The Garrett Morgan Program

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Sustainable Transportation in the 21st Century

Teacher's Guide

The Mineta Transportation Institute at San José State University named a prestigious award in honor of Garrett Morgan, the Sustainable Transportation Award. From that, the Sustainable Transportation for the 21st Century Program was founded. The program is designed to increase middle school and high school students' awareness of transportation issues.

Who was Garrett Morgan?

Garrett Augustus Morgan, an African-American inventor, was born in Kentucky in 1877 to former slaves Sydney Morgan and Elizabeth Reed Morgan. The seventh of ten children, he spent long days working on the family farm. He also attended school but had to quit at age 14 to earn a living. That did not discourage him - he moved to Cincinnati, Ohio, found work as a handyman, hired a tutor and continued learning. Mr. Morgan eventually moved to Cleveland and became prosperous as a sewing machine repairman with his own clothing manufacturing business that employed more than 30 people. Later, he established the Cleveland Call, a successful newspaper.

Inventor of the Traffic Signal

As an early owner of an automobile, Mr. Morgan believed roads could be safer if they had a better signaling device at intersections. At that time, roadways were used for every mode of transportation – autos, wagons, streetcars, horses, bikes and pedestrians. The existing signals showed only "stop" and "go", which meant that pedestrians were left to compete with traffic. As a result, Garrett Morgan invented a hand-cranked signal that would control traffic at an intersection, which would stop all traffic to allow pedestrians to cross. Just before his death in 1963, the U.S. government gave him an award for his invention.

Thank You to Our Sponsors

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Disclaimer

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Dear Teacher,

Thank you for participating in the Garrett Morgan Sustainable Transportation Competition. The Mineta Transportation Institute realizes that this is an additional activity in your already full curriculum, so we appreciate your efforts.

This learning module is an overview of sustainable transportation issues. You are welcome to cover as many of the lessons that your curriculum will support. Each lesson is all-inclusive and includes instructor information, as well as student worksheets, and other materials relevant to the lesson.

For the competition project, you can have students work in small groups or together as a class. If your class works on more than one project, please select the best one for presentation at the video conference. Students will present their project during a national, live video conference broadcast. A panel of judges will select the best project and that school will be invited to send a teacher, students, and parent or adult guardian on an all-expenses paid trip to San Jose, California to attend MTI's annual banquet. The winning class will receive \$1,000 and a plaque, while the second and third place teams will win \$300 and a plaque, and \$200 and a plaque, respectively. All students who complete will receive a signed certificate.

The video conference date is usually scheduled for mid-April, depending on the availability of the Secretary of Transportation as well as spring breaks and state testing dates for the participating schools. During the video conference, students will have the opportunity to ask questions of transportation experts and the other teams. Your sponsor will provide details about the logistics for the video conference.

We hope that you and your class enjoy this unit. Please let us know if you have suggestions or feedback.

Thank you again...

Karn Phillich

Karen Philbrick, PhD Executive Director Mineta Transportation Institute

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Hilary Nixon, PhD Director of Research and Technology Transfer Mineta Transportation Institute





Table of Contents

Acknowledgments	1
Letter to Teachers	2
Table of Contents	4
Lesson Plan 1: What Do You Know About Transportation?	5
Lesson Plan 2: Transportation History – News & Dates	7
Lesson Plan 3: Learning About Transportation Fuels	11
Lesson Plan 4: Our Class Transportation Carbon Footprint	23
Lesson Plan 5: Pretzel Power – Exploring Fuel Efficiency	32
Lesson Plan 6: Moving Beyond the Automobile – Film Guides	
Lesson Plan 7: How Walkable is Your Community	
Lesson Plan 8: Transportation Jobs and Professions	42
Lesson Plan 9: Understanding Sustainable Transportation	44
The Competition	48

Lesson Plan 1: What Do You Know About Transportation?

Description

This lesson will help the students become aware of various forms of transportation. Students will focus on why transportation is needed, the different modes of transportation, and various energy sources used by different transportation modes.

Lesson Time

• One class period

Learning Outcomes

At the completion of this lesson, students will be able to:

- List different forms of transportation;
- Explain how we use different modes of transportation;
- Identify different energy sources used by transportation;
- Describe some of the environmental impacts of transportation.

Materials

• "What Do You Know About Transportation" Student Worksheet (one copy per student, or one copy per group depending on how you structure the activity)

Instructional Activity

With guidance from the teacher, students will brainstorm and fill in the "What Do You Know About Transportation" worksheet for each of the following areas related to transportation:

- 1. How do we use transportation? Why do people need transportation?
- 2. What are the different modes/types of transportation?
- 3. What are the different energy sources used by transportation?
- 4. What are some of the environmental impacts of transportation?

The brainstorm session can take place in small groups, or in a larger classroom discussion. It may be best to focus on one question at a time. The teacher may guide students to think about transportation issues that they might not have considered. For example, how does the US Postal Service use transportation, and how do shipping companies, grocery stores, or the military use transportation? Have students consider different modes of public transportation? What about non-vehicular modes of transportation?

After the four lists are compiled, have students link the different reasons for using transportation with the various modes and energy sources of transportation. Teachers can help illustrate these relationships by drawing lines connecting the various related reasons, modes, and energy sources.

A completed example table is provided for teachers. As part of the class discussion, the instructor may ask students how these different aspects of transportation are related – for example, what modes of transportation do students use to get to/from school? What energy sources do different modes of transportation use?

Example Completed Table for Teacher

1. Uses	2. Modes	3. Energy Sources	4. Effects
Get to school	Car	Gasoline	Greenhouse gas emissions
Get to work	Light rail transit	Diesel	Climate change
Vacations	Train	Jet fuel	Smog
Shopping	Ship	Solar energy	Air pollution
Visiting	Airplane	Electricity	Fuel spills
Emergencies	Truck	Natural gas	Noise pollution
	Boat	Ethanol	Congestion
	Bicycle	Calories	
	Walking	Fuel cell	

Name: _____

Student Worksheet What Do You Know About Transportation?

Complete the following worksheet listing all that you know about the following:

- 1. What are the different ways we *use* transportation? (e.g. get to school)
- 2. What are the different modes of transportation? (e.g. car)
- 3. What are the different *energy sources* used by transportation? (e.g. gas)
- 4. What are some of the *environmental impacts* of transportation? (e.g. smog)

1. Uses	2. Modes	3. Energy Sources	4. Impacts

Lesson Plan 2: Transportation History – News & Dates

Description

This lesson will help develop students' awareness of the social, environmental, and economic costs of our transportation systems' dependence on fossil fuels through a historical perspective.

Learning Outcomes

At the completion of this lesson, students will be able to:

- Identify key events in U.S. transportation history;
- Understand the impact specific transportation-related events have had;
- Discuss the economic, social, and environmental costs and/or benefits of specific transportation-related events.

Materials

• "Transportation History: Timeline of Events" Student Handout

Lesson Time

 One class session (helpful to have students read through the timeline in advance so that they are familiar with the events)

Instructional Activity

Have students read the "Transportation History: Timeline of Events" student handout in advance. In groups, students should discuss the economic, social, and environmental costs and/or benefits of the event. Each group should identify the five events they think are most important and present those events, and why they chose them, to the class.

June 27, 1652 The first traffic law is passed in New Amsterdam (New York City). It said, "...to prevent accidents [we] do hereby ordain that no wagons, carts or sleighs shall be run, rode or driven at a gallop within this city of New Amsterdam, ... on the penalty of two pounds Flemish for the first [violation]."

So many people use the road that laws are needed to control them. Can you think of a law you would like to see to improve safety?

August 9, 1803 Robert Fulton creates a steamboat that operates up the River Seine in Paris, moving 3-4 miles per hour upstream.

Why were steamboats different? How did it benefit people?

May 3, 1869 Passenger traffic begins on the first pneumatic subway invented by Alfred Ely Beach. The Beach Pneumatic Underground Railway of New York City includes a 312 foot-long circular tube, 9 feet in diameter. The cars carry 22 passengers and are propelled by a blast of air from a rotary blower.

Social benefit: More mass transit, which improves mobility for people. Economic costs: Government pays for transit system.

January 2, 1900 The first electric bus appears on 5th Avenue in New York City. It seats eight people inside and four outside. The fare is 5¢.

Social benefit: People don't have to own a car to get to work. Economic costs: Government pays for transit system. Alternatively, the instructor can go through each event together with the class. Students can take turns reading the event out loud. The discussion for each event should focus on the economic, social, and environmental costs and/or benefits of the event. A list of guiding questions/additional comments for each event for the instructor is provided below.

October 27, 1904 The New York City Subway is the first rapid transit underground and underwater railway in the world. It runs from City Hall to West 145th St.

Do New York and other cities still use subways? What is the advantage of subways (compared to private automobiles, bus)?

April 7, 1913 The first electrically propelled ship of the U.S. Navy, the USS Jupiter, is commissioned.

Environmental cost/benefit: When this ship was built, electricity was often created by burning coal, which causes a lot of pollution. But the technology had future environmental benefits. Today we can create energy using cleaner energy sources. Social benefit: U.S. Navy was better able to protect the U.S.

November 20, 1923 Garrett Morgan is granted a patent for inventing the first practical traffic signal.

Cars were so common that they needed regulation. At that time, horses, people, wagons, and other vehicles used the roadways at the same time.

March 29, 1927 The first automobile to exceed 200 miles per hour is the "Mystery Sunbeam" driven by Major Henry O'Neil de Hane Segrave at Daytona Beach, FL. He hits 203.79 mph.

Social benefit: People can drive fast in car races instead of on the roads; entertainment for people.

Social cost: People become fascinated by cars with bigger, faster engines.

Environmental cost: Bigger engines use more fuel and create more pollution.

September 3, 1931 An experimental electric passenger train, designed by Thomas Alva Edison, is used on the Lackawanna Railroad between Hoboken and Montclair, NJ.

Using electricity instead of coal could dramatically reduce local air pollution.

July 16, 1935 The first parking meter, called The Black Mariah, is installed in Oklahoma City, OK.

Cities saw cars as a way to generate revenue.

February 20, 1941 The first jeep is introduced for military use.

Do we still drive jeeps today? Why do some people like them better than cars?

