EV Batteries Value Proposition for Ontario's Electricity Grid and EV Owners

Summary Report

PLUG 'N DRIVE

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This report is based on the work of Strategic Policy Economics

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1 INTRODUCTION

With the advent of electric vehicles (EVs), it is becoming apparent that the purchase of an EV is more than just the purchase of a new car. What distinguishes EVs from traditional internal combustion engine (ICE) vehicles is that, in lieu of a gas tank, EVs contain large batteries that store electric energy when charged and use that stored electricity to power the vehicle when it is being driven.

Electricity system operators are increasingly looking to battery storage solutions to help manage the evolving complexities of the system and support the integration of distributed energy resources (DERs). However, battery storage is expected to remain costly for many years, delaying these benefits.

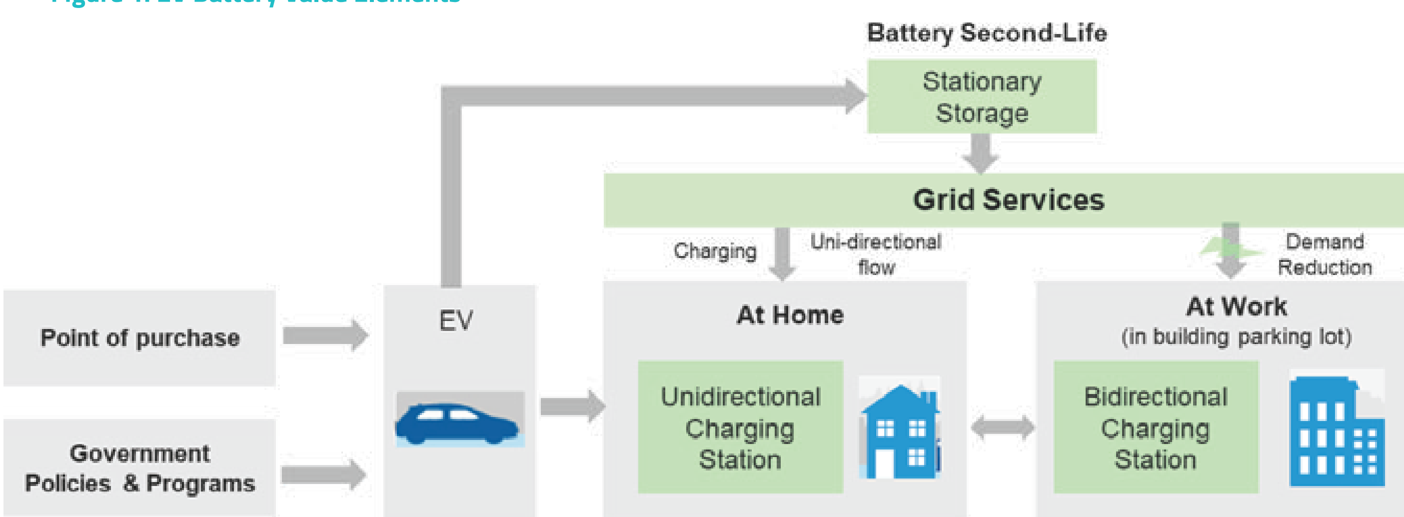
This report examines the potential for using EV batteries as electricity storage options to contribute to Ontario's electricity system, and assesses the value that EV owners may realize by supporting such use. Besides driving the car, EV batteries have two other potentially useful applications: mobile storage while they are installed in the vehicle, and second-life storage after the vehicle batteries are retired. These applications are illustrated in Figure 1.

This report found that the best way to capture the value of mobile storage from a large number of commuter vehicles is at workplaces categorized as Class B electricity consumers. EV batteries could deliver value to several stakeholders through these uses, including EV owners, workplace buildings, and the electricity system (loosely referred to in here as the grid).

Altogether, there is a potential for $38,000 in benefits per EV over its life, contributing to up to $129 million/year of benefits to the electricity system by 2035.

> *"EVs are not just cars, they are batteries that can store energy for Ontario's electricity system."*

Figure 1: EV Battery Value Elements



2 MOBILE STORAGE AND SECOND LIFE BATTERY USE

2.1 Mobile Storage

Mobile storage is the use of EV batteries to transfer energy from one location to another, and requires smart bidirectional chargers at the discharge locations. This report looks at one specific use of mobile storage, where EV owners charge their batteries overnight at home, and then, when parked at work, discharge their energy for use by the workplace building.

