The Canada Science and Technology Museum
and
Transport Canada's ecoTECHNOLOGY for Vehicles Program
present

Driving the Future:
Transportation, Energy, and the Environment

Section 1

Introduction

CANADA SCIENCE AND TECHNOLOGY MUSEUM

Canada

Introduction

In Canada today, environmental concerns are at the forefront of our collective consciousness. It seems that everyone, from policy makers to advertisers, recognizes Canadians' desire to make greener choices in their everyday lives. This is particularly true in the area of automotive technology. As Canadians, we are eager to embrace an ever-increasing range of environmentally responsible features and options, but how can we make informed choices if we do not grasp the science and technology that underlies the lifecycle of our vehicles?

Driving the Future is a teacher resource package — an exploration guide — enabling students to discover the scientific, technological, social, and environmental impacts of vehicle use in Canada. This virtual program presents the themes of transportation, energy, and the environment in a way that is accessible and interactive — combining hands-on activities with online discovery.

What this Exploration Guide Can Do For You

This exploration guide enables you and your students to explore the themes of transportation, energy, and the environment using your school's Internet connections. Our activities and worksheets will enrich your exploration of a number of excellent online resources. Featured resources include the Canada Science and Technology Museum's website, and the Transport Canada ecoTECHNOLOGY for Vehicles program website (our partner in the development of this educational resource). Blank worksheets and detailed examples can be reproduced without cost for use in your classroom. Our activities are modular, and can be completed independently.

In addition to addressing Canadian science, history, and technology, the exploration guide's activities reinforce knowledge and skills in areas such as geography, mathematics, and writing. As well as activity sheets, you will find suggestions for classroom discussions, class projects, and independent study assignments (summative evaluation projects).

Teachers may requests an answer package, which includes an educators' version of the more complicated worksheets, by e-mailing **virt_prog@technomuses.ca**. Please allow one to two weeks for reply.

Navigating Through the Exploration Guide

Each section of this exploration guide can be downloaded as a separate Adobe PDF file, allowing you to select the sections that you would like to use. Alternately, you can download the entire guide as a single Adobe PDF file. The content is identical in either case.

While the exploration guide's sections are thematic, they also encourage cross-thematic learning. There are activities within each section to suit the needs of students at a range of grade levels. **All of the exploration guide's activities are listed below:**

Section 1 Introduction

Section 2 Focus on the Fundamentals: Scientific and Technological Theory

- 2.1 Focus on the Fundamentals — Worksheet Series
- 2.2 Engines
- 2.3 Efficiency — Doing More with Less
- 2.4 Renewable and Non-Renewable Resources

Section 3 Human Impacts: Cars, Energy, and Canadian Society

- 3.1 Canada's Cars over Time
- 3.2 History of Canadian Vehicle Innovations
- 3.3 Meeting Our Energy Needs
- 3.4 Cars in Canada Today
- 3.5 Ecological Footprint
- 3.6 Selling the Science

Section 4 The Future is Green: Transportation Technology and the Environment

- 4.1 Fuels and Environmental Responsibility
- 4.2 Green Energy — Assessing Our Options
- 4.3 Energy and Fuel Efficiency
- 4.4 Future Cars

Distinctive icons throughout the exploration guide indicate key features, helping you to find your way through the text quickly and efficiently.

	**Classroom Activity**		**Discussion or Essay Topic**
	**Deeper Study**		**Website to Visit**

Curriculum Links

This guide is cross-curricular. The included activities focus on the themes of transportation, energy, and the environment from scientific, technological, historical, and social perspectives. By completing the worksheets and activities in this guide, students will also exercise their literacy, numeracy, artistic, and critical thinking skills, fulfilling specific requirements of various curricular areas.

Pan-Canadian Protocol

The Common Framework of Science Learning Outcomes, developed by the Council of Ministers of Education, Canada, includes many secondary school links to the integrated themes of transportation, energy, and the environment. A breakdown of links to the Pan-Canadian Protocol is as follows:

Grades 7 to 9:	109-4, 10, 11; 110; 112; 113; 210; 211; 308-15, 16, 17, 18; 423; 425; 426; 428; 429; 431; 432
Grades 10 to 12:	114-3, 4; 115-4, 5; 117; 118; 213-1, 6, 7; 215; 322-9; 325; 328-2; 437; 439; 440; 441; 442; 445; 448

Ontario Curriculum

Grade 9	SNC1D	Physics: The Characteristics of Electricity
	SNC1P	Physics: Electrical Applications
	CGC1D	Human-Environment Interactions
Grade 10	CHC2D	Communities; Global, National, and Local, Change and Continuity; Social, Economic, and Political Structures
Grade 11	SPH3U	Energy and Society; Electricity and Magnetism
	SVN3M	Ties to all strands
Grade 12	SCH4C	Chemistry and the Environment

Quebec Curriculum

Science and Technology

Secondary Cycle II, Year 1 — Compulsory Concepts

The Technological World — Mechanical Engineering; Electrical Engineering

Secondary Cycle II, Year 2 — Compulsory Concepts

The Technological World — Mechanical Engineering; Electrical Engineering
The Material World — Electricity, Force, and Motion
Key Topics — Climate Change; The Energy Challenge of Humankind

Science and Technology of the Environment

Key Topics — Climate Change; Energy

Other Generalized Curricula Connections

Mathematics	Number Sense and Numeration; Data Management and Probabilities; Geometry and Spatial Sense
English Language Arts	Reading, Writing, Oral Communication; Media Literacy/Studies
Fine Arts	Visual Arts; Drama

Resource Information

Anastakis, Dimitry. *Auto Pact: Creating a Borderless North American Auto Industry, 1960–1971*. Toronto: University of Toronto Press, 2005. ISBN 0802039030.

Anastakis, Dimitry. *Car Nation: An Illustrated History of Canada's Transformation Behind the Wheel*. Toronto: J. Lorimer & Co., 2008. ISBN 1552770052.

Basu, Dr. Suddhasatwa. *Recent Trends in Fuel Cell Science and Technology*. New York: Springer, 2007. ISBN 0387355375.

Boschert, Sherry. *Plug-in Hybrids: The Cars that Will Recharge America*. Gabriola Island, British Columbia: New Society Publishers, 2006. ISBN 0865715718.

Durnford, Hugh. *Cars of Canada*. Toronto: McClelland & Stewart, 1973. ISBN 0771029578.

Eriavec, Jack and Jeff Arias. *Hybrid, Electric and Fuel-Cell Vehicles*. Florence, Kentucky: Delmar Cengage Learning, 2006. ISBN 1401881084.

Hoogers, Gregor. *Fuel Cell Technology Handbook,*. Boca Raton, Florida: CRC Press, 2002. ISBN 0849308771.

Laraminie, James and John Lowry. *Electric Vehicle Technology Explained*. Etobicoke, Ontario: John Wiley & Sons Canada, 2003. ISBN 0470851635.

Monaghan, David W. *Canada's "New Main Street:" The Trans-Canada Highway as Idea and Reality, 1912–1956.* Transformation Series, no. 11. Ottawa: Canada Science and Technology Museum, 2002. ISBN 0660187205.

Morton, Desmond. *Wheels: The Car in Canada*. Toronto: Umbrella Press, 1998. ISBN 189542035.

Robertson, Heather. *Driving Force: The McLaughlin Family and the Age of the Car*. Toronto: McClelland & Stewart, 1995. ISBN 0771075561.

Sherk, Bill. *60 Years Behind the Wheel: The Cars We Drove in Canada, 1900–1960*. Toronto: Dundurn Press, 2003. ISBN 1550024655.

Sperling, Daniel. *Future Drive, Electric Vehicles and Sustainable Transportation.* Washington, D.C.: Island Press, 1995. ISBN 1-55963-327-1.

Westbrook, Micheal H. *The Electric Car: Development and Future of Battery, Hybrid and Fuel-Cell Cars*. London,England: The Institution of Electrical Engineers, 2001. ISBN 0852960131.

White, Richard. *Making Cars in Canada: A Brief History of the Canadian Automobile Industry, 1900–1980.* Transformation Series, no.15 Ottawa: Canada Science and Technology Museum, 2007. ISBN 9780660197425.

Useful Websites

Notice regarding Internet sites

The Internet links below are provided as a convenience only. We have taken care to suggest websites that are appropriate for education, but we cannot guarantee the content of any sites that are not under the control of the Canada Science and Technology Museums Corporation. Such websites may provide content or express opinions that do not necessarily represent the views of the Canada Science and Technology Museums Corporation. Should you choose to visit such websites, please do so solely at your own discretion.

Given the dynamic nature of the Internet, website addresses can change without notice.

Canada Science and Technology Museum — Online Resources

Canada Science and Technology Museum
www.sciencetech.technomuses.ca

Background Information about Electricity
www.sciencetech.technomuses.ca/english/schoolzone/Info_Electricity.cfm

Background Information about Energy and Energy Sources
www.sciencetech.technomuses.ca/english/schoolzone/info_energy.cfm

Canada Science and Engineering Hall of Fame
www.sciencetech.technomuses.ca/english/about/hallfame/u_main_e.cfm

Virtual Program — Canada Science and Engineering Hall of Fame
www.sciencetech.technomuses.ca/english/schoolzone/virtual_hall_of_fame.cfm

Transport Canada ecoTECHNOLOGY for Vehicles Program — Online Resources

ecoTECHNOLOGY for Vehicles Program
www.tc.gc.ca/etv

Vehicles
www.tc.gc.ca/eng/programs/environment-etv-vehicles-eng-433.htm

Technologies
www.tc.gc.ca/programs/environment/etv/tech-eng.htm

Glossary of Technical Terms
www.tc.gc.ca/programs/environment/etv/glossary-eng.htm

Other Online Resources

Electricity Theory — Keywords, Insulators and Conductors, Circuits, etc.
Hydro Quebec
Safety — www.hydroquebec.com/securite/index.html
Understanding Electricity — www.hydroquebec.com/comprendre/index.html

Hydrogen Fuel Cells
Government of British Columbia — www.empr.gov.bc.ca/RET/RenewableEnergyTechnologies/HFC/Pages/default.aspx
Canadian Hydrogen and Fuel Cell Association — www.h2fcc.ca
Natural Resources Canada — http://oee.nrcan.gc.ca/transportation/fuels/hydrogen-fuelcells/hydrogen.cfm

Energy Consumption
EnerGuide — http://oee.nrcan.gc.ca/EnerGuide/home.cfm
Natural Resources Canada — Stats re: Appliance Energy Consumption 1990–2006
http://oee.nrcan.gc.ca/publications/statistics/cama08/appendixd.cfm?attr=4

Canadian Innovators
Queen's University's Solar Design Team — www.qsdt.org

Canadian Companies and Innovation
Plasco Energy Group (Waste Management and Energy Production) – www.plascoenergygroup.com
Government of Quebec — www.mrn.gouv.qc.ca/energie/innovation/index.jsp
Ballard Fuel Cells — www.ballard.com
Iogen — www.iogen.ca

"Technology in the News" Case Study Resources
Canadian Wind Energy Association — www.canwea.ca/farms/casestudies_e.php
(there are four case studies here)
Oil Sands Watch (developed by the Pembina Institute) — www.oilsandswatch.org
Energy and Native Rights
http://firstnationsenergyalliance.org/home.html

Mapping Power Generation and Use
Atlas of Canada — http://atlas.NRCan.gc.ca/site/english/featureditems/index.html

The Environment and Automobile Innovations
Natural Resources Canada (Tools for purchasing a fuel-efficient vehicle)
http://oee.nrcan.gc.ca/transportation/personal/choose_vehicle.cfm?attr=0

Impacts of Bio-Fuel Production
Canadian Renewable Fuels Association — www.greenfuels.org
Natural Resources Canada — http://oee.nrcan.gc.ca/transportation/bio-fuels.cfm?attr=16
Natural Resources Canada — (comparing alternative fuel sources)
http://oee.nrcan.gc.ca/transportation/business/fuels.cfm.

Environmental Impact of Fuel/Energy Production
Oil Sands Watch (developed by the Pembina Institute) — www.oilsandswatch.org
Canadian Nuclear Safety Commission — www.nuclearsafety.gc.ca/eng/ea/index.cfm
Canadian Environmental Assessment Agency
www.ceaa-acee.gc.ca/default.asp?lang=En&n=CE87904C-1

Compare and Contrast — Technology and Its Use of Fuel/Energy
Government of Quebec
www.mrn.gouv.qc.ca/energie/hydroelectricite/index.jsp
www.hydroquebec.com/professeurs
Atomic Energy of Canada Limited — http://www.aecl.ca
CANDU nuclear reactors — www.candu.org/index.html
Bruce Power — www.brucepower.com/pagecontent.aspx?navuid=14
Canadian Nuclear Safety Commission — www.nuclearsafety.gc.ca/eng
Government of Quebec (wind power) — www.mrn.gouv.qc.ca/energie/eolien/index.jsp
Wind Energy Institute of Canada — www.weican.ca
Wind Energy TechnoCentre — www.eolien.qc.ca/?sec=publications_english

Renewable and Non-Renewable Energy
Canadian Geothermal Energy Association — www.cangea.ca
Independent Electricity System Operator (directs the flow of electricity in Ontario),
www.ieso.ca/imoweb/marketdata/genEnergy.asp

Driving the Future: Transportation, Energy, and the Environment was developed by a team of experienced educators at the Canada Science and Technology Museum, in collaboration with content experts from Transport Canada's ecoTECHNOLOGY for Vehicles Program.

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The Canada Science and Technology Museum
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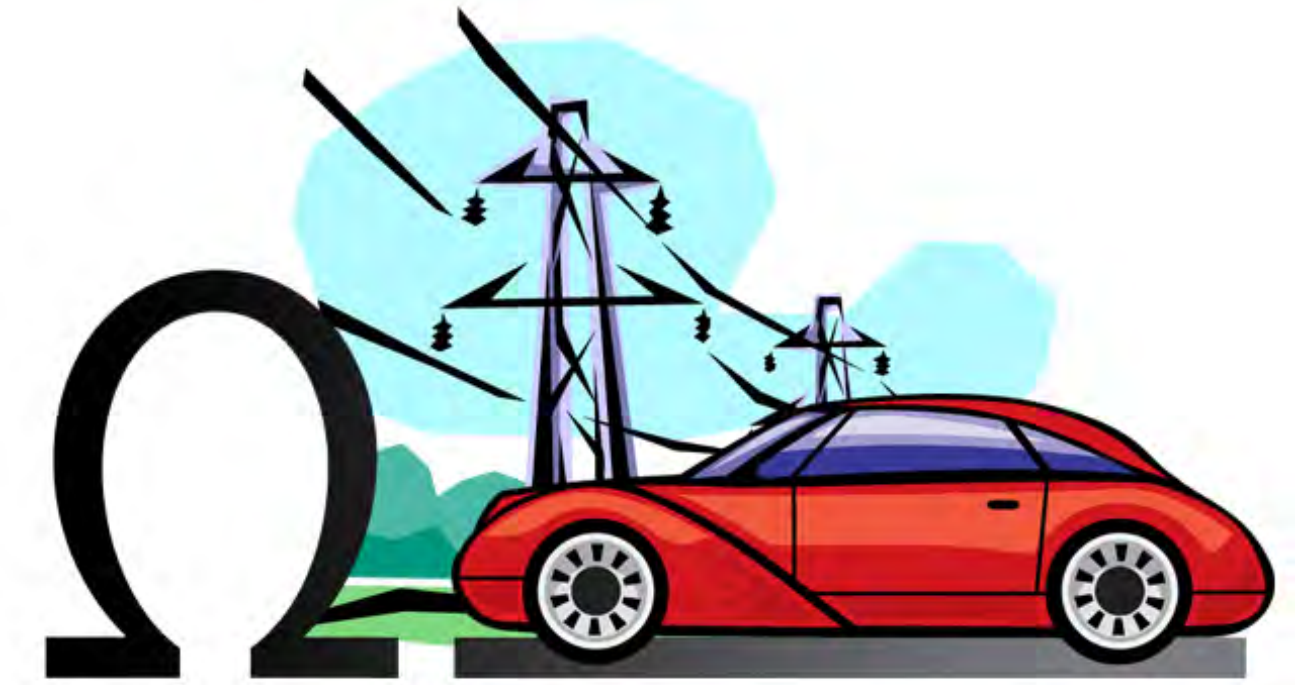
present

Driving the Future:
Transportation, Energy, and the Environment

Section 2

Focus on the Fundamentals:
Scientific and Technological Theory



CANADA SCIENCE AND TECHNOLOGY MUSEUM

Canada

Introduction

Canada has a national road network long enough to circle the globe 22 times, so it should come as no surprise that automobiles and city buses are Canada's most prevalent modes of transportation. Still, this convenience comes at a cost to our environment.

To fully grasp the impact that vehicles have on our environment and society, students must possess theoretical knowledge of transportation-related scientific and technological principles. In this section of the exploration guide, activities "focus on the fundamentals," placing core emphasis on theory-based learning.

> While this section of the exploration guide is linked to social and environmental issues, it focuses on theory. Later sections provide dynamic opportunities for students to apply their knowledge, exploring vehicle technology from a more social standpoint. **You may want to use this section concurrently with the others.**

Below is an outline of this section's structure. For a comprehensive overview of the entire exploration guide, please see Section 1 — Introduction.

2.1 Focus on the Fundamentals — Worksheet Series
2.2 Engines
2.3 Efficiency — Doing More with Less
2.4 Renewable and Non-Renewable Resources

Distinctive icons throughout the exploration guide indicate key features, helping you to find your way through the text quickly and efficiently.

 **Classroom Activity**	 **Discussion or Assignment Topic**
 **Deeper Study**	 **Website to Visit**

Activity Resources

Many of the following activities require students to conduct research online. Worksheets for all activities are included at the end of this section. Teachers may request an answer package for the more complex activity sheets by e-mailing **virt_prog@technomuses.ca**. Please allow one to two weeks for reply.

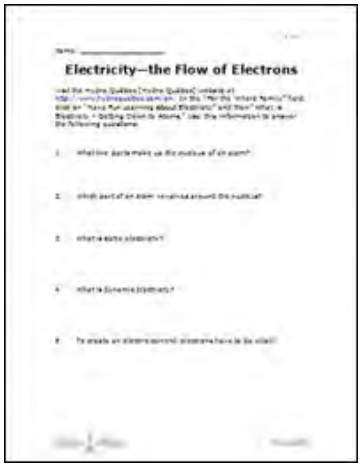
Activities

Activity 2.1: Focus on the Fundamentals — Worksheet Series

In order for students to grasp the many ways in which passenger vehicles impact our society and environment, it is essential that they have an underlying knowledge of core scientific and technological principles. How can we understand our interaction with vehicles, past and present, if we cannot comprehend the technological developments that shape today's automobiles?