June 29, 1956 President Dwight Eisenhower signs a bill that creates the first interstate highway in the U.S. The system is not completed until 1990.

He thought that if the US were attacked, military vehicles would move slowly on existing roads. So he copied the German autobahn.

August 25, 1959 An early modern type of magnetic levitation (maglev) train is described in a US Patent by G.R. Polgreen.

How do magnets allow trains to hover and to move?

April 12, 1961 The first human spaceflight is Vostok I, on which cosmonaut Yuri Gagarin of the USSR makes one orbit around Earth.

Will space travel be practical for humans? What kinds of space technology can we use for vehicles on Earth (e.g. more aerodynamic plane designs)?

October 1, 1964 Japan's Shinkansen, the first "bullet train," opens.

Why was this called a "bullet train"? Because of its speed. Does the US have bullet trains?

January 28, 1969 An oil well blows out on a Union Oil Company drilling platform five miles off the coast of Santa Barbara, CA. The beaches are covered with oil. In April 2010, the same thing happens in the Gulf of Mexico, where BP was drilling.

What are the impacts of oil spills? Takes away the beauty of our coastline and pollutes the natural environment, birds and animals are harmed. Costly to clean up.

December 31, 1973 President Nixon announces stand-by gasoline rationing in light of the Arab oil embargo. Gas stations voluntarily close on Sundays.

Do we depend too much on oil? What can we use instead?

June 28, 1979 Organization of Petroleum Exporting Companies (OPEC) raises prices on crude oil again. The price of a barrel increase 50% since a year earlier.

Who pays when oil prices go up? Who makes the money?

July 15, 1979 President Carter announces a massive six-point effort to reduce American dependence on foreign oil, including alternative energy development.

Why do you think President Carter did this? See above.

March 24, 1989 Exxon Valdez oil tanker runs aground in Alaska, spilling 232,000 barrels of oil. Only 25% of the migratory salmon population returns the following season. Thousands of otters and birds are poisoned. Many die.

Environmental, economic costs: Most of the clean-up was paid for out of a "super fund" that oil companies pay into.

July 19, 2006 The Tesla Roadster is introduced at the Santa Monica, CA airport at a 350-person, invitation-only event. The Roadster costs more than \$100,000.

What are the benefits of electric cars? How can they be improved?

April 16, 2009 President Obama unveiled his administration's blueprint for a national network of high-speed passenger trains.

What are the benefits of a high-speed train?

December 26, 2009 China introduced the world's fastest train, with average speeds of 217 miles per hour.

Do you think you will ride a high-speed train someday?

May 13, 2013 The *New York Times* runs a story about young people leading a trend toward driving less and taking transit instead.

Do you think this will continue? Why?

September 20, 2016 The U.S. Department of Transportation announces new regulations for automated vehicles and self-driving cars to ensure that they are safe.

What do you think the benefits of self-driving cars will be? Could they help elderly or disabled persons get around more easily?

Student Handout Transportation History: Timeline of Events

Date		Event
June 27, 1652	ţ	The first traffic law is passed in New Amsterdam (New York City). It said, "to prevent accidents [we] do hereby ordain that no wagons, carts or sleighs shall be run, rode or driven at a gallop within this city of New Amsterdam, on the penalty of two pounds Flemish for the first [violation]."
August 9, 1803	•	Robert Fulton creates a steamboat that operates up the River Seine in Paris, moving 3-4 miles per hour upstream.
May 3, 1869	+	Passenger traffic begins on the first pneumatic subway invented by Alfred Ely Beach. The Beach Pneumatic Underground Railway of New York City includes a 312 foot-long circular tube, 9 feet in diameter. The cars carry 22 passengers and are propelled by a blast of air from a rotary blower.
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November 20, 1923	•	Garrett Morgan is granted a patent for inventing the first practical traffic signal.
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January 28, 1969		An oil well blows out on a Union Oil Company drilling platform five miles off the coast of Santa Barbara, CA. The beaches are covered with oil. In April 2010, the same thing happens in the Gulf of Mexico, where BP was drilling.
December 31, 1973	•	President Nixon announces stand-by gasoline rationing in light of the Arab oil embargo. Gas stations voluntarily close on Sundays.
June 28, 1979		Organization of Petroleum Exporting Companies (OPEC) raises prices on crude oil again. The price of a barrel increase 50% since a year earlier.
July 15, 1979		President Carter announces a massive six-point effort to reduce American dependence on foreign oil, including alternative energy development.
March 24, 1989		Exxon Valdez oil tanker runs aground in Alaska, spilling 232,000 barrels of oil. Only 25% of the migratory salmon population returns the following season. Thousands of otters and birds are poisoned. Many die.
July 19, 2006	•	The Tesla Roadster is introduced at the Santa Monica, CA airport at a 350-person invitation-only event. The Roadster costs more than \$100,000.
April 16, 2009	•	President Obama unveiled his administration's blueprint for a national network of high-speed passenger trains.
December 26, 2009	•	China introduced the world's fastest train, with average speeds of 217 miles per hour.
May 13, 2013	•	The New York Times runs a story about young people leading a trend toward driving less and taking transit instead.
September 20, 2016		The U.S. Department of Transportation announces new regulations for automated vehicles and self-driving cars to ensure that they are safe.

Lesson Plan 3: Learning About Transportation Fuels¹

Description

This lesson will help students learn more about transportation fuels, including alternative fuels. Students will develop an understanding of some of the current issues related to petroleum as a source of fuel, as well as identify what other sources of fuel can be used by transportation. The focus is on motor vehicle transportation.

Lesson Time

 Several class periods depending on how the activity is structured

Learning Outcomes

At the completion of this lesson, students will be able to:

- List the main features of different transportation fuels;
- Compare and contrast the advantages and disadvantages of different transportation fuels.

Materials

- Alternative Fuels Information Student Worksheet Background (all students receive a copy of this worksheet)
- Alternative Fuels Information Student Worksheets Individual Fuels (assign one fuel to each group and provide a copy of the relevant worksheet)
- Student Activity Guidelines

Instructional Activity

In groups, students will conduct research on a specific fuel. All students should receive a copy of the "Alternative Fuels Information Student Worksheet - Background" handout which provides some basic information about some of the issues surrounding petroleum as a source of transportation fuel and introduces the concept of alternative fuels. Each group should be assigned to learn about one of the fuel options and present what they learn to their class. Options include: gasoline; diesel; biodiesel; hybrid electric vehicles; electric vehicles; ethanol; propane; natural gas (CNG/LPG); and hydrogen. Depending on your preference, groups could present what they have learned to the class in a variety of ways. Options include a poster and/or oral presentation, but other options are possible such as a PowerPoint presentation, a written paper, or a short video. The learning activity is intended to be flexible. Students are encouraged to look at additional resources for information as well. Some online references are provided, but you may wish to supplement with other resources as well.

As a supplemental activity you may wish to consider the following "mini activity" to help students understand some of the constraints associated with the use of alternative fuels. The U.S. Department of Energy has developed an Alternative Fueling Station Locator (http://energy.gov/maps/alternative-fueling-station-locator). At this site, you can find the locations of different types of alternative fuel stations around the U.S. You may want to list your school's address and select different fuel types to see the availability around you. Another great activity is to "Plan a Route." Maybe you want to see whether you can travel from your school to, for example, your state capital using a variety of alternative fuels. This activity can be adapted in many different ways – be creative!

http://www.need.org/files/curriculum/guides/ ElementaryTransportationFuelsInfobook.pdf and http://www.formula-hybrid.org/wp-content/ uploads/DOE-Alternative-Fuels-Teacher-Guide.pdf.

¹ This lesson is drawn from materials prepared by the National Energy Education Development Project. The original set of materials, including additional activities, can be found at:

Student Information Worksheet Alternative Fuels - Background

For more than a hundred years, petroleum has fueled our vehicles. In the United States, we use approximately 14 million barrels of oil each day to keep us on the move.² It's no wonder that petroleum is often called "black gold."

The automobile is important to the way we live. Americans drove approximately 3 trillion miles in 2014. There are a lot of vehicles driving those miles—249,000,000 personal vehicles, 11 million commercial trucks, and 872,000 buses (both school and public transit buses).

These vehicles all need fuels that we can afford and are easy to find. Today, over 99 percent of our vehicles run on gasoline or diesel fuels. America's whole system of refineries, pipelines, and service stations was designed for oil-based fuels. But there are problems with using petroleum fuels.

Today, the United States imports about half of its petroleum from other countries. We need a supply that is reliable. The unrest in the Middle East could cause oil shortages or very high prices at any time. In the summer of 2008, the cost of a barrel of crude oil soared to \$133, an all time high.

Auto manufacturers have done a good job of reducing emissions from vehicles. Since the 1960s, emissions have dropped by more than 95 percent. Still, the pollutants cause health and environmental problems, and contribute to global climate change. The vehicles on the road today cause half of the air pollution in many cities. According to the

U.S. Environmental Protection Agency, almost half of all Americans live in polluted areas. This has led to an effort to develop alternatives to petroleum fuels.

Taking An Alternative Route

The United States is big; Americans travel more miles than the citizens of any other country. And we use more petroleum than any other country. In many areas, this is causing air pollution problems.

There is no simple answer that can solve the problem, but using alternative fuels can help. Alternative fuels emit fewer air pollutants. Using alternative fuels can also reduce emission of carbon dioxide, a greenhouse gas. Combustion of any carbon-based fuel produces carbon dioxide, but the overall impact of a fuel depends on how the fuel is made. Fuels produced from biomass and from natural gas result in less carbon dioxide than fuels from petroleum.

With rising gasoline prices and concern for the environment, more and more people are looking at using alternative fuels to fuel their vehicles. Alternative fuels—such as propane, natural gas, ethanol, biodiesel, and electricity—all can help. Each of these alternative fuels has advantages and disadvantages. Every year, people have the choice of more alternative fuel vehicles.



²Source: U.S. Department of Energy (2016). Monthly Energy Review: Petroleum Consumption by Transportation and Electric Power Sectors. http://www.eia.gov/totalenergy/data/monthly/pdf/ sec3_21.pdf.

Student Information Worksheet Alternative Fuels - Gasoline

Gasoline is a fuel made from petroleum. It is used in most U.S. passenger vehicles with internal combustion engines. Americans consume about 9.2 million barrels of petroleum daily to produce finished motor gasoline. Each barrel produces an average of 19 gallons of gasoline. So that means we consume around 175 million gallons of gasoline daily.