Most EVs should have half their capacity available for mobile storage. Analysis suggests that even after accommodating commuting distances, other daily driving needs, and range anxiety, the average EV should have 220 km or 36 kWh worth of battery capacity left over for mobile storage every day.

Ontario's electricity pricing structure allows EV owners to derive value from mobile storage. In Ontario, the province's regulated rate plan (RRP) time-of-use (TOU) pricing scheme for Class B customers makes electricity less expensive for households during the night when demand is low, as show in Figure 2.

For workplaces, Class B electricity charges come in two forms: smaller businesses could be billed under the RPP TOU rates; while larger businesses with more than 50 kW of peak demand, classified as general service (GS) customers, pay an average monthly GA rate plus the hourly Ontario electricity price (HOEP). Reliable mobile storage benefits are possible for workplace buildings regardless of their rate structure: TOU rates are fixed for the specified hours; the GA does not vary on an hourly or daily basis, but the smaller HOEP rises during the day.

> *"Commuters can leverage Class B rate structures to sell electricity to their workplace."*

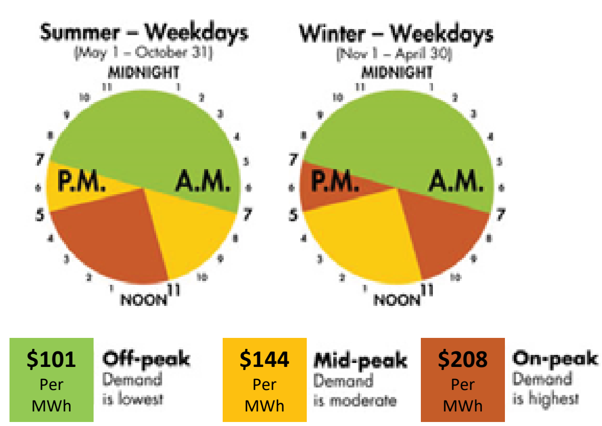
EV batteries' ability to charge and discharge at different electricity prices sets up the potential for price arbitrage. EV owners could charge their batteries with the inexpensive electricity available overnight and provide that low cost energy to the workplaces during the day. Workplace buildings could avoid high daytime prices by purchasing electricity from EVs parked onsite, and enjoy savings as a result.

> *"After EVs are no longer driven, their batteries can find a second life as storage for the electricity grid."*

2.2 Second Life Batteries

The grid could benefit from battery storage by storing nighttime energy and using it to displace daytime supplies from natural gas. However, the cost of storage is expected to remain prohibitively high. EV batteries will still have over 80% of their storage capacity after being driven for 13 years and providing mobile storage. These second life batteries (SLBs) could provide a low-cost energy storage option for the electricity grid. Some of the savings could be shared with EV owners such as in the form of a rebate on the initial cost of their batteries.

Figure 2: Ontario Regulated Rate Plan Time of Use Prices



3 VALUE TO EV OWNERS AND WORKPLACE BUILDINGS

Both EV owners and workplace buildings could benefit from using EV batteries for mobile storage. EV owners may also receive a rebate on their batteries from a second life as grid storage.

3.1 Value to EV Owners

EV owners could derive value from providing mobile storage services and selling their used batteries for second life applications.

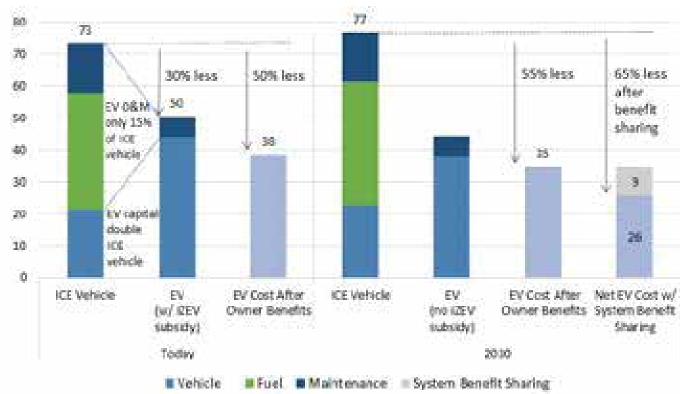
EV owners can charge their EVs at home and at night using Ontario's inexpensive and carbon- free baseload electricity supply. Under the current residential regulated price plan (RPP) rate structure, and factoring in the Ontario Electricity Rebate (OES) and the anticipated federal Clean Fuel Standard (CFS)[1], the cost of charging an EV at night could be effectively $0/MWh. Even if EV owners sold the electricity to their workplace building owners at discounts to off-peak TOU rates, they could earn $8,400 over the life of their vehicle through providing mobile storage services[2]. Under the second life battery scenario, EV owners could also sell their battery for up to 20% of the battery's initial purchase cost.

