Video: Hydrogen - The Pollution Solution

Student Objectives
The student:
- will be able to explain how fossil fuels have caused our pollution problem
- will be able to explain how hydrogen fits into our transportation future
- will be able to list several benefits of hydrogen as an energy carrier

Key Words:
emissions
inexhaustible
pollution

Time: 1 hour

Materials
- The Pollution Solution video

Background
The Air Pollution Issue

An air pollutant is classified as any substance in the air that is detrimental in some way to human health or is threatening to other forms of life. Pollutants which have an immediate effect are *primary* air pollutants, and those that become a problem when converted to other forms are *secondary* air pollutants. Primary pollutants include carbon monoxide, radioactive wastes and highly toxic compounds such as xylenes, cyantes, and atmospheric metals. Secondary pollutants include low level ozone which is produced by sunlight reacting with the exhaust from combustion engines. Some of our pollutants are natural components of the atmosphere and become pollutants when they reach critical levels that affect life. These natural pollutants include such things as volcanic eruptions, violent storms, forest fires, wind erosion, natural gases from the decay of dead organisms, and pollen and spores.

The Environmental Protection Agency (EPA) has identified six primary pollutants that present a threat to human health: carbon monoxide, low level ozone, lead, the sulfur oxides, the nitrogen oxides, and particulate matter.

Carbon Monoxide: A colorless, odorless, poisonous gas, produced by incomplete burning of carbon-based fuels including gasoline, oil and wood as well as combustion of many natural and synthetic products such as cigarettes. When carbon monoxide gets into the body, it combines with chemicals in the blood and prevents the blood from transporting oxygen to the cells of the body.

Low Level Ozone: A gas which is a variation of oxygen which contains three atoms of oxygen instead of two. Ozone occurs in nature; it is the cause of the sharp smell you notice near a lightning strike. Ozone is found in large concentrations in the stratosphere where it protects the earth from ultraviolet radiation. Ground level ozone is the main component of smog, and is a

product of reactions during combustion of coal, gasoline and other fuels, and also chemicals found in products including solvents, paints and hairspray. In humans, it can cause lung tissue damage, and create high incidences of asthma and allergenic reactions. Plants exposed to high ozone concentrations lose their chlorophyll and their food manufacturing abilities.

Lead: There has been a dramatic decrease of lead in human blood levels since the element has been removed from gasoline and paints. However, there are still many sources for lead in our environment, such as large furnaces, incinerators, and battery plants. Lead in the atmosphere can deposit into lakes and streams where it may be ingested by fish and eventually by humans. The physical effects of lead poisoning are mental impairment, central nervous system damage and high blood pressure.

Sulfur Dioxide: A gas produced by burning coal, most notably in power plants, as well as some industrial processes such as paper production and the smelting of metals. Sulfur dioxide plays an important role in the production of acid rain. Sulfur dioxide can cause nose and throat irritation and lung problems such as bronchitis.

Nitrogen Oxide: Nitrogen Oxides (NOx) are produced from burning fuels including gasoline and coal. The major sources of NOx are power plants and transportation--vehicles that burn gasoline and diesel. Nitrogen Oxides react with organic compounds to form smog, and are also major components of acid rain.

Particulate Matter: Particulate Matter (PM) includes dust, soot and other tiny bits of solid materials that are released into and move around in the air. U.S. health standards for air quality are based on the concentration of particles small enough to be inhaled deep into the lungs. These are particles with a diameter of less than 10 microns. Particulates are produced by many sources, including burning of diesel fuels, incineration of garbage, mixing and application of fertilizers and pesticides, road construction, industrial processes such as steelmaking, mining operations, agricultural burning and the operation of fireplaces and woodstoves. Particulate pollution can cause eye, nose and throat irritation and other health problems. Fine-particulate air pollution (particles with a diameter of 2.5 microns or less) tend to deposit in the alveoli of the lungs where they remain for a long time. Fine-particle pollution typically contains soot, acid condensates, and sulfate and nitrate particles. This type of pollution is thought to pose greater health risks not only because the particles can be breathed more deeply into the lungs, but also because they are more likely to be toxic than larger particles.

Scientists are unable to agree on just how stable our environment is and whether or not human activity is changing our air to a point where it could affect life as we know it. The scientific community also has been unable to determine the degree of damage that has already been done to our atmosphere. However, there are some facts that relate directly to the issue of air pollution.