History of Gasoline

Edwin Drake dug the first oil well in 1859 and distilled the petroleum to produce kerosene for lighting. He had no use for the gasoline or other products, so he discarded them. It wasn't until 1892 with the invention of the automobile that gasoline was recognized as a valuable fuel. By 1920, there were nine million vehicles on the road powered by gasoline and service stations were popping up everywhere.

During the 1950s, cars were becoming bigger and faster. Octane ratings increased and so did lead levels, as lead was added to gasoline to improve engine performance. Unleaded gasoline was introduced in the 1970s, when the health problems from lead became clear. Leaded gasoline was completely phased out in the 1980s.

Gasoline as a Transportation Fuel

Today, gasoline is the fuel used by most of the passenger vehicles in the U.S. There are about 249 million vehicles that use gasoline to travel an average of 12,000 miles per year. There are 168,000 fueling stations that provide convenient refueling for consumers. Most Americans consider gasoline the most sensible fuel for today, even if it is not an ideal fuel.

Consumers worry about the price of gasoline. During World War I, the cost of gasoline was about \$0.25 a gallon. The price of gasoline has averaged about \$2.00 a gallon in inflation-adjusted dollars for the last 80 years, until the shortages after Hurricanes Katrina and Rita and unrest in oil-producing countries such as Iran, Iraq, and Nigeria. In summer 2008, the average price for a gallon of gasoline was the highest ever at \$4.39. However, in 2015, the average price for a gallon of gasoline was only \$2.40.

Characteristics and Environmental Impacts of Gasoline

Gasoline has high energy content. It is highly flammable and toxic—gasoline vapors can cause dizziness, vomiting, and even death if inhaled in strong concentrations. Gasoline is a nonrenewable fossil fuel that produces air pollutants when it is burned. Since the 1960s, stricter environmental standards have led to gasoline and vehicle designs that have reduced vehicle exhaust emissions by 95 percent.

The Clean Air Act Amendments of 1990 required that reformulated gasoline be used in areas of the country that do not meet air quality standards, to reduce emissions ,and improve air quality. In 2002, more than a dozen different types of gasoline were required by law in the U.S.

Even with reductions in emissions, the impact of gasoline on the environment is immense, because there are so many vehicles in the United States driving so many miles. It will take the dedicated efforts of consumers, the transportation industry, and federal and state governments to make significant changes to our transportation system.



Additional Resources

U.S. Energy Information Administration: www.eia.gov Alternative Fuels Data Center: http://www.afdc. energy.gov/

Student Information Worksheet Alternative Fuels - Diesel

Diesel is a petroleum fuel that contains energy. At refineries, crude oil is separated into different fuels including gasoline, jet fuel/kerosene, lubricating oil, and diesel. Approximately ten gallons of diesel are produced from each 42-gallon barrel of crude oil. Diesel can only be used in a diesel engine, a type of internal combustion engine used in many cars, boats, trucks, trains, buses, and farm and construction vehicles.

History of Diesel

Rudolf Diesel originally designed the diesel engine to use coal dust as fuel, but petroleum was more effective. The first diesel-engine automobile trip was completed on January 6, 1930. The trip was from Indianapolis to New York City, a distance of nearly 800 miles. This achievement helped prove the usefulness of the diesel engine design. It has been used in millions of vehicles since then.

Diesel as a Transportation Fuel

Diesel fuel plays an important role in America's economy, quality of life, and national security. As a transportation fuel, it offers a wide range of performance, efficiency, and safety features. Diesel fuel contains between 18 and 30 percent more energy per gallon than gasoline. Diesel technology also offers a greater power density than other fuels, because it provides more power per volume.

Diesel fuel is used for many things. Diesel powers more than two-thirds of all farm equipment in the U.S. because diesel engines can perform demanding work. In addition, it is the most commonly used fuel for public buses and school buses throughout the U.S.

America's construction industry depends on the power of diesel fuel. Diesel engines are able to do demanding construction work, like lifting steel beams, digging foundations and trenches, drilling wells, paving roads, and moving soil—safely and efficiently. Diesel also powers the movement of America's freight in trucks, trains, boats, and barges; 94 percent of our goods are shipped using diesel-powered vehicles. No other fuel can match diesel in its ability to move freight economically.

Several auto manufacturers are in the process of releasing new models of light-duty diesels and passenger cars. Within the next few years, demand for diesel vehicles is expected to increase greatly in the U.S.

Characteristics and Environmental Impacts of Diesel

Diesel-powered cars achieve 30-35 percent better fuel economy than gasoline powered cars, especially in sport utility vehicles (SUVs) and light trucks, which now make up more than half of all new vehicle sales. Safety is another advantage of diesel fuel; it is safer than gasoline and other alternatives because it is less flammable.

The major disadvantage of diesel fuel is its harmful emissions. Pollutants associated with the burning of diesel fuel are gaseous emissions, including sulfur dioxide (SO₂) and nitrogen oxide (NOx), and particulate matter. Major progress has been made in reducing emissions from diesel engines. New diesel fuels-some of which have lower sulfur content—can also help diesel vehicles achieve lower emissions. As of 2010, new trucks and buses have near zero emission levels. Ultra low sulfur diesel (ULSD) fuel is highly refined for clean, complete combustion and low emissions. Using low sulfur diesel fuel and exhaust control systems can reduce particulate emissions by up to 90 percent and nitrogen compounds (NOx) by 25-50 percent.



Additional Resources

U.S. Energy Information Administration: www.eia.gov Alternative Fuels Data Center: http://www.afdc. energy.gov/

Student Information Worksheet Alternative Fuels - Biodiesel: Fuel from French Fries?

Biodiesel is a fuel made from vegetable oils or animal fats. It is usually made from soybean oil, but it can also be made from corn oil or even used restaurant grease and fryer oil. If it is made from restaurant oil, it can sometimes smell like french fries. Since biodiesel is made from plant and animal oils, it is a renewable fuel. We can grow more plants in a short time to make more biodiesel.

Biodiesel as a Transportation Fuel

Biodiesel works as well in engines as diesel fuel. In many ways, it is a better fuel, though it is more expensive. Burning biodiesel does not produce as much air pollution as burning petroleum fuels. This means the air is cleaner and healthier to breathe when biodiesel is used. Biodiesel is also nontoxic—it is not dangerous to people or the environment, and is safe to handle. If biodiesel spills, it is biodegradable—it breaks down quickly into harmless substances.

Biodiesel can be used instead of diesel fuel or it can be mixed with diesel fuel. It is usually mixed with diesel fuel as a two percent (B2), five percent (B5), or 20 percent (B20) biodiesel blend. Pure biodiesel is called B100. That means it is 100 percent biodiesel. The B stands for biodiesel and the number stands for the percent of biodiesel in the mixture or blend.

Most biodiesel used today is B20, which is 20 percent biodiesel and 80 percent diesel. Many school districts have begun using B20 in their school buses. In Arizona's Deer Valley Unified School District, school buses have been running on B20 since 1999. These buses drove over 2.5 million miles per year on B20. Everyone involved is pleased with the way the buses operate and believe using biodiesel improves the environment and the health of the students and drivers.

Many cities, as well as the U.S. Army, Air Force, and Department of Agriculture, are using biodiesel to run their buses, garbage trucks, snowplows, and other vehicles. These fleets have their own fueling stations. Biodiesel fuels are also becoming more available at public stations, as consumer demand grows.

Environmental Impacts

Biodiesel is a renewable fuel. It is environmentally safe, biodegradable, and reduces the emission of most air pollutants.

Biodiesel Today and Tomorrow

Today, biodiesel is mainly available through bulk suppliers. There are 198 public biodiesel refueling stations in the United States as of 2016 according to the U.S. Department of Energy. That means biodiesel is more practical for fleets with their own fueling stations. More stations will open as the demand for biodiesel grows.

Today, B20 costs a little more than diesel fuel. The cost will go down as more biodiesel is used. Many states are planning to require that all diesel fuels have a small amount of biodiesel to reduce sulfur emissions.



Additional Resources

U.S. Energy Information Administration: www.eia.gov Alternative Fuels Data Center: http://www.afdc. energy.gov/

Student Information Worksheet Alternative Fuels - Hybrids: A Great Combo

The hybrid electric vehicle, or HEV (hybrid means combination, or mixture), has a growing presence in the automotive market. HEVs have a gasoline engine and an electric motor with a battery. HEVs can run on the electric motor for short trips, using the gasoline engine for longer trips and higher speeds. HEVs on the market today have the same power and performance but can travel farther on one gallon of gas than gasoline-only vehicles.

When you drive an HEV, it feels the same as driving a regular car—except that there is very little noise when the electric motor is running the car. When you stop at a red light, for example, the gasoline engine shuts off. The car is totally quiet. When the light turns green and you step on the accelerator, the electric motor begins to move the car. The gasoline engine kicks in as you need more power and speed.

The battery that powers the electric motor is continually recharged by an on-board generator. The engine recharges the batteries whenever they are low. The regenerative braking system captures excess energy when the driver uses the brakes. This energy is also used to recharge the batteries.

Environmental Impacts

HEVs have significant environmental benefits. They reduce pollutants by one-third to one-half compared to conventional vehicles, because they use less fuel.

Hybrids Today and Tomorrow

In 2006, there were nine hybrid models available to the general public. In 2015, there were over 45 hybrid models available from almost every manufacturer, and they range from passenger cars to SUVs and pickup trucks.

Plug-In Hybrid Electric Vehicles (PHEVs)

PHEVs are very similar to HEVs. They have an internal combustion engine, an electric motor, and a large battery pack. The larger battery pack in the PHEV gives it a range of 10-40 miles on an electric only range. When the battery is depleted the car continues to operate as a hybrid or gasoline vehicle. The battery pack in a PHEV can be recharged by plugging it into a regular 120-volt electric outlet. People using a PHEV in an urban setting may be able to make their daily commute using all-electric power and then recharge the battery overnight to be ready for the next day's commute.

In 2016, there are only a few PHEV models available on the market (approximately 18), but more are expected to be available soon.



