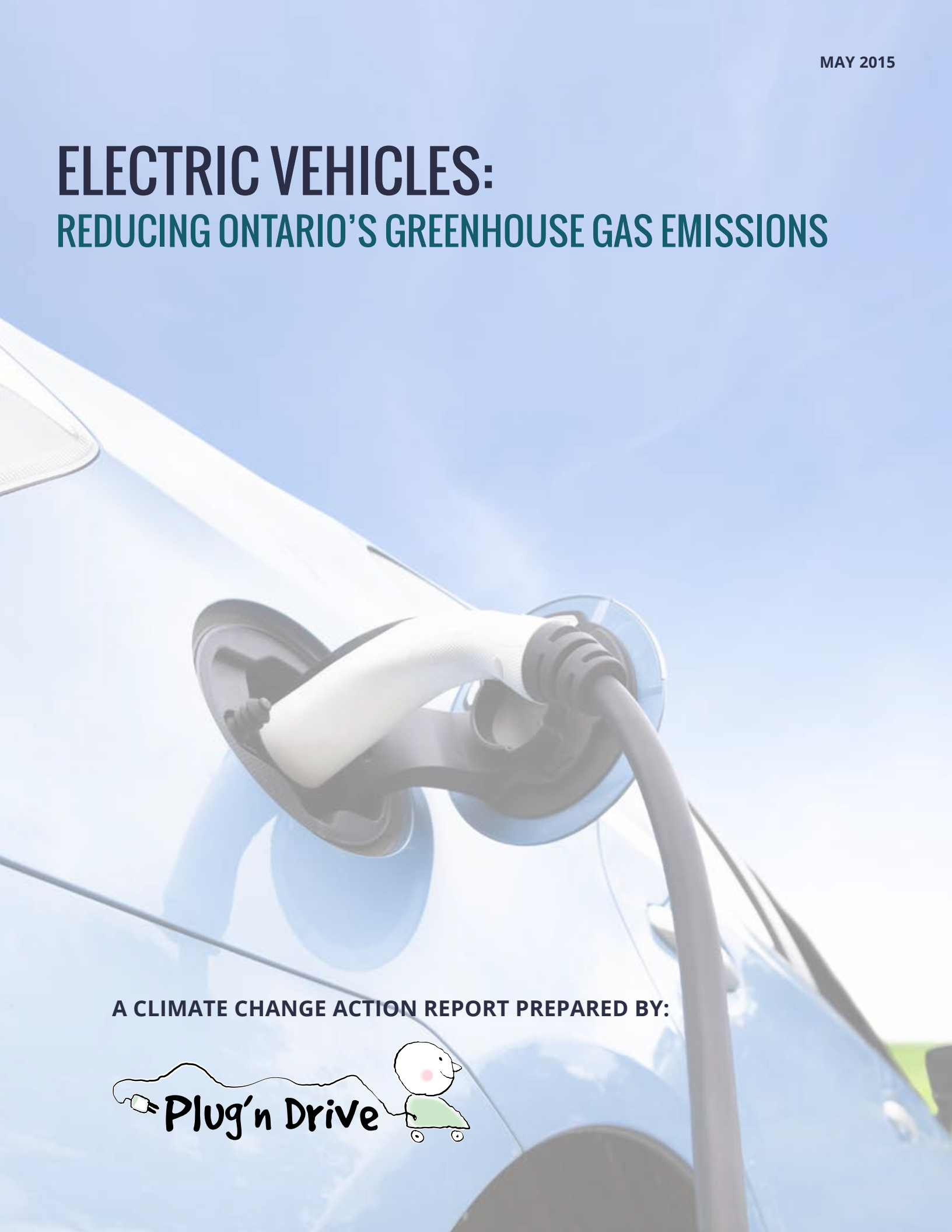
MAY 2015

ELECTRIC VEHICLES:
REDUCING ONTARIO'S GREENHOUSE GAS EMISSIONS



A CLIMATE CHANGE ACTION REPORT PREPARED BY:

Plug'n Drive

PLUG'N DRIVE - WHO WE ARE

Plug'n Drive is a non-profit organization committed to accelerating the adoption of electric vehicles (EVs) to maximize their environmental and economic benefits. Since 2011, Plug'n Drive has established itself as a leader in the EV industry, a trusted source of unbiased information on electric cars, charging stations and the electricity sector. In just under four years, Plug'n Drive has attracted an impressive list of sponsors supporting a variety of programs focused on EV education, infrastructure and research.

