see appendix). Although some emissions savings are estimated for the electric water truck, actual savings will be highly dependant on the actual emissions factor of Kuujjuaq's grid *and* on the specific vehicle use case. Using the current assumptions, the water truck appears to be an especially promising use case for EVs because:

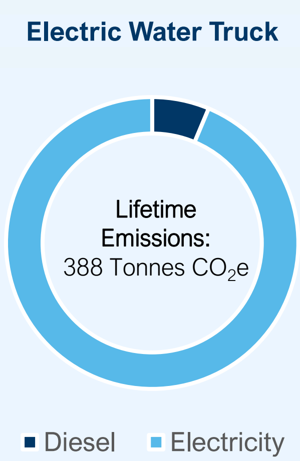
a) The truck spends a lot of time spent idling (when a diesel truck will burn a considerable amount of fuel, but an EV will use little energy),

b) The truck does a lot of low-speed driving (when the diesel truck will operate at a lower than optimal efficiency), and

c) The truck does a lot of stop-and-go driving (when the EV will benefit from regenerative braking).

The results should not be extrapolated to conclude that EVs charged with a diesel grid will provide emissions savings in all cases – in reality it will be case-specific. Of the electric water truck emissions, 94% come from electricity used to charge the vehicle and 6% are from the diesel-fired cabin heater.





Alternate Scenario: Energy from Renewables

In the alternate scenario, all vehicle and charger specification assumptions remain the same. Instead of all electricity used to charge the electric water truck coming from a diesel-powered grid, however, a portion of the energy is assumed to come from renewables. In this case, we assume a 25-kW solar panel is installed, providing approximately 60% of the energy used by the truck on an annual basis. Because the truck is assumed to charge overnight, a battery system would also be required. Alternatively, renewables that generate energy overnight (such as wind) may be used to provide a portion of the energy with no battery system, although charging would need to be more actively managed. The costs of the renewable system is not estimated for this calculation given variation in costs by location and total system size. To calculate the economic implications of installing a solar and storage system, the system upfront capital costs can be subtracted from the NPV of lifetime economic savings. For example, If a solar and storage system were to cost $100,000, the electric water truck savings would be $125,200-$100,000=$25,200.

Emissions savings grow considerably under this scenario, reaching 297 Tonnes CO_2e over the assumed 10 years of ownership. The more energy used by the truck that can be provided by renewables, the more that these emissions savings would grow.

Table 7. Water Truck Economic and Emissions Savings: Alternate Scenario

Scenario	NPV of Lifetime Economic Savings	Lifetime Emissions Savings
Main Scenario	$125,200	80 Tonnes CO_2e
Alternate Scenario	$125,200	297 Tonnes CO_2e

Next Steps for the Community

- A more detailed assessment should be completed using actual diesel water truck fuel use, maintenance costs, and purchase prices. Due to the need to transport vehicles into the community on a sealift, actual upfront costs will be higher.
- Should the community invest in electric water trucks, the mechanics staffed by the municipality to maintain and repair service vehicles will require additional training specific to EV maintenance and repair. Some investment in EV-specific servicing and repair equipment would also be required.

Learnings for Other Communities

- **In cold climates, fossil fuel heaters can extend range.** Although not available for light-duty vehicles, bus, medium and heavy-duty vehicle manufacturers increasingly offer this as an option.
- **There are other benefits beyond those quantified here.** One example includes reduction in local air pollution from diesel vehicle exhaust near homes and businesses, which can result in improved health outcomes for community members.

3.3 – Rocky Point, Morell, and Scotchford Car Sharing Program (PEI)

The Abegweit First Nation is a Mi'kmaq Band with roots in Prince Edward Island. Members live in the communities of Rocky Point, Morell, and Scotchford – which are the focus of this analysis - among other locations. The three communities are geographically spread across PEI, and members frequently travel between them. In particular, members from Rocky Point and Morell often travel to Scotchford to access medical facilities, grocery stores, education programs, and other services. A number of licensed drivers in the communities do not currently own vehicles and have trouble accessing transportation, however. To serve them, the First Nation is interested in establishing a light-duty EV car sharing program. All the communities are rural and are connected to the PEI provincial grid. Data about the potential use of the car sharing program by members was not collected, so assumptions below are hypothetical.

There are already many light-duty EV models sold in Canada today. EVs often include premium vehicle features such as (e.g. touch screens, skylights, etc.). As such, to be fully comparable, a gasoline vehicle with these more premium features was selected although less expensive gasoline vehicles are available for purchase.

