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Transportation and the Environment: Energy, Fuels and Emissions

Summary

Looking at transportation and the environment, students learn that some human-made creations, such as vehicles, can harm the natural environment. They also learn about alternative fuels and vehicles designed by engineers to minimize pollution.

Learning Objectives

After this lesson, students should be able to:

- Explain that cars are a major contributor to air pollution.
- Understand that alternative forms of transportation and new types of cars can produce fewer harmful emissions.
- Explain that environmental engineers focus on keeping air and water clean for humans and to protect the environment.
- Name two renewable energy sources.

Learning Overview

Teachers: Use the powerpoint presentation provided digitally and worksheets enclosed in the lesson in a box to complete this lesson with your students.

What are the different kinds of transportation? (List other forms of transportation on the board: cars, trains, bicycles, motorcycles, boats, etc.)

What are the ways that these vehicles can be powered?

Right now, the emissions from regular automobiles are one of the main sources of pollution, emitting 4 of the top 6 pollutants, as identified by the U.S. Environmental Protection Agency (EPA). Pollution from cars contributes to the formation of smog — a sometimes severe problem in many big cities.

However, engineers have designed different kinds of vehicles which produce fewer harmful emissions.

As a class, let's discuss these new types of motorized vehicles that are known for being *"green."*

These vehicles include **hybrids, electric vehicles, low emission vehicles, vehicles that run on biodiesel**.

Why do you think it's important to reduce emissions from cars? And, why is it important to save the environment? Saving the environment is crucial for long term human and environmental health.

Can anyone think of some things that we can do that will help save our environment and help keep it clean?

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One way that we can help preserve the environment is to use renewable energy sources.

Oil is a limited resource which is burned for energy and is not renewable. Can anyone think of renewable sources of energy that are better for the environment than oil?

Activity/Discussion

How many cars do you have in your family? Let's tally up the total number of cars for the entire class.

Knowing how many cars there are total from this class, we are going to estimate how many cars are driven in our county. (Note: To help the students, find population data for the local county. It may help to use the following method: if we have 30 students in the class, and 45 cars, that's about 1.5 cars per person. So, if there are 100,000 people in our county, and we multiply 100,000 by 1.5, that would be about 150,000 cars for our whole county.)

Does this sound like a reasonable number to you? Going beyond our estimation of cars in our county, it is estimated that there are 600 million cars driven worldwide.

Cars from the Future: Presenting Your Eco-Friendly Design Ideas - Students think about and design an alternate mode of travel that is more environmentally friendly than current motor vehicles.

Introduction/Motivation

Has anyone seen the movie *Back to the Future*? In the movie, the main character can travel through time and bring back knowledge from the future. That would be very cool to be able to do!

Well, today you are going to be engineers from the advanced FutureTech car company. FutureTech has invested much money in sending several teams of engineers into the future to find out what technology will be like in 20 years, so they can get a head-start on the competition. Your class represents the different teams that are about to become time-traveling engineers! You and your team of engineers will be sent forward to the year 2026 and will have to come back with a full report on what kind of technology is being used in the cars of the future. You then have to give the big bosses a presentation about what you found and sell your team's idea as the best one. For your designs, you must keep in mind the following constraints:

i. Must have at least 5 features
ii. Three features to decrease pollution/increase efficiency
iii. Two features to improve the appearance

Whichever team persuades the CEOs that their car findings are best will win a place in history!

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Engineers are working to make fantastic new cars that produce fewer emissions than older cars. This is important, because most cars give off pollutants that harm people, animals and even plants and buildings. Today you will get to experience what it might be like to be one of these engineers! And, since engineers need to effectively communicate their ideas, you will experience that aspect of engineering, also. Engineers must be able to present their ideas so that their bosses, other employees, and the people for whom they are making the new invention, product or design can understand how it works. Engineers also often work in groups, and they need to be able to communicate well with the other people in their group, so that they all can work together to create amazing new technology.

Materials: Cars From the Future Fill-In Worksheets, as well as the Eco-Car Checklist, one per person, paper and pencils.