Through the EV Road Show, supported by TD Bank and the Ministry of Transportation, Plug'n Drive has engaged with more than 45,000 consumers about the environmental and economic benefits of EVs. Through this educational campaign, Plug'n Drive has worked with auto manufacturers to provide over 2,500 test drives at more than 200 events across Ontario.

Through a partnership with 15 Ontario local distribution companies, Plug'n Drive launched "Charge My Car", a service to help consumers choose, buy and install charging stations. Visitors to chargemycar.ca are provided with Canada's largest selection of charging stations, along with expert customer service and connection to certified local electrical contractors for installation.

Special thanks to Plug'n Drive staff members Josh Tzventarny, Helena Vo and Brian Millar for their assistance preparing this report. This report represents the work of Plug'n Drive and does not necessarily reflect the views of our sponsors and supporters.

THANK YOU TO OUR LEAD SPONSORS FOR THEIR ONGOING SUPPORT

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EXECUTIVE SUMMARY

This report examines five different electric vehicle (EV) growth scenarios to estimate potential greenhouse gas (GHG) emission reductions and illustrate how EVs can form a key part of Ontario's Climate Change Action Plan, which calls for GHG reductions of 15% below 1990 levels by 2020 and 80% below 1990 levels by 2050, or, 26.6 and 141.6 megatonnes (Mt) respectively.

An EV driver in Ontario can reduce their vehicle's GHG emissions by 67-95% by switching from a comparable compact, full-size or mid-size gasoline car to an electric car. Plug'n Drive calculated the potential emission reductions and cost savings of the five scenarios. If Ontario were to achieve a 25% increase in EV sales to 2020, the Province would have more than 100,000 EVs on the road by 2050, reducing Ontario's GHG emissions by as much as 9.19 megatonnes, or 6.5% of Ontario's total reduction target for 2050. At the same time, EV owners would save a total of $4.4 billion on fuel costs.

The results of Plug'n Drive's analysis confirm that EVs are one of Ontario's best opportunities to reduce GHG emissions. By creating a robust set of EV friendly policies that include incentives for cars and charging stations, changes to key pieces of legislation (*Building Code Act, 1992 and Condominium Act, 1998*) and aggressive off-peak electricity pricing, the EV growth rate can be further accelerated, providing even more GHG emission reductions.

INTRODUCTION

Transportation is Ontario's leading source of GHG emissions, accounting for 34% of all GHG emissions. In 2012, this totalled 57 Mt. The Province has taken significant steps to address growing GHG emissions by investing in public transit projects and supporting municipalities through the Greenbelt Plan and Places to Grow Act, which help to create more densely populated, transit friendly communities. These initiatives are vital in terms of meeting Ontario's GHG reduction targets, but more needs to be done.

There are already more than 3,825 electric cars in Ontario and, in 2015 alone, they are estimated to reduce demand for gasoline by 5.8 million litres and reduce GHG emissions by 12,910 tonnes.

The EV growth scenarios used in this report are for illustrative purposes and do not necessarily represent predictions, which vary widely depending on who you ask. The results clearly illustrate the impact that EVs can have on GHG emission reductions in Ontario. The five scenarios are:

A. Baseline (status quo) – Growth continues at the current rate of 0.05% penetration (as measured in 2014) to 2050;
B. Sales increase 10% annually to 2020 and stabilize at 1% of total vehicle sales from 2020 to 2050;
C. Sales increase 25% annually to 2020 and stabilize at 2.4% of total vehicle sales from 2020 to 2050;
D. Sales increase 50% annually to 2020 and stabilize at 8.7% of total vehicle sales from 2020 to 2050;
E. Sales increase 100% annually to 2020 and stabilize at 32.5% of total vehicle sales from 2020 to 2050;

Using these five scenarios, Plug'n Drive calculated the number of expected EVs on the road in 2020 and 2050 as well as their corresponding GHG emission reductions. Plug'n Drive also looked at a number of economic and environmental indicators, including:

- Cost savings for consumers, as well as the potential impact on gas tax and HST revenues;
- Potential grid impact of increased electricity usage and the economic impact of increased revenues; and
- Potential for battery storage in EVs for vehicle to grid or vehicle to home applications.