Currently, PEI residents can enjoy up to $10,000 in federal and provincial incentives for full battery electric vehicles ($5,000 for plug-in hybrid vehicles). These incentives were included in the analysis, however results are also provided in an alternate scenario that highlight how the economics would change should the incentives be removed.

Figure 4. Communities of Rocky Point, Scotchford, and Morell, Including One-way Distances Between Communities in Kilometers

Vehicle and Vehicle Use Assumptions

Key assumptions for the electric car and gasoline car are included below.

Table 8. Car Vehicle and Charger Assumptions: Main Scenario

<table>
<tr><th>Vehicle Type</th><th>Metric Type</th><th>Metric</th><th>Assumption</th></tr>
<tr><td rowspan="8">Electric car</td><td rowspan="4">Technical specification</td><td>Battery Size (kWh)</td><td>64</td></tr>
<tr><td>Approximate Range (km)</td><td>285</td></tr>
<tr><td>Charger power (kW)</td><td>7</td></tr>
<tr><td>Number of chargers per truck</td><td>1</td></tr>
<tr><td rowspan="4">Cost</td><td>Upfront cost (vehicle)</td><td>$38,200</td></tr>
<tr><td>Upfront cost incentive</td><td>$10,000[8]</td></tr>
<tr><td>Upfront and installation cost (1 charger)</td><td>$10,000</td></tr>
<tr><td>Total electric car upfront cost (vehicle and chargers)</td><td>$38,200</td></tr>
<tr><td>Gasoline car</td><td>Cost</td><td>Upfront cost (vehicle)</td><td>$24,500</td></tr>
<tr><td>All</td><td>Other</td><td>Years of ownership</td><td>10</td></tr>
</table>

A level two charger delivers approximately 7 kW of power and can fully charge the car's 64 kWh battery in 9 hours, designed to be charged over night. A single level two charger per vehicle is estimated to be sufficient.

Other Assumptions

The analysis assumes that the vehicle is used by the same driver for the duration of the time it is away from its home dock. On average, a roundtrip between any two given communities is estimated to be approximately 85 kilometers. The car is estimated to drive 31,000 km annually.

Table 9. Car Route, Fuel Price, and Emissions Factor Assumptions

Metric	Assumption
Average distance driven (km)	85
Annual distance driven (km)	31,000
Diesel price ($/L)	See appendix (varies by study year)
Electricity price ($/kWh)	See appendix (varies by study year)
Emissions factor	See appendix (varies by study year)

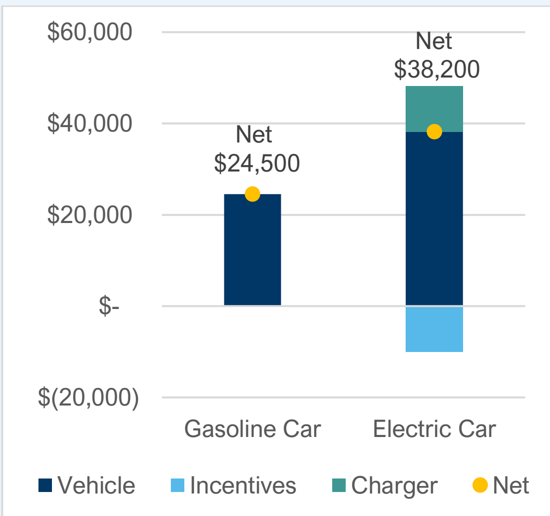
[8] Currently in PEI, light-duty BEVs are eligible for the PEI Universal EV Incentive program ($5,000) as well as the federal Incentives for Zero-Emission Vehicles (iZEV) program ($5,000). Additional information on current funding available across the country is included in the 'Funding Opportunities' chapter of this report.

Results

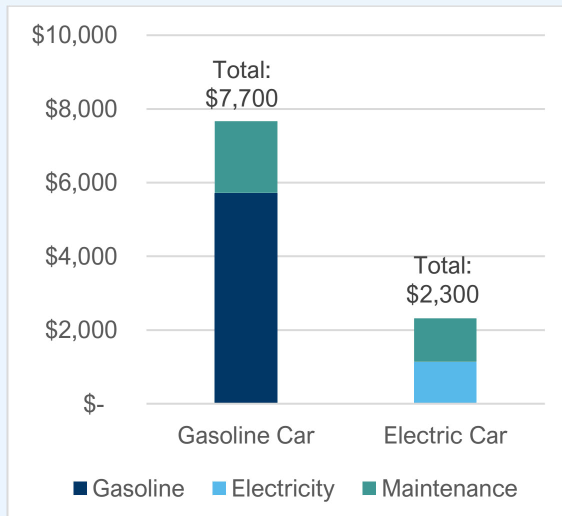
Economic Analysis

Even after incentives, the upfront cost of an electric vehicle and charging equipment is greater than a gasoline vehicle. Ownership and maintenance savings more than offset this difference, however, leading to an estimated $23,900 in savings per vehicle over the vehicle lifetime.