Procedure

1. Divide the class into groups of three students each.
2. Give each team paper, pencils and ruler.
3. Conduct the Introduction/Motivation section with the class, and hand out the Eco-Car Checklist handout, instructing them on what they must accomplish.
4. Hand out the Modes of Transportation Worksheet. Have each group rank the different vehicles in order from "greenest" to "not-as-green." (Note: It is okay if two types of transport have the same ranking – not every number needs to be used in the ranking.) As a class, discuss the answers and discuss the traits of a "green vehicle." Traits for "green vehicles" include smaller size, alternative fuel, lighter in weight, etc.
5. Hand out the Vehicle Fill-In Worksheets, and display an overhead transparency of the worksheet. Have each group fill in the answers they think are correct and then review the worksheet together as a class.
6. Give the students five minutes to brainstorm ideas of what they think the vehicles of the future will be like. Have them draw up a list of features that they want their vehicle to include.
7. Give the students 10 minutes to make a drawing of their design using the provided rulers and colored pencils.
8. After the students have had enough time to make a good drawing of their designs, tell them it is time to find a way to sell their idea!

Class Discussion and Worksheet: Ask students if they know about any current technology that is used in alternative vehicles or fuel. As a class, brainstorm different ideas of alternative vehicles that engineers have designed. Ask if anyone has seen or been in a hybrid or electric vehicle. Ask the students why these alternative methods are so important (they produce fewer emissions and require fewer fossil fuels). After the discussion, hand out the Modes of Transportation Worksheet and have the students rank different modes of transportation from "greenest" to "not-as-green." Discuss the answers as a class.

Activity Embedded Assessment

Fill in the blanks: Put up a transparency of the Vehicle Fill-in Worksheet. Have each group fill in the blanks and then share the answers with the class.

Post-Activity Assessment

Closure Discussion: Discuss as a class why engineers must be able to effectively share their ideas with their bosses, clients, employees, other engineers, and the public. Talk about the importance of being able to communicate your ideas well. Ask students if they can think of what might happen if engineers were not able to share their ideas persuasively. (Possible Answers: People may be confused about how engineering inventions work, and may not want to buy or use new inventions. It is also difficult for engineers to work together in teams if they do not do a good job of communicating their ideas to each other).

Lesson Closure

You have finally arrived in Beijing, and after discussing different modes of transportation with your classmates, you are paying extra attention to all the different types of vehicles you see on the roads. China is the most populated country in the world with over 1 billion residents. With so many people, it is logical to assume there is a lot of pollution. You have just learned about different ways to reduce pollution in automobiles, which are one of the biggest contributors to air pollution. What are some other sources of pollution? (Answer: power plants, boats, factories, etc. Note: List answers on board.) Let's brainstorm how to reduce pollution from these sources. Some solutions include using wind and/or solar power for homes/businesses, having more people drive low-emission vehicles, hybrid vehicles, etc. Also, carpooling and riding bikes more often would help greatly reduce carbon monoxide emissions. Some of these solutions include using a renewable source of energy. Who can remember two (or more) sources of renewable energy? (Answer: wind, solar, water, biodiesel) Can anyone explain why electric, hybrid or biodiesel cars are more efficient than regular cars? (Answer: They all have fewer harmful emissions than regular cars or regular gasoline.)

You have been learning about all the different things that engineers make. We now know that engineers also have to think about how to make things "green" in order to keep people and our environment healthy. Many engineers care about keeping people healthy and protecting our environment, but which kind of engineer focuses especially on keeping the air and water clean? (Answer: environmental engineers)

Now that you know how important it is to keep our environment clean, you can keep your eyes out for alternative forms of transportation. Maybe one day some of you will become environmental engineers and develop a new technology to help the environment, or as a chemical or mechanical engineer, you will design another kind of fuel or an amazing new vehicle.

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Vocabulary/Definitions

air pollutant: Six major sources of emissions to our environment include: ozone, particulate matter, carbon monoxide, nitrogen dioxide, sulfur dioxide and lead.

biodiesel: A cleaner burning automotive fuel often derived from vegetable oil.

electric vehicle: A vehicle that is powered using electricity instead of gasoline.

emissions: Substances released into the air by automobiles, factories or power plants.

hybrid vehicle: A vehicle that uses both an electric and gasoline motor to run.

hydrogen: A chemical element used in fuel cells.

ozone: Composed of three oxygen molecules; ozone high in the atmosphere protects us from the sun's UV rays, while ground level ozone contributes to smog.

pollution: The release of harmful substances into the environment.

smog: A mixture of pollutants, mainly ground-level ozone that cause decreased visibility as well as damage to the environment and human health problems.

Assessment

Pre-Lesson Assessment

Discussion Questions: Solicit, integrate and summarize student responses. Have the students form small groups and talk about different types of transport.

- What engineers do they think are involved in each type of transportation?
- How does each type of transport contribute to air pollution?
- Ask the students if they can think of means of transport that do not contribute to air pollution.
- Ask them why air pollution is a bad thing. (Answer: Because it makes people sick, hurts animals, and harms plants, trees, buildings, etc.)