REDUCING GREENHOUSE GAS EMISSIONS FROM TRANSPORTATION

Collectively, the 7.6 million light duty vehicles on Ontario's roads burn more than 16 billion litres of gasoline each year and emit nearly 37 million tonnes of GHG emissions and other pollution into the atmosphere.

Based on a lifecycle analysis of Ontario's electricity system, Plug'n Drive estimates that an EV can reduce GHG emissions by 67-95% per vehicle, varying by make, model and technology with battery electric vehicles having the lowest GHG emissions, as shown in Figure 1.

Vehicle Type	Average GHG emissions per 20,000 km driven	Source of GHG emissions
Average Battery Electric Vehicle	233 kg	Electricity Generation
Average Plug-in Hybrid Electric Vehicle	1,294 kg	Electricity Generation and Gasoline
Average Compact Gas Car	3,948 kg	Gasoline
Average Mid-Size Gas Car	4,700 kg	Gasoline
Average Full-Size Gas Car	5,029 kg	Gasoline

Figure 1 - Average Annual Greenhouse Gas Emissions by Vehicle Type (2015-2050)

The 3,825 EVs currently on the road in Ontario have the potential to offset as much as 12, 910 tonnes of GHG emissions and reduce gasoline usage by as much as 5.8 million litres per year.

Ontario's clean electricity grid is the primary reason that EVs offer such significant GHG emission reduction potential. The majority of Ontario's base load electricity capacity comes from hydroelectric and nuclear power (Figure 2), which are low emitting energy sources and are at a surplus during off-peak periods (Monday to Friday: 7:00 p.m. to 7:00 a.m. and all day Saturday and Sunday).

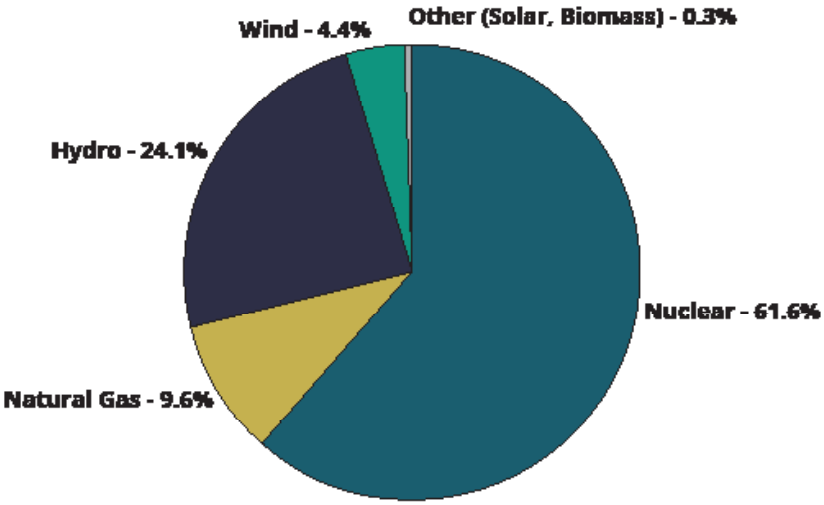

Figure 2 - Ontario's Electricity Generation Mix By Source (Source: IESO - 2014)

Encouraging EV charging during off-peak periods optimizes the use of our electricity system, taking advantage of low cost, low emitting and surplus electricity. Furthermore, using locally made electricity supports infrastructure and jobs in Ontario.

Additionally, Ontario's electricity grid is continually getting cleaner. The Ministry of Energy's Long Term Energy Plan states that by 2025, 46% of Ontario's electricity will be generated from renewable sources.

By looking at the GHG emission reduction potential per car and layering on the different EV growth scenarios, Plug'n Drive's research shows that even a 25% increase in sales (Scenario C) projects 26,181 electric cars in Ontario by 2020 and 111,753 by 2050, reducing GHG emissions by 0.315 Mt and 9.19 Mt respectively. If sales were to increase by 50% a year (Scenario D), we could expect 55,135 electric cars in Ontario by 2020 and 399,644 in 2050, with cumulative GHG emission reductions of 0.528 Mt and 31.73 Mt respectively. Even at just 10% growth in EV sales annually to 2020, Ontario would see considerable GHG emission reductions, as illustrated in Figure 3 below.