Upfront Costs



Annual Costs



Net Present Value of Lifetime Costs

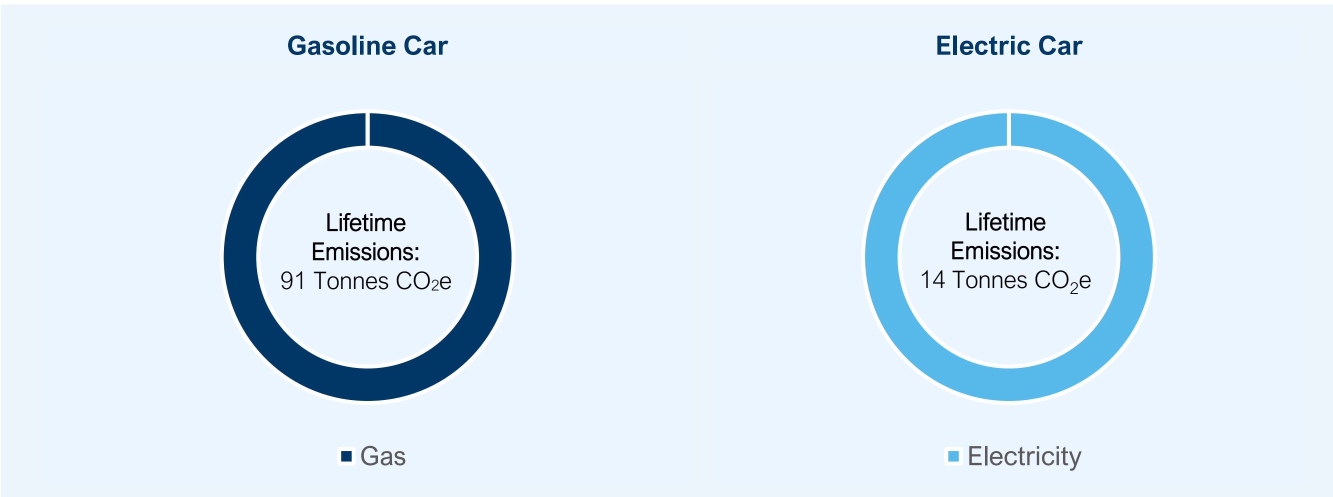
$78,400
Gasoline Car

$54,500
Electric car

$23,900
Electric Savings

Emissions Analysis

The electric car is estimated to have 85% fewer emissions (a reduction of 77 Tonnes of CO_2e over the assumed years of ownership). This analysis is based on the current emissions intensity of the PEI grid, however – reduction in this intensity (through additional consumption of renewable energy, for example) would further reduce electric vehicle emissions.



Alternate Scenario: No Incentives

Although incentives are currently in place, it is possible that incentive programs may be discontinued in the future. In this alternate scenario, all vehicle and other assumptions remain the same, but incentives are removed.

Even without incentives electric vehicles maintain an economic advantage, saving $13,900 over a gas vehicle over the assumed years of ownership.

Table 10. Car Economic and Emissions Savings: Alternate Scenario

Scenario	NPV of Electric Car Savings	Emissions Savings
Main Scenario	$23,900	77 Tonnes CO_2e
Alternate Scenario	$13,900	77 Tonnes CO_2e

Next Steps for the Community

- Survey of community members to gauge interest and estimate expected use.
- Vehicle and charger selection, purchase, and install.

Learnings for Other Communities

- **Car sharing represents a promising opportunity for EVs in many communities**. The high annual kilometers driven and the ability to set limits on how far vehicles travel allows communities to right-size batteries, selecting vehicles that will meet the needs of drivers without over-investing.
- **Similar to car sharing, light-duty fleet vehicles are another promising opportunity for EVs.** With their frequent usage and the ability to charge overnight using a lower power charger, vehicle economics for many fleet vehicles are expected to be similar to the car-sharing example featured here.
- **Incentives improve an already positive business case for many light-duty vehicle opportunities.** Although many EVs will have economic savings compared to internal combustion engine vehicles over their lifetime from reduced operations and maintenance costs, they remain more expensive upfront. Vehicle purchase incentives offset these upfront costs and improve overall economic savings.