The following worksheets introduce some of the fundamentals of vehicle technology, with special emphasis on electrical theory. These resources focus on acquiring vocabulary and understanding concepts, helping students to better understand how vehicles work. In turn, student will be better able to understand how improved vehicle design and engineering can incite tangible environmental progress.

For an overview of Transport Canada's ecoTECHNOLOGY for Vehicles program, visit its website at www.tc.gc.ca/etv.


Electricity—the Flow of Electrons

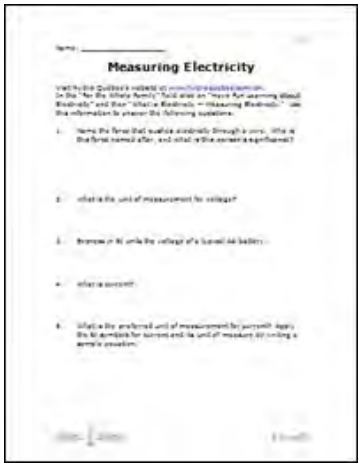
Part 1: Electricity — the Flow of Electrons

Objective: To grasp basic concepts related to electricity such as current flow, conductors, and insulators.

1. Have your students visit the Hydro Québec website at http://www.hydroquebec.com/en. In the "For the Whole Family" field, click on "Have Fun Learning about Electricity" and then "Getting Down to Atoms."
2. Working individually or in pairs, have students find the answers to the included worksheet.

Core Concepts

- Electric current is the flow of electrons through a conductor.
- Materials with electrons that have a high degree of mobility are called **conductors** (e.g., silver, copper, and gold). Materials with low electron mobility are called **insulators** (e.g., glass, rubber, and ceramic).
- Electric current can only flow if there is a continuous path into and out of a conductor. This never-ending pathway for electrons is called a **circuit**.


Measuring Electricity

Part 2: Measuring Electricity

Objective: To grasp basic concepts related to electricity — voltage, amperage, and resistance.

1. Have your students visit the Hydro Québec website at www.hydroquebec.com/en. In the "For the Whole Family" field click on "Have Fun Learning About Electricity" and then "Measuring Electricity." There, electric current is described using the analogy of water flowing through a hose.

2. The analogy of the water hose demonstrates that voltage or "push" (V), current or "flow rate" (I), and "resistance" (R) are related ($V = I \times R$). Note the core concepts listed below.

3. Working individually or in pairs, have students find answers to the included worksheet. To begin, click on "Measuring Electricity."

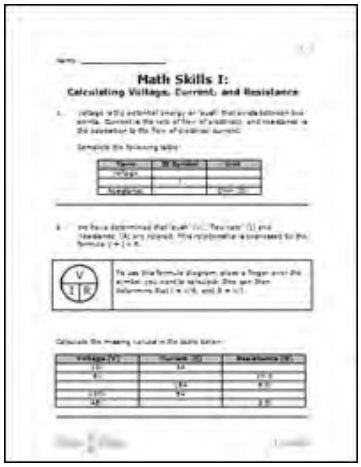
Core Concepts

Voltage (V), measured in volts, is the potential difference that exists between two points. It is the 'push.' Voltage is measured with a voltmeter.

Current (I), measured in amperes or amps, is the rate at which electricity flows. Current is measured using an ammeter.

Resistance (R), measured in ohms (Ω), is the opposition that the flow of current faces. Resistance is measured with an ohmmeter.

Power is the rate at which energy is used. Measured in units called watts, power equals the voltage times the current ($P = V \times I$). Power is measured using a wattmeter.


Math Skills I:
Calculating Voltage, Current, and Resistance

Part 3: Math Skills I — Calculating Voltage, Current, and Resistance

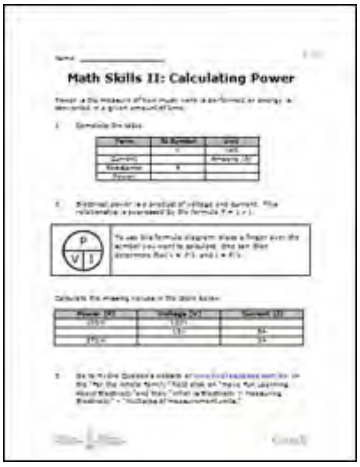
Objective: To use the formula $V = I \times R$ to calculate voltage, current, and resistance.

1. Working individually or in pairs, have students find the answers to the included worksheet.

2. The worksheet's final questions require students to visit Transport Canada's ecoTECHNOLOGY for Vehicles program website at www.tc.gc.ca/etv. Click on "Technologies," "Under the Hood," then "42-volt electrical architecture."

Core Concept:

Push (V), flow rate or current (I) and resistance (R) are interrelated. This relationship can be expressed by the formula V = I × R.


Math Skills II: Calculating Power

Part 4:

Math Skills II — Calculating Power

Objective: To calculate voltage, current, and resistance using the formula P = V × I.

1. Working individually or in pairs, have students find the answers to the included worksheet.
2. Measurement units and their prefixes are reviewed at Hydro Québec's website, at www.hydroquebec.com/en. In the "For the Whole Family" field click on "Have Fun Learning about Electricity" and then "Measuring Electricity" and "Multiples of Measurement Units."

Core Concepts

In physics, power is the measure of how much work is performed, or how much energy is converted, in a given amount of time.

The power of the internal combustion engine is the rate at which it converts chemical energy (obtained by burning fuel) into mechanical energy to drive the wheels. Mechanical power is measured in horsepower or hp.

The power (P) of a light bulb is the rate at which it turns electricity into light and heat. Electrical power is a product of voltage (V) multiplied by flow rate or current (I). This relationship can be expressed by the formula P = V x I.

Horsepower and watts are two different units used to describe the same kind of measurement — 1 hp = 746 watts.

Extension Activity

In 1831, Michael Faraday, a British scientist and inventor, began experimenting with wires in magnetic fields. He was able to demonstrate that current is generated in a wire moving with respect to a magnetic field. This effect, called electromagnetic induction, is the principle by which motors and generators work.

Have your students conduct online research, exploring Faraday's discovery for themselves. How many applications for induction can they list?

Activity 2.2: Engines

The history of engines is a story of invention, innovation, and transformation. The nineteenth century's steam locomotives transported people and cargo in unprecedented numbers — fuelling the expansion of Canada's rail system eastward, and west to the Pacific. Canada's railways expanded in step with the nation.

Engines were a force for social change in the early twentieth century, as personal automobiles increased the mobility of Canada's growing workforce. The widespread adoption of automobiles, thanks to mass production and improvements to Nikolaus Otto's internal combustion engine, has impacted both landscape and environment.

Even today, the rocket engine — the most powerful engine in existence — inspires us to imagine the possibilities of tomorrow.

In order for students to fully appreciate the impact that combustion engines and electric motors have on our environment, it is important that they understand how engines and motors work. The following activities will explore the function of engines and motors.

For an overview of the impact of steam locomotives in Canada, visit the Canada Science and Technology Museum's website at www.sciencetech.technomuses.ca. Choose "The Collection" in the left sidebar, click on "Collection Profiles," and then choose "Rail."

For additional information about steam engines, see the Museum's archived collection profiles (also accessible through the Collection Profiles webpage).

Introductory Activity: Combustion Engines in Action

Help your students to distinguish between internal and external combustion engines by having them observe working examples. A variety of examples exist on video-based social networking sites, such as YouTube or TeacherTube. You may wish to download interesting examples from home, and bring them in for your students to view as a class.

For instance, to see the Museum's Shay Locomotive and CP Edwards steamship engines in action, visit the Museum's YouTube Channel at www.youtube.com/cstmweb.


The Internal Combustion Engine

Part 1: The Internal Combustion Engine

Objective: To grasp the workings of a four-stroke engine.

1. Have students explore the workings of a four-stroke engine at http://en.wikipedia.org/wiki/Four_stroke_engine#Design_and_engineering_principles

2, Working individually or in pairs, have students answer the included worksheet.

Core Concepts

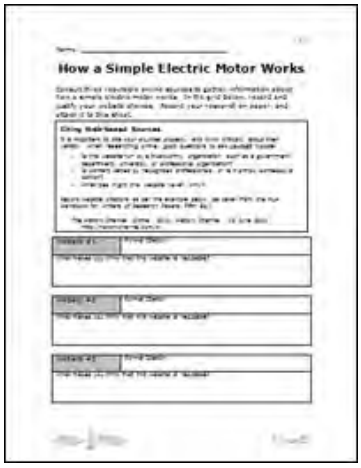
Most cars in use today run on a four-stroke (Otto's Cycle) internal combustion engine, where the fuel (gasoline) is burned inside a cylinder.

Four-stroke engines produce power with the movements (or strokes) of the piston inside the cylinder. The four strokes are: 1- induction, 2- compression, 3- power, and 4- exhaust.

For information about how a steam locomotive works, have students visit the Canada Science and Technology Museum's website at www.sciencetech.technomuses.ca. Have students select "School Zone," choose "Tell me About," and then select "Trains" from the topic list.

Core Concepts

In an external combustion engine (such as a locomotive's steam engine) a fuel is burned to heat a liquid. The liquid expands and is converted into a gas. The resulting energy is captured to drive a machine. The locomotive is a perfect example of an external combustion engine, where the fuel (coal or wood) is burned outside the cylinder. The resulting steam powers the locomotive.


How a Simple Electric Motor Works

Part 2: How a Simple Electric Motor Works

Objective: To observe the workings of a simple electric motor.

1. Have your students watch a video clip that demonstrates the assembly and function of a simple electric motor. A wealth of material exists on video-based social networking sites such as YouTube and TeacherTube. For an example, visit www.youtube.com. Type "unexplained phenomenon — simplest electric motor" into the search bar.

2. Using the included worksheet, have your students consult three online sources, collecting information about how an electric motor works. Then have students create a diagram outlining the various steps in building a simple electric motor.

Hands-On Discovery

Working individually or in pairs, have students apply the information they have gained to build a simple electric motor. Students will need a 1.5 volt AA battery, a length of wire, and a magnet.

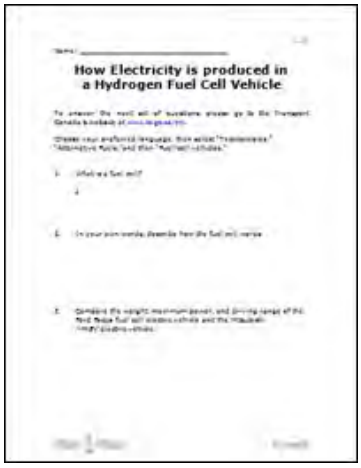
Core Concepts

Electric motors use magnets and magnetism. Magnets have a north and a south pole — opposite poles attract, and like poles repel.

Michael Faraday first demonstrated the link between electricity and magnetism. He discovered that movement between a magnetic field and a coil of wire can create electricity — this is called induction. Faraday's research led to the creation of generators and motors.

In a generator, the movement between a magnetic field and a coil of wire generates electricity. In a motor, however, electricity running through a coil of wire set in a magnetic field creates rotational motion.

For additional background information about electricity, have your students visits the Canada Science and Technology Museum website at www.sciencetech.technomuses.ca. Have them click on "School Zone and then "Tell Me About."


How Electricity is produced in a Hydrogen Fuel Cell Vehicle

Part 3: How Electricity Is Produced in a Hydrogen Fuel-Cell Vehicle

Objective: To discover how hydrogen fuel cells function.

1. Have students visit Transport Canada's ecoTECHNOLOGY for Vehicles Program website at www.tc.gc.ca/etv, and click on "Technologies."

2. Working individually or in pairs, have students find the answers to the included worksheet.

Core Concepts

Hydrogen fuel-cell vehicles work on the same principles as battery electric vehicles — the fuel cell, like a battery, powers the electric motor.

In a hydrogen fuel cell, electricity is generated through an electrochemical reaction between hydrogen and oxygen.

Research Assignment

Most automobiles, trucks, and buses in use today operate with an internal combustion engine. Have students conduct research on the products of combustion. Use some of the following questions as a guide:

- What is the chemical reaction of combustion?
- What are the resultant emissions?
- How do emissions dissipate?
- How do the chemical reactions and resultant emissions change when different fuels are used?
- What are the effects of combusted fuels on the local air quality index in high density urban areas?

Activity 2.3: Efficiency — Doing More with Less

In order for students to contextualize improvements in vehicle technology, they must firmly grasp the concept of efficiency. Efficiency is a measure of how effectively a mechanical system performs — the ratio of the power supplied to a mechanical system, and the power that it in turn delivers. No mechanical system can ever be perfectly efficient due to energy losses such as friction. Engineers attempt to minimize energy loss when designing machines, and there are a number of exciting technologies that are increasing the efficiency of new vehicles.

Vehicle efficiency is very important because increased efficiency allows for the same movement of people or goods with less fuel. This results in reduced fuel costs, as well as reduced pollution and fewer greenhouse gas (GHG) emissions.

Besides vehicle engineering, consumers' vehicle choices and driving styles can lead to increased efficiency. A vehicle's efficiency is also impacted by its fuel source. Cars, for example, can run on a variety of fuels other than gasoline such as natural gas, diesel, hydrogen, or electricity. Each of these fuels results in different kinds and quantities of atmospheric pollution.

Note

To learn more about the efficiency of fuel sources, see Section 4 of the exploration guide.

Core Concept

Efficiency is the ratio of power supplied to a machine in relation to the power that the machine puts out. This can be calculated using the following formula, where P represents power:

$$(P_{out} / P_{in}) \times 100\%$$

For more general information about efficiency, visit Natural Resources Canada's Office of Energy Efficiency's website at http://oee.nrcan.gc.ca/EnerGuide/home.cfm.


What is an Efficient Vehicle?

Part 1: What Is an Efficient Vehicle?

Objective: to grasp the concept of vehicle efficiency, and identify factors that impact efficiency.

In this activity, students examine the top three efficient vehicles in three separate years. They will analyze any increases in efficiency in an attempt to determine exactly what is meant by the term **efficiency.**

1. Have students visit the Office of Energy Efficiency website at http://oee.nrcan.gc.ca. Select "Business Transportation," "Driver Education," and then "Autosmart Video Series." Watch the first movie, entitled: *Module 1 — What is Fuel Efficiency and Why is it Important?*

2. Next, have students return to the Office of Energy Efficiency's main page. Under the "Personal Use" heading, have them select "Transportation." Have them click on "Choosing a Fuel-Efficient Vehicle," and then "The Most Fuel-Efficient Vehicles." On the provided worksheet, have students list the top rated vehicles in the various categories over three years, and answer the follow-up questions.

Part 2: Energy Efficiency through Advanced Vehicle Technologies

Objective: to discover how a variety of technologies can contribute to improving the efficiency of vehicles.

In response to public demand, vehicle manufacturers are investigating many new methods to improve vehicle efficiency. Gains in efficiency can come from many of the different systems within a vehicle, including the engine, transmission, drive train, and drive wheels.

1. Have your students explore Transport Canada's ecoTECHNOLOGY for Vehicles website at www.tc.gc.ca/etv. Have students click on "Technologies."

2. Have students click on "Under the Hood," and select three of the components that affect a vehicle's efficiency. Have them list the advantages and the disadvantages of each of their chosen components.

Oral Presentation

Based on their research about vehicle components and efficiency, have each student give an oral presentation. Students should explain which advanced technology component they think car manufacturers should adopt in all of their vehicles to improve vehicle efficiency. They should support their views with material from their research.


Improving Vehicle Efficiency

Part 3: Improving Vehicle Efficiency

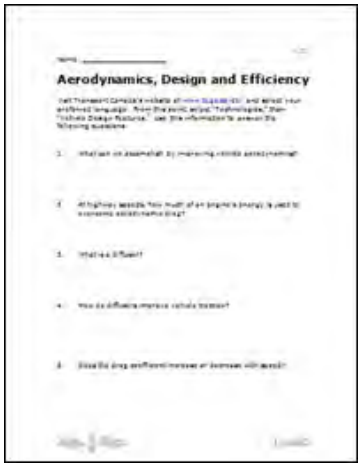
Objective: to discover ways in which vehicle efficiency can be improved.

Now that your students have discovered how vehicle efficiency is rated and classified, have them examine other ways to increase the efficiency of a vehicle. Have students visit the Office of Energy Efficiency's website at http://oee.nrcan.gc.ca.

For information about fuel-efficient driving, have students click on "Fuel-Efficient Driving," "Tips and Resources for Drivers," and "AutoSmart Thinking — Fuel-Efficient Driving Tips."

For information about car maintenance and fuel efficiency, have students click on "Vehicle Maintenance," then "Vehicle Maintenance Tips."

After completing the worksheet, conduct a class discussion about other ways to reduce the environmental impact of transportation (using public transit, walking, bicycling, etc.).


Aerodynamics, Design and Efficiency

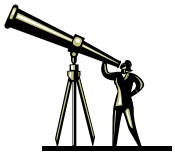
Part 4: Aerodynamics, Design, and Efficiency

Objective: To understand the concept of aerodynamics, and how aerodynamics can improve vehicle design.

1. Have your students explore Transport Canada's ecoTECHNOLOGY for Vehicles website at www.tc.gc.ca/etv. Have students click on "Technologies" then "Vehicle Design Features." This online resource provides information about how lowering aerodynamic drag can improve fuel efficiency.

2. Working individually or in pairs, have students find answers to the included worksheet.

Extension Activity — Vehicle Idling



One of the easiest ways to reduce fuel consumption, and in turn greenhouse gas (GHG) emissions and other pollutants, is to reduce the amount of time that people idle their cars. The average driver spends six minutes idling each day. Any reduction in this time can have a large impact on the amount of fuel that we use, and the pollution we release into the atmosphere.

The Natural Resources Canada (NRCan) website has a lot of information about vehicle idling and how it affects the environment. Have your students visit the Office of Energy Efficiency's website at http://oee.nrcan.gc.ca. Under the "Personal Use" heading, have students select "Transportation." Then have them select "Idling Impact Calculator" from the "Tools" sidebar.