Post-Introduction Assessment

Transportation Rating System: Ask the students to brainstorm a list of different methods of transportation. Have the students break up into groups and have each group rank the list in order from cleanest to not-as-clean. Have the students make a list of features that they will judge each mode of transport on, such as "*green*ness," efficiency, ease of use, etc. Rate each type of vehicle and total the numbers to find out which one is the best. Have each group quickly present the order that they decided, and as a class come to a consensus about which travel modes are the best for the environment.

Example:

	Greenness	Ease of Use	Cost	Fuel Efficiency	Cool Factor	TOTAL
Hybrids	8	10	5	8	8	39
Electric Cars	9	8	5	10	9	41
Regular Cars	5	10	7	4	3	29

Lesson Summary Assessment

My Life as an Environmental Engineer: Ask if any student can call out the four renewable energy sources that they learned about (wind, water, solar, biodiesel). Have students pretend to be environmental engineers and ask them to think of something they could design to help keep the water or air clean. Next, ask them to think how their invention could use a renewable energy source. For example: an air filter that is powered by biodiesel, or a water filter that uses solar energy to run the pump.

Lesson Extension Activities

Have students design their own green house, kitchen, bathroom or bedroom. Ask them to make a list of key features that help to reduce waste and use natural, sustainable products.

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Lesson Background and Concepts for Teachers

Pollution Types

The EPA has identified six common *air pollutants*: ozone, particulate matter, carbon monoxide, nitrogen dioxide, sulfur dioxide and lead.

Automobiles and other modes of transport (buses, trucks, etc.) play a large role in the emissions of many of these types of dangerous pollution, emitting four of the six common pollutants into the environment.

In New Jersey, transportation makes up %

While environmental policies have helped to greatly reduce the amount of emissions per vehicle, the number of vehicles on the road, and the distance traveled per vehicle, have both greatly increased.

Students can do their part to design the future of eco-friendly transport with the associated activity Cars from the Future: Presenting Your Eco-Friendly Design Ideas.

Ozone is composed of three molecules of oxygen, and its chemical formula is O_3. Ozone can be "good" or "bad" depending on its location. "Good" ozone is located high in the atmosphere and protects the earth from damaging UV rays from the sun. This beneficial ozone layer is slowly being destroyed by human-made chemicals. A good example of this is found in the "ozone-hole" over the North and South Poles. "Bad" ozone is found lower in the Earth's atmosphere. It is created (see the equation below) when emissions from cars, power plants, industrial boilers, refineries, chemical plants, and other sources react chemically in the presence of sunlight. "Bad" ozone contributes to both environmental and human health problems.

bad ozone = volatile organic compounds + nitrogen oxides + sunlight

As illustrated in Figure 1, motor vehicles have an enormous impact on the formation of ozone by emitting nitrogen oxides (NOx) and volatile organic compounds (VOCs).

