ELECTRIC Vehicle NEWS

Three Nations ENERGY

Doing the Math

NOTE: This activity requires access to Microsoft EXCEL and an internet connection.

How Do We KNOW Electric Vehicles Are Better?

It's all about the math. To choose the best course of action you need to collect scientific information, test and measure the results. In other words, use analytics.

Analytics is the science of analyzing raw data to make conclusions about that information.

Analytics helps people:

- predict outcomes
- answer questions and
- make informed decisions.

Scientists have been collecting the data about electric vehicles (EVs) and gasoline or internal combustion engine vehicles (ICEs) in order to see which is the best for economy and for the environment.

It is a complicated process but you can take advantage of one of the calculators available on the Internet that have the data already set up.

One calculator is provided by the Municipal Climate Change Action Centre.

## Municipal Climate Change Action Centre

Municipal Climate Change Action Centre

The Municipal Climate Change Action Centre delivers funding, technical assistance, and education to help **Alberta** municipalities, school authorities, and community organizations advance actions that lower energy costs, reduce greenhouse gas emissions, and improve climate resilience.

Electric Vehicle Savings Calculator

- Go to:
  https://mccac.ca/learning-centre/
- Select:
  Electric Vehicles Savings Calculator
  This compares the costs of gasoline-powered passenger vehicles with electric vehicles.
- (Press) View - This will download an EXCEL spreadsheet. Save and open the file.

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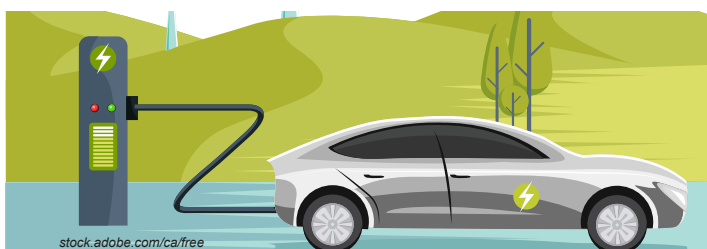
How To Use The Calculator

In the "Calculator" tab, please enter information about your vehicle usage into all green entry fields at the top and then select your vehicle preferences.

STEP 1.
Enter Usage Data:

Annual Distance Driven (km):	20000	km per year
Price of Fuel:	$1.850	per Litre Check GasBuddy Prices
Electricity Rate:	$0.10	per kWh
Lifetime Use of New Vehicle:	10	years
Additional Rebate Value:	$0	(ex. iZEV Incentive Program)

Electric Vehicle

STEP 2.
Choose Your Electric Vehicle:

F-150 LIGHTING STANDARD RANGE

Notice the information below each vehicle choice is filled in for you. This can help you select a vehicle.

Internal Combustion Engine Vehicle

STEP 3.
Choose Your ICE Vehicle:

FORD F-150

If the ICE vehicle you want to compare is not listed, go on the internet to get the details and fill in the blanks under "Other Vehicle".

Municipal Climate Change Action Centre

STEP 4.
Click Here to Compute the Savings

Reset

Press the "Click Here to Compute the Savings" button (top right-hand corner) to compute a cost and GHG comparison of the vehicles. Click the "Reset" button to start over.