Additional Resources Additional Resources U.S. Energy Information Administration: www.eia.gov Alternative Fuels Data Center: http://www.afdc. energy.gov/ U.S. Environmental Protection Agency: Transportation, Air Pollution, and Climate Change: https://www. epa.gov/air-pollution-transportation

Student Information Worksheet Alternative Fuels - Plugging Into Electric Vehicles

In 1891, William Morrison of Des Moines, Iowa, built the first electric car. By the turn of the century, there were twice as many electric vehicles (EVs) as gasoline-powered cars. There are over 20 different electric vehicle models from 12 manufacturers in the U.S. as of 2016. More than 100,000 electric vehicles were sold in the U.S. in 2015. Researchers are still working on the same problem experienced by those early electric vehicles—an efficient battery.

The Battery is the Challenge

Electric vehicles must have batteries that can be charged over and over again. Since most batteries can't store large amounts of electricity, an EV must carry as many batteries as possible. In some EVs, the batteries make up almost half the weight of the car. The batteries must be replaced every three to six years, which is expensive.

The batteries limit the range of an EVhow far it can go on a charge. The more batteries an EV has, the more range it has, to a point. Too many batteries can weigh down a vehicle, causing it to use more energy. The typical EV can only travel 50 to 130 miles between charges, although some models, such as the Tesla Model S, can travel over 200 miles. EVs can only go this far with perfect driving conditions. Weather, hills, and air conditioning can reduce the range. Even listening to the radio or turning on the lights can reduce the range. Research is being done to develop new batteries that will increase the range. These new batteries could double the range of EVs, and last longer before they have to be replaced.

Environmental Impacts

Electric vehicles produce no tailpipe emissions, but making the electricity to charge them can produce emissions. EVs are really coal, natural gas, nuclear, hydropower, and wind cars, because these fuels produce most of the electricity in the U.S.. Coal alone generates almost half of U.S. electricity. When fossil fuels are burned, pollutants are produced like those from the tailpipe of a gasoline-powered car. Power plant pollution, however, is easier to control than tailpipe pollution. Emissions from power plants are controlled and monitored carefully. And power plants are usually located outside major cities.

Maintenance

Many people like the low maintenance of electric vehicles. EVs need no engine tune-ups, oil changes, water pumps, radiators, injectors, or tailpipes. And no more trips to the gas station. EVs can be recharged at home at night when electric rates are low, making the fuel cost lower than gasoline. There are 38,540 electric charging units at public refueling stations, allowing you to recharge at the airport, in a parking garage, or even while shopping at the mall.

The Future of EVs

Today, there are not too many options if you want to drive a dedicated EV. However, more and more car manufacturers are manufacturing EVs. Some estimates say that electric vehicles will make up 35% of all global new car sales by 2040.³



³ Bloomberg New Energy Finance (2016, February 25). "Electric Vehicles to be 35% of Global New Car Sales by 2040." Available at: https://about.bnef.com/ press-releases/electric-vehicles-to-be-35-of-globalnew-car-sales-by-2040/.

Additional Resources

U.S. Energy Information Administration: www.eia.gov Alternative Fuels Data Center: http://www.afdc. energy.gov/

Student Information Worksheet Alternative Fuels - Ethanol: From Field to Fuel

Ethanol is a clear, colorless fuel made from the sugars found in plants. Ethanol can be blended with gasoline to reduce pollution from the tailpipes of vehicles. In the U.S., ethanol is usually made from corn. Today, many ethanol plants, mostly in the Midwest, produce over ten billion gallons of ethanol a year.

There are several processes that can produce alcohol (ethanol) from biomass. The most commonly used processes today use yeast to ferment the sugars and starch in the feedstock to produce ethanol. A new process breaks down woody fibers, so we can make ethanol from trees, grasses, and crop wastes. Trees and grasses need less energy than grains, which must be replanted every year.

Scientists have developed fast-growing trees that grow to size in ten years. Many grasses can produce two harvests a year for many years.

Ethanol as a Transportation Fuel

Most of the ethanol fuel used today is E10. The letter E stands for ethanol and the number stands for the percent of ethanol that is mixed with gasoline. E10 is 10 percent ethanol and 90 percent gasoline. There are fueling stations all over the country that offer E10 in their pumps. All vehicles that run on gasoline can use E10 without making any changes to their engines. You will often see stickers at the gas pump telling you that the gas may contain up to 10 percent ethanol.

When we add small amounts of ethanol to gasoline (up to 10 percent) there are many advantages. It reduces the pollution from the tailpipes of vehicles, making the air cleaner. It keeps engines running smoothly without the need for lead or other dangerous chemicals. Ethanol is produced from crops grown in the United States; it is a domestic fuel. Over ninety percent (90%) of the ethanol produced in the United States today is mixed with gasoline to make E10.

There are also cars that are designed to run on higher ethanol blends. These cars are called flexible fuel vehicles (FFVs). They can use any blend of ethanol fuel from E10 to E85. Gasoline that contains 85 percent ethanol or more is considered an alternative fuel. While there are an estimated twenty million FFVs in the United States today, many flexible fuel vehicle owners don't realize their car is a FFV. In addition, many FFVs don't have access to E85. There are just over 2,700 fueling stations with E85 pumps in the U.S.. This number is expected to keep rising in the next few years.

Ethanol can be mixed with diesel as a fuel for trucks and buses that usually run on diesel. It can also be used instead of leaded gasoline in small planes. In addition, ethanol is being tested as a fuel to produce hydrogen for fuel cell vehicles.

Environmental Impact

Ethanol is made from crops that absorb carbon dioxide and give off oxygen. This carbon cycle maintains the balance of carbon dioxide in the atmosphere when using ethanol as a fuel.

Future of Ethanol

Using ethanol as a fuel helps farmers by providing additional uses for their crops. Ethanol is a cleaner fuel than gasoline; it makes the air healthier to breathe. Using ethanol also means we don't have to import as much petroleum from other countries.

Additional Resources

U.S. Energy Information Administration: www.eia.gov Alternative Fuels Data Center: http://www.afdc. energy.gov/ U.S. Environmental Protection Agency: Transporta-

Student Information Worksheet Alternative Fuels - Propane: Not Just for Grilling

Propane is an energy-rich fossil fuel that is sometimes called liquefied petroleum gas (LPG). It is colorless and odorless; a smell is added to serve as a warning agent. Propane comes from petroleum refining and natural gas processing. Like all fossil fuels, it is nonrenewable.

Under normal conditions, propane is a gas. When propane is put under pressure or cooled to a lower temperature, however, it changes into a liquid and can be stored in tanks. Propane takes up 270 times less space as a liquid than it does as a gas, making it a portable fuel. (Portable means easy to move.)

Propane as a Transportation Fuel

Propane has been used as a transportation fuel for more than 80 years. It is commonly used as an alternative fuel for fleet vehicles like taxicabs, government vehicles, and school buses. Fleets are groups of vehicles that have their own fuel stations. For fleet vehicles, the cost of using propane is less than gasoline.

Propane is a good engine fuel. It is cleaner burning than gasoline. The engine stays clean, lasts longer, and doesn't need as much service. Vehicles can go as fast using propane and carry as much cargo as gasoline-powered cars.

Why is propane not used in more personal vehicles? We can find propane in most areas of the country, but it is not as convenient as gasoline. There are only 350 propane-fueling stations in the U.S. A regular car has to be modified (changed) to use propane, which can cost between \$4,000 to \$12,000.

Environmental Impacts

Propane engines produce less air pollution than gasoline. Carbon monoxide emissions from propane vehicles are 20 to 90 percent lower and hydrocarbon emissions are 40 to 80 percent lower than gasoline engines.

Future of Propane

Propane will mostly be used for fleet vehicles in the future. If you get a job at a company that has its own fleet, you may very well be driving a propane vehicle.



Additional Resources

U.S. Energy Information Administration: www.eia.gov Alternative Fuels Data Center: http://www.afdc. energy.gov/

Student Information Worksheet Alternative Fuels - CNG/LNG: A Natural for Vehicles

The natural gas we use for heating, cooking, clothes drying, and water heating can also be a cleaner burning transportation fuel when compressed (put under pressure). Natural gas vehicles burn so cleanly that they are used to carry TV cameras and reporters ahead of the runners in marathons. Natural gas is a nonrenewable fossil fuel with plentiful supplies in the United States.

CNG—Compressed Natural Gas

Natural gas is an energy-rich fossil fuel. It burns cleaner than gasoline, making it a good fuel source for the future. Natural gas is also less expensive than gasoline. To use natural gas in vehicles, it is put in tanks under pressure. Even under pressure, it only has about a third as much energy as gasoline. As a result, natural gas vehicles can't go as far; they have a smaller range. Range is the distance a vehicle can go on a tank of fuel. If more tanks are added, the vehicle gets heavy and can't go as far. It also has less space for cargo.

Some people worry about using CNG because natural gas is flammable—it can catch fire. Manufacturers make CNG tanks stronger than normal gasoline tanks. The fuel tanks are harder to damage in crashes than gasoline tanks. If a fuel line breaks, the natural gas will rise into the air. Gasoline is a liquid that will form puddles. Also, natural gas catches fire at a much higher temperature than gasoline, making it a little more difficult to catch fire.

Today, there are only about 1,000 natural gas fueling stations in the United States—much fewer than the 168,000 gasoline stations. Natural gas vehicles are good as fleet vehicles with their own fueling stations. Many businesses with CNG fleets say their vehicles last longer because the fuel is so clean burning.

Environmental Impacts

Natural gas is a cleaner-burning fossil fuel. Compressed natural gas vehicles produce fewer emissions than gasoline-powered vehicles. They are good to use in areas with air pollution problems.

CNG Vehicles Today and Tomorrow

Today, there are about 147,000 natural gas vehicles in the U.S., mostly in the South and West. About half of the vehicles are privately owned and half are owned by government agencies. Nearly 10,000 public transit buses around the country are using CNG as fuel.

LNG—Liquefied Natural Gas

There are about 3,400 vehicles in the U.S. that run on LNG—natural gas that is turned into a liquid by cooling it to -259°F. Most LNG vehicles are government-owned. There are 83 LNG-fueling stations as of 2016. The advantage of LNG is that natural gas takes up much less space as a liquid than as a gas, so the tanks can be much smaller. The disadvantage is that the fuel tanks must be kept cold, which uses more fuel.



