Introduction to Energy

What Is Energy?

Energy does things for us. It moves cars along the road and boats on the water. It bakes a cake in the oven and keeps ice frozen in the freezer. It plays our favorite songs and lights our homes at night. Energy helps our bodies grow and our minds think. Energy is a changing, doing, moving, working thing.

Energy is defined as the ability to produce change or do work, and that work can be divided into several main tasks we easily recognize:

- Energy produces light.
- Energy produces heat.
- Energy produces motion.
- Energy produces sound.
- Energy produces growth.
- Energy powers technology.

Forms of Energy

There are many forms of energy, but they all fall into two categories–potential or kinetic.

POTENTIAL ENERGY

Potential energy is stored energy and the energy of position, or gravitational energy. There are several forms of potential energy, including:

- **Chemical energy** is energy stored in the bonds of **atoms** and **molecules**. It is the energy that holds these particles together. Biomass, petroleum, natural gas, and propane are examples of stored chemical energy.

  During photosynthesis, sunlight gives plants the energy they need to build complex chemical compounds. When these compounds are later broken down, the stored chemical energy is released as heat, light, motion, and sound.

- **Stored mechanical energy** is energy stored in objects by the application of a force. Compressed springs and stretched rubber bands are examples of stored mechanical energy.
- **Nuclear energy** is energy stored in the nucleus of an atom—the energy that binds the nucleus together. The energy can be released when the nuclei are combined or split apart. Nuclear power plants split the nuclei of uranium atoms in a process called **fission**. The sun combines the nuclei of hydrogen atoms into helium atoms in a process called **fusion**. In both fission and fusion, mass is converted into energy, according to Einstein's Theory, $E = mc^2$.
- **Gravitational potential energy** is the energy of position or place. A rock resting at the top of a hill contains gravitational potential energy because of its position. Hydropower, such as water in a reservoir behind a dam, is an example of gravitational potential energy.

Energy at a Glance, 2011

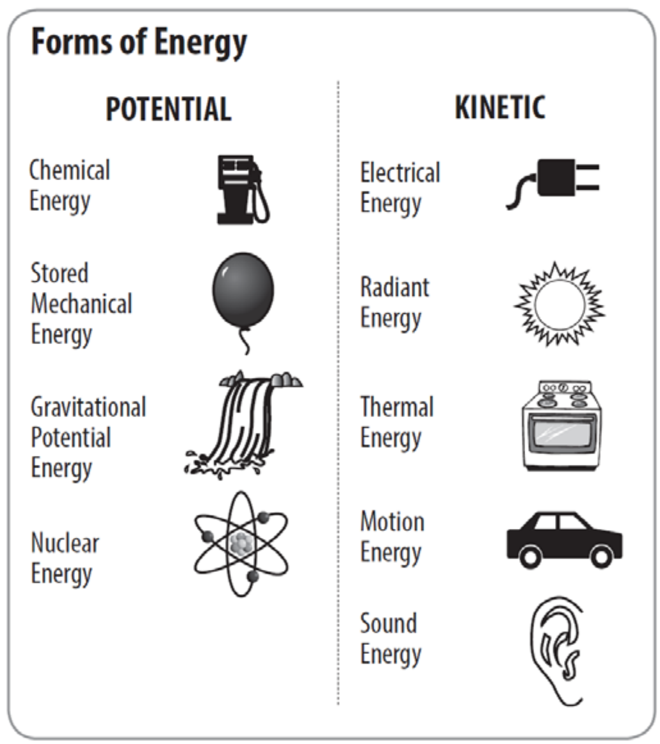
	2010*	2011
World Population	6,868,500,000	6,946,000,000
U.S. Population	309,300,000	311,600,000
World Energy Production	506.226 Q	n/a
U.S. Energy Production	74.806 Q	78.096 Q
• Renewables	8.136 Q	9.236 Q
• Nonrenewables	66.669 Q	68.860 Q
World Energy Consumption	510.551 Q	n/a
U.S. Energy Consumption	97.722 Q	97.301 Q
• Renewables	8.090 Q	9.135 Q
• Nonrenewables	89.543 Q	88.038 Q

Q = Quad (10^{15} Btu) see Measuring Energy on page 10.

*The latest year for which final data for world and U.S. is available from EIA.

Note: 2011 data for World Energy Production and World Energy Consumption are not available at time of printing.

Note: Sum of renewable and nonrenewable energy consumption do not equal total, due to independent rounding.



KINETIC ENERGY

Kinetic energy is motion—the motion of waves, **electrons**, atoms, molecules, substances, and objects.

- **Electrical energy** is the movement of electrons. Everything is made of tiny particles called atoms. Atoms are made of even smaller particles called electrons, protons, and neutrons. Applying a force can make some of the electrons move. Electrons moving through a wire are called **electricity**. Lightning is another example of electrical energy.
- **Radiant energy** is electromagnetic energy that travels in transverse waves. Radiant energy includes visible light, x-rays, gamma rays, and radio waves. Solar energy is an example of radiant energy.
- **Thermal energy**, or heat, is the internal energy in substances—the vibration and movement of atoms and molecules within substances. The faster molecules and atoms vibrate and move within a substance, the more energy they possess and the hotter they become. Geothermal energy is an example of thermal energy.
- **Motion energy** is the movement of objects and substances from one place to another. According to **Newton's Laws of Motion**, objects and substances move when an unbalanced force is applied. Wind is an example of motion energy.
- **Sound energy** is the movement of energy through substances in longitudinal (compression/rarefaction) waves. Sound is produced when a force causes an object or substance to vibrate. The energy is transferred through the substance in a wave.

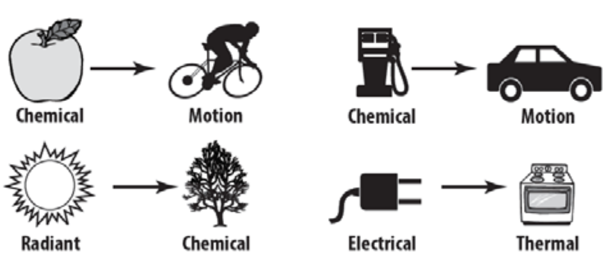
Conservation of Energy

Your parents may tell you to conserve energy. "Turn out the lights," they say. But to scientists, conservation of energy means something quite different. The **Law of Conservation of Energy** says energy is neither created nor destroyed.