SCENARIO	2015 - 2020			2015 - 2050		
	EVs on the Road in 2020	Emissions Reductions[1] (Mega-Tonnes)	Gasoline Reduction (Litres)	EVs on the Road in 2050	Emissions Reductions[1] (Mega-Tonnes)	Gasoline Reduction (Litres)
A: Status Quo	12,601	0.198Mt	88.6 Million	23,396	2.13Mt	0.96 Billion
B: 10% growth to 2020	16,771	0.236Mt	105.7 Million	45,529	3.92Mt	1.77 Billion
C: 25% growth to 2020	26,181	0.315Mt	140.9 Million	111,753	9.19Mt	4.15 Billion
D: 50% growth to 2020	55,135	0.528Mt	236.7 Million	399,644	31.73Mt	14.33 Billion
E: 100% growth to 2020	216,726	1.54Mt	689.0 Million	1,497,401	119.20Mt	53.82 Billion

Notes:
1) Emissions from electricity generation are based on IPCC 2012 lifecycle emissions, using Ontario's Long Term Energy Plan (LTEP)

Figure 3 - Projected EV Adoption in Ontario by Scenario (2015-2050)

ECONOMIC ANALYSIS

As the adoption of EVs increases, we know the reduction in gasoline sales will have a financial impact on the Province through lost gas tax and lost potential HST revenues. Conversely, electricity revenues will increase, due to increased demand for electricity to charge EVs. In addition, consumers will save considerably on fuel costs.

Many jurisdictions around North America are beginning to deal with the prospect of reduced revenues from lost gas tax. For example, Oregon recently passed legislation and has begun a pilot program that will charge drivers a monthly fee based on their kilometres driven. With the aid of a monitoring device installed in the car's on-board diagnostics port, data is collected and wirelessly transmitted to the State for assessment.

EV owners can save as much as 70% on fuel costs by switching from a gas car to an electric car, representing tremendous savings that would, undoubtedly, be reinvested in the local economy. Even in the most conservative scenario, consumers can save a total of $1.0 billion by 2050. It is important to consider these significant consumer savings in any economic argument about the loss of gas tax. As shown in Figure 4 below, the new electricity revenue and consumer savings far exceed the lost gas tax in every scenario.

Additionally, there is significant evidence to suggest that EVs have greatly reduced maintenance requirements compared to gas vehicles, especially the full electric variants which do not require oil changes, air filters, exhaust systems, belts, spark plugs or transmission fluid. Additionally, the regenerative braking mechanism in EVs extends the life of brake pads.

More in depth information about EV maintenance costs will become available as the existing stock of electric cars age and more data is made available. It is safe to say that the consumer savings from reduced maintenance could be significant, but has not been included in this economic analysis.

Scenario	Lost Gas Tax[1]		New Electricity Revenue[2]		Consumer Savings[3]	
	2015-2020	2015-2050	2015-2020	2015-2050	2015-2020	2015-2050
A : Status Quo	$12.1 M	$130.8 M	$20.9 M	$226.9 M	$94.2 M	$1.0 B
B : 10% growth to 2020	$14.4 M	$240.7 M	$24.9 M	$417.7 M	$112.4 M	$1.9 B
C: 25% growth to 2020	$19.2 M	$564.1 M	$33.3 M	$978.9 M	$149.9 M	$4.4 B
D: 50% growth to 2020	$32.2 M	$1.9 B	$55.8 M	$3.4 B	$251.8 M	$15.2 B
E: 100% growth to 2020	$93.7 M	$7.3 B	$162.6 M	$12.7 B	$733.1 M	$57.2 B

Notes:
1) Gas tax remains constant at $0.136/L
2) Electricity tariff remains constant at $0.114/kW
3) Consumer savings is: (cost of driving a gas car) - (cost of driving an electric car) 20,000km

Figure 4 - Projected Economic Analysis by Scenario (2015-2050)

GRID IMPACTS AND VEHICLE TO GRID

The Province's local distribution companies (LDCs), electricity transmitters and generators will benefit fro the increased demand for electricity to charge EV batteries. Based on current vehicle specifications and testing from Natural Resources Canada, Plug'n Drive has determined that the average battery electric vehicle uses 4,091 kWh of electricity per year and the average plug-in hybrid electric vehicle uses 2,512 kWh of electricity and 490 litres of gasoline per year[1].