Additional Resources

U.S. Energy Information Administration: www.eia.gov Alternative Fuels Data Center: http://www.afdc. energy.gov/ U.S. Environmental Protection Agency: Transporta-

Student Information Worksheet Alternative Fuels - Road to the Future: Hydrogen Fuel Cells

Hydrogen is the most abundant element in the universe, but it doesn't exist on Earth as a gas. We have to make it from other materials. One way is to split water molecules apart—into hydrogen and oxygen. Another is to break down molecules of natural gas, biomass, or coal. Fuel cells use hydrogen and oxygen to produce electricity without harmful emissions; water is the main by-product. Hydrogen is a gas at normal conditions, which makes it harder to move and store than liquid fuels. We have no widespread system today to move and store it.

For the 2017 model year, there were three fuel cell vehicle models available in the U.S. – the Honda Clarity, Hyundai Tucson, and Toyota Mirai. Their availability is quite limited and there were only 31 hydrogen fueling stations nationwide, mainly in California. Hydrogen fuel cells use hydrogen and oxygen to make electricity without harmful emissions; water is the main by-product. Today, it costs a lot to make hydrogen fuel, but research is underway to find better ways to produce and use it. The biggest obstacle to widespread use will be storage. The low energy content of hydrogen will require fuel tanks six times larger than gasoline tanks. Its environmental benefits, however, mean that in the future, hydrogen fuel cell vehicles may be a common sight on the roadways of America. The U.S. Department of Energy is supporting hydrogen fuel cell research because hydrogen is such a clean and abundant fuel.



Additional Resources

U.S. Energy Information Administration: www.eia.gov Alternative Fuels Data Center: http://www.afdc. energy.gov/

Transportation Fuels Student Activity Guidelines

In groups, students will learn about a specific transportation fuel and present what you have learned to your class. The focus is on fuels used primarily by cars and trucks, as well as buses.

1. Read the "Alternative Fuels Information Student Worksheet – Background" to learn some background information about transportation fuels, particularly the role of petroleum and why people are looking at alternative sources of fuel.

2. Read the "Alternative Fuels Student Information Worksheet" for the fuel your group has been assigned (e.g. gasoline, diesel, biodiesel, etc.).

3. As a group, develop a list of facts that you want to teach your class about your fuel. In addition to the Information Worksheet, you may want to consult some additional resources, either those listed on the worksheet or other resources identified by your teacher. Here is a list of questions to help you gather information:

- a. Is your fuel renewable or nonrenewable?
- b. How is your fuel made?
- c. Is your fuel available in your area? (Hint: consider looking at the Department of Energy's Alternative Fuel Station Locator at: http://energy.gov/maps/alternative-fueling-station-locator.)
- d. What types of vehicles can use your fuel? (Check out www.fueleconomy.gov for information about what cars used alternative fuels)
- e. What are the costs associated with your fuel?
- f. What are the environmental advantages and disadvantages of your fuel?
- g. What are the challenges to developing a widespread market for your fuel?
- h. Would you buy a vehicle that uses your fuel? Why or why not?

4. Prepare a poster with information about your fuel. Your teacher will provide additional information about the size and specific contents for your poster. Write them down here:

5. Prepare a short oral presentation for your class about your fuel. Your teacher will provide additional information about the size and specific contents for your presentation. Write them down here:



Lesson Plan 4: Our Class Transportation Carbon Footprint⁴

Description

Students will learn to measure, analyze, and interpret transportation data. They will better understand the impact of their transportation choices on CO₂ emission levels. The term "CO₂ footprint" is introduced and students will consider how to reduce their CO₂ footprint with regard to getting to and from school.

Lesson Time

- 30 45 minutes to calculate and collect all the data
- 20 30 minutes to answer general questions and discuss results

Learning Outcomes

At the completion of this lesson, students will be able to:

- Measure the CO₂ emissions produced by a classroom of students getting to and from school;
- Analyze their personal as well as their class' contribution to CO₂ emissions;
- Brainstorm ways to reduce their CO₂ footprint, both as individuals and as a class.

Materials

- Transportation Carbon Footprint Student
 Worksheet (one per student)
- School population data (how many students attend your school)
- Transportation Carbon Footprint Summary Table.
- Transportation Carbon Footprint General Questions Handout

Instructional Activity

- Lead a discussion using the "Introduction" to this lesson. You may find it useful to review additional online sources such as "Greenhouse Gas Emissions" from the U.S. Environmental Protection Agency at https://www.epa.gov/ghgemissions.
- 2. Have each student complete the Transportation Carbon Footprint Student Worksheet. You may want to ask students to complete steps 1 and 2 of the assignment worksheet in advance. All students will answer the first three questions. Then, depending on how the student travels to/from school, the student will follow the set of questions from Sections A-D, accordingly.
- Summarize each student's estimate of the individual lbs CO₂ emitted per person per year in the "Transportation Carbon Footprint Summary" sheet (this sheet could be written on the board, or presented using an overhead project, or other display means depending on your classroom).

- 4. Use the "Transportation Carbon Footprint General Questions" to lead a discussion with your students about their transportation carbon footprint. The questions can be modified to accommodate specific circumstances in your school/classroom.
- 5. Additional Information: if a student travels to school using one mode (e.g. carpool), and then back home using a different mode (e.g. bus), it will be necessary to slightly modify the approach used to calculate the carbon footprint. For example, instead of starting with roundtrip distance, start with one-way distance and then follow the steps in each relevant section to calculate the one-way carbon footprint and then add the two results together. This can also be a great add-on activity for the students requiring quantitative problem solving if you provide some example scenarios. You can even consider adding in extra trips such as a detour to an after-school activity, etc.

4 This lesson is adapted from the Class Transportation Survey developed for the Cool School Challenge sponsored by the National Wildlife Federation. More information can be found at: http://www.greeneducationfoundation.org/institute/lesson-clearinghouse/503-Class-Transportation-Survey.html

Student Worksheet Transportation Carbon Footprint

Introduction

Roughly one-quarter of U.S. greenhouse gas emissions come from the transportation sector: trains, planes, boats, trucks, cars, etc.⁵ Choices made everyday about how to get to school, work, the mall, etc., directly impacts the size of your CO₂ "footprint."

Your CO₂ "footprint" is basically a measurement of how much carbon dioxide is emitted into the atmosphere as a result of your individuation actions. Transportation choices are just one component of a CO₂ footprint – but can often be the most significant. How big is **your** transportation footprint? And how does it compare with that of your classmates?

Through this activity you'll conduct a survey to identify the different modes of transportation you and your classmates use to get to and from school. You'll then use this information to calculate the combined impact of those choices on your CO₂ footprint.

3. How do you typically get to and from school? In the

table below, find the option which best fits your mode of

transportation and then complete the relevant section.

Assignment Steps

1. Find out the round trip distance from your home to school. You can either do this by noting the mileage while doing the journey or go to an online map program (e.g. maps.google.com) and put in the correct addresses to calculate the distance.

Round trip distance to and from school: _____ Miles

2. If you travel to and from school in a car (either alone or in a carpool), determine the average fuel economy of that vehicle in miles per gallon by checking www. fueleconomy.gov. (Hint: use the Find a Car feature and enter the year, make, and model to get the fuel economy.) Write that information below.

Fuel economy: _____ Miles per gallon

If you get to and from school by...

Complete the following section:

Car, driving alone	Section A
Carpool – with other students from your school	Section B
Bus – public or school bus	Section C
Walk, bike or other zero-emission mode	Section D

⁵ U.S. Environmental Protection Agency, 2016. "Sources of Greenhouse Gas Emissions." Accessed October 20, 2016 from https://www.epa.gov/ghgemissions/ sources-greenhouse-gas-emissions.

Section A: Transportation = Car, driving alone

1. Estimate gallons of gas consumed each day getting to and from school. Show your work.

Use your answers to questions 1 and 2 in the first section of this Transportation Carbon Footprint worksheet to help you answer this question.

Answer: _____ gallons of fuel consumed

 Calculate the CO₂ emissions of your commute. Each gallon of gasoline burned emits 20 lbs of CO₂. Use your answer from #1 above to help you answer this question. Show your work.

Answer: _____ lbs CO₂ emitted getting to and from school

3. Estimate your annual CO₂ emissions from getting to and from school. Assume 180 school days and use your answer from #2 above to help you. Show your work.

Answer: _____ lbs CO₂ emitted getting to and from school

4. Estimate your CO₂ footprint of your school from transportation. What if every student at your school produced the same amount of CO₂ as you, just by getting to and from school? What would your school's CO₂ footprint from transportation be? Multiply your answer from #3 by the number of students at your school. Show your work.

Answer: ______ lbs CO₂ generated per year

Section B: Transportation = Carpool

1. Estimate gallons of gas consumed each day getting to and from school. Show your work.

Use your answers to questions 1 and 2 in the first section of this Transportation Carbon Footprint worksheet to help you answer this question.

Answer: _____ gallons of fuel consumed

2. Calculate the CO₂ emissions of your commute. Each gallon of gasoline burned emits 20 lbs of CO₂. Show your work.

Answer: _____ lbs CO₂ emitted getting to and from school

3. Calculate your individual impact. How many people shared your ride? Divide your total from #2 by the number of people in your carpool (include yourself!) to calculate the individual CO₂ emissions of each person in the carpool. Only include students from your school in your carpool calculation. Do not include others (e.g. driver, siblings at other schools, etc.)

Answer: _____ lbs CO₂ emitted per person

4. Estimate your annual CO₂ emissions from getting to and from school. Multiply your total from #3 above by 180 school days. Show your work.

Answer: ______ lbs CO₂ generated per year

5. Estimate your CO₂ footprint of your school from transportation. What if every student at your school produced the same amount of CO₂ as you, just by getting to and from school? What would your school's CO₂ footprint from transportation be? Multiply your answer from #4 by the number of students at your school. Show your work.

Section C:

Transportation = Bus (public or school bus)

1. Estimate the amount of fuel used by the bus. Buses get about 5 miles per gallon of diesel. Calculate the gallons of diesel used by the bus. Show your work.

Use your answers to questions 1 and 2 in the first section of this Transportation Carbon Footprint worksheet to help you answer this question.