When we use energy, we do not use it completely—we just change its form. That's really what we mean when we say we are using energy. We change one form of energy into another. A car engine burns gasoline, converting the chemical energy in the gasoline into motion energy that makes the car move. Old-fashioned windmills changed the kinetic energy of the wind into motion energy to grind grain. Solar cells change radiant energy into electrical energy.

Energy can change form, but the total quantity of energy in the universe remains the same. The only exception to this law is when a small amount of matter is converted into energy during nuclear fusion and fission.

Energy Transformations



Efficiency

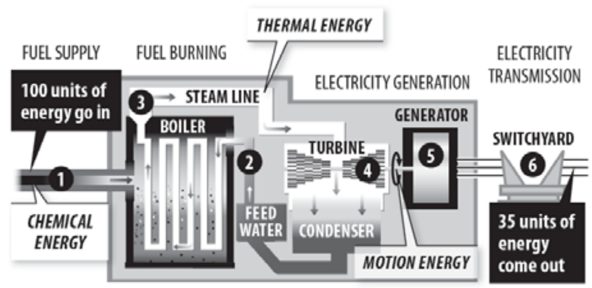
Energy efficiency is the amount of useful energy you can get out of a system. In theory, a 100 percent energy efficient machine would change all of the energy put in it into useful work. Converting one form of energy into another form always involves a loss of usable energy, usually in the form of thermal energy.

In fact, most energy transformations are not very efficient. The human body is no exception. Your body is like a machine, and the fuel for your "machine" is food. Food gives us the energy to move, breathe, and think. But your body isn't very efficient at converting food into useful work. The rest of the energy is transformed into thermal energy.

An incandescent light bulb isn't efficient either. A light bulb converts ten percent of the electrical energy into light and the rest (90 percent) is converted into thermal energy. That's why a light bulb is so hot to the touch.

Most electric power plants that use steam to spin turbines are about 35 percent efficient. It takes three units of fuel to make one unit of electricity. Most of the other energy is lost as waste heat. The heat dissipates into the environment where we can no longer use it as a practical source of energy.

Efficiency of a Thermal Power Plant



How a Thermal Power Plant Works

1. Fuel is fed into a boiler, where it is burned to release thermal energy.
2. Water is piped into the boiler and heated, turning it into steam.
3. The steam travels at high pressure through a steam line.
4. The high pressure steam turns a turbine, which spins a shaft.
5. Inside the generator, the shaft spins coils of copper wire inside a ring of magnets. This creates an electric field, producing electricity.
6. Electricity is sent to a switchyard, where a transformer increases the voltage, allowing it to travel through the electric grid.

Energy Efficiency formula:

$$\frac{\text{Output}}{\text{Input}} \times 100$$

Output energy is also Useful energy

Energy Efficiency Worksheet

Show all calculations with units

1. 3.2 tons of coal is used to provide enough heat to bring the temperature of 2.0×10^5 gallons of water up 30^0 F. The heat value of one ton of coal is 2.5×10^7 BTU/ton. One gallon of water weighs 8 lbs and BTU's are calculated by multiplying pounds of water by their change in temperature in degrees Fahrenheit.

a. What is the input energy?

b. What is the useful energy?

c. What is the efficiency?

2. A cord of wood is used in a wood stove/fireplace to heat a house. If the transfer from the wood to the house is 70% efficient, how much heat will be delivered? The heat in a cord of wood is 2.0×10^7 BTU.

b. Where did the waste energy go? Look at a fireplace to figure this out.

Introduction to Energy

Sources of Energy

People have always used energy to do work for them. Thousands of years ago, early humans burned wood to provide light, heat their living spaces, and cook their food. Later, people used the wind to move their boats from place to place. A hundred years ago, people began using falling water to make electricity.

Today, people use more energy than ever from a variety of sources for a multitude of tasks and our lives are undoubtedly better for it. Our homes are comfortable and full of useful and entertaining electrical devices. We communicate instantaneously in many ways. We live longer, healthier lives. We travel the world, or at least see it on television and the internet.

The ten major energy sources we use today are classified into two broad groups—nonrenewable and renewable.

Nonrenewable energy sources include coal, petroleum, natural gas, propane, and uranium. They are used to generate electricity, to heat our homes, to move our cars, and to manufacture products from candy bars to MP3 players.

These energy sources are called nonrenewable because they cannot be replenished in a short period of time. Petroleum, a fossil fuel, for example, was formed hundreds of millions of years ago, before dinosaurs existed. It was formed from the remains of ancient sea life, so it cannot be made quickly. We could run out of economically recoverable nonrenewable resources some day.

Renewable energy sources include biomass, geothermal, hydropower, solar, and wind. They are called renewable energy sources because their supplies are replenished in a short time. Day after day, the sun shines, the wind blows, and the rivers flow. We use renewable energy sources mainly to make electricity.

