“Electric Car: American Industry and Innovation”
Science Lesson Plan

is a feature of

A daily news broadcast for High School and Middle School students now under development by MacNeil/Lehrer Productions

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Winter, 2009

Dear Educator,

the.News online video reports for *the.Gov* provide middle and high school students with a valuable exercise in science, social studies and language arts. This video report on the "Electric Car: American Industry and Innovation" at www.pbs.org/newshour/thenews/thegov explores how this new technology is driving development of the electric car and public policy. Lesson plans for social studies, science and language arts are available in the "For Educators" section of the website. All videos and curricula have been informed by *the.News* instructional design that can be found on the website www.pbs.org/newshour/thenews. *the.Gov* is open-captioned. The curriculum includes content-based standards, discussion questions, student activities, vocabulary and primary reference sources. A complete transcript of each video report includes time codes to assist in isolating specific segments of the video. This material is presented as options to fit teachers' instructional needs.

We have also added, starting with this video segment, references to Larry Bell's "The 12 Powerful Words." Relevant "powerful words" are highlighted in **bold** in the lesson plans and in the transcript (to denote where they are used in the video segment).

We welcome our new partners at the Omaha Public Schools who have joined *the.News* in a special pilot project during the 09-10 school year. We are also launching a new authoring tool for students called *YOU.edit*, to launch in early 2010. It will give students an online tool to remix the content of *the.Globe* reports (as well as all the other *the.News* videos), so they can create their own multimedia presentations. This editing tool will reside on our website so that it will be available to all students with an internet connection. It will be password protected so that it can serve as a viable educational asset that allows classroom teachers to assign multimedia projects within the security and content safety of *the.News* website.

For the first time we are now providing answers **to our student "thought starter" questions found on the home page (and on the Educators Page) underneath the video.**

#1 Denise Gray is in charge of battery development for GM. The fuel for electric vehicles is electricity stored in a battery. It provides power to one or more electric motors.
#2 Detroit Edison's research shows that generating the power to run one electric vehicle creates less pollution than running a gas engine.
#3 There is no standard for the plug or box used to charge an electric vehicle's batteries.

For more information and questions about this material contact me at kjaffe@newshour.org

Sincerely,

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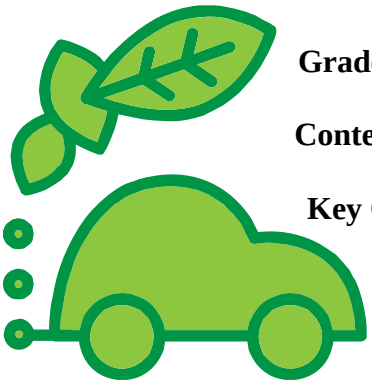
“Electric Car: American Industry and Innovation”

This lesson was designed to support *the.News* video “Electric Car: American Industry and Innovation” The video can be found online at http://www.pbs.org/newshour/thenews/thegov.



Grade Level: Grades 7–12

Content Areas: Science

Key Concept(s)

Students will become familiar with how an electric car and a car with an internal combustion engine work. They will “assemble” an electric car motor from a bin of “parts,” among which are distractor parts from an internal combustion engine.

Objectives:

Students will

- Be able to **explain** how internal combustion engines and electric motors power cars and **compare** and **contrast** the two.
- Be able to diagram the way an electric motor powers a plug-in electric car, label the component parts, and **describe** how the system works.
- Conceive a “fantasy” part to add to an electric car that overcomes at least one drawback of these vehicles.

Omaha Public Schools Science Standards Grades 7-8
Grade 7
http://www.ops.org/District/LinkClick.aspx?fileticket=Hbqyrrg2ydM%3d&tabid=912&mid=2006
Standard 4: Investigate and describe the transfer of energy using simple machines.

Omaha Public Schools Science Standards Grades 9–12
Physics
Standard 3: Investigate and apply the effects of forces on motion.
Standard 4: Investigate motion and technological design.
Standard 6: Examine interactions of energy and matter.

Key Vocabulary:

- **Electric motor**: a machine that converts energy from electricity into mechanical energy
- **Controller**: is a device that regulates the amount of power that goes to the electric motor.
- **Crankshaft**: a shaft that drives or is driven by a crank, e.g. one attached to a connecting rod in an internal-combustion engine
- **Internal combustion engine**: an engine in which fuel is burned in combustion chambers within the engine, instead of in an external furnace, and in which the energy released moves one or more pistons
- **Piston**: a metal cylinder that slides up and down inside a tubular housing, receiving pressure from or exerting pressure on a fluid,

especially one of several in an internal-combustion engine

- **Potentiometer**: a device for measuring an unknown potential difference or electromotive force by comparing it to a known standard.