Review the Results

Compare Vehicles

The first three items have a bar graph below them comparing the electric vehicle with the ICE you chose.
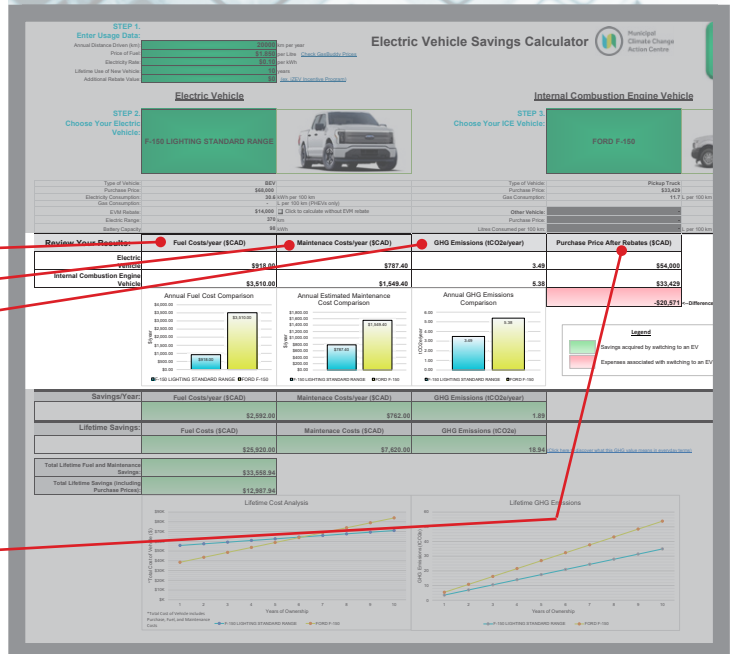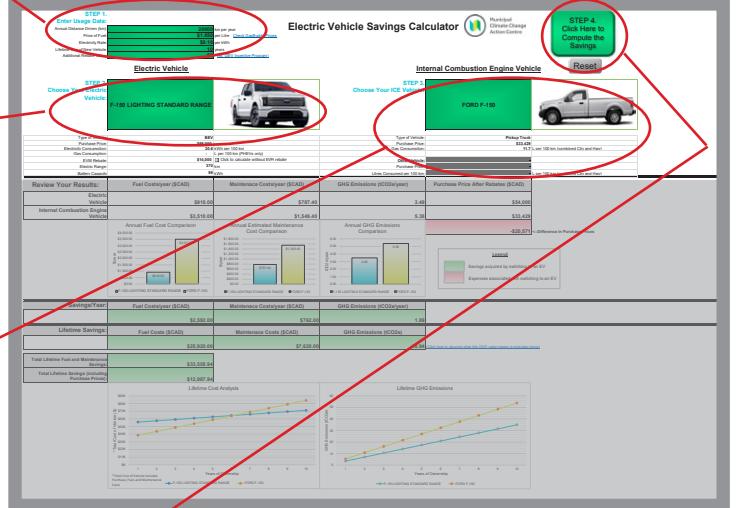
◆ Fuel Cost Per Year

◆ Maintenance Cost Per Year

◆ GHG Emissions (tCO2e/yr)
   Short for "tonnes of carbon dioxide equivalent," tCO2e is a handy way of talking about all Greenhouse Gas (GHG) emissions. There are six main GHGs, so it's helpful to count them with a single unit: tCO2e. "Tonne" is the same as metric ton.

◆ Purchase Price

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More Information

◆ Savings Per Year

◆ Lifetime Savings

◆ Total Lifetime Savings Fuel and Maintenance

◆ Total Lifetime Savings Including Purchase Price

◆ Graphs

- Lifetime Cost Analysis - compares yearly expenses over time for both vehicles
- Lifetime GHG Emissions - compares GHG emissions over lifetime of both vehicles

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How Are GHG Emissions Measured?

GHG emissions are often measured in carbon dioxide (CO_2) equivalent. To convert emissions of a gas into CO_2 equivalent, its emissions are multiplied by the gas's Global Warming Potential (GWP). The GWP takes into account the fact that many gases are more effective at warming Earth than CO_2, per unit mass.

For more about GWPs see Canada's website:

https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/quantification-guidance/global-warming-potentials.html

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Greenhouse Gas Equivalencies Calculator

So you have a GHG number for your vehicle - what does that mean?

Use this calculator to convert emissions or energy data into concrete terms you can understand — such as the annual CO2 emissions of cars, households, and power plants.

Instructions:

- Go to the website or use the QR code:
  https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/calculator/ghg-calculator.cfm#results

- Select "If You have Emissions data" tab

- Type into the first box for "CO2 - Carbon Dioxide or CO2 Equivalent*"

- Use the GHG Emissions (tCO2e/yr) number you found for a vehicle when you used the **Electric Vehicles Savings Calculator**. Type this number in.

- Choose the unit "Metric Tons".

- Press green "Calculate" button

- "Equivalency Results" will appear. View all of the ways to describe your emission number.

If You Have Energy Data | **If You Have Emissions Data**

Please note that these estimates are approximate and should not be used for emission inventory or formal carbon footprinting exercises. Read more about the caveats and explanations on the Calculations and References page

Amount	Unit	Gas
3.49	Metric Tons	CO_2 - Carbon Dioxide or CO_2 Equivalent*
	Metric Tons	Carbon or Carbon Equivalent
	Metric Tons	CH_4 - Methane
	Metric Tons	N_2O - Nitrous Oxide
	Metric Tons	HFC-23 - Hydrofluorocarbon gases
	Metric Tons	CF4 - Perfluorocarbon gases
	Metric Tons	SF_6 - Sulfur Hexafluoride

Calculate

*If your estimated emissions of methane, nitrous oxide, or other non-CO_2 gases are already expressed in CO_2 equivalent or carbon equivalent, please enter your figures in the row for CO_2 or carbon equivalent.