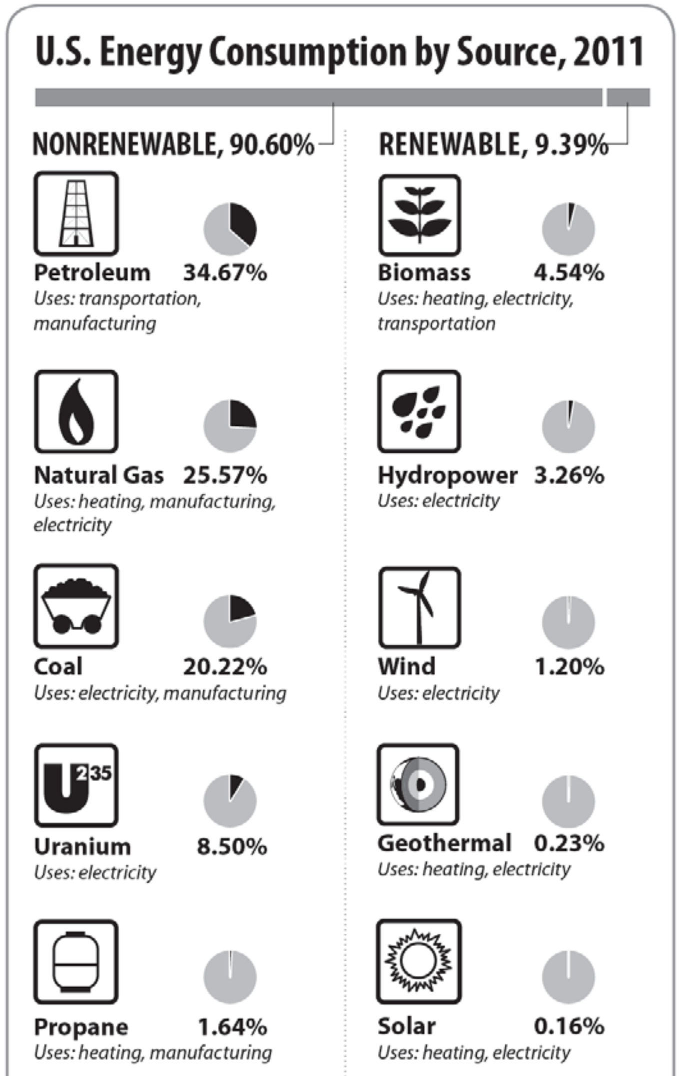
Is electricity a renewable or nonrenewable source of energy? The answer is neither. Electricity is different from the other energy sources because it is a **secondary source of energy**. That means we have to use another energy source to make it. In the United States, coal is the number one fuel for generating electricity.

Measuring Energy

"You can't compare apples and oranges," the old saying goes. That holds true for energy sources. We buy gasoline in gallons, wood in cords, and natural gas in cubic feet. How can we compare them? With British thermal units (Btu), that's how. The energy contained in gasoline, wood, or other energy sources can be measured by the amount of heat in Btu it can produce.

One Btu is the amount of thermal energy needed to raise the temperature of one pound of water one degree Fahrenheit. A single Btu is quite small. A wooden kitchen match, if allowed to burn completely, would give off about one Btu of energy. One ounce of gasoline contains almost 1,000 Btu of energy.

Every day the average American uses about 855,000 Btu. We use the term quad (Q) to measure very large quantities of energy. A quad is one quadrillion (1,000,000,000,000,000 or 10^{15}) Btu. The United States uses about one quad of energy every 3.75 days. In 2007, the U.S. consumed 101.296 quads of energy, an all-time high.



* Total does not equal 100% due to independent rounding.
Data: Energy Information Administration

Energy Use

Imagine how much energy you use every day. You wake up to an electric alarm clock. You take a shower with water warmed by a hot water heater using electricity or natural gas.

You listen to music on your MP3 player as you dress. You catch the bus to school. And that's just some of the energy you use to get you through the first part of your day!

Every day, the average American uses about as much energy as is stored in seven gallons of gasoline. That's every person, every day. Over a course of one year, the sum of this energy is equal to about 2,500 gallons of gasoline per person. This use of energy is called **energy consumption**.

Energy Users

The U.S. Department of Energy uses categories to classify energy users—residential, commercial, industrial, and transportation. These categories are called the sectors of the economy.

▪ Residential/Commercial

Residences are people's homes. Commercial buildings include office buildings, hospitals, stores, restaurants, and schools. Residential and commercial energy use are lumped together because homes and businesses use energy in the same ways—for heating, air conditioning, water heating, lighting, and operating appliances.

The residential/commercial sector of the economy consumed 40.74 percent of the total energy supply in 2011, more energy than either of the other sectors, with a total of 39.640 quads. The residential sector consumed 21.619 quads and the commercial sector consumed 18.021 quads.

▪ Industrial

The industrial sector includes manufacturing, construction, mining, farming, fishing, and forestry. This sector consumed 30.592 quads of energy in 2011, which accounted for 31.44 percent of total consumption.

▪ Transportation

The transportation sector refers to energy consumption by cars, buses, trucks, trains, ships, and airplanes. In 2011, the U.S. consumed 27.079 quads of energy for transportation. About 93 percent of this energy was from petroleum products such as gasoline, diesel, and jet fuel.

Energy Use and Prices

In 1973, Americans faced a major oil price shock due to an **oil embargo**. People didn't know how the country would react. How would Americans adjust to skyrocketing energy prices? How would manufacturers and industries respond? We didn't know the answers.

Now we know that Americans tend to use less energy when energy prices are high. We have the statistics to prove it. When energy prices increased sharply in the early 1970s, energy use dropped, creating a gap between actual energy use and how much the experts had thought Americans would be using.

The same thing happened when energy prices shot up again in 1979, 1980, and more recently in 2008—people used less energy. When prices started to drop, energy use began to increase.

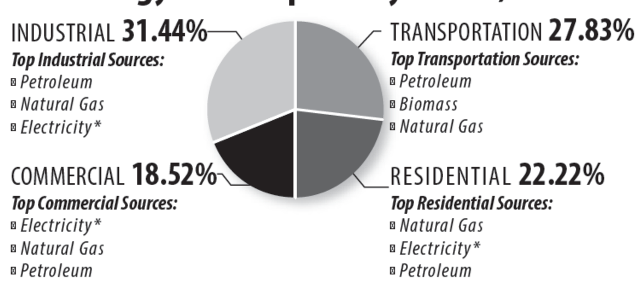
We don't want to simplify energy demand too much. The price of energy is not the only factor in the equation. Other factors that affect how much energy we use include the public's concern for the environment and new technologies that can improve the efficiency and performance of automobiles and appliances.

Most reductions in energy consumption in recent years are the result of improved technologies in industry, vehicles, and appliances. Without these energy conservation and efficiency technologies, we would be using much more energy today.

In 2011, the United States used 29 percent more energy than it did in 1973. That might sound like a lot, but the population increased by over 47 percent and the nation's **gross domestic product** was 1.7 times that of 1973.