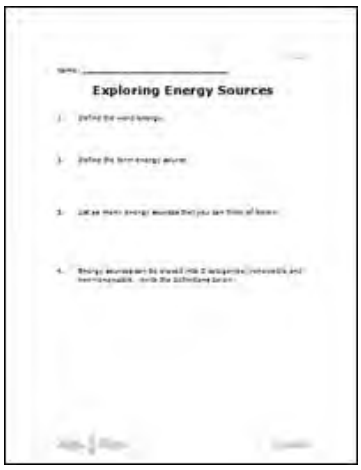
Using this calculator, have students determine the impact that their community could make if it reduced its vehicle idling time by a mere two minutes per day. This could culminate in students creating a "No Idling" campaign in their school or community — disseminating the important knowledge that they have gained. Note that the Office of Energy Efficiency has a variety of resources on their website aimed at helping individuals take action in the area of vehicle idling awareness.

Activity 2.4: Renewable and Non-Renewable Resources

It is important for students to know the difference between renewable and non-renewable energy sources in order to understand how trends in energy consumption affect Canadian society — now and in the future. Is our energy consumption sustainable, and if not, what can we do today to ensure there is enough energy for tomorrow?

For more information about renewable and non-renewable resources, visit the Climate Change North website at www.climatechangenorth.ca. Type "Renewable Energy" in the search pane.

To learn more about the advantages and challenges of using renewable resources, Visit the Natural Resources Canada's Office of Energy Efficiency's website at http://oee.nrcan.gc.ca. Enter "advantages and challenges" in the search pane, and select "Calendar Club – Lessons."


Exploring Energy Sources

Part 1: Exploring Energy Sources

Objectives: to define renewable and non-renewable energy, to classify energy sources into these two categories, and to identify trends in Canadian energy consumption by energy type.

1. As an introduction to this activity, ask students what they think of when they hear the word **energy**. As a class, come up with a definition for the terms **energy** and **energy source**. Students can write down these definitions on their worksheet (questions 1 and 2) for future reference.
2. Have students list as many energy sources as they can, writing them on the board. Students can add this list to their worksheet as their answer to question 3.
3. Have your students complete the rest of their worksheet individually or in pairs. Students will need to access the *Canadian Atlas* at www.canadiangeographic.ca/atlas/. Alternately, students could use a printed Canadian atlas, but their answers may differ from those contained in the Virtual Program's answer sheet package.


How Long Can You Go?

Activity 1

Part 2: How Long Can You Go?

Objectives: to explore how conservation and the use of renewable energy sources can slow the exhaustion of non-renewable resources.

In this activity, students explore how non-renewable resources can be exhausted over time.

1. Divide your class into groups of four to six students.
2. Give each group a bag containing 100 craft beads — 94 of one colour and 6 of another. The beads represent the ratio of non-renewable and renewable energy (at a 6% renewable energy consumption rate).
3. Have the students complete this activity by following the instructions on the provided worksheet, and recording their results on the data recording sheet provided.
4. Once students have completed the activity, you can follow up by introducing them to the concept of sustainability.

This activity was inspired by the "Renew-a Bean" exercise in *Renewables are Ready: A Guide to Teaching Renewable Energy in Junior and Senior High School Classrooms*, by the Union of Concerned Scientists ©, 2003. This resource is available online at: www.ucsusa.org/assets/documents/clean_energy/renewablesready_fullreport.pdf

Note

A good follow-up to this activity can be found in Activity 3.5. The “Ecological Footprint” activity enables students to calculate the environmental impact of their daily activities.

Name: _____

Electricity — the Flow of Electrons

Visit the Hydro Québec website at www.hydroquebec.com/en. In the "For the Whole Family" field, click on "Have Fun Learning About Electricity" and then "Getting Down to Atoms." Use this information to answer the following questions:

1. What two parts make up the nucleus of an atom?

2. Which part of an atom revolves around the nucleus?

3. What is static electricity?

4. What is dynamic electricity?

5. To create an electric current, what do electrons have to do?

6. What is special about the electrons found in materials that are good electrical conductors? Provide two examples of conductors.

7. What can the electrons of materials that are non-conductors not easily do? Provide two examples of non-conductors.

8. Explain direct current (DC).

9. Explain alternating current (AC).

Name: _____

Measuring Electricity

Visit Hydro Québec's website at www.hydroquebec.com/en.
In the "For the Whole Family" field click on "Have Fun Learning about Electricity" and then "Measuring Electricity." Use this information to answer the following questions:

1. Name the force that pushes electricity through a wire. Who is this force named after, and what is this person's significance?

2. What is the unit of measurement for voltage?

3. Express the voltage of a typical AA battery in SI units.

4. What is current?

5. What is the preferred unit of measurement for current? Apply the SI symbols for current and its unit of measurement by writing a sample equation.

6. What opposes the flow of electrons in a conductor?

7. What is the SI unit for measuring resistance?

8. What is the full name of the German physicist who formulated Ohm's Law?

9. For a given amount of water pressure, which will have the greatest rate of flow — a small nozzle, or a large one? Apply this analogy to explain the flow rate of electricity.

10. Name the unit used for measuring electrical power, and explain how it is calculated.

11. Using the analogy of the water hose, explain how voltage, amperage, and resistance are related.

Name: _____

Math Skills I —
Calculating Voltage, Current, and Resistance

1. Voltage is the potential energy or “push” that exists between two points. Current is the rate of flow of electricity, and resistance is the opposition to the flow of electrical current.

   Complete the following table:

Term	SI Symbol	Unit
Voltage		
	I	
Resistance		Ohm (Ω)

2. We have determined that push (V), flow rate (I) and resistance (R) are related. This relationship is expressed by the formula $V = I \times R$.

To use this formula diagram, place a finger over the symbol you want to calculate. One can then determine that $I = V/R$, and $R = V/I$.

Calculate the missing values in the table below:

Voltage (V)	Current (I)	Resistance (R)
12V	3A	
6V		10 Ω
	15A	8 Ω
120V	5A	
48V		2 Ω

To answer the following questions, go to Transport Canada's ecoTECHNOLOGY for Vehicles website at www.tc.gc.ca/etv.

To access information about the 42-volt architecture for car batteries, click on "Technologies," "Under the Hood," and "42-volt electrical architecture."

3. The electrical sub-systems (components) and circuitry found in most of today's cars are based on the 12-volt car battery. List three advantages of switching to a 42-volt electrical architecture.

4. In your own words, explain the main advantages of adopting a 42-volt electrical architecture. Name some of the vehicle electrical sub-systems that would benefit.

Name: _____

Math Skills II — Calculating Power

Power is the measure of how much work is performed or energy is converted in a given amount of time.

1. Complete the table.

Term	SI Symbol	Unit
	V	volt
current		ampere
resistance	R	
power		

2. Electrical power is a product of voltage and current. This relationship is expressed by the formula P = V × I.

To use this formula diagram, place a finger over the symbol you want to calculate. One can then determine that V = P/I, and I = P/V.

Calculate the missing values in the table below.

Power (P)	Voltage (V)	Current (I)
100W	120V	
	12V	5A
270W		2A

3. Go to Hydro Québec's website at www.hydroquebec.com/en. In the "For the Whole Family" field click on "Have Fun Learning about Electricity" and then "Measuring Electricity" and "Multiples of Measurement Units."

   The prefixes below are used extensively in electrical theory to express units of measure. Complete the following table:

Number	Scientific Notation	Prefix	Symbol
1 000		kili	
	10^6		M
1 000 000 000			G
	10^{12}	tera	

4. Go to Transport Canada's ecoTECHNOLOGY for Vehicles website at www.tc.gc.ca/etv. On this page, click on "Vehicles," choose "Hybrid and Plug-in Hybrids," and then select the "Toyota 2010 Prius."

   How many watts of energy does the electric motor in a Prius produce? How many kilowatts is this?

Did you know?

The mechanical power of an internal combustion engine is measured in horsepower (hp). Mechanical and electrical power use two different units to describe the same kind of measurement: 1 hp equals 746 watts. These units of measurement can be used interchangeably.

5. Go to the Canadian Wind Energy Association website at www.canwea.ca/wind-energy/windfacts_e.php and click on "Wind Technology."

   Determine the energy output of the technologies listed in the table below.

Energy Source	Kilowatts (kW)	Watts (W)
small wind		
turbines 5 years ago		
turbines today		
Toyota Prius electric motor		

6. Search online to find the name of the principle by which the electric motor and generator work. To whom do we owe this discovery?

Name: _____

The Internal Combustion Engine

1. Who holds the first patent for the internal combustion engine?

2. Name the German engineer who was the first to use the internal combustion engine in a car.

3. Name the four strokes of Otto's internal combustion engine.

4. During the induction stroke, what does the piston do?

5. At the induction stroke, what is forced into the cylinder?

6. During the compression stroke, what is compressed?

7. In order for compression to occur, are both the intake and exhaust valves of the cylinder kept open or closed?

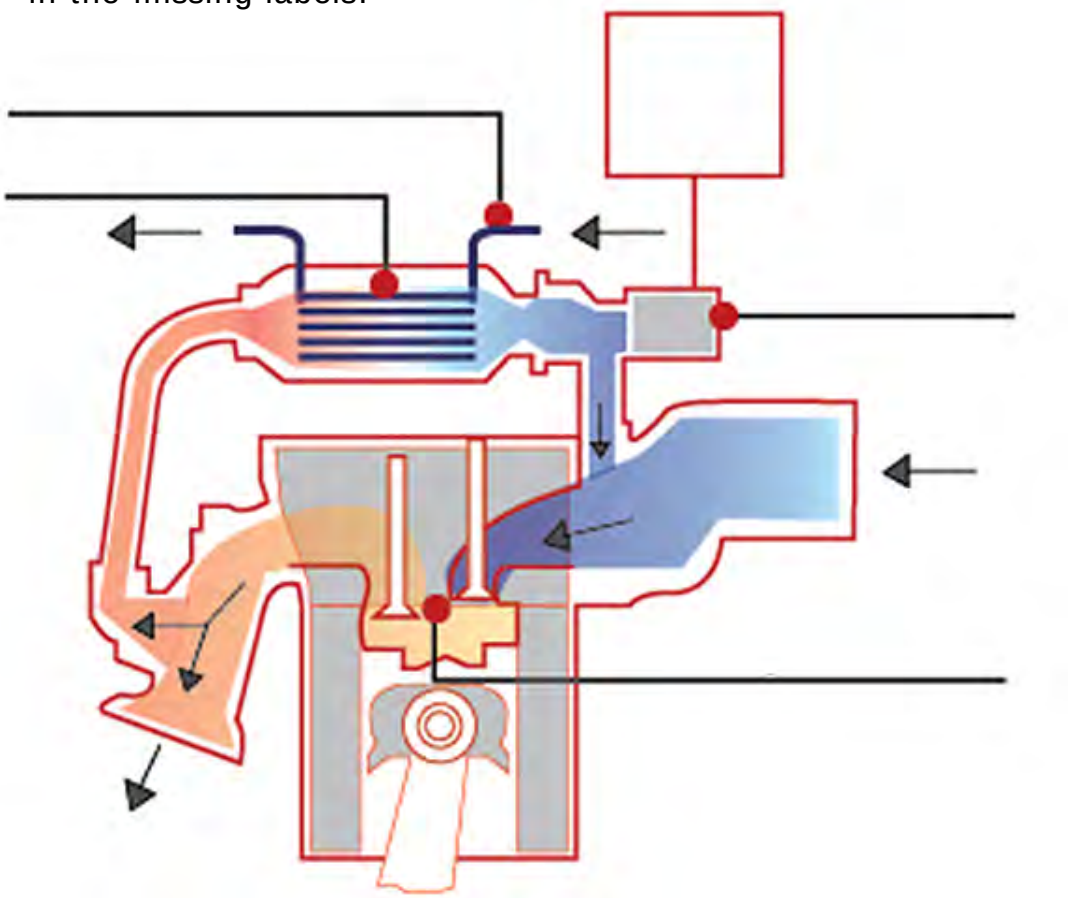
8. What happens to the fuel-air mixture when the piston reaches the top of the cylinder?

9. Fill in the missing key words.

   During the exhaust stroke, the piston once again returns to _____ while the exhaust valve is _____. This action _____ the products of combustion from the cylinder by pushing the _____ through the exhaust valve(s).

To answer the next set of questions, please go to the Transport Canada's ecoTECHNOLOGY for Vehicles website at www.tc.gc.ca/etv. Click on "Technologies," then under "Types of Technologies" click on "Under the Hood." Under "Emission Controls," click on "Exhaust Gas Recirculation."

10. The image below shows the exhaust gas recirculation system. Fill in the missing labels.



Credit: Transport Canada's ecoTECHNOLOGY for Vehicles Program

11. When were exhaust gas systems in cars introduced?

12. In your own words, explain what an exhaust gas recirculation system does.

13. What combines with oxygen and sunlight to produce smog? What is the symbol?

14. Under “Emission Controls,” click on “Mercedes-Benz BlueTEC with AdBlue.” Label the four stages of the Diesel Exhaust Treatment System on the picture below.

Credit: Transport Canada’s ecoTECHNOLOGY for Vehicles Program

Name: _____

How a Simple Electric Motor Works

Consult three reputable online sources to gather information about how a simple electric motor works. Record your research on paper. Record and justify your website choices on the grid below, and attach it to your research notes.

Citing Web-Based Sources

It is important to cite your sources properly, and think critically about their validity. When researching online, good questions to ask yourself include:

- Is this website run by a trustworthy organization such as a government department, university, or professional organization?
- Is content vetted by recognized professionals, or is it simply somebody's opinion?
- What bias might this website have? Why?

Record website citations using the steps listed below:

Order of Reference Elements:

1. **Name of website author or organization:** last name, comma, first name, period
2. **Title of the website:** in italics, comma; if citing an article within the website, insert the title of the article, in quotation marks, followed by a comma and then the italicized title of the website
3. The **date of the website's last update**, comma
4. The **name of any organization** associated with the website (if not the author), comma
5. The **website URL**, in parentheses, comma
6. The **date** that you consulted the website, period

Example:

Canada Agriculture Museum. *Bees: A Honey of an Idea*, 2009, (http://www.agriculture.technomuses.ca/english/bees/default.php), 11 August 2010.

Website #1	Formal Citation:
What makes you think that this website is trustworthy?	

Website #2	Formal Citation:
What makes you think that this website is trustworthy?	

Website #3	Formal Citation:
What makes you think that this website is trustworthy?	

Name: _____

How Electricity is produced in a Hydrogen Fuel-Cell Vehicle

To answer the next set of questions, please go to the Transport Canada's ecoTECHNOLOGY for Vehicles website at www.tc.gc.ca/etv, and select "Technologies," "Alternative Fuels," and then "Fuel-Cell Vehicles."

1. What is a fuel cell?

2. In your own words, describe how a fuel cell works.

3. Compare the weight, maximum power, and driving range of the Ford Focus fuel-cell electric vehicle and the Mitsubishi i-MiEV battery electric vehicle.

4. What three environmental benefits of hydrogen fuel-cell vehicles does the ecoTECHNOLOGY for Vehicles program list on its website?

Name: _____

What is an Efficient Vehicle?

Visit the Office of Energy Efficiency's website at http://oee.nrcan.gc.ca. Under the "Personal Use" heading, select "Transportation," then click on "Choosing a Fuel-Efficient Vehicle," and then "The Most Fuel-Efficient Vehicles."

1. Determine the most fuel-efficient compact car, mid-size car, and pick-up truck for three years of your choice, and examine their operating costs and annual emissions. Record this information in the grid below.

	Vehicle Model Name	Annual Fuel Cost ($)	Annual CO_2 Emissions (kg)
Year			
Compact Car			
Mid-Size Car			
Truck			
Year			
Compact Car			
Mid-Size Car			
Truck			
Year			
Compact Car			
Mid-Size Car			
Truck			

2. Which vehicle in your completed grid is the most efficient? Why do you think that this is?

3. What year in your grid produced the most efficient vehicle? Why do you think that this is?

4. List some other factors, aside from efficiency, that might determine which vehicle a consumer purchases.

Name: _____

Improving Vehicle Efficiency

Visit the Office of Energy Efficiency's website at http://oee.nrcan.gc.ca. Under the "Personal Use" heading, select "Transportation."

For information about fuel-efficient driving, click on "Fuel-Efficient Driving," "Tips and Resources for Drivers," and "AutoSmart Thinking — Fuel-Efficient Driving Tips."

For information about car maintenance and fuel efficiency, click on "Vehicle Maintenance," then "Vehicle Maintenance Tips."

Use these web pages to assist you in answering the following questions:

---

1. An 8 psi pressure reduction can result in an efficiency loss of _____ and possibly reduce the life of your tires by up to _____.

2. Some of the best ways to reduce fuel consumption involve changing your driving style. What three driving-style changes does Natural Resources Canada suggest for reducing your fuel consumption?

3. What two methods does Environment Canada suggest for cooling your car without using its air conditioning system?

4. Why can using cruise control reduce your fuel consumption?

5. Reducing your car's speed from 120 km/h to 100 km/h, a reduction of 16%, can save ____% in fuel consumption.

6. You should turn off your car if you will be idling for more than _____ seconds (when not in traffic).

7. By servicing your vehicle regularly, for instance changing the _____, _____, and _____ , you will ensure your car's optimum performance and fuel efficiency.

8. In gasoline-run vehicles, the spark plugs ignite the fuel-air mixture. Why would a poorly maintained ignition system affect fuel efficiency?

9. It is important to keep your vehicle in good working order — for safety reasons as well as to ensure peak efficiency. A poorly maintained engine can use up to _____ more fuel than a vehicle that is in top shape.

Name: _____

Aerodynamics, Design and Efficiency

Visit Transport Canada's ecoTECHNOLOGY for Vehicles website at www.tc.gc.ca/etv and select "Technologies," then "Vehicle Design Features." Use this information to answer the following questions:

1. What can we accomplish by improving vehicle aerodynamics?

2. At highway speeds, how much of an engine's energy is used to overcome aerodynamic drag?

3. What is a diffuser?

4. How do diffusers improve vehicle traction?

5. Does the drag coefficient increase or decrease with speed?

6. What is a wheel-well fairing?

7. Wheel-well fairings reduce aerodynamic losses by doing what?

Name: _____

Exploring Energy Sources

1. Define the word *energy*.

2. Define the term *energy source*.

3. List as many energy sources as you can think of below.

4. Energy sources can be placed into two categories: renewable and non-renewable. Define these categories below.

5. Use these definitions to decide which of the energy sources listed in question 3 are renewable or non-renewable.

Renewable Energy Sources	**Non-Renewable Energy Sources**

6. For help in answering the following questions visit the *Canadian Atlas* website at www.canadiangeographic.ca/atlas/

a. How much of the energy we use in Canada comes from renewable energy sources?

b. In the box below, draw a pie chart that illustrates the total energy consumption in Canada by resource type. Label each resource, and colour code the chart to differentiate between renewable and non-renewable resources.