Equivalency Results

CO_2 emissions from

1.1 passenger vehicles	1,487 litres of gasoline consumed	2.3 homes' electricity use for one year
0.047 tanker trucks' worth of gasoline	0.817 homes' energy use for one year	145 propane cylinders used for home barbeques

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COMPARE AN EV TO AN ICE (___/25 pts)

INSTRUCTIONS

Step 1. Open the Electric Vehicle Savings Calculator as described on page 1.

Step 2. To see how the Calculator works, enter the following information:

- Annual Distance Driven: 20000 km
- Price of Fuel: 1.85 per litre
- Electricity Rate: 0.10 per kWh
- Lifetime of New Vehicle: 10 years
- Additional Rebate Value: 0
- Choose Electric Vehicle: Ford F150 Lightning Standard Range
- Choose ICE: Ford F150

Step 3. Press green "Click here" button

Step 4. Now you can view the results and answer these questions.

FILL IN THE BLANK

1. How much electricity does the F150 Lightning use in 100 km? _____ kWh (1 pt)

2. What is the F150 Lightning range on an average single charge? _____ km (1 pt)

3. How much gasoline does the standard F150 use in and average 100 km? _____ L (1 pt)

4. What does GHG mean? _____ _____ (1 pt)

5. What does tCO2e stand for? _____ _____(1 pt)

6. Why is tCO2e used? _____ _____ _____ (2 pts)

7. COMPLETE THE CHART (9 pts)

	F150 ICE	F150 Lightning EV	EV SAVINGS/YR
Fuel cost/yr	$	$	$
Maintenance/yr	$	$	$
GHG (tCO2e/yr)			

8. How are the EV Savings calculated in the chart above?
_____
_____ (2 pts)

9. How would you calculate Lifetime Savings for the information in the chart above? _____
_____ (2 pts)

10. Look at the Lifetime Cost Analysis graph. What two values are being compared? _____
_____ (2 pts)

11. Using the Lifetime Cost Analysis graph - how many years do you need to own the F150 EV to break even on the cost of the vehicle compared to the savings? _____
_____ (1 pts)

12. Using the Lifetime GHG Emissions graph - what happens over time to the amount of GHG's produced by the F150 ICE compared to the EV? _____
_____ (2 pts)

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BONUS (5 points)

Go back to the calculator and try comparing other vehicles. Fill in a chart like Question #7 for the two new vehicles

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If your students do not have access to the internet, you can download the EXCEL calculator for them.

If they do not have access to EXCEL, you can provide a printout of page 7 for them to analyze instead.

Answer Key

1. 30.6 kWh

2. 370 km

3. 11.7 L

4. Greenhouse Gas

5. tonnes of carbon dioxide equivalent

6. There are six main GHGs, so it's helpful to count them with a single unit.

7.

	F150 ICE	F150 Lightning EV	EV SAVINGS/YR
Fuel cost/yr	$3,510.00	$918.00	$2,592.00
Maintenance/yr	$1,549.40	$787.40	$762.00
GHG (tCO2e/yr)	5.38	3.49	1.89

8. Take the values for the F150 ICE and subtract the F150 EV.

9. Multiply by the *Lifetime Use of the New Vehicle*, which is 10 (in this example).

10. Total Cost of the Vehicle and Years of Ownership

11. 6 years

12. The rate of GHG production for the ICE increases much more than the EV.

BONUS (5 points)

Answers will vary

Enrichment Activity

Have students explore the Greenhouse Gas Equivalencies Calculator described on page 3. If students plug in the GHG number from the first activity, (3.49 metric tons tCO2e/yr in this example), this calculator will provide the following:

Equivalency Results

CO_2 emissions from

1.1 passenger vehicles	*or*	1,487 litres of gasoline consumed

or

0.047 tanker trucks' worth of gasoline	*or*	0.817 homes' energy use for one year

or

2.3 homes' electricity use for one year	*or*	7.9 barrels of oil consumed

or

145 propane cylinders used for home barbeques

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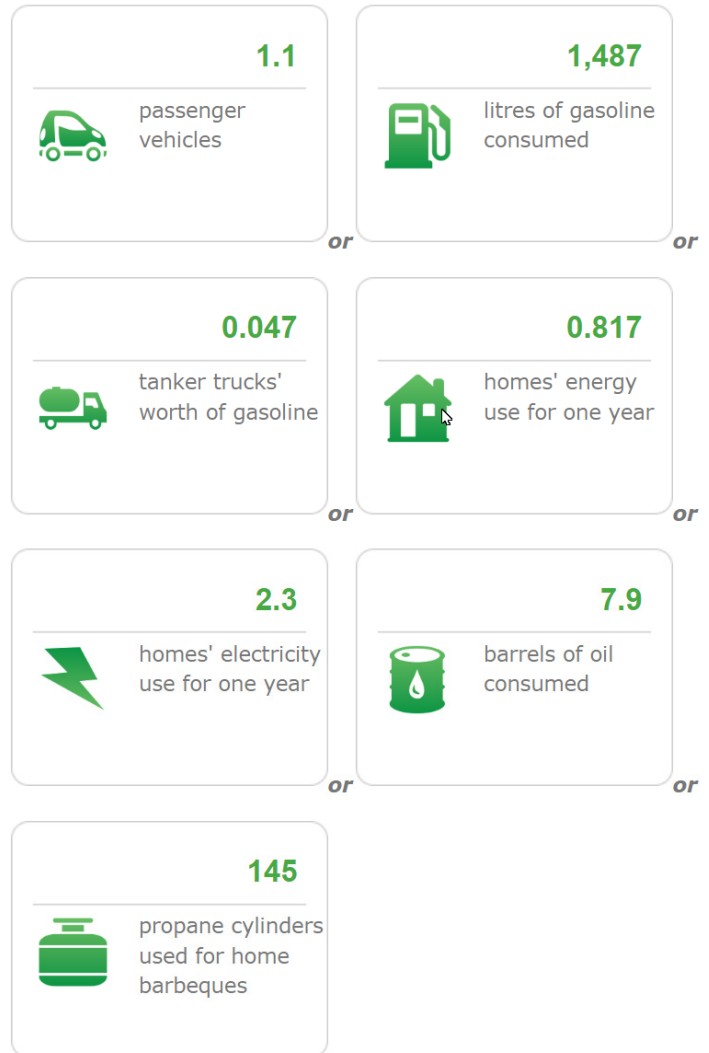
Science Grade 9

Unit D: Electrical Principles and Technologies
1. Investigate and interpret the use of devices to convert various forms of energy to electrical energy, and electrical energy to other forms of energy

2. Describe technologies for transfer and control of electrical energy

3. Identify and estimate energy inputs and outputs for example devices and systems, and evaluate the efficiency of energy conversions

Science 14

Unit B: Understanding Energy Transfer Technologies
3. Describe and compare simple machines as devices that transfer energy and multiply forces or distances

- Explain the need to encourage and support the development of machines that are efficient and rely upon renewable energy sources (e.g., hand-wound radios, solar-powered calculators, solar cookers)

Science 24

Outcomes for Science, Technology and Society (STS) and Knowledge
1. Investigate and interpret transformation and conservation of various forms of energy in physical and technological systems

2. Investigate and analyze electrical energy conversion devices in terms of energy conversions, rate of energy transfer and efficiency

Unit B: Understanding Common Energy Conversion Systems

Science 10

Unit B: Energy Flow in Technological Systems

- Forms of energy, energy transformation, renewable and non-renewable energy

- Efficient use of energy and the environmental impacts of the inefficient use of energy

- Explain the need for efficient energy conversions to protect our environment and to make judicious use of natural resources (e.g., advancement in energy efficiency; Aboriginal perspectives on taking care of natural resources)

Science 20

Unit B: Changes in Motion

Specific Outcomes for Science, Technology and Society

- Explain that the goal of technology is to provide solutions to practical problems

Science 30

Unit C: Electromagnetic Energy

Key Concepts:

- Devices based on electric and magnetic fields (electric motors, generators and transformers)

Career And Technology Studies (CTS)

Natural Resources (NAT)

The focus of the NAT cluster is for students to develop and apply the knowledge, skills and attitudes to work individually and collectively, as private citizens and as members of the work force, toward the conservation and responsible use of energy and natural resources.

Trades, Manufacturing & Transportation (TMT)

The focus of the TMT cluster is for students to develop and apply important knowledge, skills and attitudes relative to the manufacture and assembly of products from individual components and the processing of raw materials into products.

Math - all grade levels

Analyze data, charts and graphs and draw general conclusions from them.

Explore the Analytics of GHG Reduction

As mentioned in the introduction to this activity, measurement is essential to solving problems, making good decisions and taking action. This means using analytics.

A useful resource is the Climate Action website:

https://climateactionworks.ca/
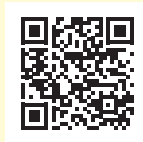
Greenplanet Energy Analytics (GEA) has developed and maintains a collection of case studies and success stories in a sophisticated database that focus on "climate action" to reduce greenhouse gas emissions.