If every person in the United States today consumed energy at the rate we did in the 1970s, we would be using much more energy than we are—perhaps as much as double the amount. Energy efficiency technologies have made a huge impact on overall consumption since the energy crisis of 1973.

U.S. Energy Consumption by Sector, 2011



*Electricity is an energy carrier, not a primary energy source.
Note: Figures are independently rounded, and do not add up to 100%.
Data: Energy Information Administration

Nonrenewable Energy Videos

INTRODUCTION | HOW WE MAKE AND USE ENERGY

COAL		NUCLEAR
OIL	ELECTRICITY	HYDRO
NATURAL GAS	TRANSPORTATION	WIND
BIOMASS	HEAT	SOLAR
BIO FUELS		GEOTHERMAL

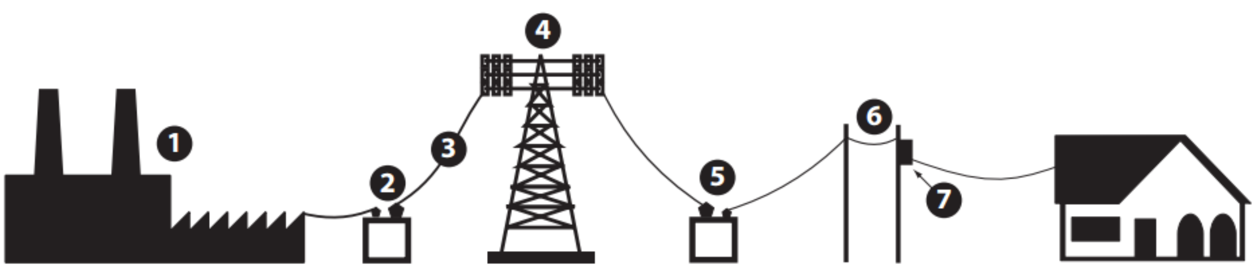
ENERGY LAB | HOW ELECTRICITY IS MADE

1. Describe a generator.

2. Describe how a generator is turned.

ENERGY LAB | THE ELECTRIC GRID

1. Label each step.



2. Why does electricity have to be constantly monitored and generated?

ENERGY LAB | THE DEMAND CURVE

1. What is baseload? What energy sources usually generate baseload?

2. How is the peak load met? What additional energy sources are used?

ENERGY LAB | HOW BATTERIES WORK

1. What are the three parts of a battery?

2. Batteries don't supply much power compared to their cost. What's the benefit of batteries?

ENERGY LAB | STORING ELECTRICITY

1. How would the ability to store electricity change the way it is produced?

ENERGY LAB | EFFICIENCY

1. Why is it important to reduce peak load? (3 reasons)

Chapter 19:
Nonrenewable Fossil Fuel



	Coal	Oil	Natural Gas	Other Fossil Fuels- Oil sands/tar shale, Oil shale, methane hydrate
Description/Definition				
State of Technology, Availability, & Economics				
How It is retrieved				
How it produces energy				
Byproducts				
How is the retrieval and/or byproducts harmful or beneficial to the environment?				

How are the byproducts regulated?				
Advantages				
Disadvantages				
Nations with the Largest Reserves (Top 3)				
"Need to know" vocab words				
Complete Infographics on the following pages				

COAL VIDEOS

ENERGY LAB| WHAT IS COAL?

1. What did coal start as? How did it get to be a rock?
2. Where can we find coal today?
3. What are the benefits of coal?
4. What countries use coal?
5. Draw the molecular structure of coal. Just kidding.
6. What compounds are released when coal is burned?
7. What are the drawbacks of coal?

ENERGY LAB| CLEAN COAL?

1. Describe the technologies that are currently in place to “clean” the process of coal burning.
2. Why aren’t these technologies used globally?

SWITCH | FOUNDATIONAL ENERGIES: COAL

1. The Belle Ayr Mine (Wyoming) is in the largest coal reserve in the world. How many people per year are powered by coal from this mine? (Use scientific notation!)
2. What type of mining is being used here?
3. Do they practice reclamation? How?
4. What are the advantages of coal?
5. The Parish Generating Station in Texas is the largest coal power plant in the United States. How many people does it serve each year?
6. What is the process for producing electricity?(5 steps)

   ________________ → ________________ → ________________ → ________________ → ________________

7. Add another advantage to number 4.

8. What are the disadvantages of coal?

9. What step will have to be taken to make coal more climate friendly? How will this be done?

10. How does David Crane define “clean coal”? Will we be able to achieve this? Why or why not?

Energy Infographics

Directions:

You must create a graphic design of each different energy source. Each energy source will have its own infographic. Each bullet must be represented in an image, graphic, graph, or some other visual. Your group will decide how to organize your infographic so that it makes sense. Make sure your infographic is cohesive.

9 strategies for Infographics (you do not need to use them all):

1: Organize
2: Make Visible
3: Establish Context
4: Simplify
5: Add Redundancy
6: Show Cause and Effect
7: Compare and Contrast
8: Create Multiple Dimensions
9: Integrate

1. **Coal**
   - Rock that is pressurized, solidified ancient plant material. Original source of energy is the sun with photosynthesis.
   - Surface mining and subsurface mining scar the land, cause habitat destruction and deforestation, increase erosion, and cause water pollution from sedimentation and acid mine drainage
     - Acid mine drainage: exposed S in the waste reacts with Oxygen and Water to form Sulfuric Acid (H_2SO_4) which acidifies soil and surface water, lowering pH and causes metal ions like Aluminum to leach into the water and soil. This increases toxicity of the water and causes trees, plants, and animals to die.
   - We Burn coal to release energy. Coal releases a lot of energy.
   - The burning of coal transfers chemical potential energy into heat. That heat is used to convert water to steam. The steam turns a turbine which is connected to a generator that creates electricity. The entire process is about 30% efficient.
   - When coal burns, its chemical products are: CO_2, CO, H_2O, NOx, SO_2, mercury, and fly ash.
     - CO_2, H_2O, NOx are GHG’s
     - NOx and SO_2 cause acid deposition when the react with water and cause lower pH in surface water and increase in metal ion leaching (like Al) making the water toxic.
     - Mercury is a neurotoxin and can bioaccumulate and biomagnify in seafood. Higher trophic levels contain higher levels of mercury. It is the cause of Minamata disease and lowered IQ.
     - Fly ash can be PM 2.5 which can get into the blood stream and cause respiratory problems like difficulty breathing and chest congestion.
   - Coal makes up about 40% of the global electricity production.
   - The US, China, and Russia have the largest coal reserves.
   - China is industrializing quickly and uses more coal than any other nation.