4. Funding Opportunities

4.1 – Funding Opportunities

The table below includes a summary of EV-related funding available at the federal, provincial, and territorial level.

Table 11. EV-Related Funding Opportunities (Current as of November 2021)

Jurisdiction	Funding Organization	Program Name	Funding Type	Program Description	Relevant Links
Canada-wide	Transport Canada	Incentives for Zero-Emission Vehicles (iZEV) Program	Vehicle purchase incentive	Rebates to buy or lease new Zero Emission Vehicle (ZEV). Long-range vehicles eligible for up to $5,000, shorter-range vehicles eligible for up to $2,500.	Incentives for purchasing zero-emission vehicles
Canada-Wide	NRCan	Zero Emission Vehicle Infrastructure Program (ZEVIP)	Charging infrastructure	Cost-sharing contribution agreements for eligible charging infrastructure projects. The program targets multiple infrastructure streams (e.g. public places, on-street, workplaces, multi-unit residential buildings, commercial and public fleets). NRCan's contribution is limited to 50% of total project costs up to a maximum. Maximum varies by charger type and power output.	Zero Emission Vehicle Infrastructure Program
BC	CleanBC	Go Electric Passenger Vehicle Rebates	Vehicle purchase incentive	Rebates to buy or lease new Zero Emission Vehicle (ZEV). Long-range vehicles eligible for up to $3,000, shorter-range vehicles eligible for up to $1,500.	Go Electric Passenger Vehicle Rebate
BC	CleanBC	Go Electric Fleets Program	Fleet support	Rebates and technical support for B.C. registered companies, non-profit organizations, and public entities interested in transitioning fleets to ZEVs. Support ranges from training sessions and support from a ZEV fleet advisor to rebates for facilitiy assessments, electrical infrastructure, and charging station purchase and installation.	Go Electric Fleets

BC	CleanBC, BC Hydro, FortisBC	Go Electric Public Charger Program	Public charging infrastructure	Rebates of $20,000 per <50 kW DCFC, to up to $130,000 per >100 kW DCFC are available for Indigenous communities. Additional funding is available for Level 2 chargers. Applicants may be a business, not-for-profit, local government, Indigenous community, or public sector organization located and operating in B.C. Some geographical restrictions apply. Note: This program is not stackable with the federal ZEVIP program - applicants should select the program that best suits their needs.	Public Charger Program
BC	CleanBC, BC Hydro, FortisBC	Go Electric Single Family Home Charger Rebate	Home Charging Infrastructure	Rebate of up to 50% of the purchase and installation costs of an eligible Level 2 EV charger to a maximum of $350 for single family homes. Indigenous community members are eligible for enhanced rebate offers - up to 75% of eligible costs up to $750.	Home Charger Rebate
BC	CleanBC, BC Hydro, FortisBC	Go Electric Apartment and Condo Building Charger Rebate	Home Charging Infrastructure	Rebates for apartment and condo buildings to support the creation of an EV-ready plan (up to $3,000), to install required electrical infrastructure (up to $600 per parking space to a maximum of $80,000), and to purchase and install level 2 networked chargers (up to $2,000 per parking space to a maximum of $14,000). Enhanced rebates are available for Indigenous communities and select municipalities.	Rebates for home and workplaces
BC	CleanBC, BC Hydro, FortisBC	Go Electric Workplace Charger Rebate	Workplace Charging Infrastructure	Rebates for workplaces of up to $2,000 per level 2 networked charger for employee use, to a maximum of $14,000. Enhanced rebates are available for Indigenous communities and select municipalities.	
BC	Plug In BC	Specialty Use Vehicle Incentive	Vehicle purchase incentive	Rebates of up to $100,000 are available for a variety of speciality use vehicle types (motorcycles, carbon e-bikes, medium and heavy-duty vehicles, and more).	Specialty Use Vehicle Incentive