Answer: _____ gallons of fuel consumed

2. Calculate the CO₂ emissions of your commute. Each gallon of diesel burned emits 22 lbs of CO₂. Calculate the amount of CO₂ generated by the bus for each round trip journey. Show your work.

Answer: _____ lbs CO₂ emitted getting to and from school

3. Calculate the CO₂ emissions per passenger. How many people shared your ride? Estimate the number of students who rode the bus with you today. Then calculate the CO₂ lbs emitted per passenger on the bus. Show your work.

Answer: _____ Ibs CO₂ emitted per person

4. Estimate your annual CO₂ emissions from getting to and from school. Multiply your total from #3 above by 180 school days. Show your work.

Answer: _____ lbs CO₂ emmitted per person per year

5. Estimate your CO₂ footprint of your school from transportation. What if every student at your school produced the same amount of CO₂ as you, just by getting to and from school? What would your school's CO₂ footprint from transportation be? Multiply your answer from #4 by the number of students at your school. Show your work.

Answer: ______ lbs CO₂ emitted per year by the whole school

Section D: Transportation = Walk, bike, skateboard, or other emission-free mode of transport

Your CO₂ footprint equals zero!

If everyone in your school traveled as you did today, this part of the CO₂ school footprint would be zero!



Transportation Carbon Footprint Data Summary Table

Record each student's data in the table below and add up the CO₂ emissions for the entire class.

Student	Pounds of CO ₂ per year	Mode

Transportation Carbon Footprint Data Summary Table (continued)

Student	Pounds of CO ₂ per year	Mode
Total for the Class:		

Class Transportation Survey General Questions

- 1. What is the most common way students in your class get to and from school? Why do you think this is the case?
- 2. Which mode of transportation generates the most CO₂ per person in your class?
- 3. How many students generated "zero" pounds of CO₂ from their commutes?
- 4. Looking at the Transportation Carbon Footprint Data Summary Table, how many students in your class ride the bus to and from school?
- 5. What might be some ways to increase bus ridership?
- 6. Looking at the Transportation Carbon Footprint Data Summary Table, how many students in your class walk or bike to and from school?
- 7. What might be some ways to increase walking and biking to school?
- 8. If you do not currently walk or bike to school, would you consider either of these options as possible for you? Why or why not?
- 9. Looking at the Transportation Carbon Footprint Data Summary Table, how many students in your class carpool to and from school?
- 10. What might be some ways to increase carpooling to school?
- 11. How might your class decrease its transportation CO₂ footprint?

Lesson Plan 5: **Pretzel Power – Exploring Fuel Efficiency**⁶

Description

In this lesson, students will learn about the energy efficiency of different kinds of vehicles and the benefits of carpooling.

Lesson Time

• One class period

Learning Outcomes

At the completion of this lesson, students will be able to:

- Compare fuel efficiency across different vehicles;
- Calculate how much gas is needed to travel a specific distance depending on fuel efficiency.

Materials

- 3" x 5" index cards
- Internet access for students
- Bag of pretzels
- Plastic sandwich bags
- Three signs (Home, Near Town, Far Town)
- Automobile Cards

Instructional Activity

Prepare the following:

- Prepare a plastic bag with 10 pretzels for each student.
- Print the signs: "Home," "Near Town," and "Far Town." The signs should be large enough to see from across the room.
- Select a large area and place the Home, Near Town, and Far Town signs on poles or walls. The distance from Home to Near Town should be approximately 50 student steps. The distance to Far Town should be approximately 100 student steps. (Do not give these distances to students.)

For the activity, first have students look up a car they would like to drive on www.fueleconomy.gov. On 3" x 5" cards, students should record the car's name, model year, and combined miles per gallon. If available, also note the number of passengers or obtain that information from the manufacturer's website. Alternatively, students can use the pre-made automobile cards in this curriculum guide – print, cut, and tape or paste to the index cards.

Next, distribute the bags of pretzels to each student. Tell students not to eat the pretzels until they are told to. Explain to the students that each pretzel represents one gallon of gasoline, and each step (heel-to-toe) the student takes represents one mile traveled. Students should next calculate how many steps then can take for each gallon of gasoline (i.e. pretzel) consumed. For example, a 2012 Audi A3 (see pre-made automobile cards) has a combined MPG of 34. Therefore each pretzel would allow the student to take 34 steps.

The activity takes place in two rounds.

Round One

Use only 5 pretzels (maximum) for this round. Each student will use their car's combined MPG and attempt to travel from "Home" to "Near Town" and back. If anyone runs out of fuel (i.e. pretzels), he/she must stay at that point until Round One is over. Line up at "Home" and start stepping!

Discuss with the students:

- Which cars got you to work and home? Which didn't?
- Did anyone have extra fuel remaining?
- What alternatives to driving your own car are there?

(Continued on next page)

⁶ This lesson is adapted from the Elementary Transportation Fuels Infobook developed by the National Energy Education Development Project. The complete resource can be found at: http://www.need.org/files/curriculum/guides/ElementaryTransportationFuelsInfobook.pdf

Instructional Activity (cont'd)

Round Two

Using the remaining five pretzels, have students travel from "Home" to "Far Town" using the same basic instructions as for Round One (i.e. each pretzel is one gallon of gas and the combined MPG is how many steps the student can take for each pretzel). But in this round, allow the students to negotiate and combine pretzels for fuel. Just remember to take into consideration the number of passengers the vehicle can accommodate – a compact car can't carry as many people as a van, for example. Discuss with the students:

- Who made it to "Far Town" and back? How did you do this?
- Who did not make it to "Far Town" and back? Why not?

Lesson 5: Pretzel Power - Explore Fuel Efficiency Automobile Cards

1			
2012 Audi A3		2012 Bentley Contine	ental GT
FIIFI	Diesel	FUE	Flav Fuel F85
CLASS	Small Station Wagon		Compact
NUMBER OF PASSENGERS	5	NUMBER OF PASSENGERS	4
	34	COMBINED MPG	10
			10
2012 BMW Gran Turi	smo	2012 Bugatti Vevron	
FUEL	Gas	FUEL	Gas
CLASS	Large	CLASS	Two-Seater
NUMBER OF PASSENGERS	5	NUMBER OF PASSENGERS	2
COMBINED MPG	18	COMBINED MPG	10
(
2012 Buick LaCrosse	eAssist	2012 Buick Verano	
FUEL	Hybrid Electric	FUEL	Gas
CLASS	Midsize	CLASS	
		CLASS	Compact
NUMBER OF PASSENGERS	5	NUMBER OF PASSENGERS	Compact 5
NUMBER OF PASSENGERS COMBINED MPG	5 29	NUMBER OF PASSENGERS	Compact 5 25
NUMBER OF PASSENGERS COMBINED MPG	5 29	NUMBER OF PASSENGERS COMBINED MPG	Compact 5 25
NUMBER OF PASSENGERS COMBINED MPG	5 29	NUMBER OF PASSENGERS COMBINED MPG	Compact 5 25
NUMBER OF PASSENGERS COMBINED MPG	5 29	NUMBER OF PASSENGERS COMBINED MPG	Compact 5 25
NUMBER OF PASSENGERS COMBINED MPG	5 29 de FSV	CLASS NUMBER OF PASSENGERS COMBINED MPG	Compact 5 25
NUMBER OF PASSENGERS COMBINED MPG 2012 Cadillac Escala	5 29 de ESV	2012 Chevrolet Cama	Compact 5 25
NUMBER OF PASSENGERS COMBINED MPG 2012 Cadillac Escala FUEL	5 29 de ESV Flex Fuel E85	CLASS NUMBER OF PASSENGERS COMBINED MPG 2012 Chevrolet Cama FUEL	Compact 5 25 Aro Gas
NUMBER OF PASSENGERS COMBINED MPG 2012 Cadillac Escala FUEL CLASS	5 29 de ESV Flex Fuel E85 SUV	CLASS NUMBER OF PASSENGERS COMBINED MPG 2012 Chevrolet Cama FUEL CLASS	Compact 5 25 Aro Gas Compact
NUMBER OF PASSENGERS COMBINED MPG 2012 Cadillac Escala FUEL CLASS NUMBER OF PASSENGERS	5 29 de ESV Flex Fuel E85 SUV 8	CLASS NUMBER OF PASSENGERS COMBINED MPG 2012 Chevrolet Cama FUEL CLASS NUMBER OF PASSENGERS	Compact 5 25 Aro Gas Compact 4
NUMBER OF PASSENGERS COMBINED MPG 2012 Cadillac Escala FUEL CLASS NUMBER OF PASSENGERS COMBINED MPG	5 29 de ESV Flex Fuel E85 SUV 8 12	CLASS NUMBER OF PASSENGERS COMBINED MPG 2012 Chevrolet Cama FUEL CLASS NUMBER OF PASSENGERS COMBINED MPG	Compact 5 25 Aro Gas Compact 4 22

2012 Mazda 5 FUEL Gas CLASS Minivan NUMBER OF PASSENGERS 6 COMBINED MPG 24	2012 Nissan LeafFUELElectric (Dedicated)CLASSMidsizeNUMBER OF PASSENGERS5COMBINED MPG99MPGe
2012 Smart Fortwo CoupeFUELGasCLASSTwo-SeaterNUMBER OF PASSENGERS2COMBINED MPG36	2012 Toyota Camry FUEL Gas CLASS Midsize NUMBER OF PASSENGERS 5 COMBINED MPG 28
2012 Toyota Highlander HybridFUELHybrid ElectricCLASSSUVNUMBER OF PASSENGERS7COMBINED MPG28	2012 Toyota PriusFUELHybrid ElectricCLASSMidsizeNUMBER OF PASSENGERS5COMBINED MPG50
2012 Volkswagen Passat FUEL Diesel CLASS Midsize NUMBER OF PASSENGERS 5 COMBINED MPG 34	2012 Volkswagen Touareg FUEL Diesel CLASS SUV NUMBER OF PASSENGERS 5 COMBINED MPG 22