These two benefits could make the lifetime cost of owning an EV 30% less expensive than owning a new ICE vehicle today, as shown in Figure 3. This cost comparison benefit will improve over the next 10 years. Furthermore, if 55% of the benefits to the electricity system (described in section 4.0) are shared with EV owners, the cost of EV ownership could drop to almost one third of an ICE vehicle in 2030. Such a cost differential has the potential to be a game changer for EV adoption.

3.2 Value to Workplace Buildings

Workplace buildings can save on electricity costs by purchasing electricity from EVs parked on their premises at less than 60% of their normal electricity rates. This applies to Class B businesses using either TOU or GS rates. Upgrading to Level 2 bidirectional chargers required for mobile storage would cost the workplace building $669/year, and a markup on these costs could easily be allocated from the potential EV owner and system savings to form a positive business case for the upgrades.

Figure 3: EV Lifetime Ownership Cost Advantage



> ***Mobile storage and Second Life Battery benefits could make EV ownership one-third the cost of traditional cars."***

[1] Federal purchase incentive based on Government of Canada. Clean Canada: promoting the environment and growing our economy. 2019

[2] Assuming a 13-year vehicle life.

4 ELECTRICITY SYSTEM IMPACTS

In addition to providing value for EV owners and workplace buildings, EV battery use as mobile storage may also deliver benefits to the electricity system. Coupling with SLB applications could ultimately result in lower electricity prices for consumers and less greenhouse gas emissions.

4.1. Effect of Mobile Storage on Electricity Demand

The use of mobile storage would increase Ontario's residential electricity demand at night when EVs are being charged, and reduce daytime demand at the workplace when the batteries are discharged. Analysis suggests that Ontario could have as many as 18,555 vehicles participating in mobile storage by 2030. All of these vehicles charging at night and discharging in the day would increase the average daily demand at night by 665 MWh across the province, while reducing average demand in the day by 565 MWh, as shown in Figure 4.

This daily commuter behavior leads to 164 GWh of nighttime charging per year and 140 GWh of daytime discharging. Discharging the EV batteries during the day will reduce the daytime demand on the grid, which in turn will reduce the demand for natural gas fired generation, avoiding the cost of purchasing natural gas and also potentially avoiding up to 55 kt/year of GHG emissions.

> *"Second life batteries can help replace natural gas, lowering rates and reducing emissions."*

4.2. Integrating Storage with Other Resources to Reduce the Use of Natural Gas

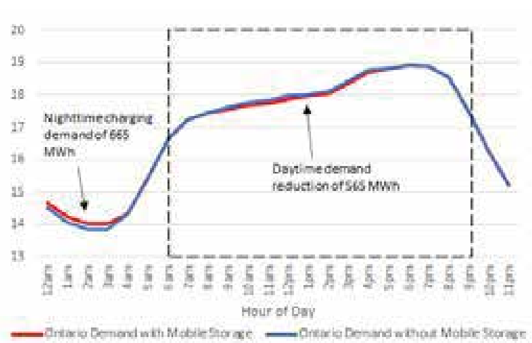
DER storage systems have the potential to provide benefits to the system by shifting demand for grid supply away from peak times and offering other reliability services.

In such a DER context, SLBs have the potential to work well with other resources, producing synergies that could help reduce the need for natural gas generation.[3]

In one possible scenario, DER grid storage using available SLBs could be used together with nuclear generation to displace natural gas generation and avoid 6.9 Mt of emissions at a low cost. Under a mobile storage scenario, this scenario could have an additional greenhouse gas emissions reduction benefit of 12.2 kt/year.

Figure 4: Impact of Mobile Storage on Ontario's Daily Demand Profile

(GW by hour; 2035, average summer demand)



[3] CCRE. Renewables-Based Distributed Energy Resources in Ontario: Some Unfortunate Truths. 2019

5 VALUE TO ELECTRICITY SYSTEM

The electricity system could realize a total of $129 million worth of benefits per year from mobile storage and SLB use. As shown in Figure 5, these benefits accrue from four main value areas:

1. daytime demand reduction,
2. nighttime electricity savings,
3. emissions savings, and
4. SLB benefits.