- World population is six million, and continues to increase. Humans have colonized and now affect every continent on our earth. The number of people living in urban areas is projected to reach 50% worldwide by 2005
- Many of the new technologies have created waste products that are emitted into our atmosphere during product manufacturing or product use
- Many of our lakes and forests have become acidic in the past fifty years.

Is air pollution a health threat?

- The number of asthma cases has increased from 10.4 million to 14.6 million from 1990 to

1994. Studies have shown that this is attributable to chemicals found in air pollution

- Every year, some 64,000 people may die prematurely from cardiopulmonary causes linked to particulate air pollution, according to an analysis conducted by the National Resource Defense Council. In the most polluted cities, lives are shortened by an average of one to two years.
- Depending on which air toxins an individual is exposed to, the health effects can include damage to the immune system, as well as neurological, reproductive (e.g., reduced fertility), developmental, and respiratory problems. The susceptibility of certain population groups to the toxic or non-toxic exposures, such as the elderly and children has to be given special consideration. Moreover air pollution induces early fatigue, and effectively an overall reduction in efficiency and potential even in the otherwise healthy human beings. This can slacken the progress of a nation, its economy and commerce. Thus, the government needs to be pro-active to understand the implications of pollution on human health and take appropriate corrective measures. See chart below.

Hydrogen in transportation

The world's leading automakers are in a race to bring fuel cell vehicles to the marketplace. Hydrogen fuel cells have the potential to power cars, trucks, and buses without producing harmful emissions. Vehicles powered by fuel cells will be cleaner and quieter, and consume less energy than those powered by internal combustion engines. And because the hydrogen used in fuel cells can be produced from a variety of sources, we won't need to rely on just one source of fuel for our transportation.

In comparison to the internal combustion engine, a fuel cell power system doesn't have as many moving parts, is nearly silent, doesn't get as hot and has fewer mechanical parts. PEM fuel cells can capture 50% or more of hydrogen's energy to power a car, while the internal combustion engines in today's cars convert less than 20% of the energy in gasoline into power. And while automotive engineers have found ingenious ways to make internal combustion engines run more cleanly and efficiently, there's a limit to how good these engines can ever be.

About 60 million new cars are sold worldwide each year. Automotive industry leaders have speculated that fuel cell vehicles could account for 20 to 25 percent of new car sales within the next 20 to 25 years, a potential market of 12 million to 15 million vehicles each year.

Procedure

1. Show the 6 minute video.
2. Take a few minutes to discuss the video and discuss any questions that arise. If the students ask a question and you don't know the answer, ask if anyone in the class would like to research the question for the class (possibly for extra credit) and report back with the answer next class period.
3. Lead a discussion on pollution and the future of transportation. Things to discuss:
    - What sources of air pollution have they noticed in their community? *(Make sure to include any factories and power plants you may have in your area, as well as school buses, and lawn equipment–an often overlooked source of air pollution)*
    - What effects of air pollution have they noticed in their community? *(You may choose to discuss the increase in asthma that has been documented in children*

their age.)

- What can be done to clean up this air pollution?
- What kind of car do they think they will be driving in 15 - 20 years? What do they envision it looking like? How will they refuel it?
- What did the video mean when it said that hydrogen was 'inexhaustible'? How can we get hydrogen?
- Since it takes some form of energy to release hydrogen from water (or other molecules such as methane), how can we use energy to produce energy–don't we have a total net loss in this situation? *(This is where renewable energy sources come in–their energy is also inexhaustible)*
- What is the future of petroleum products--how long will they be affordable for general consumption? How will we transition to another energy source?
- Can conservation alone provide enough energy for our growing world population? *Make sure you mention that the U.S. consumes 25% of the world's total oil production, but is only 10% of the world's population.* Should we restrict either population or energy consumption, and if not, how do we cope with the shortages? How many is 'too many' cars (or people)?
- What kind of careers in energy are going to be opening up?

Further Research

1. Which auto manufacturers are working on hydrogen fuel cell vehicles? How long do they predict it will be until they are on the market?
2. How do scientists think the hydrogen vehicles of the future will be refueled–at a service station or at home?
3. Draw your concept of a future fuel cell vehicle.

Internet Sites

http://www.gm.com/company/gmability/edu_k-12/
General Motor's hydrogen transportation site for students. Includes games, stories and activities about hydrogen in transportation.

http://www.pbs.org/wgbh/nova/sciencenow/3210/01-car-nf.html
Nova Science Now. Interactive site shows how a fuel cell car works.

http://www.smogcity.com/
Sacramento Metropolitan Air Quality Management District's Smog City site. Interactive game lets students examine the roles of population, emissions and weather on air pollution and health.

http://www.epa.gov/kids/
Environmental Protection Agency, Environmental Kids Club. Activities for students and teachers on pollution, the environment, and recycling.