2012 Honda Civic NGVFUELNatural Gas (Dedicated)CLASSCompactNUMBER OF PASSENGERS5COMBINED MPG31	2012 Honda InsightFUELHybrid ElectricCLASSCompactNUMBER OF PASSENGERS5COMBINED MPG42
2012 Jeep Grand CherokeeFUELFlex Fuel E85CLASSSUVNUMBER OF PASSENGERS5COMBINED MPG14	2012 Kia Optima HybridFUELHybrid ElectricCLASSMidsizeNUMBER OF PASSENGERS5COMBINED MPG37
2012 Lexus LS 460 FUEL Gas CLASS Midsize NUMBER OF PASSENGERS 5 COMBINED MPG 19	2012 Lexus RX 450H FUEL Gas CLASS SUV NUMBER OF PASSENGERS 5 COMBINED MPG 30
2012 Lincoln Navigator FUEL Gas CLASS SUV NUMBER OF PASSENGERS 7 COMBINED MPG 16	2012 Maybach 57 FUEL Gas CLASS Large NUMBER OF PASSENGERS 4 COMBINED MPG 12

2012 Ford E350 Wago	on	2012 Ford Escape Hyb	Drid
FUEL	Gas	FUEL	Hybrid Electric
CLASS	Passenger Van	CLASS	SUV
NUMBER OF PASSENGERS	11	NUMBER OF PASSENGERS	5
COMBINED MPG	11	COMBINED MPG	32
2012 Ford F150 FUEL CLASS NUMBER OF PASSENGERS COMBINED MPG	Gas Pickup Truck 3 17	2012 Ford Fiesta FUEL CLASS NUMBER OF PASSENGERS COMBINED MPG	Gas SubCompact 5 33
2012 Ford Focus EV FUEL CLASS NUMBER OF PASSENGERS COMBINED MPG	Electric (Dedicated) Compact 5 105 MPGGE	2012 Ford Fusion FFV FUEL CLASS NUMBER OF PASSENGERS COMBINED MPG	Flex Fuel E85 Midsize 5 16
2012 GMC Sierra 15 H	Hybrid	2012 Honda Civic Hyb	brid
FUEL	Hybrid Electric	FUEL	Hybrid Electric
CLASS	Pickup Truck	CLASS	Compact
NUMBER OF PASSENGERS	6	NUMBER OF PASSENGERS	5
COMBINED MPG	21	COMBINED MPG	44

Lesson Plan 6: Moving Beyond the Automobile – Film Guides⁷

Description

In this lesson, students will watch a series of short videos produced by Streetfilms.org and engage in a class discussion about different forms of transportation.

Lesson Time

• One class period

Learning Outcomes

At the completion of this lesson, students will be able to:

• Identify the benefits and drawbacks of three forms of transportation alternatives.

Materials

- Internet access to watch the following short (3-4 min) films by Streefilms.org
 - Bus Rapid Transit: http://www.streetfilms.org/ mba-bus-rapid-transit/
 - Bicycling: http://www.streetfilms.org/mbabicycling/
 - Car Sharing: http://www.streetfilms.org/mbacar-sharing

Instructional Activity

Arrange to view each of the three films and then facilitate a discussion with students using the questions posed below. The films are short (3-4 minutes each). This could be assigned as homework if students have internet access available outside of school, or could be viewed during class.

Each of the forms of transportation illustrated in these 3 films (bus rapid transit, cycling, and carsharing) have potential as an alternative to a privately-owned vehicle used by an individual or family. These are also considerably more sustainable ways of getting around. Each has different benefits and drawbacks, which after watching all three, could be discussed as a class.

Bus Rapid Transit (BRT)

Synopsis: BRT provides faster, more reliable bus service, and has the potential to meet more remote locations in a city. Exclusive lanes for bus-only use, special waiting stations up on a platform with advance payment, and buses are given priority at intersections.

- What are the critical components that distinguish Bus Rapid Transit (BRT) from regular bus service?
- Where are the best Bus Rapid Transit Systems in the world?
- What are the benefits of Bus Rapid Transit?
- How is BRT less expensive than building other forms of public transit, like a subway, for example?
- Why is it important to improve bus ridership?

- What are some of the problems with buses in your community?
- What changes do you think would make bus riding more popular? Would BRT be a good option?

Carsharing

Synopsis: Carsharing reduces the number of car trips an individual takes, and allows people to avoid buying a car. It also encourages transit ridership, walking, and biking, except at times when a car is necessary.

- What are the personal benefits of carsharing or ridesharing?
- What are the shared benefits of carsharing or ridesharing?
- How has carsharing been incorporated into public transportation systems?
- How do cities support car sharing?

Concluding Questions

- How does each of these films convey a sustainable way of getting around our cities and towns?
- Do you think one of these choices would work better for your community than others? Which one and why?
- Could these methods of getting around be used in conjunction with each other? For example, do you think people would bike to a BRT station?

⁷ This lesson is adapted from a curriculum guide developed by Streetfilms.org as part of their "Moving Beyond the Curriculum" program. The complete program, including links to all films is available at: http://www.streetfilms.org/moving-beyond-the-automobile/curriculum/

Lesson Plan 7: How Walkable is Your Community⁸

Description

This lesson will help students learn about how safe and comfortable it is to walk in their community. Students will conduct a simple walkability assessment, using a tool very similar to what professionals use to conduct a similar type of assessment.

Learning Outcomes

At the completion of this lesson, students will be able to:

- Conduct a simple walkability assessment and evaluate the outcomes;
- Describe what conditions make an area more or less walkable:
- Identify the benefits of walking;
- Identify the factors that impede walking.

Lesson Time

- One class period, plus homework
- Optional: One class period guest speaker

Materials

- How Walkable Is Your Community? Student Worksheet/ Checklist
- Table to Facilitate Classroom Discussion (for teacher)

Instructional Activity

First, provide an overview of why being able to comfortably and conveniently walk places is important. Engage your students in a brief discussion.

- What are some of the benefits of walking?
 - Improved fitness
 - Cleaner air
 - Reduced risks of certain health problems
 - Greater sense of community (when you get out a walk, you run into neighbors and can develop good relations with your community)
- What factors can make it difficult to walk places?
 - Lack of sidewalks
 - Busy traffic streets / hard to cross from one side of the street to the other
 - No amenities (e.g. shade, interesting places to walk to)

Students should identify a place to walk. This could be the route to school, a friend's house, or just somewhere fun to go. Each student can pick a different place for their walk. Review the How Walkable Is Your Community Checklist with the students and explain how they will complete it after their walk. For example, with each question, there is both a rating scale (1 to 5) as well as details regarding some of the potential problems they may encounter on their way. You can also encourage students to complete the walk with a parent or other adult guardian.

After students complete their walkability assessment, lead a classroom discussion about their experience. Encourage students not only to describe some of the problems they encountered, but also some ideas for how they could address the problems. Some ideas are presented below (several are actions the students could take in partnership with their parents or other adults).

Table to Facilitate Classroom Discussion

Ch	ecklist Question	What can you do now	What you and your community can do with more time
1.	Did you have room to walk?	 Pick another route for now. Tell your local traffic engineering or public works department about specific problems and provide a copy of the checklist 	 Speak up at community meetings or your local planning commission meeting. Write or petition city for walkways and gather neighborhood signatures Make media aware of the problem(s) Work with a local transportation engineer to develop a plan for a safe walking route
2.	Was it easy to cross streets?	 Pick another route for now. Share problems and checklist with local traffic engineering or public works department Trim your trees or bushes that block the street and ask your neighbors to do the same Leave nice notes on problem cars asking owners not to park there 	 Push for crosswalks/signals/parking changes/curb ramps at city meetings Report to traffic engineer where parked cars are safety hazards Report illegally parked cars to the police Request that the public works department trim trees or plants Make media aware of the problem(s)
3.	Did drivers be- have well?	 Pick another route for now. Set an example: ask your parents/adult drivers to slow down and be considerate of others Encourage your neighbors to do the same Report unsafe driving to the police 	 Petition for more enforcement Request protected turns Ask city planners and traffic engineers for traffic calming ideas Ask schools about getting crossing guards at key locations Organize a neighborhood speed watch program
4.	Was it easy to follow safety rules?	 Educate yourself about safe walking Organize families in your neighborhood to walk together to school 	 Encourage schools to teach walking safety Help schools start safe walking programs Encourage corporate support for flexible schedules so parents/adults can walk children to school
5.	Was your walk pleasant?	 Pick another route for now Ask neighbors to keep dogs leashed or fenced Report scary dogs to the animal control department Report scary people to the police Report lighting needs to the police or appropriate public works department Take a walk with a trash bag Plant trees, flowers in your yard 	 Request increased police enforcement Start a crime watch program in your neighborhood Organize a community clean-up day Sponsor a neighborhood beautification or tree-planting day Begin an adopt-a-street program Initiate support to provide routes with less traffic to schools in your community

As an optional activity, contact your local planning agency (this is usually a city agency, but could be a county agency) and ask if one of their staff planners could come visit your classroom. Ideally, a person who focuses on pedestrian planning would be a great person to have visit. Another option would be to check if your local area has a Safe Routes to School program.

Student Worksheet/Checklist How Walkable Is Your Community?

Location of walk:

Rating Scale:

🗆 Yes 🗖 No

🗆 Yes 🗖 No

🗆 Yes 🗖 No

Yes No

Rating (circle one)

1 2 3 4 5 6

1. Did you have room to walk? Yes Some problems: Sidewalks or paths started and stopped Sidewalks were broken or cracked Sidewalks were blocked with poles, signs, shrubbery, dumpsters, etc. No sidewalks, paths, or shoulders Too much traffic Something else

Rating (circle one) **1 2 3 4 5 6** Locations of problems:

2. Was it easy to cross streets?

Yes Some problems:

- 🔲 Road was too wide
 - Traffic signals made us wait too long or did not give us enough time to cross
 - Needed striped crosswalks or traffic signals
 - Parked cars blocked our view of traffic
 - □ Trees or plants blocked our view of traffic

Locations of problems:

 Needed curb ramps or ramps needed repair
 Something else ______

Rating (circle one)

1 2 3 4 5 6

Yes

3. Did drivers behave well

Some problems: Drivers...Backed out of the driveways

- without looking
 - Did not yield to people crossing the street
 - □ Turned into people crossing the street
 - Drove too fast
 - □ Sped up to make it through traffic lights or drove through traffic lights?
 - □ Something else _____

Rating (circle one) 1 2 3 4 5 6 Locations of problems:

5. Was your walk pleasant?

🗌 Yes	Some problems:	
	Needed more grass, flowers, or trees	
	Scary dogs	
	Scary people	
	Not well lighted	
	Dirty, lots of litter or trash	
	Dirty air due to automobile exhaust	
	Something else	
Rating	(circle one) Locations of problems:	
12	3 4 5 6	

4. How about safety? Could you and your child...

and be seen by drivers?

before crossing streets?