Mobile storage would see commuters charging their EVs at night and discharging them to workplace buildings at day, resulting in 164 GW worth of increased demand at night. The increase in nighttime demand would make more efficient use of Ontario's baseload hydro and nuclear resources, with the off peak TOU rates collected from EV owners resulting in an injection of $17 million to the system annually.

Meanwhile, the reduction in demand in the daytime from mobile storage would displace 140 GWh of natural gas fired electricity, the avoided HOEP cost of which would reduce system costs by $5 million annually. These reduced emissions would also deliver savings to the system in the form of avoided carbon taxes, saving $3 million annually at the future federal carbon price of $50/tonne.

SLB use also has the potential to provide benefits to the electricity system by improving the economics of DER grid storage systems. These resources have the potential to deliver cost and emissions benefits to the system, but are currently prohibitively expensive due to the cost of new batteries. However, as shown in Figure 6, SLBs could be 46% less costly than new batteries for grid storage in 2025, and 64% less costly in 2035. These cost declines could lower the cost of storage for DER enough to compete with the expected cost of natural gas-fired generation. By helping to provide this low-cost solution to lowering emissions, EVs could create a further $105 million worth of savings for ratepayers.

Figure 5: Total Electricity System Impact ($M/Year)

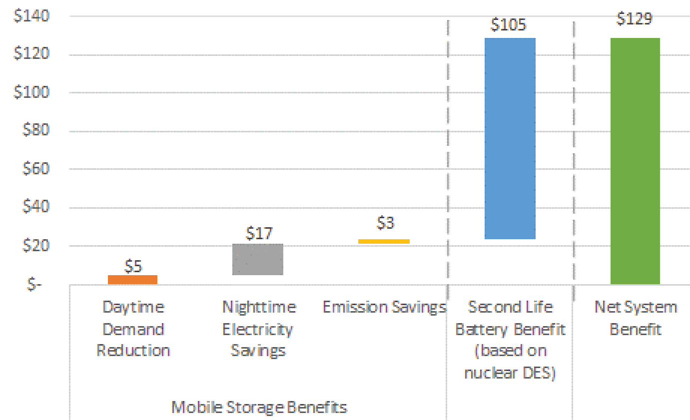
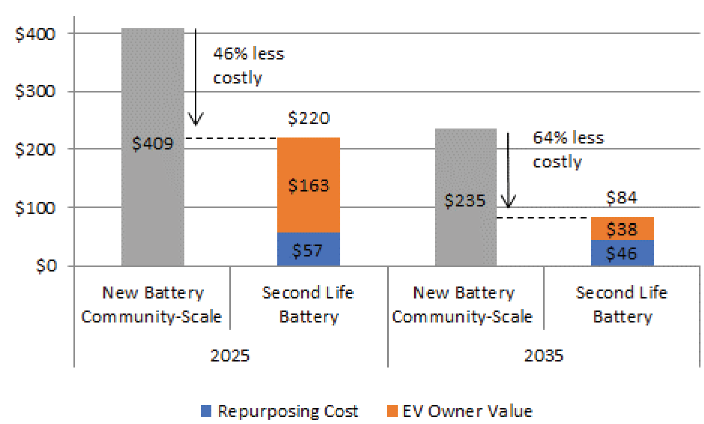


Figure 6: Cost of New vs. Second Life Battery Storage ($/kWh)



> *Through mobile storage and SLB use, EV batteries could create $129 million per year in benefits to the electricity system.*