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Energy	**Standard 1**	**SC.B.1.3-**	**X**	**X**					
	Standard 2	**SC.B.2.3-**	**X**	**X**					
Processes that Shape the Earth	**Standard 1**	**SC.D.1.3-**							
	Standard 2	**SC.D.2.3-**	**X**	**X**					
How Living Things Interact With Their Environment	**Standard 1**	**SC.G.1.3-**							
	Standard 2	**SC.G.2.3-**	**X**			**X**			
Nature of Science	**Standard 1**	**SC.H.1.3-**							
	Standard 2	**SC.H.2.3-**							
	Standard 3	**SC.H.3.3-**				**X**			

Benchmark SC.B.1.3.1 - The student identifies forms of energy and explains that they can be measured and compared.

Grade Level Expectations

The student:

Sixth

- understands that energy can be converted from one form to another

Eighth

- knows examples of natural and man-made systems in which energy is transferred from one form to another.

Benchmark SC.B.1.3.2 - The student knows that energy cannot be created or destroyed, but only changed from one form to another.

Grade Level Expectations

The student:

Sixth

- understands that energy can be changed in form
- uses examples to demonstrate common energy transformations

Benchmark SC.B.2.3.1 - The student knows that most events in the universe involve some form of energy transfer and that these changes almost always increase the total disorder of the system and its surroundings, reducing the amount of useful energy.

Grade Level Expectations

The student:

Sixth

- understands that energy moves through systems

Eighth

- understands that as energy is transferred from one system to another there is a reduction in the amount of useful energy
- knows that energy transfer is not efficient.

Benchmark SC.B.2.3.2 - The student knows that most of the energy used today is derived from buring stored energy collected by organisms millions of years ago.

Grade Level Expectations

The student:

Seventh

- knows that fossil fuels are found in the Earth, they are nonrenewable, and the advantages and disadvantages of their use

Eighth

- knows how fossil fuels are formed in the Earth, why they are nonrenewable, and the advantages and disadvantages of their use.

Benchmark SC.D.2.3.1 - The student understands that quality of life is relevant to personal experience.

Grade Level Expectations

The student:

Sixth

- knows that a change in the environment affects the quality of life

Seventh

- knows ways to conserve and recycle resources.

Benchmark SC.D.2.3.2 - The student knows the positive and negative consequences of human action on the Earth's systems.

Grade Level Expectations

The student:

Sixth

- knows positive and negative consequences of human action on the Earth's sytems.

Benchmark SC.G.2.3.1 - The student knows that some resources are renewable and others are nonrenewable.

Grade Level Expectations

The student:

Sixth

- knows renewable and nonrenewable energy sources

Seventh

- understands the importance of informed use of natural resources

Eighth

- knows that some resources are renewable and others are nonrenewable.

Benchmark SC.G.2.3.4 - The student understands that humans are a part of an ecosystem and their activities may deliberately or inadvertently alter the equilibrium in ecosystems.

Grade Level Expectations

The student:

Sixth

- understands that humans are a part of an ecosystem and their activities may deliberately or inadvertently alter the equilibrium in the ecosystem.

Seventh

- knows ways that human activities may deliberately or inadvertently alter the equilibrium in the ecosystem

Eighth

- extends and refines knowledge of ways that human activities may deliberately or inadvertently alter the equilibrium in the ecosystem.

Benchmark SC.H.3.3.4 - The student knows that technological design should require taking into account constraints such as natural laws, the properties of the materials used, and economic political, social, ethical, and aesthetic values.

Grade Level Expectations

The student:

Sixth

- knows some ways that scientific discoveries create new technologies that affect society

Seventh

- knows that the designs used for technological improvements should consider the values of society
- uses the knowledge of political, social, and economic ramifications of certain scientific research to evaluate its role in society

Eighth

- knows that technological design should require taking into account constraints such as natural laws, the properties of the materials used, and economic, political, social, ethical, and aesthetic values.

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emissions - a substance discharged into the air, especially by an internal combustion engine

inexhaustible - cannot be entirely consumed or used up

pollution - the contamination of soil, water, or the atmosphere by the discharge of harmful substances.