Sources: Encarta and About.com

McRel
www.mcrel.org)
Science
Standard 9: Understands the sources and properties of energy

Level III (Grades 6–8)

- Knows that energy is a property of many substances (e.g., heat energy is in the disorderly motion of molecules and in radiation; chemical energy is in the arrangement of atoms; mechanical energy is in moving bodies or in elastically distorted shapes; electrical energy is in the attraction or repulsion between charges)
- Knows that electrical circuits provide a means of transferring electrical energy to produce heat, light, sound, and chemical changes
- Knows the organization of a simple electrical circuit (e.g., battery or generator, wire, a complete loop through which the electrical current can pass)
- Understands the origins and environmental impacts of renewable and nonrenewable resources, including energy sources like fossil fuels (e.g., coal, oil, natural gas)

Level IV (Grades 9_12)

- Knows that all energy can be considered to be either kinetic energy (energy of motion), potential energy (depends on relative position), or energy contained by a field (electromagnetic waves)

Standard 10: Understands forces and motion

Level III (Grades 6–8)

- Knows that just as electric currents can produce magnetic forces, magnets can cause electric currents

Level IV (Grades 9–12)

- Knows that magnetic forces are very closely related to electric forces and can be thought of as different aspects of a single electromagnetic force (moving electric charges produce magnetic forces and moving magnets produce electric forces); the interplay of these forces is the basis for electric motors, generators, radio, television, and many other modern technologies

Materials:

- "Electric Car: American Industry and Innovation" from *the.Gov*
  http://www.pbs.org/newshour/thenews/thegov
- Internet access
- Student Handout
  • "Under the Hood" diagram and parts list

Time Frame:
Two class periods, one for research and the second to complete the handout.

Background:
Everyone is trying to go green these days, and automakers are listening. Concerns about the environment and rising costs of fossil fuels are driving automakers to design and build cleaner, more energy efficient vehicles. Much of the focus is on electric vehicles (EVs). You may be familiar with the Ford Fusion Hybrid, Honda Insight, and Toyota Prius, which are hybrid cars that run partly on electric power and partly on gasoline. Hybrids still make up the majority of EVs, but attention is shifting to plug-in cars that do not rely as much on gasoline.

First, look at the internal combustion engine that powers the vast majority of cars today. See an animation of such an engine at "How Car Engines Work" (http://auto.howstuffworks.com/engine1.htm). Gasoline is the fuel that drives these engines.

Partnership for 21st Century Skills
Creativity and Innovation
- Use a wide range of idea creation techniques (such as brainstorming)
- Create new and worthwhile ideas (both incremental and radical concepts)

Critical Thinking and Problem Solving
- Analyze how parts of a whole interact with each other to produce overall outcomes in complex systems
- Solve different kinds of non-familiar problems in both conventional and innovative ways
- Identify and ask significant questions that clarify various points of view and lead to better solutions

Information Literacy
- Access information efficiently (time) and effectively (sources)
- Evaluate information critically and competently
- Use information accurately and creatively for the issue or problem at hand
- Manage the flow of information from a wide variety of sources

ICT (Information, Communications and Technology) Literacy
- Use technology as a tool to research, organize, evaluate and communicate information
- Use digital technologies (computers, PDAs, media players, GPS, etc.), communication/networking tools and social networks appropriately to access, manage, integrate, evaluate and create information to successfully function in a knowledge economy

When it is ignited by a spark plug inside the engine, the fuel produces gases that expand with a great deal of energy. The internal combustion engine captures the gases and forces them into a

chamber that pushes a series of pistons and rods to turn a crankshaft and drive the car's axels. It works in four steps, which is why it is called a four-stroke engine.

1. Intake. Air and a small amount of fuel get pulled into the engine cylinder through an intake valve as the piston moves down.
2. Compression. The piston moves up, compressing the air and fuel into a smaller space within the cylinder.
3. Combustion. When the piston reaches the top of the cylinder, a spark from the spark plug ignites the fuel mixture, creating an explosion that forces the piston down again.
4. Exhaust. When the piston reaches the bottom again, a valve opens that lets the spent fuel or exhaust out. This is what leaves through the car's tailpipe.

As you probably know, the fuel that powers an internal combustion engine is toxic, nonrenewable, and often expensive. The exhaust created is polluting and contains carbon dioxide, a greenhouse gas that contributes to global warming.

An electric car runs on electricity stored in batteries that is delivered to an electric motor, in this case a direct current (DC) motor. You can see an example of this type of engine setup at this "How Electric Cars Work" page: http://auto.howstuffworks.com/electric-car2.htm. Here's how a plug-in electric car is powered.