Coal Infographic

OIL VIDEOS

ENERGY LAB | HOW OIL IS MADE

1. How is oil made?

2. What can be made from oil?

ENERGY LAB | DRILLING FOR OIL

1. How does an oil rig work?

2. How is new technology being used to make drilling more effective?

3. How does offshore drilling differ?

ENERGY LAB | UNCONVENTIONAL SOURCES OF OIL

1. Where is oil found?

2. How is oil being extracted from "unconventional reservoirs"?

3. What unconventional source is rock that contains kerogen, a waxy organic solid that can be converted into oil?

4. What unconventional source can be mined and melted or melted underground to release oil?

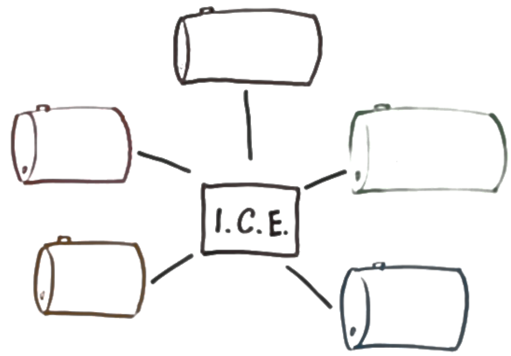
5. What are the environmental concerns with extraction of unconventional oil?

6. Why are we turning to unconventional reservoirs?

ENERGY LAB | OIL AND TRANSPORTATION ALTERNATIVES

1. Why are oil based fuels dominant in the transportation market?

2. What fuels can run an internal combustion engine?



3. How is the internal combustion engine used differently in a hybrid car?

4. What is the drawback of electric cars (run only by an electric motor and battery)?

5. What could be the power source of the car of the future?

2. Oil/Petroleum Infographic
    - Liquid that is pressurized ancient plant material. Original source of energy is the sun with photosynthesis.
    - We use drill bits and precise technology including sonar to find and drill for new oil reserves. This requires a large amount of human input and money to make work.
    - Drilling for oil on land can scar the land as equipment and roads are created to move in and out of locations.
    - Drilling for oil underwater can cause massive oil leaks and spills like BP Deepwater Horizon Oil spill in the Gulf Coast. It causes damage to ecosystems, wildlife (birds) and tourism, recreation of the beaches.
    - Oil must be transported from the location it is found in to the location it will be used. This requires ships, and trucks, and pipelines to move it. These use oil as a transportation fuel, which increases the amount of oil needed to mine.
    - Oil Sands or Tar sands are mined like coal and degrade the land, use large amounts of water, and create water pollution.
    - We are in peak oil production now. Oil reserves are declining.
    - Oil releases a lot of energy when it is burned.
    - Oil is a liquid and is easily stored and transported. It is the major transportation fuel.
    - Before crude oil is burned, it is separated into its different components by fractional distillation. Crude oil becomes: paint thinner, tar, jet fuel, diesel, asphalt, and plastics!
    - When Oil burns, it releases CO_2, H_2O, NO_x. It also is itself a VOC and can evaporate quickly.
        - CO_2, H_2O, and NOx are GHG.
        - NOx is also responsible for Acid deposition.
        - NOx + VOC + Sunlight → Ozone + PANs = photochemical smog
        - Ozone is much worse in the summer due to sunlight driving the reaction.
        - Breathing ozone can trigger a variety of health problems including chest pain, coughing, throat irritation, and congestion. It can worsen bronchitis, emphysema, and asthma. Ground

level ozone also can reduce lung function and inflame the linings of the lungs. Repeated exposure may permanently scar lung tissue.
    - Ozone interferes with the ability of sensitive plants to produce and store food and harms their appearance.
- The top countries with oil reserves are Saudi Arabia, Venezuela, and Canada (tar sands).
- Since 2018, the US has been the top producer and consumer of petroleum because of fracking oil shale.
- Oil makes up about 32% of the world's energy production.

Oil Infographic

NATURAL GAS VIDEOS

ENERGY LAB | WHAT IS NATURAL GAS?

1. Describe natural gas. How is it formed?

2. What are some alternative sources of natural gas that are currently being developed and used?

3. Where is most commercial natural gas found?

4. How is natural gas extracted?

ENERGY LAB | USES OF NATURAL GAS

1. What is natural gas? What can be made from natural gas?

2. What is produced when we oxidize (burn) natural gas? $CH_4 + O_2 \rightarrow$ __________ + __________ + __________

3. What things in your house may be powered directly by natural gas?

4. How much electricity is produced in the U.S. using natural gas as a fuel source?

5. How is natural gas used in transportation?

ENERGY LAB | BENEFITS OF FRACKING

1. Unconventional oil and gas have created over _____ jobs and added over _____ dollars to the U.S. economy.

2. How long will it take these numbers to double?

3. How has the supply of natural gas changed since 2005? How has this affected the price?

4. How do natural gas emissions compare to coal emissions?
5. How have CO_2 emissions changed in the U.S. since 2005? Why?