Each record is an actual success story with every effort to reasonably and accurately *quantify* both the *economic costs* and

benefits, and the *climate benefit* in terms of GHG reduction.

Calculator Tools

The site provides carbon / GHG reduction calculators that can work in parallel with the database. These tools make the calculations as transparent as possible, and can be customized for local data.

This site will also serve as a teaching and learning tool for students and decision-makers in the schools, First Nations communities, municipalities, businesses and non-profit societies.

Sample Data for the EV Savings Calculator

Electric Vehicle Savings Calculator

Municipal Climate Change Action Centre

STEP 4.
Click Here to Compute the Savings

Reset

STEP 1.
Enter Usage Data:

Annual Distance Driven (km):	20000	km per year
Price of Fuel:	$1.850	per Litre Check GasBuddy Prices
Electricity Rate:	$0.10	per kWh
Lifetime Use of New Vehicle:	10	years
Additional Rebate Value:	$0	(ex. iZEV Incentive Program)

STEP 2.
Choose Your Electric Vehicle:

F-150 LIGHTNING STANDARD RANGE

Type of Vehicle:	BEV
Purchase Price:	$68,000
Electricity Consumption:	30.6 kWh per 100 km
Gas Consumption:	- L per 100 km (PHEVs only)
EVM Rebate:	$14,000 ☐ Click to calculate without EVM rebate
Electric Range:	370 km
Battery Capacity:	98 kWh

Internal Combustion Engine Vehicle

STEP 3.
Choose Your ICE Vehicle:

FORD F-150

Type of Vehicle:	Pickup Truck
Purchase Price:	$33,429
Gas Consumption:	11.7 L per 100 km (combined City and Hwy)
Other Vehicle:	
Purchase Price:	
Litres Consumed per 100 km:	L per 100 km (combined City and Hwy)

Review Your Results:

Fuel Costs/year ($CAD)

Electric Vehicle	$918.00
Internal Combustion Engine Vehicle	$3,510.00

Annual Fuel Cost Comparison

$4,000.00	
$3,500.00	$3,510.00
$3,000.00	
$2,500.00	
$2,000.00	
$1,500.00	
$1,000.00	
$500.00	$918.00
$0.00	

■ F-150 LIGHTNING STANDARD RANGE ■ FORD F-150

Maintenace Costs/year ($CAD)

	$787.40
	$1,549.40

Annual Estimated Maintenance Cost Comparison

$1,800.00	
$1,600.00	$1,549.40
$1,400.00	
$1,200.00	
$1,000.00	
$800.00	$787.40
$600.00	
$400.00	
$200.00	
$0.00	

■ F-150 LIGHTNING STANDARD RANGE ■ FORD F-150

Purchase Price After Rebates ($CAD)

	$54,000
	$33,429

-$20,571 <--Difference in Purchase Prices

Legend

■ Savings acquired by switching to an EV
■ Expenses associated with switching to an EV

GHG Emissions (tCO2e/year)

	3.49
	5.38

Annual GHG Emissions Comparison

6.00	
5.00	5.38
4.00	
3.00	3.49
2.00	
1.00	
0.00	

■ F-150 LIGHTNING STANDARD RANGE ■ FORD F-150

Savings/Year:

Fuel Costs/year ($CAD)	$2,592.00
Maintenance Costs/year ($CAD)	$762.00
GHG Emissions (tCO2e/year)	1.89

Lifetime Savings:

Fuel Costs ($CAD)	$25,920.00
Maintenance Costs ($CAD)	$7,620.00
GHG Emissions (tCO2e)	18.94 (Click here to discover what this GHG value means in everyday terms)

Total Lifetime Fuel and Maintenance Savings:	$33,558.94
Total Lifetime Savings (including Purchase Prices):	$12,987.94

Lifetime Cost Analysis

$90K	
$80K	
$70K	
$60K	
$50K	
$40K	
$30K	
$20K	
$10K	
$K	

Years of Ownership 1 2 3 4 5 6 7 8 9 10

*Total Cost of Vehicle includes Purchase, Fuel, and Maintenance Costs

■ F-150 LIGHTNING STANDARD RANGE ■ FORD F-150

Lifetime GHG Emissions

60	
50	
40	
30	
20	
10	
0	

Years of Ownership 1 2 3 4 5 6 7 8 9 10

■ F-150 LIGHTNING STANDARD RANGE ■ FORD F-150

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