As of March 1, 2015, there were 3,825 EVs in Ontario which, combined, use approximately 12,000 kWh of electricity per year. Even if EV sales were to stay constant at today's modest rates, more than 183,000 MWh of electricity would be used for EV charging by the year 2020 and more than 1.9 million MWh by 2050 (Figure 5).

Scenario	Total Electrical Draw for EV Charging		Peak Demand for EV Charging in 2050[1]	# of Electric Vehicles in Ontario by 2050
	2015-2020	2015-2050		
A : Status Quo	183,425 MWh	1,991,119 MWh	79,088 MWh	23,396
B : 10% growth to 2020	218,882 MWh	3,664,334 MWh	153,905 MWh	45,529
C: 25% growth to 2020	291,782 MWh	8,586,822 MWh	377,765 MWh	111,753
D: 50% growth to 2020	490,072 MWh	29,665,767 MWh	1,350,940 MWh	399,644
E: 100% growth to 2020	1,426,415 MWh	111,423,540 MWh	5,061,751 MWh	1,497,401

Notes:
1) These estimates do not account for the uptake of photovoltaic and battery installations, which can offset demands for EV charging. For example, 32% of EV owners in California have already installed systems on their home and an additional 16% plan to in the future.

Figure 5 - Projected Electricity Demand by Scenario (2015-2050)

The majority of residential EV owners will charge during off-peak hours, while their vehicle is parked in their garage or driveway, using Ontario's low cost surplus electricity[2]. Even so, it will be important to ensure that electric vehicles do not lead to an increase in day time peak demand by giving drivers an incentive to charge during off-peak hours. This can be accomplished through education and an aggressive off-peak pricing or 'peak saver' program for EVs.

Unique to EVs is their potential to be used for energy storage, charging during off-peak periods and then returning electricity to the grid during peak periods when it's most needed. This can help local utilities meet electricity demand during peak periods and may, in the future, avoid the need to build additional generation facilities. Already, the 3,825 EVs in Ontario have the capacity to store as much as 80MWh of electricity.

[1] Electricity and gasoline consumption calculated by Plug'n Drive using the vehicle efficiency specifications set out in the NRCan Fuel Efficiency Guide 2015. The above quoted numbers assume an annual driving distance of 20,000 km.

[2] As illustrated by Toronto Hydro's Electric Vehicle pilot program and research from California's Plug-in Electric Vehicle Owners survey, research shows that most EV drivers (between 70% and 90%) charge their cars off-peak.

The available storage under the different EV penetration scenarios is substantial and can create a variety of opportunities to shift demand (Figure 6).

There are many jurisdictions working to unlock the potential for these vehicle-to-grid technologies. For example, Burlington Hydro, Oakville Hydro, PowerStream, Toronto Hydro and others have taken a lead role in developing smart charging systems that will allow for vehicle-to-grid applications.

Similarly, the Smart Grid Fund, funded by the Ministry of Energy, is looking at opportunities to develop smart home charging systems that could allow for an EV program similar to the 'peak saver' program for air conditioners. These projects will provide important results, allowing Ontario to take full advantage of the potential use of EVs for load shifting in the future.

Scenario	2015-2020		2015-2050	
	EVs on the Road in 2020	Total Storage Potential	EVs on the Road in 2050	Total Storage Potential
A : Status Quo	12,601	1,235 MWh	23,396	13,412 MWh
B : 10% growth to 2020	16,771	1,474 MWh	45,529	24,682 MWh
C: 25% growth to 2020	26,181	1,965 MWh	111,753	57,841 MWh
D: 50% growth to 2020	55,135	3,301 MWh	399,644	199,827 MWh
E: 100% growth to 2020	216,726	9,608 MWh	1,497,401	750,546 MWh

Figure 6 - Projected Electricity Storage Potential in EV Batteries by Scenario (2015-2050)

CONCLUSION

Based on Plug'n Drive's analysis, EVs have the potential to significantly reduce GHG emissions and provide economic value to Ontario and its citizens. We need to accelerate EV adoption in order to capitalize on these potential environmental and economic benefits. A robust and comprehensive set of EV friendly policies would help achive this goal. Plug'n Drive supports the following initiatives to further accelerate EV adoption:

1. Implement a Price on Carbon – We support the move towards a price on carbon and see merits in both the carbon tax and cap and trade systems.