6. What is happening to CO_2 emissions in developing countries? Why?

ENERGY LAB | RISKS OF FRACKING: WATER

1. What is fracking?

2. How much water does a typical natural gas well use?

3. What makes up frack fluids?

4. What have studies shown about groundwater contamination?

5. What are the likely sources of groundwater contamination?

6. How is frack fluid disposed of after use?

ENERGY LAB | RISKS OF FRACKING: METHANE

1. How might methane get into groundwater?

2. Why are we concerned about methane in the atmosphere?

3. Natural Gas
   - Traditionally found above Oil or Coal reserves.
   - Gas that is pressurized ancient plant material. Original source of energy is the sun with photosynthesis.
   - Untraditionally found in: methane hydrates in ice or below oceans, in deep wells under the water table and hydraulic fracturing is used to remove; can be recaptured from landfills and livestock (dairy farming has cows already inside).
   - Gas is tapped and trapped in a pipe and can be pressurized and transported via pipes.
   - Difficult to transport Natural gas from other continents.
   - Gas burns efficiently releasing a high energy heat.
   - Most natural gas is Methane, but there is some butane and propane as well.
   - When Natural gas burns, it releases CO_2 and H_2O.
     - CH_4, CO_2, and H_2O are all GHGs.
   - Fracking uses large amounts of water, adds chemicals that can be toxic into the water so it is difficult to recycle.
   - Fracking creates small fissures which can increase seismic activity and cause small earthquakes.
   - Natural gas can help transition to energy alternatives.
   - Russia, Iran, and Qatar have the largest reserves, however the US has increased it's production and consumption of natural gas because of Fracking and we are now the number 1 producer and consumer of natural gas.

Natural gas infographic

NOVA Treasures of the Earth - POWER

http://www.pbs.org/wgbh/nova/earth/treasures-earth-power.html

1. Record 3 facts about the electric grid in New York City:

2. Describe how a turbine works to create electricity:

3. Who has the largest coal reserves in the world? _________________________
4. Coal now produces _______________ of our electricity in the US.
5. Which type of coal is the most valuable? ________________________________
6. Coal deposits are found in ancient _______________________________
7. Coal is made out of hydro______________________________
8. When coal is burned, carbon atoms recombine with _____________________________
9. Heat and light is the process of electrons _________________________________
10. Coal drove the _____________________________________revolution.
11. What does oil power?

12. Describe what CO2 does in our atmosphere:

13. Fossil fuels provide _____________% of our worlds energy.
14. How are plastics made from hydrocarbons?

15. How do we benefit from plastic?

16. List some problems with plastics.

17. Why is natural gas seen as a bridge to more sustainable energy?
18. What happens in nuclear fusion?

19. How many TW can the sun produce? __________How many TW do humans need?_____________
20. Why is pure silicon, a semi-conductor, important?

21. How are they trying to bring the cost of PV cells (solar panels) down?

22. How does a PV cell (solar panel) create electricity?

23. What's a drawback to solar energy? How are they trying to solve the problem?

24. Why is lithium used in rechargeable batteries (including your cell phone)?

25. How is China a paradox?

26. Nuclear energy supplies ___________________% of the worlds energy.

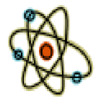
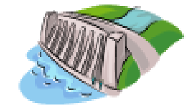
27. Uranium releases ____________________________ naturally

28. How does a uranium reactor work?

29. Nuclear power does NOT release ____________________ in the atmosphere.

30. List one way we are trying to find new energy sources that aren't hydrocarbons.

Chapter 20: Conventional Alternatives to Fossil Fuels

	Nuclear Power (if there is 1 box, write about fission ONLY)		Bioenergy	Hydroelectric Power
	Fission	Fusion		
Description/Definition				
Renewable or nonrenewable?				
State of Technology, Availability, & Economics				
How It is retrieved				
How it produces energy				
Byproducts				
How is the retrieval, building of and/or byproducts harmful or beneficial to the environment?				

NUCLEAR VIDEOS

ENERGY LAB | HOW NUCLEAR WORKS

1. What does nuclear power have in common with conventional fuel power?

2. How is energy released from uranium?

3. How is uranium different than other energy sources?
4. What are the energy densities of the following (MJ/kg)?
   wood _____, sugar _____, coal _____, fat _____, gasoline _____, natural gas _____, hydrogen _____, uranium _____

5. How long will one load of fuel last with a power plant running at full capacity, 24/7?

ENERGY LAB | NUCLEAR RISKS, POTENTIAL SOLUTIONS

1. What is nuclear waste?

2. What do we do with nuclear waste in the U.S.?

3. What are the potential uses for nuclear waste?

4. What does Dr. Tinker mean when he says "proliferation" is a risk of nuclear power?

5. Why was Chernobyl a much worse disaster than Three Mile Island or Fukushima?

6. What is the benefit of the pebble bed, LFTR, or Fusion design for future reactors?

<u>The Eyes of Nye: Nuclear Energy</u>

1. What is being illustrated in the opening sequence with the magician?

2. What are 3 fears from nuclear power plants?

3. What are the 2 major nuclear disasters that have occurred over the past 31 years?

4. How many nuclear power plants are there in the US? _______
5. Describe a nuclear chain reaction.

6. How does the fission of uranium make electricity?
7. How much Electricity can the nuclear generator produce? _______
8. How much nuclear waste does a nuclear power plant make in 60 years? ________

9. Compare that to a coal plants waste. ___________________________
10. What happens to the used cores?

11. Describe the structure of the dry cask storage.

12. What is the radiation level outside of a dry cask? _______ what is the radiation in a dental x-ray? _______
13. How many years would it take for the nuclear waste to be benign? _________
14. What is ionizing radiation? ______________________________ Why is it a problem? ______________________________ How can we protect ourselves from it? _____________________________
15. Where is Yucca Mountain? ____
16. What are we going to do at Yucca Mountain?

17. Why Yucca Mountain?

18. In 1987, Yucca Mountain was designated as the repository for nuclear waste.
19. What is the main concern with storing waste in Yucca Mountain? Why? Is this a large problem in Yucca Mountain? Why or why not?

20. What happened to the radio equipment left in yucca mountain for 6 months?

21. How did the DOE change the rules to still maintain Yucca Mountain as a waste storage site.

22. Where did the 10,000 years number come from?

23. What are some of our problems with enriched plutonium (Pu)?

24. What is a half-life?

25. How long is Pu's ½ life? ___________________________________

26. What is the legal requirement for storing Pu?

27. What do most independent analysts think we should do?

28. How much nuclear waste has been generated since 1945? __________________

29. Why can't we put this nuclear waste into space?

30. What is transmutation?
31. What does Bill Nye think we should do about nuclear power? Do you agree?

Half Life Problems Name______________________Per _______

1. Radon has a half life of 3.8 days. After 7.6 days, 6.5g remain. What was the mass of the original sample?

2. The half life of Cs-137 is 30.2 years. If the initial mass of the sample is 1.00kg, how much will remain after 151 years?