AB	Municipal Climate Change Action Centre	Electric Vehicles for Municipalities Program	Incentive for feasibility studies, vehicles, and charging stations	Rebates available to municipalities in Alberta for feasibility studies (50% of cost to a maximum of $6,000), non-road electric vehicles (30% of cost to a maximum of $50,000 per vehicle), fully electric vehicle and long-range plug-In hybrid electric vehicle ($14,000), and shorter-range plug-in hybrid electric vehicle ($7,000), and medium and heavy-duty fully electric and plug-in hybrid vehicles (30% of costs up to $300,000 per vehicle). Rebates for charging stations will also be available, but program is currently under development.	Electric Vehicles for Municipalities Program
ON	Plug 'N Drive	Used EV Incentive	Vehicle purchase incentive	Rebates of $1,000 for the purchase of a used fully-electric car.	Used Electric Vehicle Incentive
ON	Plug 'N Drive	Scrappage Incentive	Vehicle purchase incentive	Rebates of $1,000 for Ontario drivers who recycle their personal-use gas vehicle towards the purchase of a used fully-electric car.	Used Electric Vehicle Scrappage
QC	Government of Quebec	Roulez Vert New Vehicle Purchase Incentive	Vehicle purchase incentive	Rebates of up to $8,000 for the purchase or lease of a new electric vehicle.	New Vehicle Rebate Program
QC	Government of Quebec	Roulez Vert Used Vehicle Purchase Incentive	Vehicle purchase incentive	Rebates of up to $4,000 for the purchase or lease of a used electric vehicle.	Used vehicle rebate
QC	Government of Quebec	Roulez Vert Home Charging Incentive	Home Charging Infrastructure	Rebates of up to $600 for the purchase and installation of a 240-volt home charging station.	Home charging station rebate
QC	Government of Quebec	Roulez Vert Multi-Residential Charging Incentive	Home Charging Infrastructure	Rebates of up to 50% of eligible costs for apartment and condo buildings to purchase and install EV charging stations in parking stalls. Maximum of $5,000 per stall and $25,000 per building.	Multi-unit building charging station rebate

QC	Government of Quebec	Ecocamionnage program	Vehicle purchase incentive	Rebates of up to $75,000 or up to 50% of the incremental cost of an electric truck compared to a diesel equivalent. *Current program ended March 2021, however a new version of the program is under development.*	Programme d'aide Écocamionnage
QC	Government of Quebec	Transportez Vert	Vehicle purchase incentive	Rebates of up to $100,000 or up to 50% of the incremental cost of an electric bus compared to a diesel/gas equivalent	Transportez vert
NB	NB Power	Plug-IN NB New Electric Vehicle Rebate	Vehicle purchase incentive	Rebates of up to $5,000 are available towards the purchase of a new fully electric vehicle or long-range hybrid and up to $2,500 toward the purchase of a new short range plug-in hybrid.	Plug-In NB
NB	NB Power	Plug-In NB Used Electric Vehicle Rebate	Vehicle purchase incentive	Rebates of up to $2,500 are available towards the purchase of a used fully electric vehicle and up to $1,000 toward the purchase of a used plug-in hybrid.	Plug-In NB
NB	NB Power	Home Charging Station Rebate	Home Charging Infrastructure	Rebates of 50% of the purchase and installation cost of a home charging station are available, up to $750.	Plug-In NB
NS	EV Assist Nova Scotia	Electrify Nova Scotia Rebate Program	Vehicle purchase incentive	Rebates of up to $3,000 are available towards the purchase of a new fully electric vehicle, and $2,000 for a used fully electric vehicle. Rebates of up to $3,000 are available for new long-range plug-in hybrid vehicles, and $1,000 for used plug-in hybrid vehicles.	EV Assist Rebates
PEI	The Government of Prince Edward Island	PEI Universal EV Incentive	Vehicle purchase incentive, Home charging infrastructure	Rebates of up to $5,000 are available towards the purchase of a new or used fully electric vehicle, and $2,500 for a new or used plug-in hybrid. Those who receive a rebate will also receive a free level 2 charger (one per household).	PEI Universal EV Incentive

NL	NL Hydro	EV Rebate Program	Vehicle purchase incentive	Rebates of $2,500 are available for the purchase or lease of fully electric vehicles	Electric Vehicle Rebate Program
YT	Yukon Government	ZEV Rebate Program	Vehicle purchase incentive	Rebates of $5,000 for purchase or lease of new fully electric vehicles, hydrogen fuel cell vehicles, or plug-in electric vehicles with a minimum battery capacity of 15 kWh. Rebate of $3,000 for purchase or lease of new plug-in hybrid electric vehicle with a battery capacity less than 15 kWh.	Zero-Emission Vehicle Rebate
NT	Arctic Energy Alliance	EV and Home Charging Infrastructure Rebate Program	Vehicle and charging infrastructure purchase incentive	Rebates of $5,000 are available towards the purchase of a new fully electric or plug-in hybrid vehicle. Rebates of $500 for a level 2 charger. *Rebates available for current year have been spoken for and new applications will be placed on a waiting list.*	Electric Vehicle Rebates

5. Vehicle Availability

5.1 – Vehicle Availability

The table below outlines the availability of electrified vehicle models. This only includes an assessment of whether EVs are being manufactured and are for sale somewhere in Canada – local availability will vary.