Name: _____

How Long Can You Go?

Materials

- 1 bag containing 100 beads per group
- 1 data record sheet per group

In this activity, your group simulates the use of renewable and non-renewable energy sources over time. Your teacher will tell you which bead colours represent renewable and non-renewable energy sources.

Every student in your group will take a turn drawing ten beads from the bag. Each turn will represent one year of energy consumption.

Activity 1

Instructions

1. The first person in your group will draw ten beads out of the bag without looking. Record the number of renewable and non-renewable beads you drew from the bag on Table 1 of your Data Record Sheet.
2. Set all non-renewable beads aside — they are used up! Any renewable bead should be returned to the bag.
3. Repeat steps 1 and 2 as many times as necessary until all non-renewable beads are used up.

Questions

1. How many years did it take to run out of non-renewable energy?

2. When the non-renewable energy ran out, was there enough energy to meet the needs of the next year (ten beads)?

3. How could you make the energy supply last longer?

Activity 2

Is there a way to ensure an adequate supply of energy for the future? Let's find out what would happen if society becomes more conscious of its energy use, decreasing consumption by about 3% per year.

Instructions

1. Have one student from your group begin by drawing beads out of the bag without looking. This student should draw the first quantity of beads listed on Table 2 of the Data Record Sheet. Note: the amount of beads decreases by about 3% each year.
2. Record the number of renewable and non-renewable beads you draw from the bag on Table 2 of your Data Record Sheet.
3. Set all non-renewable beads aside — they are used up! Any renewable beads should be returned to the bag.
4. Repeat steps 1, 2, and 3 as many times as necessary until all non-renewable beads are used up.

Questions

1. How many years did it take to run out of non-renewable energy in activity 2? Compare your results to activity 1.

2. A sustainable use of energy ensures that there will always be enough energy for the future. By reducing the energy consumption by about 3% per year, was there enough energy to meet the needs of the next year when the non-renewable energy ran out (was the energy consumption sustainable)?

3. In your opinion, is Canada's present energy consumption sustainable? If not, what can we do to make it sustainable?

Names of Group Members: _____

How Long Can You Go?
Data Record Sheet

Each draw of beads from the bag represents one year of energy use. If you draw a non-renewable bead, set it aside. If you draw a renewable bead, return it to the bag. Record how many renewable and non-renewable beads you draw each year in the tables below.

Table 1

Year	1	2	3	4	5	6	7	8	9	10	11	12
# of Beads to Draw	10	10	10	10	10	10	10	10	10	10	10	10
Renewable												
Non-Renewable												

Year	13	14	15	16	17	18	19	20	21	22	23	24
# of Beads to Draw	10	10	10	10	10	10	10	10	10	10	10	10
Renewable												
Non-Renewable												

Table 2

Year	1	2	3	4	5	6	7	8	9	10	11	12
# of Beads to Draw	10	10	9	9	9	9	8	8	8	8	7	7
Renewable												
Non-Renewable												

Year	13	14	15	16	17	18	19	20	21	22	23	24
# of Beads to Draw	7	7	7	6	6	6	6	6	5	5	5	5
Renewable												
Non-Renewable												

The Canada Science and Technology Museum
and
Transport Canada's ecoTECHNOLOGY for Vehicles Program
present

Driving the Future:
Transportation, Energy and the Environment

Section 3

Human Impacts:
Cars, Energy, and Canadian Society

CANADA SCIENCE AND TECHNOLOGY MUSEUM

Canada

Introduction

Transportation technology is a complex topic that branches into many scientific and technological fields. Still, most students will relate to cars on a social level. We have personal relationships with our vehicles — choosing them (or admiring them) based on our personal needs, wants, and lifestyles.

Cars have had a profound impact on Canadian society. Canada has contributed many notable innovations to the automotive sector throughout its history. Cars, in turn, have shaped the Canadian landscape, notably with the emergence of commuter suburbs.

This section of the exploration guide focuses on the impact that vehicles have had on Canadian society. Activities combine historical and social investigation with scientific study, helping students to contextualize current issues related to automobiles, energy production and use, and the environmental repercussions associated with the lifecycle of vehicles.

The following is an outline of this section's structure. For a comprehensive overview of the entire exploration guide, please see Section 1.

3.1 Canada's Cars over Time
3.2 History of Canadian Vehicle Innovations
3.3 Meeting Our Energy Needs
3.4 Cars in Canada Today
3.5 Ecological Footprint
3.6 Selling the Science

Distinctive icons throughout the exploration guide indicate its key features, helping you to find your way through the text quickly and efficiently.

 **Classroom Activity**	 **Discussion or Assignment Topic**
 **Deeper Study**	 **Website to Visit**

Activity Resources

Many of the following activities require students to conduct research online. Worksheets for all activities are included at the end of this section. Teachers may request an answer package for the more complex activity sheets by e-mailing **virt_prog@technomuses.ca**. Please allow one to two weeks for reply.

Activities

Activity 3.1: Canadian Cars over Time

In order for students to fully grasp the impact that cars have on our lives, it is important that they understand the evolution of the relationships that Canadians have with automobiles. What factors have led cars to play such a central role in Canadians' lives? How have cars changed Canadian society — and how has Canadian society changed automobiles?

For some background information about automobiles and the car industry in Canada, visit the *Canadian Encyclopedia* online at www.thecanadianencyclopedia.com and enter "automobile" in the search field.


Oral History
Interview Prompt Sheet

Part 1: Oral History

Objective: to better understand, from an individual perspective, the ways in which automobiles have changed the lives of Canadians.

1. As a brief introductory activity, conduct a class discussion about the role that cars play in our lives. Ask students how their life would be different without access to automobiles. How would they travel to school, to work, or to social events? You may wish to record key ideas about the ways in which vehicles factor into your students' lives.
2. Using the provided prompt sheet, have your students record an oral history about the role of cars in the life of a parent, grandparent, or older neighbour. Students can capture their interviews with audio or video media, or record them in text. This activity helps students gain insight into how profoundly, and how rapidly, cars have changed Canadian society.

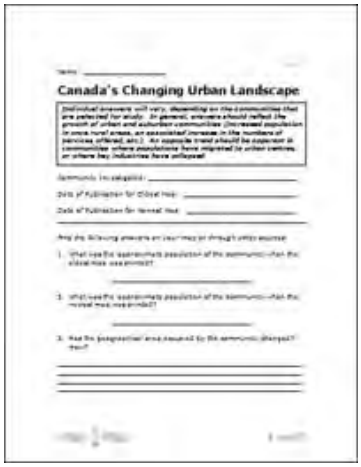
Part 2: Life in the Suburbs

Objective: to contextualize the ways in which automobiles have impacted Canadian society.

1. Have your students use primary source materials to investigate some of the concrete effects that cars have had on Canadians' lives. In pairs or as a class, have students search for and explore media resources related to the development of Canada's suburbs

on the CBC archives website at http://archives.cbc.ca. This resource provides context for the popularity of suburban living, and show how suburban life influenced Canadian social values in the postwar era.

2. In a group discussion, have your students compare what they have seen in the media clips with the information they gathered through their oral history activity. 1) Did their interviewees express similar ideas? 2) Has our view of suburban life changed over time? If so, how? 3) What might this tell us about the bias of primary sources?


Canada's Changing Urban Landscape

Part 3: Canada's Changing Urban Landscape

Objective: to examine the impact of transportation technology on Canada's landscape and urban development.

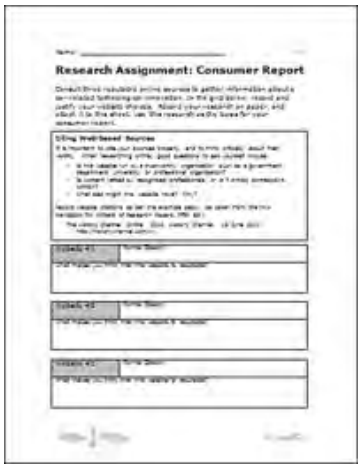
This activity can either be done as a classroom task or as a homework assignment. For this activity, students will need two maps, each depicting the same region (city, township, or village) at different times in history. There should be at least twenty years difference between the two maps — even better if you can find a copy of an antique map (which may be available online, through a local library, or at a community museum).

1. Depending on the maps available, either have students investigate a community of their choosing, or have all students examine their own community.
2. Distribute the worksheets and maps (if you are providing the maps). Have students work in pairs and use the maps to answer the questions on the worksheet. Additional library research may be required to answer some questions.

Core Concepts

As students will have learned from this activity, the prevalence of automobiles has influenced the location and size of communities, as well as the services that they have offered over time.

The evolution of transportation is also reflected in the urban design of cities — this is one factor that helps us to estimate when different areas of a city were built. Most city centres were built when transportation relied on walking and streetcars. The roads tend to be laid out in dense grid patterns that allow for shorter walking distances. With the emergence of cars as the dominant means of transportation, urban density gradually reduced and grid-patterned street networks were replaced with the curvilinear streets that are now common in newer suburbs.


Research Assignment: Consumer Report

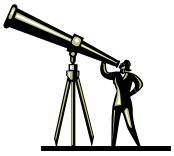
Research Assignment: **Consumer Report**

Have students, working individually or in small groups, select one of the car-related innovations below. Using the included Internet research guide, have students collect information about their chosen innovation. Have students present their research in the form of an investigative consumer report. You may choose to have students film their presentations as television reports.

Possible Topics: air bags, anti-lock brakes (ABS), electronic stability control (ESC), catalytic converters, seat belts, power steering, tinted windows, heated seats, window defrosters, winter tires, variable geometry turbocharging (VGT), common rail direct injection, continuously variable transmissions, dual-clutch transmissions, low rolling resistance tires

For more information about car-related innovations, have your students explore the Transport Canada ecoTECHNOLOGY for Vehicles Program website at www.tc.gc.ca/etv.

Extension Activity



Video Rant

Have your students consider the many positive and negative impacts that automobiles have on Canadian society by taking an environment-related position on the following statement: “Cars should be banned from urban areas.” Have students script a rant in which they present their position in an entertaining manner while still supporting their views with relevant evidence. Have students engage with questions related to the social costs and benefits of automobiles, alternatives to fossil fuels, etc. You may choose to have students upload their work to a social media website such as YouTube.

Activity 3.2: History of Canadian Vehicle Innovations

The following activity resources will help your students to grasp Canada's contributions, past and present, to the field of vehicle technology. Canadians have contributed many innovations and inventions to the field of transportation technology — the sway bar, the tubeless tire, the snowmobile, and the dump truck to name but a few. Currently, Canadians are involved in researching new battery technologies, hydrogen fuel cells, and improvements to synthetic fuels. It is essential for today's students to explore the history of innovation if Canada is to advance in the areas of vehicle and fuel technology — meeting the environmental and social challenges of this century, and possibly the next.

For more information about historical developments in vehicle technology, you can consult the Canada Science and Technology Museum's collection profile entitled "Automobiles." This pdf document can be accessed through our website at www.sciencetech.technomuses.ca. From the homepage, select "The Collection," navigate to "Collection Profiles," and browse the "Collection Profile Archive."

You can also consult the *Canadian Encyclopedia*'s article about the history of vehicle transportation at www.thecanadianencyclopedia.com.

For teaching resources related to innovations that are currently being researched by Transport Canada, please refer to Activity 2.3: "Efficiency — Doing More with Less" (contained in Section 2 of this exploration guide).

Part 1: Canadian Innovators

Objective: to discover Canadian technological innovations related to transportation and/or energy production.

1. Working individually or in groups, have your students select a topic from the list below. These individuals and companies are tied to the field of vehicle manufacturing, fuels development, or component design.

Possible Research Topics:

- New diesel technologies
- Bombardier and the snowmobile
- New developments in wind energy generation
- Abraham and the invention of kerosene
- Ballard fuel cells
- Plug-in hybrid electric conversion modules
- Electric battery technology
- Solar-powered cars
- Biofuels

2. Have your students conduct research about their chosen topic. The Canada Science and Technology Museum's website is a good starting point, available at www.technomuses.sciencetech.ca. Search for Canada's Science and Engineering Hall of Fame. Students may also want to visit Innovation Canada's website at www.innovationcanada.ca. As well, to better understand emerging technologies, students may wish to consult Transport Canada's ecoTECHNOLOGY for Vehicles Program website at www.tc.gc.ca/etv.

3. Using the information that they collected, have students create PowerPoint presentations describing the innovation, who was involved in its discovery or development, and how the innovation has impacted Canadian society.


Canadian Research on Cleaner Vehicles

Part 2: Canadian Research on Cleaner Vehicles

Objective: to explore the role of the public sector as a catalyst for research and innovation in Canada.

The National Research Council Canada (NRC) funds research in a wide variety of scientific domains, including transportation. Have your students visit the NRC's website at www.nrc-cnrc.gc.ca and explore one of the transportation fields in which NRC is working. Have them fill out the provided worksheet to summarize their findings.

Part 3: Clean Vehicle Technology
Surveying Canadian Research and Development

Objective: to explore the role of the public sector as a catalyst for research and innovation in Canada.

Transport Canada's Transportation Development Centre (TDC) undertakes a variety of research and development projects aimed at improving the safety, security, energy efficiency, and accessibility of the Canadian transportation system, while protecting the environment.

1. Have your students explore the TDC website at www.tc.gc.ca/tdc. From the program's main page, have students access the project directory. Have your students select "Road Transportation" from the list. From there, they can navigate a variety of headings and view brief profiles of past or current TDC research and development projects.

2. Individually or in pairs, have your students conduct further research about one of the projects listed under "Electric Vehicle Technology Development Program" or "Regulations and Standards: Alternative Fuels." Ask students to conduct research, ensuring that they understand the technology behind the innovation, at Transport Canada's ecoTECHNOLOGY for Vehicles Program website at www.tc.gc.ca/etv.

3. Have students present their findings in the form of a formal five-paragraph essay (writing a thesis, and proving it with formal arguments supported by research). Students' research should aim to answer the following questions:

   - What is the innovation? What does it do? How does it work?
   - How is this innovation an improvement over current technology?
   - Who/what groups stand to benefit from this research project?
   - Why can we classify this innovation as "Clean Vehicle Technology"?
   - Why would this innovation (or why would it not) be adopted by consumers in the near future?
   - What might need to change before this technology is introduced into the Canadian marketplace (e.g., regulations, codes, standards)?

Extension Activities

As a class, have your students brainstorm current environmental issues that might be linked to automobile production, use, and disposal. Write these issues on slips of paper, and put them in a hat. Divide the class into several small teams, and have each team select an environmental issue from the hat. Give teams twenty minutes to:

1. come up with a car-related invention or innovation to solve this problem (or begin to solve this problem);
2. create a quick sketch of their invention or innovation;
3. describe how their idea would help society; and
4. identify possible challenges in having their idea produced and accepted by the public.

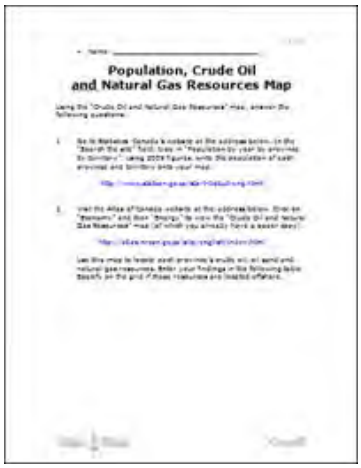
Have your students present their ideas to the class.

Activity 3.3: Meeting Our Energy Needs

Canada ranks fifth in the world in energy production[1] and eighth in energy consumption[2]. This might initially sound positive, but it is troubling that Canada does not rank better given that the country has vast stores of natural resources, and is one of the least densely populated on the planet.

To help students better understand domestic energy production, this section examines our energy resources and population base. Questions considered include: What are primary and secondary energy producers? How is energy supplied in order to meet consumer demand? What are the impacts of the energy conversion and transportation processes on local ecosystems?

For an overview of Canada's energy sector, visit the Natural Resources Canada "Energy" website at www.nrcan-rncan.gc.ca/com/eneene/index-eng.php and click on "Energy Sources."


Population, Crude Oil and Natural Gas Resources Map

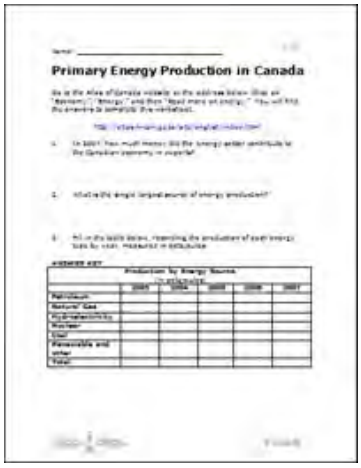
Part 1: Population, Crude Oil, and Natural Gas Resources Map

Objective: to locate and identify petroleum-based energy resources in Canada.

This activity will require your students to have a copy of Natural Resources Canada's map "Crude Oil and Natural Gas Resources," available on the *Atlas of Canada* website at http://atlas.nrcan.gc.ca/site/english/index.html. Click on "Economy" then "Energy." Distribute copies of the map to your students, along with the worksheet from this package.

Have students work individually or in pairs to find answers to the worksheet. This will involve conducting Internet research.

[1] Foreign Affairs and International Trade Canada, 2006
[2] Natural Resources Canada, *Atlas of Canada*, 2009


Primary Energy Production in Canada

Part 2: Primary Energy Production in Canada

Objective: to gain an understanding of energy production in Canada.

Have your students visit the *Atlas of Canada* website at http://atlas.nrcan.gc.ca/site/english/index.html, then click on "Economy," then "Energy." Have students work individually or in pairs to find answers to the worksheet.

Core Concepts

The law on the conservation of energy states that energy cannot be created nor destroyed — it can only be converted from one form to another (i.e. the chemical energy stored in a piece of wood is released under combustion as heat, light, and sound energy).

Primary energy is energy found in nature that has not been transformed or converted, i.e., solar, wind, fossil fuel, geothermal, nuclear, tidal, and biomass energy. When primary energy is converted into more useful forms, it is termed **secondary energy**. Examples include gasoline (which is transformed and refined from petroleum), and electricity (which is transformed from primary sources such as water, coal, oil, natural gas, wind, solar, nuclear or combinations of these).

The **joule** is a unit that measures work and energy. A joule is the energy exerted by the force of one Newton to move an object a distance of one metre (1 Watt-hour is equal to 3600 joules). When measuring energy reserves or energy production, the unit **petajoule** is often used, where 1 petajoule = 10^{15} joules.