3. Carbon-14 has a half life of 5730 years. Consider a sample of fossilized wood that when alive would have contained 24g of C-14. It now contains 1.5g. How old is the sample?

4. A 64g sample of Germanium-66 is left undisturbed for 12.5 hours. At the end of that period, only 2.0g remain. What is the half life of this material?

5. With a half life of 28.8 years, how long will it take 1g of strontium-90 to decay to 125mg?

6. Co-60 has a half life of 5.3 years. If a pellet that has been in storage for 26.5 years contains 14.5g of Co-60, how much of this radioisotope was present when the pellet was put in storage?

1. Nuclear Fission - Infographic
    - Large amounts of energy are released from the splitting of a heavy unstable atom. We use Uranium -235 or Plutonium-239. Both are unstable isotopes that, when struck by a neutron, split into fission fragments releases large amounts of energy.
    - Nuclear chain reaction. Neutron strikes a U-235 atom which splits into fission fragments and releases neutrons. These neutrons strike other U-235 atoms that split and release fission fragments and neutrons. This cycle is perpetuated and can continue for years.
    - Nuclear reactions are very hot and need to be constantly controlled with large inputs of water. Water cools the reactions and acts a moderator to absorb excess neutrons to help control the reaction.
    - Nuclear power plants have no atmospheric emissions.
    - Nuclear power plants release lots of heat into the atmosphere and local water source as thermal pollution.
    - We mine for Uranium and Plutonium which scars and degrades the land.
    - Nuclear is non-renewable energy.
    - The fission fragments are still radioactive and can emit large amounts of radiation for 10,000-260,000 years. If exposed, this can create radiation poisoning in the water and crops that we grow in addition to causes increased rates of thyroid cancer in people.
    - We cannot turn this radioactive waste into safer substances yet.
    - We know it can take 10,000-260,000 years to make these substances safe because we can calculate the time it takes for ½ of the substance to become stable is a half life. The half life of plutonium is 24,000 years.
    - Waste is stored on site of generation in dry casks.
    - Proposed long term storage site is Yucca Mountain in Nevada. NIMBY
    - Have had 3 serious meltdowns: 3 mile Island in Pennsylvania, Chernobyl in the Ukraine, and Fukushima in Japan . Have caused large amounts of radiation exposure.
    - Price Anderson act in US to reduce liability of nuclear power plants in case of a meltdown.
    - Huge start up costs and maintenance costs
    - France obtains most of its electricity from nuclear power

Nuclear Fission Infographic

1. Hydroelectric (dams)
    - Converts gravitational potential energy into kinetic energy of motion
    - Renewable
    - Powered by the sun powering the water cycle through evaporation and precipitation.
    - Dam holds back water to a high level and then as water is released through the dam, it turns a turbine that is connected to a generator that creates electricity.
    - Dams flood the area behind them, turning the river into a lake/reservoir.
        - Pros: recreation, water for irrigation, power generation, no emissions
        - Cons: high evaporation, loss of habitat above dam and below dam may suffer from lack of sedimentation, loss of salmon/fish spawning grounds, thermal pollution, may displace people/homes
    - 90% of Norway's energy comes from hydro.

2. Biofuels (burning, biodiesel, ethanol)
    - Original source of energy is the sun using photosynthesis
    - Using current plant products (wood, corn, sugar) for fuel
    - No net carbon emissions if using land already used for farming. There is a net carbon increase in the atmosphere if land is cleared or deforested and then planted with crops (corn/sugar).
    - If we use high input agriculture for growing corn or sugar cane to create ethanol for transportation, uses large amounts of water, fossil fuels, fertilizers, pesticides
        - Fertilizers cause eutrophication and dead zones
        - Pesticides cause indiscriminate killing of beneficial species such as bees/pollinators and decomposers
        - Brazil ferments sugar cane into ethanol. New fields in Brazil come from rain forest degredation
    - Burning wood releases lots of smoke, PM, toxins, CO_2 into the atmosphere
    - Novel biomass sources are switch grass and algae that can take in more CO_2 and don't require the high inputs of corn and sugarcane.

Chapter 21: "New" Renewable Energy Options

	Solar Energy			Wind	Geothermal	Hydrogen	Tidal
	Passive Solar	Active Solar	Photovoltaic Cells				
Description/Definition							
State of Technology, Availability, & Economics							
How it produces energy							
Byproducts and regulations associated with energy source							
How is the building of, maintenance and/or byproducts harmful or beneficial to the environment?							

Nova's *Saved by the Sun* Online Video Q&A Worksheet - Visit the following URL, watch each chapter online, and respond to the questions below. http://www.pbs.org/wgbh/nova/solar/program.html

Ch. 1 The Solar Resource

1. Who put solar panels on the White House?
2. How long has solar been around?
3. A solar cell is also called a _______________ cell.
4. If you increase the number of solar rays, you increase your yield of ________.
5. What substance is inside a solar cell?
6. Explain how a solar cell works (press pause to write down your answer).
7. Homes can be powered by a combination of solar energy and energy from the electric _________.
8. When a solar cell generates electricity it is in the form of ________current, so it needs to be transformed into _______ current.

Ch. 2 The Energy Crunch

9. How much does it cost to outfit a home with solar panels?
10. Who can help pay for your solar panels?
11. Reducing your ________ footprint means you reduce _________ gas which reduces global __________.
12. Name 3 effects of climate change (global warming).
    a)
    b)
    c)
13. The energy obtained from solar cells is hard to _________.
14. The grid manager oversees the supply and demand of _________.
15. What will happen if your community exceeds its energy supply?
16. For any particular area, when energy supply doesn't meet the demand, we have to get energy from ____________ and ___________ energies.

Ch. 3 Powering City Life

17. Burning fossil fuels exacerbates ____________ _____________.
18. The fear with nuclear power is ______________________________________.
19. Cramer Junction, the biggest solar _________ plant in the world, uses a trough of _________ to heat up a tube of synthetic oil.
20. __________ powers turbines, which generates electricity.
21. In the process of transferring energy, some of it is _____________.
22. What popular city is expanding its use of solar energy?
23. Can batteries store solar energy that gets produced in the daytime?