Table 12. Summary of Vehicle Availability

Vehicle Category	Vehicle	Availability of Electrified Models
Off-road vehicle	Snowmobile	None currently available. Some models expected to be available as of 2022. Wider availability expected by 2025.
	Quad	Limited availability with limited performance. Higher performance models expected to be available as of 2022. Wider availability expected by 2025.
	Side-by-side	Limited availability with limited performance. Higher performance models expected to be available as of 2022. Wider availability expected by 2025.
Light-duty vehicle	Car	More than 30 models available (combination of BEV and PHEVs).
	SUV	Limited but growing availability of BEV and PHEV models, with several new models introduced in 2021.
	Pick-up truck	None currently available. Some models expected to be available as of 2022. Wider availability expected by 2025.
Medium-duty truck	Delivery vehicles	Limited but growing availability of BEV options.
	Medium vocational trucks	Limited availability of BEV options with a focus on select vocational segments (e.g. utility bucket trucks).
Heavy-duty truck	Short-haul freight	Limited but growing availability of BEV options for both straight-trucks and semi-trucks, with several models introduced in 2021.
	Long-haul freight	No availability of long-range (e.g. 500km+) BEV options for straight-trucks or semi-trucks. First option expected in 2022/23.
	Heavy vocational trucks	Limited availability of BEV options with a focus on select vocational segments (e.g. refuse collection trucks).
Bus	Transit	Many BEV models available in various configurations.
	Coach	Limited availability with first BEV models introduced in 2021.
	School	Many BEV models available, primarily Type C school buses.

6. Identifying Opportunities for EVs

6.1 – EV Opportunity Identification Checklist

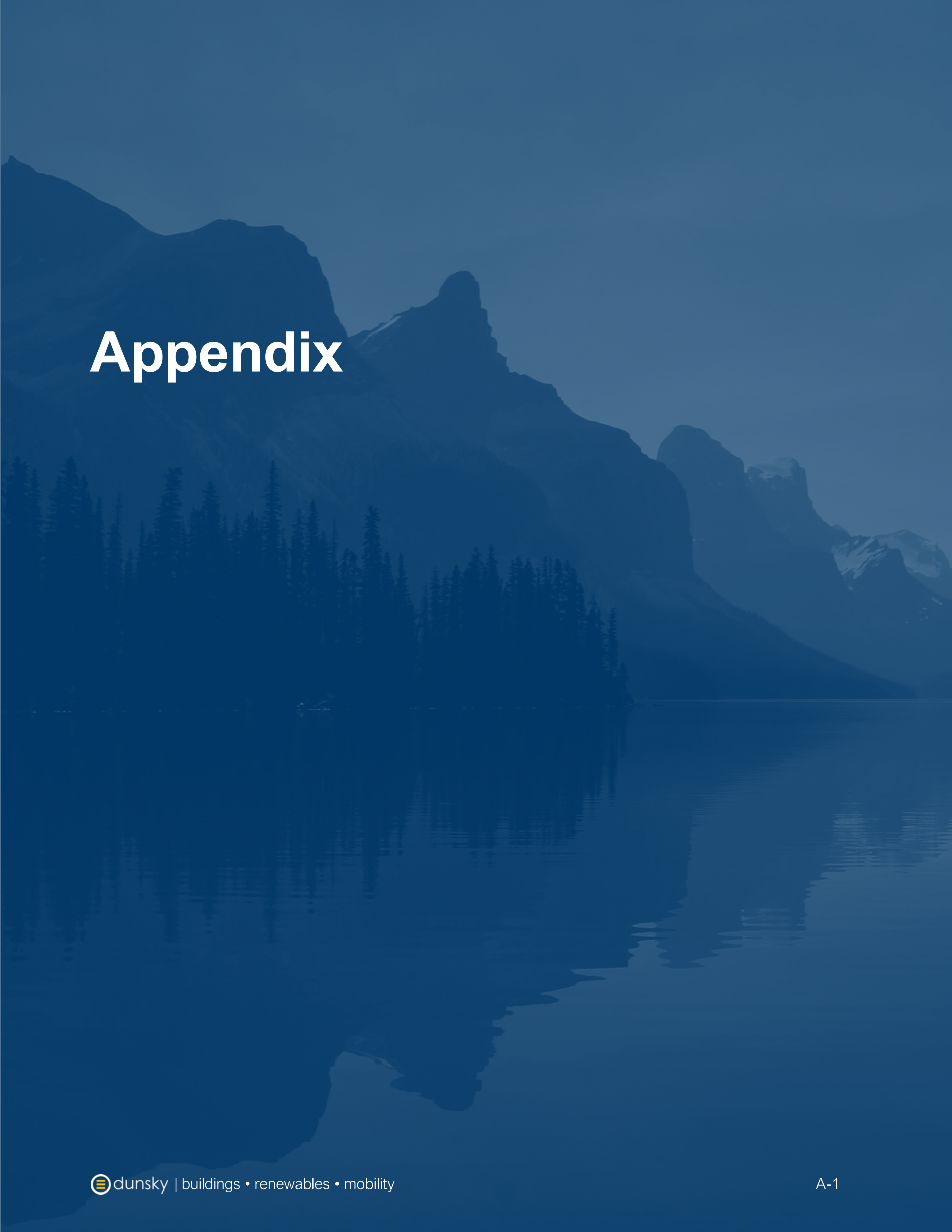
When rural and remote communities are assessing opportunities for EVs, they should keep the following checklist in mind:

- ✓ **Emissions impacts:** If using a remote grid to charge, will a portion of the energy come from renewables or from diesel generation that would otherwise go to waste, either now or in the near future (e.g. if renewable generation is planned)?
- ✓ **Economics:** Do vehicles have mid-to-high annual kilometers?
- ✓ **Model availability:** Are there electrified models available for the type of vehicle of interest?
- ✓ **Range adequacy:** Will the vehicle range go as far as needed single charge (even in cold conditions)? Alternatively, are there charging stations along the routes travelled that could be used?

If 'yes' to all, EVs are expected to be beneficial, offering cost and emissions savings while meeting transportation needs.

6.2 – Next Steps for Communities

- Identify opportunities for EVs using checklist above
- Review available funding opportunities
- Assess training requirements (e.g. for mechanics)
- Consider a EV-first procurement policy for fleets (e.g. for public services like schools, utilities, health service, etc)



Appendix

Other Assumptions: Red Rock Indian Band Member Bus Service

Electricity Prices[9]
Same for all scenarios

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
$/kWh	$0.107	$0.107	$0.108	$0.107	$0.109	$0.111	$0.112	$0.113	$0.114	$0.114

Diesel Prices[10]
Same for all scenarios

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
$/L	$1.46	$1.59	$1.66	$1.73	$1.80	$1.83	$1.87	$1.91	$1.94	$1.94

Grid Emissions Factors[11]
Same for all scenarios

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
g CO_2e /kWh	45	63	53	82	75	72	67	73	71	84

Vehicle Efficiency

Scenario	Diesel Bus Efficiency (L/km)[12]	Electric Bus Efficiency (kWh/km)[13]
Main Scenario	0.25	0.48
Alternate Scenario	0.42	0.48

Vehicle Operations and Maintenance Costs[13]

Scenario	Diesel Bus ($/km)	Electric Bus ($/km)
All Scenarios	$0.53	$0.37

Discount Rate Used for Net-Present Value Calculation: 7% (same for all scenarios)

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[9] Current rates sourced from Ontario Energy Board. Trend over study period taken from Canada's Energy Future 2021 Study, Commercial Electricity Rates (Evolving Scenario). Carbon pricing assumptions were further adjusted to reflect the updated Minimum National Pollution Price Schedule (2023-2030), reaching $170/tonne CO_2e by 2030.

[10] Current rates sourced from Government of Ontario motor fuel prices. Trend over study period taken from Canada's Energy Future 2021 Study, Transportation Diesel Prices (Evolving Scenario). Carbon pricing assumptions were further adjusted to reflect the updated Minimum National Pollution Price Schedule (2023-2030), reaching $170/tonne CO_2e by 2030.

[11] The Atmospheric Fund. (2019). A Clearer View on Ontario's Emissions: A Clearer View on Ontario's Emissions. Available online.