Part 3: Environmental Assessment

The Effects of the White Rose Offshore Oil Development Project on Offshore Fisheries

Objective: to explore the possible effects of oil extraction on a local ecosystem.

Have your students visit the Canadian Environmental Assessment Agency at www.ceaa.gc.ca. Have students click on "Environmental Assessments," "Newfoundland and Labrador," and find the "White Rose Offshore Oil Development." Direct students to the "Comprehensive Study Report" available through "Consultation Documents."

Using the information provided on this website as a case study, have your students write a news magazine exposé highlighting the accidental and cummulative effects that offshore oil development can have on local fish, marine bird, and mammal populations.

Additional Online Resources

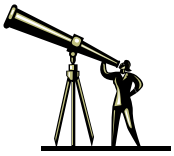
Statistics Canada's website, www.statcan.gc.ca, presents a variety of reports, including an energy balance sheet for each province. In the "Search the site" field, type "Report on Energy Supply and Demand in Canada." Table 1 lists primary and secondary energy for each province.

Research Assignment

The community of Norman Wells, NWT, was established as a result of petroleum reserves found in the area. Have students investigate, present, and discuss some or all of the following issues:

- What is the history of the region?
- In an ecosystem that is sensitive to change, what is the environmental impact of the pipeline constructed to Zama City?
- The Sahtu Land Claim Agreement of 1994 recognizes Dene and Metis peoples' ownership of land in the region, and provides financial compensation for land use. How does this impact the petroleum industry in Norman Wells?

Extension Activity



Have students access the Statistics Canada website at www.statcan.gc.ca and find the report entitled "Human Activity and the Environment: Annual Statistics 2009." Suburban expansion and dependence on the automobile for daily commuting have led to a greater demand for fuel. New technologies are emerging to offset reliance on gasoline, but barriers still exist. Investigate, research, and discuss.

Activity 3.4 Cars in Canada Today

There are many ways that cars impact our environment. The types of vehicles that we choose to drive, from sub-compact cars to SUVs, impact the environment throughout their lifecycles. The age of our vehicles also factors into their environmental impact, as newer cars are significantly more energy efficient and produce far fewer emissions than older cars.

The following exercises help students to learn more about vehicle emissions, and how their choices as consumers can have an environmental impact.

For more information about emissions from various types of vehicles, visit Natural Resources Canada's Office of Energy Efficiency website at http://oee.nrcan.gc.ca. Under "Personal Transportation," have students select "Choosing a Fuel-Efficient Vehicle."


Classifying Vehicles by Category

Classifying Vehicles by Category

Objective: to classify different types of vehicles, assess how they fulfill consumers' needs, and consider their fuel efficiency.

Vehicles can be classed based on their size and their emissions. Have your students classify the cars in their school's parking lot based on the EcoEnergy classification system.

1. Have students go to the school parking lot and write down the make, model, and year of 20 vehicles.

2. Have your students explore Natural Resources Canada's *Fuel Consumption Guide* (focusing on pages 1–18 of the 2010 guide) found on the Office of Energy Efficiency's website at http://oee.nrcan-rncan.gc.ca. Have students select "Personal Transport," then choose "Compare Vehicles" from the side toolbar, and then select "Fuel Consumption Guide."

   This guide outlines the efficiency of different vehicles available to the Canadian public in 2010. Have students pay particular attention to the list of the different vehicle classification categories on page 8. These categories are used in this activity.

3. Have students fill in the worksheet using the information they gathered in the school parking lot.

Additional Online Resources

For more information about cars and fuel efficiency, visit these websites:

Transport Canada's ecoTECHNOLOGY for Vehicles Program
(discover a wealth of information related to advanced technologies aimed at improving the efficiency of passenger vehicles)
www.tc.gc.ca/etv

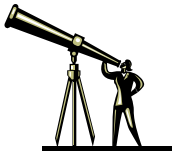
Transport Canada's Fuel Consumption Program
(content related specifically to the calculation of fuel consumption ratings found in the Fuel consumption Guide and on EnerGuide Labels)
www.tc.gc.ca/fcp

EcoACTION
(explore the tools and calculators)
http://ecoaction.gc.ca

Canadian Vehicle Manufacturers Association
(see content about vehicle emissions, listed in the "Current Issues" section)
http://cvma.ca

Canadian Automobile Association
(explore "Eco-driving" in the "Public Affairs" section)
www.caa.ca

Extension Activity



In an ideal world, drivers would choose cars that best meet their needs without being oversized (as larger vehicles generally use more fuel, and produce more emissions).

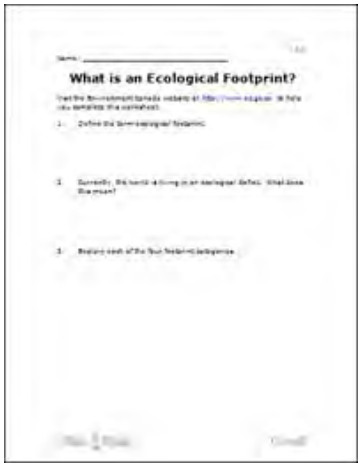
Lead a class discussion about "The Future of Driving in Canada." Do your students think consumers can/should move away from larger vehicles? What about hybrid and electric vehicles, and alternative fuels? Did your class see any evidence through the previous activities to indicate that Canadians are altering their vehicle purchasing choices?

Activity 3.5: Ecological Footprint

The ecological footprint is a metaphor that can help students to grasp the impact of their resource consumption. An ecological footprint measures the area of land and water required to produce the natural resources consumed by the human population. Currently, the world is living in an ecological deficit — our lifestyles require more natural resources than the Earth is able to supply. How many Earths would we need to sustain our lifestyle? What can we do now to ensure that there are enough resources for tomorrow? These are important questions for students to consider.

For some background information about ecological footprints, visit the Environment Canada website at www.ec.gc.ca, and enter "ecological footprint" in the search line.

To take an ecological footprint quiz, and for information on how to reduce your footprint, visit the Center for Sustainable Economy website at www.myfootprint.org.


What is an Ecological Footprint?

Part 1: What is an Ecological Footprint?

Objective: to grasp the concept of an ecological footprint, and understand the need for sustainable resource consumption.

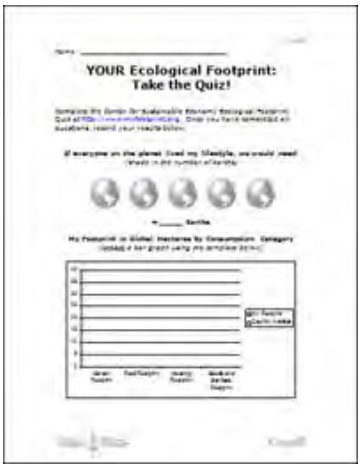
The concept of sustainability was introduced at the end of Section 2 of this resource package. Now, this activity builds on this understanding, enabling students to further explore the concept of sustainability through the concept of the "ecological footprint."

1. As an introduction to this activity, discuss the concept of sustainability with your students. Ensure that they understand that a sustainable use of resources ensures that there will always be enough resources for the future.
2. Ask students if they think that most people live sustainably, and if they themselves live sustainably. Collect thoughts and opinions from the students as a class.
3. Ask students if they have heard of the term *ecological footprint*. Solicit answers from the class. Explain that an ecological footprint is a good way to measure sustainability.
4. Have your students visit Environment Canada's website at www.ec.gc.ca. Have them enter "ecological footprint" in the search line. Have students use this information to complete the associated worksheet.

Part 2: YOUR Ecological Footprint

Objective: for students to measure their own ecological footprints, and explore ways to decrease their negative environmental impact.

In this exercise, students will measure their ecological footprints by completing an online quiz. They will then explore ways to decrease their own ecological footprint by creating a "Plan of Action."


YOUR Ecological Footprint:
Take the Quiz!

1. YOUR Ecological Footprint: Take the Quiz!

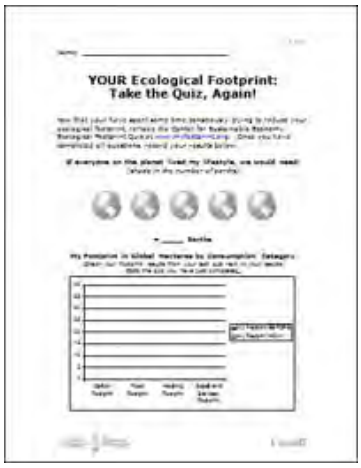
NOTE: This activity is best done at the beginning of the unit, to give the students enough time to implement their "Reduce YOUR Ecological Footprint: Plan of Action" before re-taking the quiz.

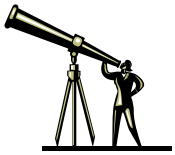
Have students complete the ecological footprint quiz on the Center for Sustainable Economy website at www.myfootprint.org. Have students record their quiz results on the worksheet provided in this guide.


Reduce your Footprint:
YOUR Plan of Action

2. Reduce your Footprint: YOUR Plan of Action

Have students complete the "Reduce your Footprint: YOUR Plan of Action" worksheet. To help them complete their plan, students should use the "Reduce your Footprint" link on the Center for Sustainable Economy's Quiz Results page.


YOUR Ecological Footprint:
Take the Quiz, Again!



Extension Assignment

Take the Quiz Again!

Give students an ample amount of time (three to four weeks) to implement their Plan of Action, and then have them re-take the online quiz. This will ensure that their quiz results reflect changes in their lifestyles.

Have students record their quiz results and answer the questions on the "YOUR Ecological Footprint: Take the Quiz, Again!" worksheet sheet provided in this guide.

Activity 3.6: Selling the Science

When you think about green vehicle technologies, what comes to mind? Hydrogen fuel cells? Tiny electric cars? Hybrid technologies? It may surprise your students to learn just how many innovations, large and small, contribute to the "greening" of Canada's cars.

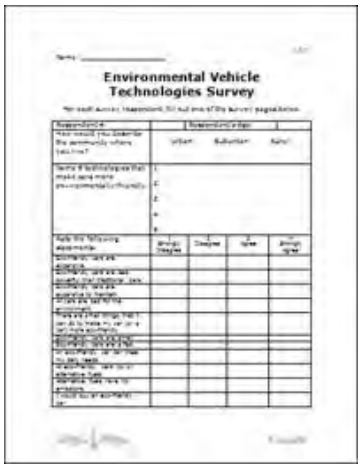
Over time, Canadian governments have taken steps to reduce the harmful impact of vehicles on our environment, such as the banning of leaded gasoline in 1990, and the creation of vehicle emission testing programs. Automakers have also taken steps to improve the environmental impact of their vehicles, for instance, by installing catalytic converters since the 1970s. Even simple improvements to vehicle design, like the inclusion of aerodynamic spoilers, can make a meaningful difference for our environment.


Advanced Technologies

Part 1: Advanced Technologies

Objective: to discover how specific technologies can reduce the environmental impact of Canada's cars.

1. Have your students visit Transport Canada's ecoTechnology for Vehicles Program website at www.tc.gc.ca/etv, and click on "Technologies."
2. Using the worksheet included in this guide, have students explore the specific technologies, large and small, that contribute to the environmental improvement of vehicles.


Environmental Vehicle Technologies Survey

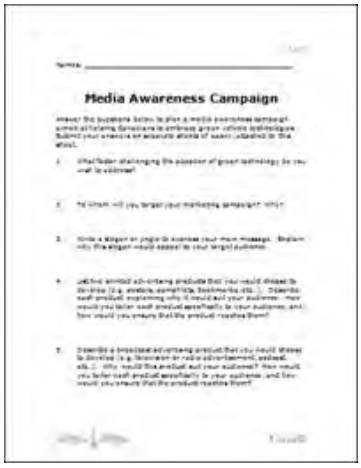
Part 2: Environmental Vehicle Technologies Survey

Objective: to explore barriers that prevent people from adopting vehicle technologies that are less harmful to the environment.

1. Using the worksheet included in this guide, have students conduct a survey analyzing the public's understanding and use of "green" vehicle technologies. Encourage students to ensure that their survey includes a wide sample size (at least ten people), and a variety of demographic profiles (e.g., age and gender), to ensure that they will be able to make credible projections based on their findings. This activity can be done individually or in pairs.

Note: Since you will require a lot of survey sheets, you may wish to print them double-sided, or on scrap paper.

2. Have students compile a three to five-page written report based on their survey findings. They should:
    - begin their report with a summary of their findings
    - identify and explore three statistical patterns and relationships (e.g., does age impact someone's inclination to believe that "green" cars lack power?)
    - conduct research to evaluate the validity of these beliefs, and determine whether these beliefs/realities pose a challenge to the adoption of "green" technologies (e.g., do cars that are less harmful to the environment lack power? How so, and should this really concern consumers?)
    - conclude by suggesting targeted actions that can be taken to improve the adoption of "green" vehicle technologies in Canada



Media Awareness Campaign

Group Project

Media Awareness Campaign

Traditionally, fuel consumption and vehicle emissions have not been primary concerns for Canadian consumers. New technologies that improve fuel efficiency and reduce polluting emissions often face barriers to market introduction. Consumers are sometimes off put by the "sticker-shock" associated with new technologies, as well as misconceptions about safety performance.

1. In small groups, have your students select one common misconception that prevents people from embracing a vehicle technology that is less harmful to the environment. Drawing upon the information gathered in the previous survey activity, have students plan a media awareness campaign to address their chosen misconception. The included worksheet will assist students in developing this campaign.

2. Have students develop the broadcast media product that they described in the worksheet. Encourage students to be creative, while also demonstrating a sound knowledge of automotive technology and barriers to its adoption. Be sure that students script their presentation — you may wish to collect their scripts as an aspect of your evaluation. Have students present their work in class. You may also wish to have students share their work online through your school's website or via social media (such as YouTube).

Name: _____

Oral History
Interview Prompt Sheet

There is an art and technique to successfully recording oral history. It is important to have your interviewee answer specific focused questions. Still, your questions should be open enough to allow the interviewee to elaborate their answers with rich historical detail. You want your interview to be engaging, but not to lack focus.

Use the following questions and prompts as a guide as you record an oral history about the role of cars in Canadians' lives.

Name of Interview Subject: _____

Interview Subject's Date of Birth: _____

Where did you live during your youth?
Was this area rural, urban, or suburban?

Did your family have a car when you were growing up?
What type of car was it? In what year was it produced? Was it purchased new or used? How old were you at the time? How was it different from today's cars? How large was it? What type of fuel did it use? Did it have any safety devices such as seat belts or air bags?

What was your family car used for?
Who drove the family car? When? Why? Did you use the car to travel to school or social activities? Did you take family vacations in the car?

Did your extended family and friends have cars? How were their cars different from your family's car?

Have you ever owned a car? If so, describe your first car. If not, why have you never owned a car?

Would you say that cars have played an important role in your life? Why? How?

How do you think your life would be different if cars were the same today as they were in your youth?

Name: _____

Canada's Changing Urban Landscape

Community Investigated: _____

Date of Publication for Oldest Map: _____

Date of Publication for Newest Map: _____

Find the following answers on your map or through other sources:

1. What was the approximate population of the community when the oldest map was printed?

2. What was the approximate population of the community when the newest map was printed?

3. Has the geographical area occupied by the community changed? How?

4. Locate the downtown area on both of the maps. Has the community's urban core shifted? Are there more or fewer people living in the community's urban core?

5. Does the community still exist as the same type of municipal entity? Is it part of the same township or county? Has it merged with surrounding towns, villages, or cities?

6. How many schools were located in the community according to the first map? According to the second map?

7. What types of services (e.g., stores, hospitals, restaurants, sports and entertainment venues, religious institutions) were located in this community when the first map was printed? How has this changed by the second printing?

Now make an educated guess…

8. What can we surmise about the community's population and composition by the number of schools located within its boundaries?

9. What can we surmise about the community's population and composition by changes in the number and types of services offered?

10. When the first map was printed, do you think that most adult residents worked in the community, or commuted to work in other areas? Do you think this had changed by the time the second map was printed?

11. What do you think was the primary mode of transportation in the community when the first map was printed? Would this have shifted by the time the second map was printed?

Name: _____ 3.1C

Research Assignment: Consumer Report

Consult three reputable online sources to gather information about a car-related technological innovation, and record your research notes on paper. In the grid below, record and justify your website choices, and attach it to your research notes. Use this research as the basis for your consumer report.

Citing Web-Based Sources

It is important to cite your sources properly, and think critically about their validity. When researching online, good questions to ask yourself include:

- Is this website run by a trustworthy organization such as a government department, university, or professional organization?
- Is content vetted by recognized professionals, or is it simply somebody's opinion?
- What bias might this website have? Why?

Record website citations using the steps listed below:

Order of Reference Elements:

1. **Name of website author or organization:** last name, comma, first name, period
2. **Title of the website:** in italics, comma; if citing an article within the website, insert the title of the article, in quotation marks, followed by a comma and then the italicized title of the website
3. The **date of the website's last update**, comma
4. The **name of any organization** associated with the website (if not the author), comma
5. The **website URL**, in parentheses, comma
6. The **date** that you consulted the website, period

Example:

Canada Agriculture Museum. *Bees: A Honey of an Idea*, 2009, (http://www.agriculture.technomuses.ca/english/bees/default.php), 11 August 2010.

Website #1	Formal Citation:
What makes you think that this website is trustworthy?	

Website #2	Formal Citation:
What makes you think that this website is trustworthy?	

Website #3	Formal Citation:
What makes you think that this website is trustworthy?	

Name: _____

Canadian Research on Cleaner Vehicles

The National Research Council Canada (NRC) is the Government of Canada's premier organization for research and development. It has been conducting research related to energy, transportation, health, material science, agriculture, building science, and numerous other fields since 1916.

Explore the NRC's website at www.nrc-cnrc.gc.ca, investigating the topic of aerodynamics, fuel cells, or new battery technologies. Use the information you find to complete this worksheet.

Chosen Topic:_____

1. What research is the NRC conducting in the field that you have chosen to research? Describe this research area.

2. Explain at least one benefit of this research.

3. How could the results of this research help Canadians in their daily lives?

4. Why do you think that the Canadian government is investing money in this type of research?

Name: _____

Population, Crude Oil and Natural Gas Resources Map

Using the "Crude Oil and Natural Gas Resources" map, complete the described tasks and answer the questions:

1. Visit Statistics Canada's website at www.statcan.gc.ca/start-debut-eng.html. In the "Search the site" field, type in "Population by year by province by territory." Record the population of each province and territory on your map.