2. Continue the EV Incentive Program – The Province's EV incentive programs are an important tool for helping consumers and businesses offset the upfront costs of purchasing an EV and charging station. The Province recoups its investment through electricity revenues and consumer savings.

3. Accelerate the Deployment of a Public Charging Network – Ontario lags behind British Columbia and Québec in public charging infrastructure. Government support for networked Level 2 chargers (240V 30A) and DC Fast Chargers (for highway/longer distance travel) is the most effective way to reduce range anxiety, extend driving ranges and encourage inter-city travel.

4. Incent Off-Peak Charging – The introduction of a 'super low' rate for electricity during off-peak periods would encourage drivers to charge their vehicles when it is best suited to the needs of the electricity system.

5. Homes and Condos – The *Building Code Act, 1992* and the *Condominium Act, 1998* need revisions that would help make the installation of charging stations easier in new homes and multi-unit residential dwellings.

6. Consider Replacement of the Gas Tax – Lost gas tax revenues due to the introduction of EVs is a legitimate concern. The Province needs to begin researching alternatives, including a tax for kilometres driven or a carbon tax.

7. EV Owners Survey – Little data exists on Ontario's EV owners. A survey of Ontario's EV owners can help the Province and its stakeholders better understand what has influenced existing owners. The California Plug-in Electric Vehicle Owner Survey has been an effective means of gathering information and improving programming.

8. Battery End of Life – The lithium-ion battery packs in today's electric vehicles are designed to have a usable life of 8-12 years before needing replacement. A provincial system, such as the Ontario Electronic Stewardship, would be ideally suited to identify and capitalize on future opportunities, such as reusing batteries for energy storage and/or recycling the materials.

9. Government Fleets – The Province took a lead role when it added electric vehicles to Ontario's Public Services fleet. Similar initiatives should be encouraged in municipalities and with other large Ontario based fleets.

10. Ontario Energy Board to Clarify View on Electric Vehicles – Many stakeholders in the electric vehicle industry believe that EV charging might be considered the reselling of electricity and therefore require a license from the OEB. The OEB should clarify that installation of level 1 or 2 charging does not constitute the resale of electricity.

Electric Vehicles:
Reducing Ontario's Greenhouse Gas Emissions

APPENDIX
The following assumptions have been made during the preparation of this report:

1. For simplicity, the terms Greenhouse Gas (GHG) and Carbon Dioxide (CO_2) are used interchangeably in this report. Plug'n Drive understands that GHG is made up of other components, but also recognizes that most of the GHG emissions associated with the burning of gasoline and the generation of electricity take the form of CO_2.

2. Plug'n Drive assumes that all gas vehicle sales will grow 2% annually in accordance with past trends and ownership levels remain constant.

3. Future gains in fuel efficiency and uptake of alternative fuels (i.e. hydrogen, propane, natural gas, compressed air, etc.) are not taken into consideration.

4. A ratio of 55:45 (Battery Electric Vehicles: Plug-In Hybrid Electric Vehicles) is used for electric vehicle sales through to 2050. Plug'n Drive assumes that the current ratio of vehicles will remain the same throughout the modeling, though it is likely that Battery Electric Vehicles will gain in popularity as battery technology increases performance and access to public charging stations is more readily available.

5. Prices remain constant throughout the analysis: Gas $1.30/L; Gas Tax ¢13.6/L; and Electricity ¢11.4/kWh. These conservative estimates have been utilized to simplify the economic calculations in the report which are secondary to the primary goal of measuring GHG emissions. It is acknowledged that energy prices will fluctuate significantly over the next 35 years and if anything, higher gas prices will only lead to increased EV adoption.

6. Vehicles are assumed to drive 20,000 km per year. Battery Electric Vehicles (BEV) drive 100% on electricity while Plug-in Hybrid Electric Vehicles (PHEV) are presumed to drive 60% on electricity and 40% on gas. Some PHEV owners drive almost entirely on electricity and this 60:40 ratio should be considered conservative.

7. The Life-cycle assessment of Ontario's electricity system is based on IPCC 2012 standards for grams of carbon dioxide equivalent per kWh of electricty generation.

Nuclear	Natural Gas	Coal	Hydro	Wind	Solar
16 g	469 g	1,001 g	4 g	12 g	22 g

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