[12] PenState College of Engineering. (2016). Federal Transit Bus Test, Vicinity 30 Foot Test. Available online.

[13] California Air Resources Board. (2020). Advanced Clean Fleets: Cost Workgroup Cost Data and Methodology Discussion Draft. Available online.

Other Assumptions: Kuujjuaq Water Truck

Electricity Prices[14]

Same for all scenarios

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
$/kWh	$0.099	$0.100	$0.100	$0.101	$0.102	$0.103	$0.103	$0.103	$0.104	$0.105

Diesel Prices[15]

Same for all scenarios

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
$/L	$2.33	$2.53	$2.64	$2.74	$2.84	$2.91	$2.95	$2.98	$3.00	$3.00

Emissions Factors[16]

Scenario	g CO_2e/kWh
Main Scenario (diesel generator grid)	787
Alternate Scenario (diesel generator grid + solar)	315

Vehicle Efficiency[17]

Scenario	Diesel Water Truck Efficiency (L/km)	Electric Water Truck Efficiency (kWh/km)
All Scenarios	0.31	1.04

Vehicle Operations and Maintenance Costs[17]

Scenario	Diesel Bus ($/km)	Electric Bus ($/km)
All Scenarios	$0.68	$0.48

Discount Rate Used for Net-Present Value Calculation: 7% (same for all scenarios)

[14] Current rates sourced from Hydro Quebec (Business rates north of the 53rd parallel). Trend over study period taken from Canada's Energy Future 2021 Study, Commercial Electricity Rates (Evolving Scenario). Carbon pricing assumptions were further adjusted to reflect the updated Minimum National Pollution Price Schedule (2023-2030), reaching $170/tonne CO_2e by 2030.

[15] Current rates provided by personal contact. Trend over study period taken from Canada's Energy Future 2021 Study, Transportation Diesel Prices (Evolving Scenario). Carbon pricing assumptions were further adjusted to reflect the updated Minimum National Pollution Price Schedule (2023-2030), reaching $170/tonne CO_2e by 2030.

[16] Diesel generator grid value taken from Environment and Climate Change Canada's Greenhouse Gas Inventory, isolated diesel grid value. Diesel generator grid + solar value estimated assuming 60% of energy to charge vehicle from solar generation.

[17] California Air Resources Board. (2020). Advanced Clean Fleets: Cost Workgroup Cost Data and Methodology Discussion Draft. Available online.

Other Assumptions: Rocky Point, Morell, and Scotchford Car Sharing Program

Electricity Prices[18]

Same for all scenarios

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
$/kWh	$0.152	$0.155	$0.157	$0.161	$0.164	$0.167	$0.169	$0.172	$0.175	$0.175

Gasoline Prices[19]

Same for all scenarios

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
$/L	$1.35	$1.38	$1.41	$1.45	$1.48	$1.51	$1.54	$1.58	$1.62	$1.61

Grid Emissions Factors[20]

Scenario	g CO_2e/kWh
All Scenarios	200

Vehicle Efficiency[21]

Scenario	Gasoline Car Efficiency (L/km)	Electric Car Efficiency (kWh/km)
All Scenarios	$0.12	$0.23

Vehicle Operations and Maintenance Costs[22]

Scenario	Gasoline Car ($/km)	Electric Car ($/km)
All Scenarios	$0.07	$0.04

Discount Rate Used for Net-Present Value Calculation: 7% (same for all scenarios)

[18] Current rates sourced from Maritime Electric. Trend over study period taken from Canada's Energy Future 2021 Study, Commercial Electricity Rates (Evolving Scenario). Carbon pricing assumptions were further adjusted to reflect the updated Minimum National Pollution Price Schedule (2023-2030), reaching $170/tonne CO_2e by 2030.
[19] Current rates sourced from Gas Buddy. Trend over study period taken from Canada's Energy Future 2021 Study, Transportation Gasoline Prices (Evolving Scenario). Carbon pricing assumptions were further adjusted to reflect the updated Minimum National Pollution Price Schedule (2023-2030), reaching $170/tonne CO_2e by 2030.
[20] Legislative Assembly Prince Edward Island Special Committee on Climate Change. (2021). First Report of the Second Session, Sixty-sixth General Assembly. Available online.
[21] Sourced from Dunsky Internal database, a compilation of light-duty vehicle efficiencies from various sources.
[22] Argonne National Laboratory. (2021). Comprehensive Total Cost of Ownership Quantification for Vehicles with Different Size Classes and Powertrains. Available online.

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