2. Visit the *Atlas of Canada* website at http://atlas.nrcan.gc.ca/site/english/index.html. To view the "Crude Oil and Natural Gas Resources" map (of which you already have a paper copy), click on "Economy" then "Energy."

   Use this map to locate each province and territory's crude oil, oil sands, and natural gas resources. Enter your findings in the following table. Specify on the grid if these resources are located offshore.

Crude Oil and Natural Gas Resources			
Province or Territory	**Crude Oil**	**Oil Sands**	**Natural Gas**
Newfoundland and Labrador			
Prince Edward Island			
Nova Scotia			
New Brunswick			
Quebec			
Ontario			
Manitoba			
Saskatchewan			
Alberta			
British Columbia			
Yukon			
Northwest Territories			
Nunavut			

3. Zoom in on your specific region or city.

   i. Are you in an environmentally fragile area? Explain.

   ii. Are there pipeline and refining infrastructures nearby?

   iii. List the environmental impacts.

Name: _____

Primary Energy Production in Canada

Go to the *Atlas of Canada* website at http://atlas.nrcan.gc.ca/site/english/index.html. Click on "Economy," "Energy," and then "Read More on Energy," where you will find the information to complete this worksheet.

1. In 2007, how much money did energy sector exports contribute to the Canadian economy?

2. What is the single largest source of energy production?

3. Fill in the table below, recording the production of each energy type by year, measured in petajoules.

Production by Energy Source (in petajoules)					
Sources	**2003**	**2004**	**2005**	**2006**	**2007**
Petroleum					
Natural Gas					
Hydroelectricity					
Nuclear					
Coal					
Renewable and Other					
Total					

4. Which sources of energy listed in the table are considered primary? Why?

5. Give one example of a secondary energy source.

6. What could account for the rise in production of the six energy sources listed in question 3?

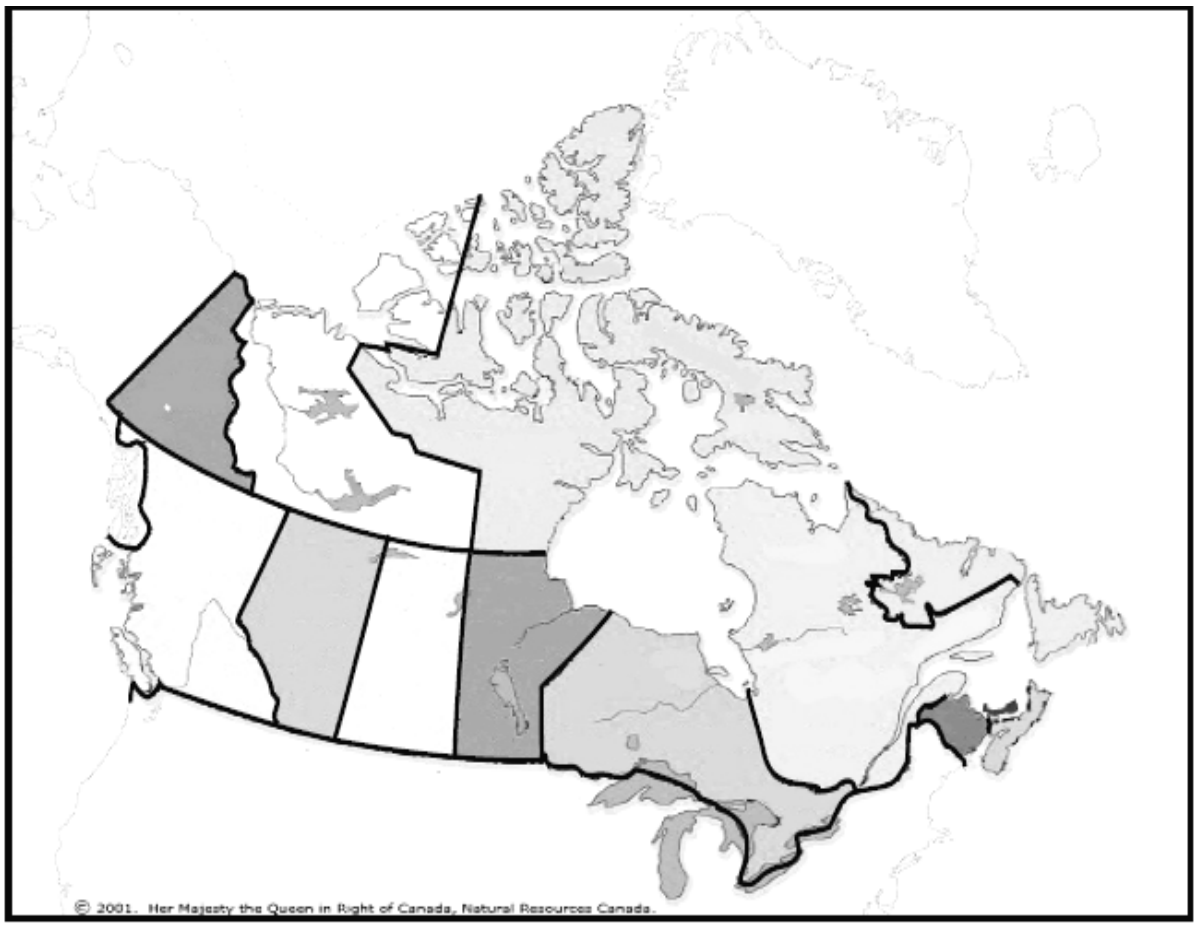
For the next set of questions, click on the "Crude Oil and Natural Gas Resources" map, and unclick "Sedimentary Basins."

7. Click on "Crude Oil Pipelines," and zoom in on Norman Wells, NWT.

    a) Locate each of the following locations, and plot them on the map that follows:

    - Norman Wells, NWT
    - Tulita, NWT
    - Wrigley, NWT
    - Fort Simpson, NWT
    - Assumption, AB
    - Rainbow Lake, AB
    - Slave Lake, AB
    - Edmonton AB (provincial capital)

    b) Trace the route of the crude oil pipeline from Norman Wells, NWT, to its end point.



8. What do you find on the outskirts of this ending point city that transforms crude oil into secondary energy (i.e., more useful forms of energy)? Give examples.

9. Fill in the blanks.

"As of January 2009, Canada had _____billion barrels of proven oil reserves, second only to_____; 95% of these reserves are in _____, the majority in the _____of northern Alberta."

10. Where do the oil pipelines eventually lead?

Name: _____

Classifying Vehicles by Category

1. Examine the cars in your school parking lot. Record the make, model, and approximate year of twenty cars in the chart below. Try to get a mix of new and older cars, as well as a variety of types (cars, minivans, trucks, SUVs, etc).

2. Visit Natural Resources Canada's website at http://oee.nrcan-rncan.gc.ca to access their 2010 fuel consumption guide. The guide can be reached by selecting "Personal Transport," choosing "Compare Vehicles" from the side toolbar, and then selecting "Fuel Consumption Guide." Using the information provided in this guide, enter each car's class in the chart below.

	Make	Model	Year (approx.)	Vehicle Class
	e.g., Toyota	e.g., Corolla	e.g., 2008	e.g., mid-size car
1				
2				s
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

3. Calculate the percentage of each vehicle class present in your sample group. List this below. (The vehicle classes below are illustrated in the Fuel Consumption Guide.)

Two-Seater Car: _____%
Sub-Compact Car: _____%
Compact Car: _____%
Mid-Size Car: _____%
Full-Size Car: _____%
Station Wagon: _____%
Pickup Truck: _____%
Special Purpose Vehicle: _____%
Minivan: _____%
Large Van: _____%

4. Looking at the figures above, what can you surmise about the needs of your school's drivers?

Name: _____

What is an Ecological Footprint?

Visit the Environment Canada website at www.ec.gc.ca to help you complete this worksheet.

1. Define the term *ecological footprint*.

2. Currently, the world is living in an ecological deficit. What does this mean?

3. Explain each of the four footprint categories.

Name: _____

YOUR Ecological Footprint: Take the Quiz!

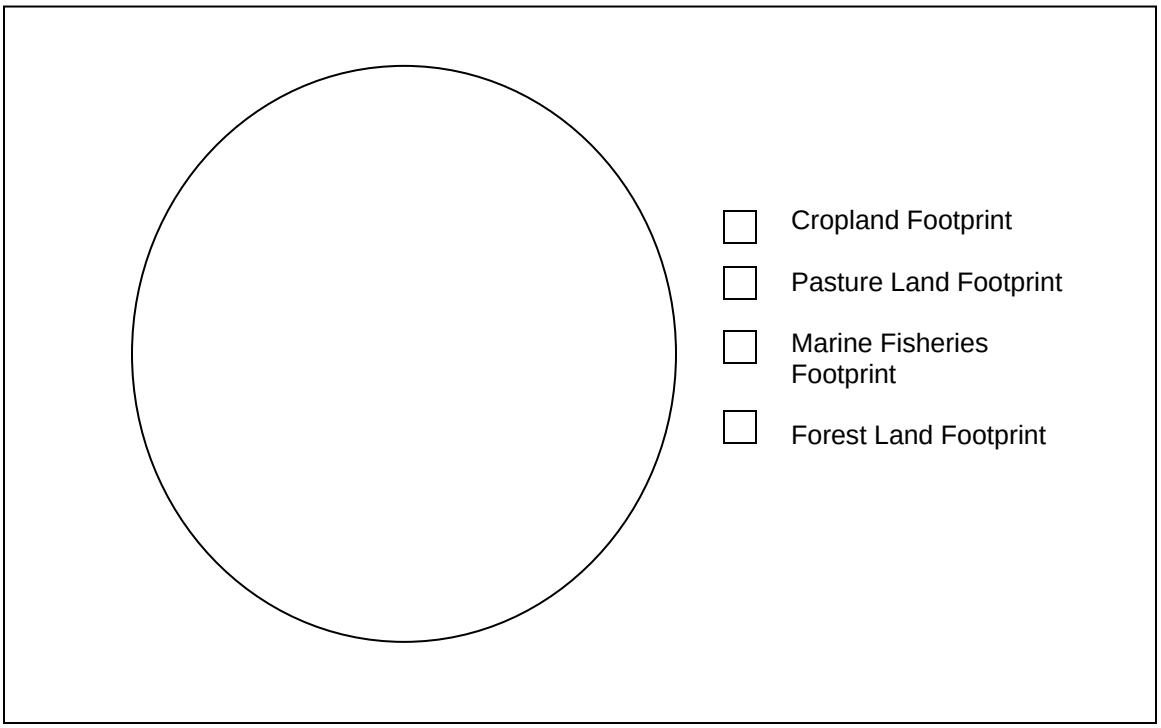
Complete the Center for Sustainable Economy Ecological Footprint Quiz at www.myfootprint.org. Once you have completed all questions, record your results below.

If everyone on the planet lived my lifestyle, we would need:
(shade in the number of earths)

= _____ Earths

My Footprint in Global Hectares by Consumption Category
(create a bar graph using the template below)

My Footprint Share by Biome
(create a pie chart using the template below)



Name: _____

Reduce your Footprint: YOUR Plan of Action

Once you have completed the Center for Sustainable Economy Ecological Footprint Quiz and have recorded your results, complete the worksheet below to create an action plan to reduce your ecological footprint. Use the **Reduce your Footprint** link on your quiz results page to help you.

Plan of Action: How I will reduce my footprint

The following are three major ways that you can reduce your carbon footprint. For each, include two examples of things that YOU will do to reduce your footprint.

To reduce my carbon footprint, I will:

1. Use cleaner transport by:

2. Add energy-saving features to the home by discussing with my parents/guardians the options of:

3. Adopt energy saving habits by:

List two ways YOU will reduce your food footprint.

To reduce my food footprint, I will:

List two major ways that you can reduce your housing footprint, including something that YOU personally will do to reduce your footprint.

To reduce my housing footprint, I will:

1. Suggest sustainable building materials, furnishings, and cleaning products, discussing the following options with my parents/guardians:

2. Adopt water-saving habits by:

List two ways YOU will reduce your goods and services footprint.

To reduce my goods and services footprint, I will:

By following your Plan of Action, you will reduce your ecological footprint — leaving behind a greener earth for future generations.

GOOD LUCK!

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Name: _____

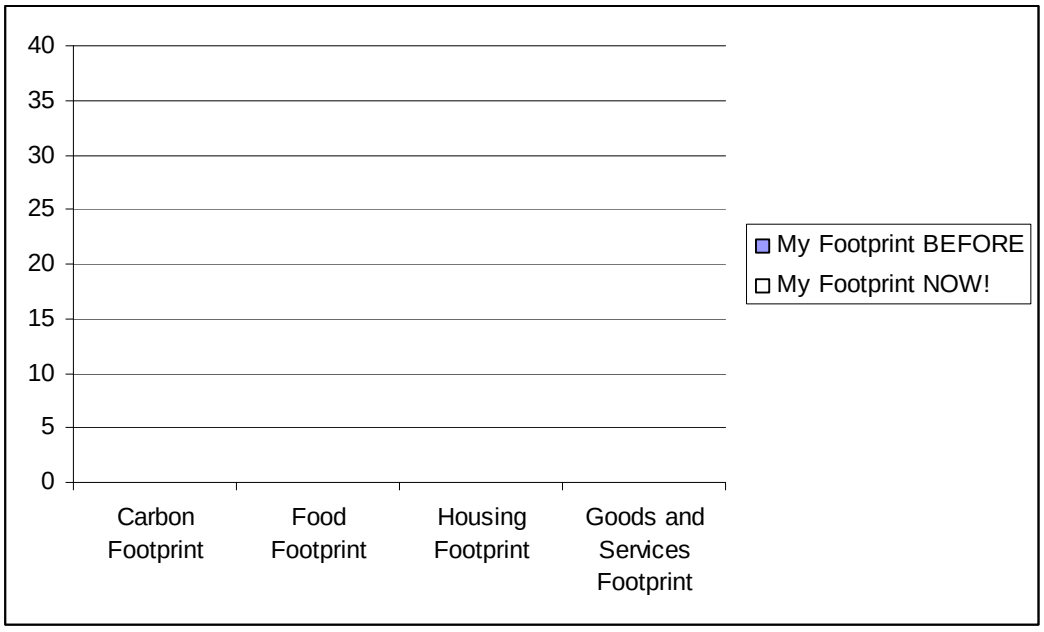
YOUR Ecological Footprint: Take the Quiz, Again!

Now that your have spent some time consciously trying to reduce your ecological footprint, re-take the Center for Sustainable Economy Ecological Footprint Quiz at www.myfootprint.org. Once you have completed all questions, record your results below.

If everyone on the planet lived my lifestyle, we would need:
(shade in the number of earths)

= _____ Earths

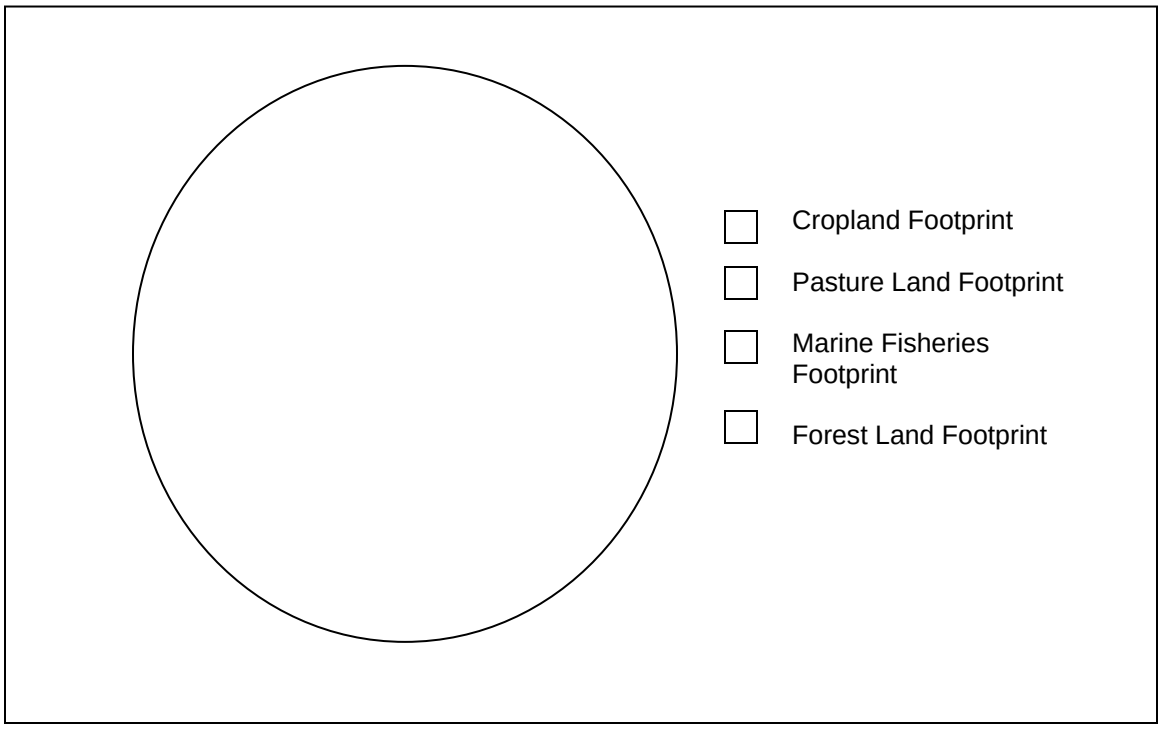
My Footprint in Global Hectares by Consumption Category
(Graph your footprint results from your last quiz next to your results from the quiz you have just completed.)



CANADA SCIENCE AND TECHNOLOGY MUSEUM

Canada

My Footprint Share by Biome
(create a pie chart using the template below)



Questions:

1. Compare your results with your previous results. Is there a difference?

2. Has your ecological footprint increased or decreased?

3. Describe two changes that you made in your lifestyle that you think had the most impact on your results.

4. Do you think that you can maintain these changes in your lifestyle? Explain.

5. Describe one additional change that you could make to further decrease your ecological footprint.

6. Do you think that society's resource use can ever become sustainable? Can everyone bring their footprint down to just one Earth? Explain.