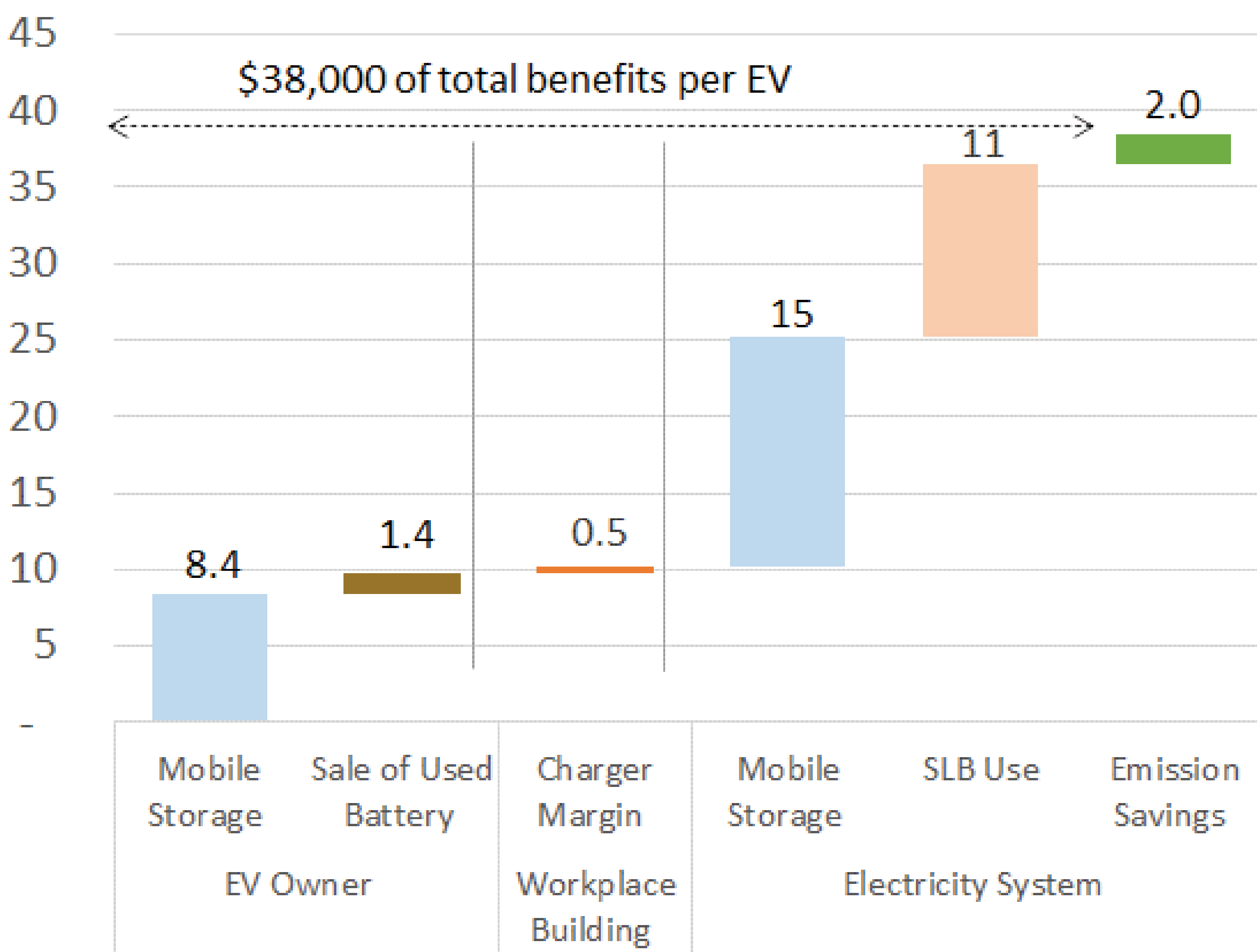
6 SUMMARY AND RECOMMENDATIONS

Through mobile storage and second life uses, EV batteries could create value for EV owners, workplace buildings, and the electricity system.

The best way to capture this value of mobile storage from a large number of commuter vehicles is at workplaces categorized as Class B consumers, where both those workplaces and residents could benefit from pricing arbitrage. Each battery could generate even more value when used in a second life application like grid storage.

When used in both of these ways, the value generated by EVs extends beyond the EV owners and workplace buildings engaging in mobile storage, and brings benefits to the electricity system as a whole. From all of these sources, each EV battery could create up to $38,000 of value, as summarized in Figure 7.

Figure 7: Lifetime Benefit of Using EV Batteries in the ELectricity System
($000s per EV purchased in 2030)



In order to maximize the benefits of using EV batteries for the electricity system, proponents of EVs should consider:

1. Developing a business model whereby the value elements described in this report can be best used to optimize EV adoption and further enhance benefits to the electricity system. Business model considerations could include grid ready EV batteries, updated warranty considerations, and more aggressive TOU pricing.

2. Advocating to ensure that the Federal Clean Fuel Standard accurately accommodates the emission content of the electricity system at the specific times when EVs are being charged.

3. Developing a more refined forecast of EV adoption in Ontario over the next 5 to 10 years, to reflect not only the implications of using EV batteries in the electricity sector, but also trends such as increasing concern over climate change and plans in the auto sector to move away from ICE vehicle production.

4. Other infrastructure recommendations may be warranted such as building code requirements for enabling future integration of residential EV chargers and bidirectional chargers in the workplace.

   Advocating for the incorporation of low-emission solutions to Ontario's electricity capacity needs that are required to enable the value of the CFS. The forecast for Ontario suggests that increased natural gas-fired generation may eliminate EVs as a GHG emission reduction option.