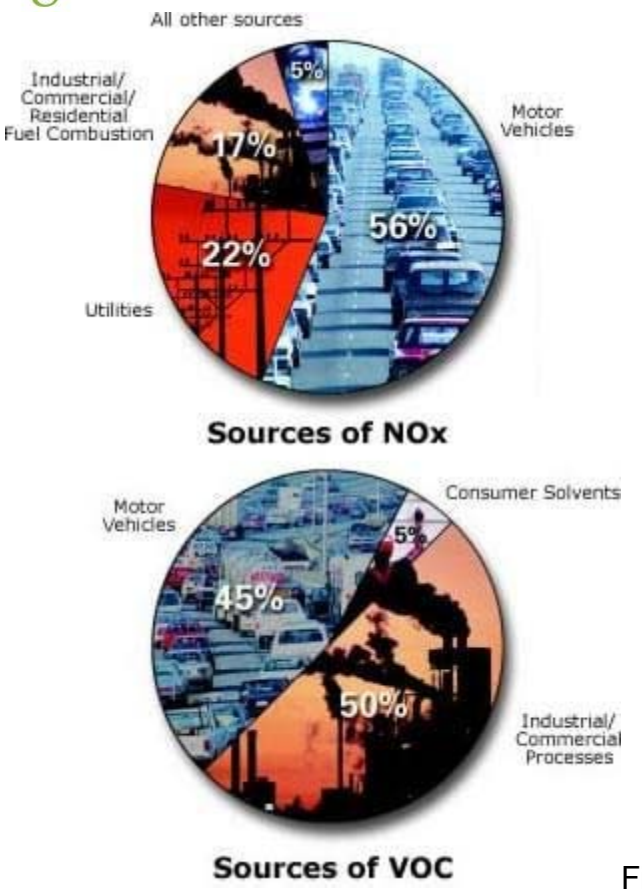

Figure 1. Sources of NOx and VOCs. copyright

Particulate matter is what you see when there is haze or smog in the air. Particulate matter can either be directly emitted from vehicles, factories, farming activities and fires, or it can be the indirect result of burning fuels in the presence of sunlight and water vapor, such as fuel combustion in vehicles and power plants (see Figure 2). Particulate matter plays a huge role in health problems and also impacts the delicate chemical balance of eco-systems. Particulate matter is also responsible for the oftentimes permanent staining of statues and buildings.

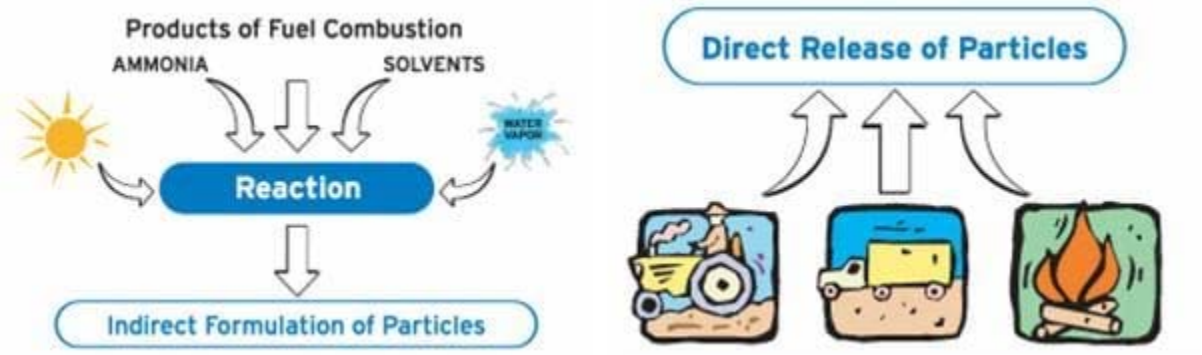

Figure 2. Particulate matter is both directly and indirectly emitted into the environment. copyright

Carbon monoxide (CO) is a gas that is released when fuel is not burned completely. Carbon monoxide is very dangerous to human health, and, ironically, more than one half of the CO emissions come from on-road vehicles. Other sources include non-road vehicles, such as trains and airplanes, industrial processes, fuel combustion and miscellaneous sources, such as forest fires. The breakdown of percentages of CO contribution to our environment is shown in Figure 3. Carbon monoxide, an organic compound, also contributes to the formation of ground level smog or ozone.

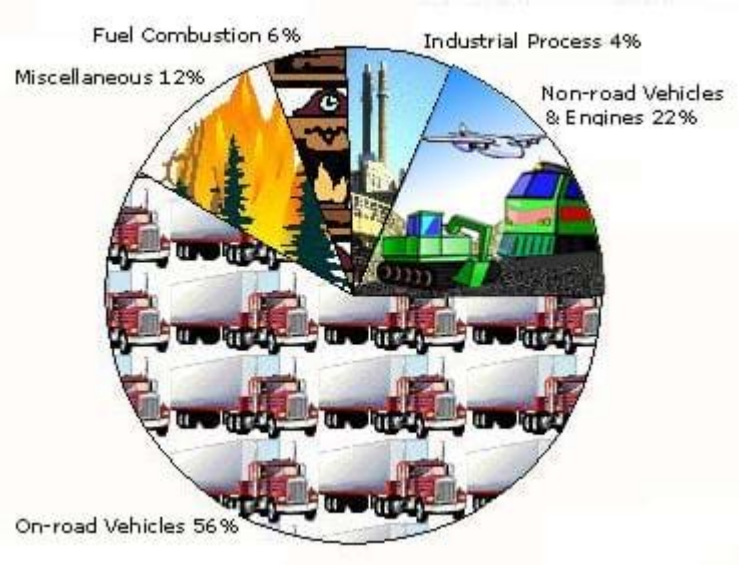

Figure 3. On-road vehicles account for more than half the carbon monoxide (CO) emissions.

Nitrogen oxides (NOx) refers to a group of gasses that contain nitrogen and oxygen. They are one of the primary components of ozone, and the main source is, again, motor vehicles. NOx contributes to the formation of acid rain and deteriorates water quality. NOx emissions also contribute to atmospheric particles which cause respiratory problems and visibility impairment.