Name: _____

Advanced Technologies

Visit the Transport Canada ecoTECHNOLOGY for Vehicles Program at www.tc.gc.ca/eng/programs/environment-etv-tech-eng-123.htm

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Exploring the "Vehicle Design Features" Section

1. It is estimated that how much of an engine's energy is used to overcome aerodynamic drag at highway speeds?

2. What is a diffuser, and what is its purpose?

3. What is a wheel-well fairing, and what is its purpose?

Exploring the "Alternative Fuels" Section

4. How is a Flexible Fuel Vehicle (FFV) different from a traditional vehicle?

5. List the three types of hybrid-electric vehicles. Surmise and state their main advantage and/or disadvantage.

6. What resources can be used to produce bio-diesel? Name the process that is used.

7. What products can be used to produce cellulose ethanol? What does the main chemical process involve?

8. What is the main advantage of cellulose ethanol?

9. Given what you have learned, which technologies would you want to adopt if you were purchasing a new car? Why? What might prevent you from adopting these technologies?

Name: _____

Environmental Vehicle Technologies Survey

For each survey respondent, fill out one of the survey pages below

Respondent #		Respondent's Age:	
How would you describe the community where you live?	Urban Suburban Rural		
Name 5 technologies that make cars more environmentally friendly:	1. 2. 3. 4. 5.		

Rate the following statements:	1 Strongly Disagree	2 Disagree	3 Agree	4 Strongly Agree
"Green" cars are expensive.				
"Green" cars are less powerful than traditional cars.				
"Green" cars are expensive to maintain.				
All cars are bad for the environment.				
There are small things that I can do to make my car (or a car) more eco-friendly.				
"Green" cars are small.				
"Green" cars are a fad.				
A "green" car can meet my daily needs.				
All "green" cars run on alternative fuels.				
Alternative fuels have no emissions.				
I would buy a more environmentally friendly car.				

Names: _____

Media Awareness Campaign

Answer the questions below to plan a media awareness campaign aimed at helping Canadians to embrace “greener” vehicle technologies. Submit your answers on separate sheets of paper, attached to this sheet.

1. What factor challenging the adoption of “green” technology do you wish to address?

2. Who is the target audience for your marketing campaign? Why?

3. Write a slogan or jingle to express your main message. Explain why this slogan would appeal to your target audience.

4. List two printed advertising products that you would choose to develop (e.g., posters, pamphlets, or bookmarks). Describe each product, explaining why it would suit your audience. How would you tailor each product specifically to your audience, and how would you ensure that the product reaches them?

5. Describe a broadcast advertising product that you would choose to develop (e.g., television or radio advertisement, or podcast). Why would this product suit your audience? How would you tailor each product specifically to your audience, and how would you ensure that the product reaches them?

The Canada Science and Technology Museum
and
Transport Canada's ecoTECHNOLOGY for Vehicles Program
present

Driving the Future:
Transportation, Energy, and the Environment

Section 4

The Future is Green:
Transportation Technology and the Environment

CANADA SCIENCE AND TECHNOLOGY MUSEUM

Canada

Introduction

Transportation technology has a profound impact on Canadian society given our country's vast, diverse landscape. Increasingly, Canadians are becoming aware of the impact that their transportation choices have on our environment.

This exploration guide takes a holistic approach to examining the environmental impacts of passenger vehicles. Limiting students' study to vehicle efficiency or emissions would only provide them with part of the picture. It is important to expand beyond these concepts, exploring their deeper implications. What is the environmental impact of extracting or generating different energy sources? How can we balance our practical needs with making sound environmental choices? By examining these issues, students will better comprehend the complex realities that inform contemporary environmental discourse.

The following is an outline of this section's structure. For a comprehensive overview of the entire exploration guide, please see Section 1.

4.1 Fuels and Eco-Friendliness
4.2 Green Energy — Assessing Our Options
4.3 Energy and Fuel Efficiency
4.4 Future Cars

Distinctive icons throughout the exploration guide indicate key features, helping you to find your way through the text quickly and efficiently.

 **Classroom Activity**	 **Discussion or Assignment Topic**
 **Deeper Study**	 **Website to Visit**

Activity Resources

Many of the following activities require students to conduct research online. Worksheets for all activities are included at the end of this section. Teachers may request an answer package for the more complex Activity Sheets by e-mailing **virt_prog@technomuses.ca**. Please allow one to two weeks for reply.

Activities

Activity 4.1: Fuel and Eco-Friendliness

In an effort to reduce our dependence on fossil fuels and make vehicles more environmentally friendly, car manufacturers and consumers are considering a wide range of fuels. Available options now include propane, compressed natural gas, diesel, battery electric power, hybrid power, and hydrogen fuel cells — not to mention advances in gasoline technology.

Which option is the best? Consumers want vehicles that perform well and are economical to run. There is a wide discrepancy in the costs of the various alternative fuels and fuel systems. Furthermore, some fuel types are not yet widely available — finding them at the local service station can be difficult.

The following activity guides students as they examine the output, cost, and environmental friendliness of various fuel types.

For some background information about fuel efficiency and emerging technologies, you may wish to explore the following online resources:

Transport Canada's ecoTECHNOLOGY for Vehicles Program
www.tc.gc.ca/etv
This website offers a wealth of information about advanced vehicle technologies.

Natural Resources Canada's Office of Energy Efficiency
http://oee.nrcan.gc.ca
Click on "Personal Transportation," select "Alternative Fuels," and select "Personal."

This website offers information about alternative fuels for personal use and the new stricter regulations that govern their use in Canada.

The Atlas of Canada
http://atlas.nrcan.gc.ca
This website offers a variety of educational geographic, historical, and economic maps. Many maps relate to energy and resource production, such as oil.

Hydrogen and Fuel Cell Progress in Canada
www.hydrogeneconomy.gc.ca
This Government of Canada website provides information about developments related to hydrogen and fuel cells.

For resources related specifically to how electricity is produced in a hydrogen fuel-cell vehicle, please refer to Part 4 of Activity 2.1: "Focus on the Fundamentals Worksheet Series" (contained in Section 2 of this exploration guide).


The Advantages and Disadvantages of Different Fuel Types

Part 1: The Advantages and Disadvantages of Different Fuel Types

Objective: to compare the advantages and disadvantages of different fuel types.

To begin, have your students access the Transport Canada's ecoTECHNOLOGY for Vehicles Program website at www.tc.gc.ca/etv, choose "Technologies," then select "Alternative Fuels."

Ask your students to compare and contrast three different fuel types, using the provided worksheet to synthesise the information that they gather. Students will be asked to complete SWOT grids for each of the fuel types (SWOT = Strengths, Weaknesses, Opportunities, Threats).

The focus of student analysis should be the advantages and disadvantages of their chosen fuel types. Students should be encouraged to explore a variety of reputable sources in completing this activity.


Know Your Fuels
Where do they come from?
What do they cost?

Part 2: Know Your Fuels: Where do they come from? What do they cost?

Objective: to compare the sources, costs and availability of various fuel types across Canada.

Have students visit the following Natural Resources Canada web pages, and use this information to answer the questions on the provided worksheet.

Atlas of Canada — Economy Section
http://atlas.nrcan.gc.ca
Under the "Explore Our Maps" heading, select "Economy" and then "Energy."

Fuel Prices by City or Region
http://nrcan.gc.ca/eneene/focinf-eng.php
Select "Energy" from the left-side menu, then choose "Gasoline prices."

Office of Energy Efficiency — Types of fuel in your area
www.oee.nrcan.gc.ca/transportation/personal/find-refueling-station.cfm

Extension Activity

Have your students locate and present Canada's fuel resources on a map of Canada. Students could select one energy sector (oil, natural gas, hydroelectricity, or nuclear energy) to map.

Students could then map the means by which their chosen resource is distributed (including major pipelines, transmission lines, or highways on their map). Students can then list the price of their selected resource for each of Canada's provincial capitals (and other major cities).


Different Fuels, Different Vehicles, Different Choices – Data Sheet #1

Part 3: Different Fuels, Different Vehicles, Different Choices

Objective: to synthesize numerous streams of data, comparing the power output to the carbon content of different fuel types.

Using the provided data sheets and worksheets, have your students examine the relationship between the power output and carbon content of various fuels.

For this activity, students will need to refer to fuel prices in their community. This information can be accessed through Natural Resources Canada's website at http://nrcan.gc.ca. Select "Energy" from the left-side menu, and then choose "Gasoline Prices."

For activities aimed at teaching mathematical calculations related to electricity and power, please refer to Activity 2.1: "Focus on the Fundamentals Worksheet Series" (contained in Section 2 of this Exploration Guide).

Culminating Assignment :
Debating the Full Lifecycle of a Fuel Type

1. Divide your class into five groups.
2. Each group will present one of the following fuel types: gas, liquefied natural gas (LNG), diesel, hybrid and battery electric, and hydrogen fuel-cell electric.
3. Have students prepare a five-minute presentation about their fuel type. The purpose of the presentation is to highlight the advantages of this fuel type. Each presentation should include information about the fuel type, including:

- cost
- power
- availability
- how this fuel reaches the consumer
- environmental impacts of use in the vehicle
- environmental impacts of producing the fuel
- opportunities for using the fuel
- drawbacks/challenges of using the fuel

4. Have each group make their presentation, arguing why their fuel should be the fuel of the future for vehicle transportation.
5. Open the floor for discussion.

Activity 4.2: Green Energy — Assessing our Options

Alternative vehicle fuels are energy sources that are not derived from petroleum — unlike traditional vehicle fuels such as gasoline and diesel. Increasingly, vehicles are being designed to operate using alternative fuels. As such, the term *fuel* is often used in a broader sense. A fuel is now considered any agent (liquid or otherwise) that is used to propel a vehicle.

The following activity set helps your students to understand the advantages and disadvantages of alternative fuels by exploring how alternative fuels can benefit the environment, the economy, and the consumer.

For information on alternative fuels and technologies for vehicles, visit Transport Canada's ecoTECHNOLOGY for Vehicles website at www.tc.gc.ca/etv and enter "eTV Alternative Fuels Definition" in the search line.

You can also visit the Natural Resources Canada — Office of Efficiency website at http://oee.nrcan-rncan.gc.ca and enter "Alternative Fuel Information for Consumers" in the search line.


Alternative Fuels and Vehicle Technologies: Assessing our Options

Part 1: Alternative Fuels and Vehicle Technologies — Assessing our Options

Objective: to compare various alternative vehicle fuels and technologies.

1. As an introduction to this activity, brainstorm alternative vehicle fuels and technologies with your students. What makes a fuel "alternative"? Can students name any alternative fuels? Record all ideas on the board.

2. Have your students complete the "Alternative Fuels and Vehicle Technologies: Assessing our Options" worksheet. To complete this exercise, students should visit Transport Canada's ecoTECHNOLOGY for Vehicles Program website at www.tc.gc.ca/etv, and the Natural Resources Canada's Office of Efficiency website at http://oee.nrcan-rncan.gc.ca.
3. Ask students which of the alternative fuels or vehicle technologies they think is the best option for the environment. Which is the best option for consumers? What would they choose? Why? Discuss as a class.


Advertising Alternative Fuels: Planning Your Ad

Part 2: Advertising Alternative Fuels

Objective: to create an advertisement for an alternative fuel.

Have students apply the knowledge they gained through their research to devise an advertisement for the alternative fuel of their choice. In small groups, have students choose a type of alternative fuel and create an advertisement for it. Have each group fill out the "Advertising Alternative Fuels: Planning Your Advertisement" worksheet to help them with the planning process. Each group should present their advertisement to the class.

Showcasing Student Excellence

Teachers — you can send your students' print advertisements to the Canada Science and Technology Museum for possible display. Note that students' work will not be returned. Email pdf or jpeg copies to virt_prog@technomuses.ca, or mail hardcopies to:

Alternative Fuel and Technology Advertisements
c/o Canada Science and Technology Museum
1867 St Laurent Blvd
P.O. Box 9724, Station T
Ottawa, ON K1G 5A3
Attention: Education, Programs and Events

Assignment: Technology in the News — Investigating Biofuel

Have students, working individually or in small groups, find a news article related to agriculture and biodiesel. Have them research the topic of their article further, and present a PowerPoint presentation to the class about the article's central question, concern, or position on the topic.

This activity helps students gain a broader insight into contemporary debates surrounding the issue of biofuels, such as:

- the implications of diverting crops from food to fuel production
- the development of farmlands for fuel crops (animal habitat loss)
- the use of pesticides and fertilizers on non-food production crops

Activity 4.3: Energy and Fuel Efficiency

Much of Canada's economic growth relies on the energy sector's production and export of crude oil and petrochemicals. It is estimated that at current rates of production, Canada's known oil reserves may be depleted in 200 years.

New energy technologies strive to shift our reliance on non-renewable energy sources such as oil. The following activities will help students to navigate this shift, understanding the impact of their choices as future consumers.

For an overview of the energy sector in Canada, visit the Centre for Energy website at www.centreforenergy.com/AboutEnergy/

Several teaching resources may be obtained by clicking on "Energy Education," then "Counting on Gasoline."

Part 1: The EnerGuide® Label

Objective: to comprehend how consumers can use the EnerGuide label to guide their purchasing decisions.

Working individually or in pairs, have your students visit the Office of Energy Efficiency website at http://oee.nrcan.gc.ca to answer the questions on the associated worksheet.

Core Concepts

ENERGY STAR is the international symbol for products that have been tested and deemed energy efficient. Household appliances, home heating and cooling systems, office equipment, consumer electronics, lighting, windows, doors and even new homes can receive ENERGY STAR certification.

The kilowatt-hour (kWh) is the standard measure of the amount of electrical energy that a device uses in a one-hour period. Since local utilities sell electricity by the kilowatt-hour, one can calculate the efficiency and cost of running home electronics or appliance over time.

EnerGuide vehicle labels can be found on all new passenger cars, vans and pickup trucks. The label shows the city and highway fuel consumption ratings and an estimated annual fuel cost for a particular vehicle.


Identifying Fuel Consumption Ratings and Classifying Fuel Efficiencies

Part 2: Identifying Fuel Consumption Ratings and Classifying Fuel Efficiencies

Objective: to identify and chart the fuel efficiency of a variety of vehicles, noting how age and size affect efficiency.

Fuel consumption ratings are used by consumers to help them compare the fuel consumption of various makes and models of vehicles — helping them to select the most fuel-efficient vehicle that meets their everyday needs.

1. Provide students with copies of the included worksheet. In small groups, have students visit the school parking lot and write down the make, model and approximate year of ten vehicles.

2. Have your students explore the Office of Energy Efficiency's website at http://oee.nrcan.gc.ca. Have students select "Personal Transport," and then "Fuel Consumption Ratings." Students can use this information to complete the associated worksheet.

For an associated activity, where students classify vehicle types and surmise factors that influence consumers' car-buying decisions, please refer to Activity 3.4: "Cars in Canada Today" (contained in Section 3 of this exploration guide).

Additional Online Resources: For more information about cars and fuel efficiency, please consult the following websites:

EcoACTION
http://ecoaction.gc.ca
Explore the tools and calculators.

Canadian Vehicle Manufacturers Association
http://cvma.ca
See content about vehicle emissions, listed in the "Current Issues" section.

Canadian Automobile Association
http://www.caa.ca
Explore the "Eco-driving" in the "Public Affairs" section.


What Vehicle Meets your Needs?

Part 3: What Vehicle Meets Your Needs?

Objective: to explore the link between fuel efficiency and consumer choice.

1. Have your students visit Natural Resources Canada's Office of Energy Efficiency website at http://oee.nrcan.gc.ca and select "The EnerGuide Label," where students will find the information required to answer the associated worksheet.

2. Have a class discussion about the factors that would influence the students' own decisions if they were to purchase a car. What would be most important to them — the type of vehicle, the vehicle's price, the cost of operating the vehicle, its look, its performance, or its environmental impact? Why?

Discussion Topic: Consider the following scenarios as they relate to energy consumption and the environment. (These scenarios could also serve as starting points for research or presentation topics).

- My dream car is a two-seat supercharged eight-cylinder muscle car that does 0 to 100 km in less than five seconds. What compromises could I make to select a car that has a less negative environmental impact, but that I would still enjoy driving?
- I live an active lifestyle and drive a mid-size car. I often use roof-mounted carriers, boxes, and ski/bike racks. How does this impact my fuel consumption?
- I need a three-bedroom home for my family. I can only afford to buy a home in the suburbs, which is 25 km away from where I work — a 75-minute commute during rush hour. My colleague, on the other hand, lives in a one-bedroom apartment and can walk to work in only ten minutes. To what degree should one compromise one's lifestyle to make environmentally friendly choices?

Activity 4.4: Future Cars

With so many new vehicle technologies on the market today, how can we know which innovations will help to reduce fuel consumption, emissions and other pollutants? What will the car of the future look like? How will society's lifestyles change?

Given the fast pace of technological change, these are important questions for today student's — tomorrow's consumers — to contemplate.

For information about alternative fuels and vehicle technologies, visit Transport Canada's ecoTECHNOLOGY Program website at www.tc.gc.ca/etv. Click on the "Technologies" icon.

You can also visit Natural Resources Canada's Office of Energy Efficiency at http://oee.nrcan-rncan.gc.ca. Enter "Alternative Fuel Information for Consumers" in the search line.


The Car of the Future

Product Features

The Car of the Future

Objective: to explore current automotive technologies and innovations, and apply this knowledge by designing the "green car of the future."

1. As an introduction to this activity, ask students if they know of any technologies that make today's vehicles less harmful to the environment. List students' answers on the board, and discuss as a class.

2. Have students review the green technologies listed on Transport Canada's ecoTECHNOLOGY for Vehicles Program website at www.tc.gc.ca/etv. This information about current 'green' vehicle technologies will serve as a reference for students as they design their own "Car of the Future."

3. Have students work in small groups to design the "Car of the Future" using the provided worksheets.

Extension Activity 1

Based on their work completing the "Car of the Future" worksheets, have students create posters illustrating their cars and highlighting their futuristic and/or environmentally conscious features.

Showcasing Student Excellence

Teachers — you can send copies of your students' posters to the Canada Science and Technology Museum for possible display. Note that students' work will not be returned. Email pdf or jpeg copies to virt_prog@technomuses.ca, or mail hardcopies to:

Car of the Future Posters
c/o Canada Science and Technology Museum
1867 St Laurent Blvd
P.O. Box 9724, Station T
Ottawa, Ontario K1G 5A3
Attention: Education, Programs, and Events

Extension Activity 2

Have students conduct research by reading news articles and blogs that make projections about the "Car of the Future" to find out how energy needs and environmental problems will affect the way that we buy, drive, and maintain our cars.

Have students, in turn, write their own article or blog about how their lifestyles may change if Canadians adopt changing values in relation to their cars. Students' work should showcase their newly-gained knowledge of "green" vehicle technologies.