Cross at crosswalks or where you could see

Stop and look left, right and then left again

Walk on sidewalks or shoulders facing

traffic where there were no sidewalks?

Locations of problems:

Cross with the light?

How does your neighborhood stack up?

Add up your ratings and decide

1. <u> </u>	26-30	Celebrate! You have a great neighborhood for walking.
3	21-25	Celebrate a little. Your neighborhood is pretty good.
4	16-20	Okay, but it needs work.
5 Total:	11-15	It needs lots of work. You deserve better than that.
	5-10	It's a disaster for walking!

Name:

Lesson Plan 8: Transportation Jobs and Professions

Description

This lesson will help the students learn about careers and professions in transportation.

Learning Outcomes

At the completion of this lesson, students will be able to:

• List and define transportation careers by their work tasks, educational requirements, rewards, challenges, and drawbacks.

Lesson Time

• One class period with homework

Materials

• Career Matrix Handout

Instructional Activity

Begin class with a discussion that contributes to student understanding of transportation career possibilities.

Ask students: What is a career? (Definition: An occupation or profession requiring special transportation. If often becomes a person's life's work.)

Ask students: What are your parents' careers? (Respond to student answers by connecting some of their parents' professions with transportation. Almost all careers face transportation issues related to their work – for example, firefighters drive large fire trucks though traffic to save lives, nurses travel to and from hospitals at all hours of the day.)

Briefly review with students the transportation career possibilities from these websites (and there are many other online sources with information about career options as well):

- http://www.careeroverview.com/ transportation-careers.html
- http://study.com/article_directory/q_p/page/ Transportation%20and%20Distribution/q_p/ Careers_and_Occupations_List.html
- http://learningpath.org/article_directory/sh/page/ Distribution,%20Transportation,%20and%20Materials%20 Moving/sh/Job_Titles_and_Careers_List.html
- http://www.owlguru.com/career/list/transportation/

Direct students to complete the Career Matrix Handout. This can be done in class, as homework, by individual students, or in small groups. Students will research transportation careers and professions from the websites above (or other websites that you identify or ask the students to research) and learn about the work tasks, educational requirements, rewards, challenges, and drawbacks of that career.

Research three transportation care requirements, reward, challenge, a	eers from the following websites, or and drawback of that career.	r other resources as directed by you	ur teacher. For each career, write as	least one work task, educational
Transportation Center	Work Tasks	Educational	Rewards	Challenges
		Requirement		
Highway engineer	Plans highways and other roads	College degree with specialty in engineering.	Helps traffic move. Helps people get from one place to another. Can see things they've planner.	Must be exact with math and science. Mistakes can cause problems for many people.
Airline pilot	Controls and flies airplane	Extensive, specialized, technical flight school training and Federal Aviation Administration (FAA) licensing.	Provides important service. Good salaries.	Responsible for people's lives.
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43 | Sustainable Transportation in the 21st Century

Career Matrix Handout

Lesson Plan 9: Understanding Sustainable Transportation

Description

In this lesson, students will be introduced to the definition of sustainable transportation. They will think critically about the main choices, benefits, and costs associated with sustainable transportation.

Learning Outcomes

At the completion of this lesson, students will be able to:

- Analyze, compare, and contrast the various options and characteristics of sustainable transportation;
- Understand the definition of sustainable transportation.

Lesson Time

• One class period

Materials

• Understanding Sustainable Transportation Student Worksheet

Instructional Activity

Students should complete the two tables on the "Understanding Sustainable Transportation Student Worksheet." Sample tables have been completed and are shown below. Answer can vary, but the intent is that students are able to explain their responses within the context of sustainable transportation. Encourage students to think creatively and critically. For the table on assessing sustainable transportation options, ask students to specific both a mode and energy source and to think beyond systems they may be familiar with. Encourage them to think of new transportation configurations.

Example Table for Teachers: Characteristics of Sustainable Transportation

Characteristic	Why is it Desirable?
1. Fast	So people will want to use it and it can be used for many purposes, such as emergencies or going to school or work.
2. Convenient	So people will be able to go when and where they want. Mass transit should be convenient to homes and businesses so people can get to where they want to go without having to walk long distances.
3. Efficient	So it doesn't use too much fuel, or maybe uses renewable fuel sources. This could also mean that the system is faster than driving a car in traffic.
4. Non-polluting and cares for the Earth	So we can have clean air to breathe and don't leave future generations with pollution, messy clean- ups, or disposal problems.
5. Fair / affordable	So people who need transportation will have access to it, and many people can afford to get where they need to go.
6. Safe for people and animals	So people and employees don't get hurt using or working around the system or the fuel required to operate it. If it is a mass transit or high-speed system, it must have fences to barriers so animals and people don't get hurt or killed by the system.

Example Table for Teachers Assessing Sustainable Transportation

Mode	Positive Attributes	Negative Attributes
1. Mass transit underground system that runs only on renewable energy	Non-polluting fuel source; many people can ride; limited interaction with animals and people (non-riders) to limit accidents	Transit isn't typically as fast or convenient as private automobile; expensive to dig the tunnels; doesn't provide emergency transportation;
2. Mass transit system that runs on a combination of renew- able energy and fossil fuels	Technology already exists; many people can ride; could be less expensive to build that other systems; running on both renewable and fossil fuels reduces dependence on fossil fuels and can reduce pollution	Transit isn't typically as fast or convenient as private automobile; still relies on fossil fuel; doesn't provide emergency transportation
3. Commuter air planes	Fast; no traffic jams; technology already exists	Very expensive; uses a lot of fossil fuel; lim- ited number of airports (and many aren't big enough to support this)
4. Express electric overhead tram system	Depending on source of electricity, could be non-polluting; doesn't contribute to traffic jams; many people could ride	Expensive to build; could be visually unattractive with overhead systems all over the place

Student Worksheet Understanding Sustainable Transportation

By now you already know a lot about transportation. If somebody asked you what sustainable transportation was, you'd probably have quite a bit to say. You could tell them about the different fuels available and explain the various social, economic, and environmental costs associated with them. You could also talk about why transportation must be convenient and fast so people will use it. You could explain benefits and drawbacks of mass transportation. How much the transportation costs and whether it can be made available to all are other issues that you might discussion with someone who asked you about transportation.

But it someone asked you for a definition of sustainable transportation, you might have a bit of trouble. People who work on many issues related to sustainability have developed the following definition: "meeting the needs of the present without compromising the ability of future generations to meet their own needs."

When you think about it, this definition includes many possibilities related to transportation. What might those be? Sustainable transportation can include using mass transit, like buses, trains, light rail, and carpools. It could also be about using fuel efficiently. If can be about how employers address transportation issues by allowing employees to telecommute, have staggered shifts, or work longer hours so they don't have to make so many trips to work or drive during rush hours. All of these concepts, and many others, are part of sustainable transportation.

Characteristics of Sustainable Transportation

Complete the table below to identify and explain six desirable characteristics of sustainable transportation.

Characteristic	Why Is it Desirable?
1.	
2	
2.	
3.	
4.	
5	
6.	

Assessing Sustainable Transportation Modes

List four sustainable transportation modes and several positive and negative attributes for each.

Mode	Positive Attributes	Negative Attributes
1.		
2.		
3.		
4.		

The Competition

The Competition

It is not necessary to create a project based exclusively on the material in this workbook. These exercises simply provide insight into transportation, energy sources, environmental effects, career choices, etc. Your project should incorporate any aspect of sustainable transportation and you are encouraged to be as creative as you like – just make sure you can defend the feasibility of your project.

The Project

Your project could be based on a vehicle and/or a system of transportation or an idea for solving part(s) of the sustainable transportation problem. Below are some suggestions:

- **Project.** Develop your own transportation system or mode. This can be a new car, a better bus, or a transportation plan for an entire city or one just for friends. In the past, many teams have created vehicles that use solar or wind power. We encourage you to be creative and come up with something new. Imagination counts!
- Legislation. If you were mayor, governor, or president, what laws do you think would help make better transportation systems? Develop some local, state, or federal legislation that will promote sustainable transportation and explain why it will be beneficial. What problems still remain to be solved?
- **Research Study.** Document current sustainable transportation practices in your community. The project can include any transportation mode, method, or anything that encourages sustainable transportation where you live. Are those practices successful? How can they be improved? What problems are still not being addressed? What particularly groups of people are not being served? How would you serve them better?

The Presentation

Each school will identify one team of students (maximum 5 students) to present their project to a panel of judges during a video conference presentation. Often teams use PowerPoint slides as part of their presentation (no more than 10 slides), but you can also include a short video (no longer than 2 minutes), a model, or other display. Just make sure that the

materials you use in your presentation can be clearly visible on a video conference screen. **The presentation must be no more than 8-10 minutes.**

Details regarding the specific time, location, and other logistics related to the video conference will be provided separately.

Judging Criteria

The competition will have three impartial judges who will have no personal interest in the outcome. They will award a maximum of 130 (plus extra credit during the Q&A) based on several criteria, including:

- Does the project clearly solve part of the sustainable transportation problem?
- Is the presentation clearly done / do the students speak clearly and knowledgeably?
- Do the students ask and answer questions clearly?
- Does the team work well together and are them prepared?

Here are some hints as you prepare for your presentation:

- Judges like presentations that are enthusiastic and clear.
- Practice several times! Judges can tell when you haven't practiced.
- Have other students challenge your idea so you can learn how to defend it.
- Speak clearly and slowly. The judges want to hear you.
- Have fun! Everyone is really interested in your project.

Extra Credit

During the video conference, your team will receive extra points for asking questions of the other competing teams and answering questions you receive from the other teams. You will also be able to ask questions of the Secretary of Transportation and other transportation leaders if they have time. Here is a form that you can use to help you prepare your questions. Bring several copies to the video conference. As each team makes their presentation, write down the questions you want to ask. You may want to have a few questions prepared in advance for the Secretary of Transportation and other transportation leaders.

Question for which team?			
What is your question?			

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