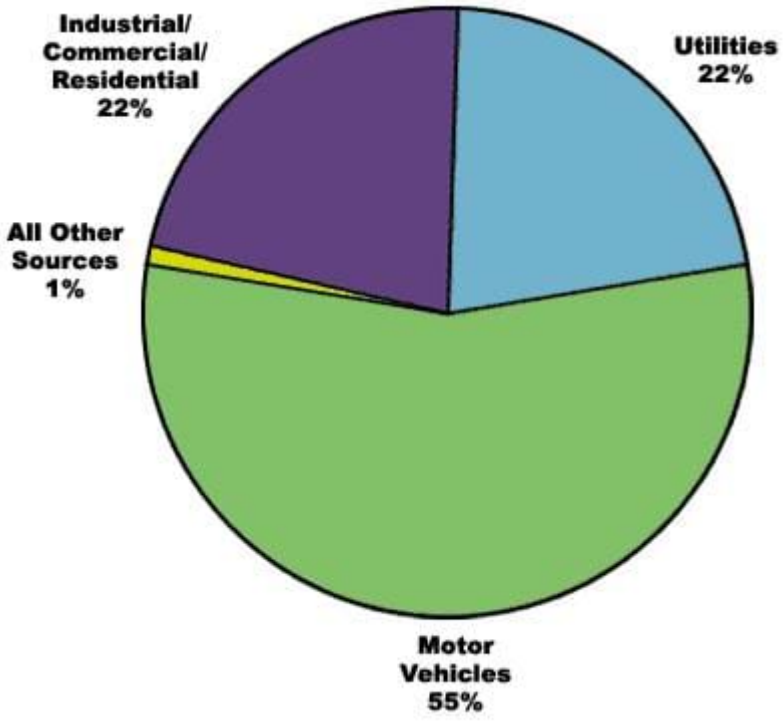

Figure 4. Motor vehicles account for more than half the nitrogen oxide (NOx) emissions.

Sulfur dioxide (SO_2) comes mainly from burning coal in large industrial processes, but also from trains and boats with coal-burning engines. Sulfur dioxide contributes to respiratory illness, acid rain and visibility impairment. Motor vehicles contribute 5% of sulfur dioxide emissions. The majority of *lead pollution* now comes from metal processing. However, in the 1970s, motor vehicles were responsible for almost 80% of lead pollution. Environmental laws leading to the removal of lead from gasoline have essentially eliminated on-road vehicle lead pollution.

Vehicle/Fuel Alternatives

As seen recently in the news media, alternative fuels and vehicles have been developed and are gaining mainstream popularity.

The main two types of alternative vehicles are *hybrid* and *electric*. The common hybrid vehicle is a gas-electric hybrid, utilizing both gas and electric engines to increase fuel efficiency and greatly decrease emissions. Electric vehicles rely solely on electric battery power to run the vehicle, which causes them to have no need for gasoline and very low emissions. Each vehicle has its limitations, though both show a movement towards decreasing vehicle emissions and taking responsibility for protecting our environment.

Biodiesel is an animal fat- or vegetable oil-based alternative fuel which has much lower emissions than regular unleaded or diesel fuels. Biodiesel is a sustainable and non-toxic resource that can be made locally and from recycled ingredients, such as vegetable (soybean) oil used at restaurants. These ingredients are processed at a refinery and

turned into a fuel-grade product. Remember, you cannot just put vegetable oil into your vehicle's gas tank and expect it to run – that would definitely harm your car's engine.

Other possibilities for alternative vehicles in the future include increasing the efficiency of hybrids and ease of use of electrics as well as the development of hydrogen-powered cars. Hydrogen cars are close to zero emissions and use an infinitely renewable resource.

Clean Energy

Several methods of producing energy have less impact on the environment. Each method has its pros and cons. Some examples are:

Wind Turbines – Clean energy using wind power; limited by the amount of wind available. Solar Power – Clean energy using the sun; limited by weather (i.e., the number of sunny days or hours available); photovoltaic cells are still quite expensive.

Biodiesel – Fewer harmful emissions than regular gasoline or diesel; must have a diesel engine to use biodiesel, and gas stations selling biodiesel are still sparse in some states.

Nuclear Power – While a fairly clean source of energy, it is very controversial as there are huge health risks associated with it should an accident or contamination occur with its use.

Hydroelectric Power – Energy from flowing or falling water; though a cleaner and renewable form of energy, there are controversial issues involved dealing with changing a natural water course and the impact on the ecosystem.