Name: _____

The Advantages and Disadvantages of Different Fuel Types

To complete this activity visit Transport Canada's ecoTECHNOLOGY for Vehicles Program website at www.tc.gc.ca/etv. Choose "Technologies," and select "Alternative Fuels."

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1. Select three of the following fuel types or systems to research

- advanced diesels
- advanced gasoline
- hybrids and plug-in hybrids
- battery-electric vehicles
- hydrogen fuel cell electric vehicles
- biodiesel
- ethanol
- liquefied petroleum gas (LPG or auto propane)

2. For each selected fuel, complete the following SWOT grids (SWOT = strengths, weaknesses, opportunities, threats). When filling out the SWOT grid, keep the following in mind:

Strengths: characteristics or attributes of the fuel that are helpful to achieving greater use.

Weaknesses: characteristics or attributes of the fuel that are detrimental to achieving greater use.

Opportunities: external factors or conditions that are helpful to achieving the objective of using this fuel.

Threats: external factors or conditions that are detrimental to the objective of using this fuel.

Some questions to consider:

- Is the fuel easy to find (e.g., at local filling stations)?
- Is this expected to change?
- In the case of liquid fuels, how much does one litre of the fuel cost?
- In the case of electricity, what is the cost for one kilowatt-hour?
- If you were buying a vehicle, would you consider this fuel as an alternative? Why or why not?

Fuel Type/System #1:	
Strengths:	Weaknesses:
Opportunities:	Threats:

Fuel Type/System #2:	
Strengths:	Weaknesses:
Opportunities:	Threats:

Fuel Type/System #3:	
Strengths:	Weaknesses:
Opportunities:	Threats:

3. On a separate sheet, explain which of the three fuel types or systems you believe is the best technology to reduce transportation emissions. Present a balanced answer, expressing how the costs or challenges posed by the fuel type are outweighed by its benefits.

Name: _____

Know Your Fuels
Where do they come from?
What do they cost?

Discover the different ways that we get the energy that powers our transportation network. Learn about where this energy comes from, see how it reaches the consumer, and find out why it costs what it does.

Visit the following Natural Resources Canada web pages. These resources will give you the information required to complete this worksheet.

Atlas of Canada — Economy Section
http://atlas.nrcan.gc.ca

Under the "Explore Our Maps" heading, select "Economy" and then "Energy," were you will find energy maps, electrical generating maps, and renewable energy maps

Fuel Prices by City or Region
http://nrcan.gc.ca

Select "Energy" from the left-side menu, then choose "Gasoline Prices," where you can find information about the price of various fuel types in the city or region in which you live.

Office of Energy Efficiency — Types of Fuel in Your Area
www.oee.nrcan.gc.ca/transportation/personal/find-refueling-station.cfm

Here you can find the types of fuel that are available in your area.

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1. Where does most of the oil and gas in Canada come from?

2. Which province produces the most hydroelectricity?

3. Which province has the most nuclear reactors used to produce electricity? How many does it have in operation?

4. Which province produces the most uranium? How does this province generate most of its electricity?

5. How are oil and gas transported to provinces that do not produce their own?

6. Where would you expect to find the cheapest gasoline and diesel fuel prices? Why?

7. Use the NRCan website to find out the price of fuel in one city in each province. Explain why you think prices differ throughout Canada.

8. The main attraction of plug-in hybrid electric and battery electric vehicles is that they produce fewer emissions (because they burn less or no fossil fuels). However, if the electricity that powers these cars was produced by burning coal, this would still result in pollution and carbon dioxide being released (known as lifecycle or well-to-wheel emissions). Keeping this in mind, which provinces and territories would benefit most from the widespread use of electricity-powered cars? Why?

Different Fuels, Different Vehicles, Different Choices — Data Sheet #1

Use the information provided in the Data Sheets to answer the questions that follow.

Energy Content of Fuel

Fuel Type	MJ/kg	kg Carbon/Litre
Regular gasoline	47	2.34
Premium gasoline	46	2.34
Auto propane or LPG (60% propane + 40% butane)	51	1.49
Ethanol*	31	0.81 (0)
Gasohol (10% ethanol + 90% gasoline)*	45	2.19
E85 (85% ethanol + 15% gasoline)*	28	1.04
Diesel	48	2.63
Biodiesel*	42	1.07 (0)
Liquid hydrogen**	130	0

*Note that ethanol and biodiesel are made from vegetation that captures carbon during its lifecycle. This vegetation is then made into fuel. The carbon released during their burning is carbon that was captured by the plant while it was growing, resulting in no net carbon release.

**Hydrogen is often produced with electricity made by burning fossil fuels. While burning hydrogen itself does not produce any carbon, unless the hydrogen is produced from a clean energy source, carbon will have been released in its production.

Carbon dioxide produced per kilowatt-hour (kWh) from different fuel sources:

Source	CO_2 / kWh
Coal (with carbon capture)	320 grams
Standard coal plant	1119 grams
Hydro electricity	18 grams
Nuclear	15 grams
Gas fired plants (natural gas boiler)	606 grams
Gas fired plants (natural gas turbine)	494 grams

Different Fuels, Different Vehicles, Different Choices — Data Sheet #2

Technical Vehicle Data

Volkswagen Polo Bluemotion TDI

Fuel type	Diesel
Fuel efficiency	City: 4.9 L/100 km Highway: 3.2 L/100 km
Driving range	1,190 km

Mitsubishi i-MiEV

Fuel type	Electricity
Battery type	Lithium-ion
Charge capacity	16 kWh
Recharging time	7 hrs / 200V / 15A 14 hrs / 100V / 15A
Driving range	120 km

Subaru Forester PZEV (PZEV=Partial Zero Emission Vehicle)

Fuel type	Gasoline
Fuel efficiency	City: 10.4 L/100 km Highway: 7.7 L/100 km
Driving range	700 km

2010 Toyota Prius

Battery type	Sealed nickel-metal-hydride (NiMH)
Fuel type	Gasoline / electricity
Fuel efficiency	City: 3.7 L/100 km Highway: 4.0 L/100 km
Recharging time	Does not apply — the batteries charge when driving and braking
Driving range	1,100km

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Canada

Name: _____

Different Fuels, Different Vehicles, Different Choices — Answer Sheet

For this activity, refer to fuel prices in your community. This information can be found on the Natural Resources Canada's website at http://nrcan.gc.ca. Select "Energy" from the left-side menu, then choose "Gasoline prices."

Compare the emissions and operating costs of four different vehicles. Answer the following questions, showing your equations:

1. How much would it cost to drive 100 km in the city in the VW Polo Bluemotion TDI?

2. How much would it cost to drive 100 km on the highway in the VW Polo Bluemotion TDI?

3. How much carbon would a 100-km drive in the city in the VW Polo Bluemotion TDI produce?

4. How much carbon would a 100-km drive on the highway in the VW Polo Bluemotion TDI produce?

5. How much would it cost to drive 120 km in the city in the Mitsubishi i-MiEV? Look up local electricity prices in kilowatt-hours in your area, and use the formula below to calculate your answer.

$$\frac{\text{Battery's usable capacity (kWh)}}{\text{Total vehicle range (km)}} \times \text{Cost of electricity (\$/kWh)} = \textbf{Cost per km}$$

6. How much would it cost to drive 120 km on the highway in the Mitsubishi i-MiEV?

7. How much carbon would a 120-km drive in the Mitsubishi i-MiEV produce if the electricity was generated by coal?

8. How much carbon would a 120-km drive in the Mitsubishi i-MiEV produce if the electricity was generated by hydro?

9. How much carbon would a 120-km drive in the Mitsubishi i-MiEV produce if the electricity was generated by nuclear energy?

10. How much would it cost to drive 100 km in the city in the Subaru Forester PZEV?

11. How much would it cost to drive 100 km on the highway in the Subaru Forester PZEV?

12. How much carbon would a 100-km drive in the city in the Subaru Forester PZEV produce?

13. How much carbon would a 100-km drive on the highway in the Subaru Forester PZEV produce?

14. How much would it cost to drive 100 km in the city in the Toyota Prius?

15. How much would it cost to drive 100 km on the highway in the Toyota Prius?

16. How much carbon would a 100-km drive in the city in the Toyota Prius produce?

17. How much carbon would a 100-km drive on the highway in the Toyota Prius produce?

18. Knowing what you have now learned about the gas consumption and operating costs of each of the featured vehicles, which do you believe is the best choice for consumers? Why? What concerns factor into your decision?

Name: _____

Alternative Fuels and Vehicle Technologies: Assessing our Options

Visit the websites below to help you fill out this table comparing different alternative fuels and vehicle technologies.

Transport Canada's ecoTECHNOLOGY for Vehicles Program
www.tc.gc.ca/etv
Hint: enter "etv alternative fuels definition" in the search line.

Natural Resources Canada – Office of Efficiency
http://oee.nrcan-rncan.gc.ca
Hint: enter "Alternative Fuel Information for Consumers" in the search line.

Comparison of Alternative Fuels and Vehicle Technologies

Alternative Fuel Type / Vehicle Technology	Description	Environmental and Economical Advantages	Overall Disadvantages
Battery Electric			
Biodiesel			

Alternative Fuel Type / Vehicle Technology	Description	Environmental and Economical Advantages	Overall Disadvantages
Ethanol			
Hydrogen Fuel Cell Electric			
Compressed Natural Gas			

Name: _____

Advertising Alternative Fuels: Planning Your Ad

To be better prepared to create your advertisement, use this worksheet as a planning tool.

Alternative fuel to be advertised:

Medium to be used to advertise:

Target audience:

1. Complete the following grid to start planning your media campaign:

Type of fuel:
Why is it “good”? Why should people care?
Who would be attracted by this reason? Who will care about your message?
What media will best serve this audience?

2. Based on the grid above, choose a main message for your advertisement (use this to create your jingle/slogan):

3. Choose a jingle or slogan for your advertisement (something your audience will remember):

4. Key points your advertisement will make about the fuel type (two to four keys points):

Name: _____

The EnerGuide Label

Visit Natural Resources Canada's Office of Energy Efficiency website at http://oee.nrcan.gc.ca to answer the following questions. In the "For Personal Use" field, click on "Residential" then "Major appliances," and then "The EnerGuide Label."

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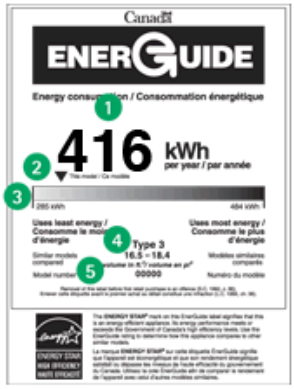
1. What information does the EnerGuide label provide for consumers?

2. Identify the five components of the black and white EnerGuide label.



3. From the website's right field, select "Clothes Dryers." What is the average consumption in kWh of a standard clothes dryer in 1990, compared to 2003? How much more efficient are newer models?

4. In your classroom, school, or home, find five appliances with EnerGuide labels and list in kWh the amount of electrical energy that they consume.

Appliance	Energy Consumed (kWh)

Return to the Office of Energy Efficiency's homepage. In the "Personal Use" field, click on "Transportation" then "Purchasing a Fuel-Efficient Vehicle," then "The EnerGuide Label."

5. Use your mouse to scroll over the gas pump on the EnerGuide label. What driving distance is EnerGuide's estimated annual fuel cost based on?

6. In calculating the estimated annual fuel cost of a vehicle, what percentage of annual driving is estimated to be "city driving"? What percentage is estimated to be "highway driving"?

Name: _____

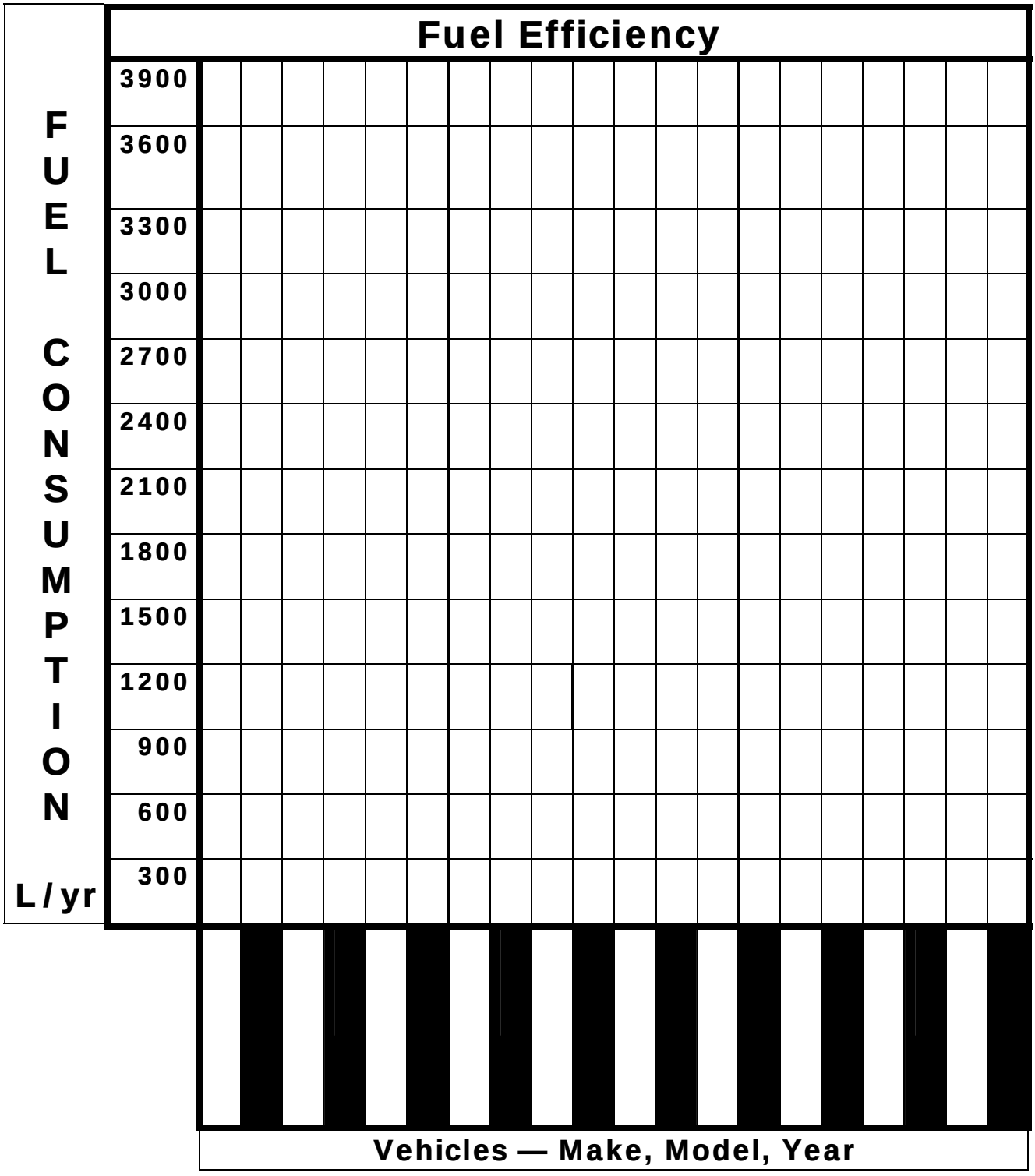
Identifying Fuel Consumption Ratings and Classifying Fuel Efficiencies

1. Working in groups, look at the vehicles in your school's parking lot. On the chart below, write down the make, model, and approximate year of ten cars. Try to get a mix of new and older cars, as well as a variety of types (cars, vans, trucks, etc.).

	Make	Model	Year (approx.)	Fuel Consumption Rating
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

2. Visit the Office of Energy Efficiency's website at http://oee.nrcan.gc.ca to determine and record the fuel consumption rating of each vehicle. In the "Personal Use" section, select "Personal Transport," and then "Fuel Consumption Ratings."

3. Use this data to plot the efficiency of the vehicles on the provided graph. You will need to consider how many litres of fuel, on average, each vehicle consumes per year. (Hint: remember that the EnerGuide estimates that the average Canadian drives about 20,000 km a year.)



Name: _____

What Vehicle Meets your Needs?

Consult Natural Resources Canada's Office of Energy Efficiency website at http://oee.nrcan.gc.ca to help you answer the questions below.

To learn about options and choices when buying a car: In the Transportation section, select "Personal," then "Most Fuel-Efficient Vehicles" from the right sidebar.

To determine what vehicles best meet the needs of different consumers: In the Transportation section, select "Personal," choose "Choosing a Fuel-Efficient Vehicle," and then select "Tips on Buying a Vehicle."

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1. A couple without children lives and works in the downtown core. Their commute to work is less than 10 km. Every month or two, they take a trip out of the city to visit friends and family in other towns that are two to three hours away. What do you think is the most efficient vehicle that would meet their needs?

2. A couple with three children live in the suburbs and commute 40 km each day — dropping children off at school and getting to work. Most of their commute is on the highway but due to traffic, it is often stop-and-go. What do you think is the most efficient vehicle that meets their needs?

3. A single man lives and works on his farm. He needs to be able to transport heavy equipment, tools, and animal feed in his vehicle. Nearly all of his driving is on highways, travelling from his home to the nearest town. What do you think is the most efficient vehicle that meets his needs?

4. A family with two young children lives close to work and school, and walks and bikes most days. Sometimes they drive if the weather is bad, and they also use the car to travel into the city for shopping and weekend activities. What do you think is the most efficient vehicle that meets this family's needs?

5. A woman works as an electrician and uses her vehicle to transport herself and her tools to her various job sites. She lives in a small town, and her work can take her around town, or to many of the small communities located within 50 km of her home. What do you think is the most efficient vehicle that meets her needs?

Name: _____

The Car of the Future

Use this worksheet to design the "Car of the Future." Demonstrate your knowledge of vehicle technologies, and Canadians' future transportations needs, as you complete this worksheet.

To explore existing "green" vehicle technologies, and gain inspiration for this activity, visit the Transport Canada ecoTECHNOLOGY for Vehicles Program website at www.tc.gc.ca/etv. Click on the "Technologies" icon.

Product Features

Exterior Design

Illustrations of your car:	Notes:

Performance

Fuel type _____

_____

_____

Engine _____

_____

_____

Transmission _____

_____

_____

Environmental Features

Enhancements _____

_____

_____

Emission controls _____

_____

_____

Specifications

Model name		
Fuel type		
DIMENSIONS		
Length	cm	
Width	cm	
Height	cm	
CAPACITIES		
Seating	persons	
Fuel tank	litres	
ENGINE		
Type		
TRANSMISSION		
Type		
ENHANCEMENTS		
EMISSION CONTROLS		