1. The car is plugged into an electric outlet until its batteries are fully charged.
2. The driver steps on the car's accelerator, which is connected to two potentiometers, devices that direct the amount of power needed to move the car. If you step lightly on the accelerator, the potentiometers send a signal for a smaller amount of power than if you floor it.
3. According to the amount of power needed, the controller pulls power from the batteries and sends it to the electric motor.
4. Inside the electric motor is a metal coil that generates a magnetic field when it is charged with electricity. Magnets surrounding the coil work with the magnetic field to keep the coil spinning very fast. It's this spinning coil that attaches to an axel that drives the car. A diagram of the inner workings of an electric motor is at this howstuffworks page: http://electronics.howstuffworks.com/motor1.htm. More examples are at Explain that Stuff! (http://www.explainthatstuff.com/electricmotors.html)

Cars powered solely by electric motors require no gasoline, produce no emissions, and run very quietly. But they do have drawbacks. Many plug-in electric cars can only store enough power in the batteries for short trips (50 miles or less) before having to be recharged. There are vehicles, such as those produced by Tesla Motors, that can travel more than 240 miles on a single charge, but these vehicles are very expensive. Stopping by the gas station won't work for a plug-in car, so you have to be near an outlet in order to recharge. And while the car produces no pollution itself, it relies on electricity produced by power plants that are usually coal fired and produce a great deal of pollution and greenhouse gases.

Lesson Plan:

1. Hold an initial discussion to find out what students know about electric cars and what they'd like to learn about them. A KWS chart on the board that you fill in as a group will aid in this discussion. The chart consists of three columns: "what you know," "what you want to learn," and "sources for more information." Add students' responses to the appropriate section of the chart.

2. Explain that students are going to "build" an electric car, but first they'll need to do some research to find out how electric cars work and how they differ from most of the cars on the road today—those with internal combustion engines. Allow one class period for the research and point students toward good resources, which are listed below. Note: Students will soon learn that there are various types of electric cars. There are purely electric cars that run solely on batteries that are charged by being plugged in to an electric outlet. Other electric cars can be charged by solar panels rather than electricity. There are hybrids that have both an electric motor and a gasoline engine. And there are cars powered by electricity generated chemically in a fuel cell. For the purposes of this activity, students should focus on plug-in electric cars that run on charged batteries rather than hybrids or fuel cells.
3. Hand out the "Under the Hood" diagram and parts list.
4. For part 1, students should draw a simple diagram showing the components that power an electric car and how they go together. When they get to the electric motor, they should also show the motor's working parts. Students should label the parts using the "parts list." Some of the parts in the list are not associated with an electric car but an internal combustion engine and act as distractors, and some (accelerator, axel, batteries) may be part of both systems.

5. In part 2, students write a description of how electricity powers the car and also how an electric motor differs from an internal combustion engine. Finally students will design and **describe** a fantasy part that helps to overcome a drawback inherent in today's electric cars.

Assessment:

Evaluate students' diagrams and descriptions from the handout.

Extension:

Take the next step in designing an alternative fuel vehicle at the Fuel Our Future Now Web site (http://fuelourfuturenow.com/). Here you'll find lesson plans and information for middle and high school students that steer them toward designing transportation for the future. The Virtual Design Lab (http://fuelourfuturenow.com/media/virtual-labs/design-test/index.html) allows students to design and alternative fuel vehicle and test it.

Resources:
Explain that Stuff: Electric Cars: http://www.explainthatstuff.com/electriccars.html

howstuffworks "Electric Car": http://auto.howstuffworks.com/electric-car.htm

howstuffworks "How Car Engines Work":
http://auto.howstuffworks.com/engine1.htm

Encarta's Electric Car: http://encarta.msn.com/encyclopedia_761580732/electric_car.html

Tesla Motors "Under the Skin" design pages:
http://www.teslamotors.com/design/under_the_skin.php

Activity Designer:
Rhonda Lucas Donald is a freelance writer and educational consultant.

Student Handout

Under the Hood

Part 1: Draw a diagram of an electric motor—including its main internal parts—and the additional parts needed to power a car. Be sure to label the parts.

[Leave space for drawing the diagram. The drawing space could look like the outline of a car as viewed from above.]

Part 2: **Describe** how an electric car works and **compare** and **contrast** it with how an internal combustion engine works. Finally, imagine a fantasy part that will overcome at least one drawback associated with plug-in electric cars. Add your fantasy part to the diagram and **explain** its function.

(see next page for parts list)

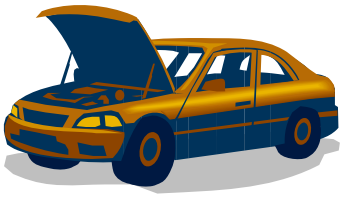
Parts List
accelerator
axel
batteries
coil
controller
electric motor
exhaust pipe
fuel lines
intake valve
magnets
piston
potentiometers

Student Handout Key

Part 1

See the diagram at the howstuffworks page http://auto.howstuffworks.com/electric-car2.htm for an example of the type of diagram students will draw. There are different types of electric motor designs, so student drawings will vary. Parts that should be included in the overall diagram are:

accelerator
potentiometers
batteries
controller
electric motor



Parts inside the electric motor are the coil and magnets. Axels may or may not be included in student diagrams.

Part 2

Refer to the background information for descriptions of how electric motors and internal combustions engines work and how they are alike and different. Fantasy parts may be just about anything as long as students thoughtfully consider how to solve a drawback to existing electric cars.