Ch. 4 The German Experiment

24. By 2020, what percentage of Germany's energy will come from solar?
25. German panel owners make _______ for installing solar panels.
26. Despite the high cost of solar energy in their country, Germans like solar panels because it helps save the _________________ for future generations.
27. Mass production of solar panels means more __________ and lower __________.

Ch. 5 Good Business?

28. The USA gets what percentage of its energy from solar and wind energies?
29. What grocery store has installed solar panels on its roof?
30. Solar energy can offset the high cost of grid energy during peak hours (i.e., when air conditioning is being used the most). In what season, and during what time of day is grid energy most expensive?
31. ________ is a company that installs solar panels on retails stores to make long-term gains.
32. More advanced solar cells, like multi-junction cells, are more efficient because they can absorb additional _______________ of light.

Ch. 6 The Future Energy Mix

1. Because of advanced solar panels, the Rovers on Planet __________ have lasted ____________ years instead of 3 months.
2. What might help lower the cost of solar panels?
3. Lovins aims to wean the USA off of fossil fuels by __________.
4. What US state is leading the country in the early stages of its solar revolution?

1. Solar
   - PV uses solar radiation to excite and electron and generate and electric current.
     - Sets of PV are called arrays
     - Made of silicon and some metals
     - Difficult to store this energy once it is produced. Developing batteries
     - Only generates electricity in sunny weather. Not on cloudy days or at night.
   - Concentrated Solar Power uses mirrors to intensify solar energy and heat an oil that converts to steam that turns a turbine which powers a generator which makes electricity
     - In very sunny areas/deserts
     - Centralized energy source as opposed to decentralized energy sources on rooftops
   - No emissions
   - High start up costs, but costs are being subsidized and going down and technology and demand increase.

2. Geothermal
    - Energy from the heat and magma inside the earth surface.
    - Only in areas with seismic activity, earthquakes, volcanoes, hot springs.
    - Can use hot water directly or convert hot water into steam to turn turbines, turn a generator and create electricity.
    - Ground-source heat pumps can use heat transfer to efficiently heat and cool buildings by transferring hot water and cool water into homes from the ground.
    - Iceland gets the majority of its power from geothermal.

3.Wind

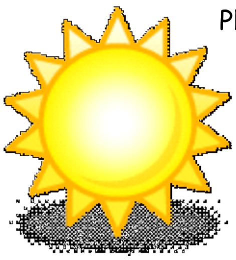
- Turbines are powered by wind currents. Connected to generators that convert into electricity
- Wind is formed because of the uneven heating of the earth. The original source of energy is the sun.
- Wind farms are in areas with high wind generation: On mountain ridges or offshore have the highest wind generating potential.
- No emissions
- Produce 20xs more energy than they consume
- Wind power varies with time and weather
- Wind turbines kill may birds
- Have some noise pollution and visual pollution (NIMBY) with offshore wind

4.Tidal Energy

- Like dams, erect a dam across the outlets of tidal basins with extreme tides.
- As tide goes out, water is held back. When a certain gradient is reached, water is allowed to flow, like it does in a dam, and turns a turbine, generator, electricity is generated.
- Fish and marine organisms can get chewed up in the turbines.
- Bay of Fundy in Canada

5. Hydrogen

a. Generated from electrolysis of water: $H_2O \rightarrow H_2 + O_2$
b. Hydrogen is a potential transportation fuel
c. Required high energy input and uses expensive metals like Platinum in electrolysis process.
d. Clean emissions of H_2O when burned
e. Energy efficient and quiet



Photovoltaic Power – practice with West Ranch High School

https://easyview.auroravision.net/easyview/index.html?entityId=967882

A grid-connected PV system is placed on the parking lot of West Ranch HS. The PV array with an area equal to 300 square meters (about 3, 000 square feet) the parking lot and is south-facing. The power rating of this PV system is 200kW, meaning that it will produce 200 kW under peak sunlight conditions. The installed cost of this system is $1,000,000.

1. The PV system is operating in a location where the annual average daily incident solar energy (the insolation) on the array equals 200 kWh/m2/day. Calculate the average amount of solar energy incident on the PV array each day.

Answer__________ (kWh/day)

2. The efficiency of the PV system equals 10 percent (that is, 10 percent of the solar energy incident on the array is transformed into useful electric power). Calculate the daily average electric energy produced by this system.

Answer____________ (kWh/day)

3. Calculate the average amount of electric energy produced by this system each year.

Answer____________ (kWh/year)

4. Over the next 20 years, U.S. annual electric energy consumption is projected to increase by 1.5 trillion kWh. How many parking lot PV systems would be needed to supply 10 percent of this additional energy?

Answer_____________

5. Calculate the cost of installing these PV systems.

Answer____________ ($)

6. Assuming the electric energy produced by these PV systems is worth 10 cents per kilowatt-hour, these residential systems would generate electric energy worth $5 billion/year. Calculate the simple payback period for these PV systems. (Payback period is the time it takes for a system's net benefits to equal its cost.)

Answer______________ (years)

Anaerobic methane digesters have been used for many years to reduce energy costs on farms throughout Europe and on some large farms in the United States. The digesters operate by using anaerobic bacteria to break down animal waste. During the process, which typically uses a tank heated to about 100°F (38°C) to speed the reactions, raw manure is broken down and methane is produced. The methane can then be used to generate electricity or produce heat.

For a certain dairy farm with 500 cows, the cost of installing a digester is approximately $400,000. Assume that the farm uses 800,000 kilowatt-hours (kWh) of electricity each year at a cost of $0.10 per kWh. The waste from a single cow can produce 3.0 kWh of electricity each day.

(a) Describe the steps by which methane produced in the digester can be used to generate electricity.

(b) Discuss TWO environmental benefits that may result from the installation of an anaerobic methane digester.

(c) Assuming that the cost of electricity remains constant and the farmer starts using the manure from the cows in an anaerobic digester to produce electricity on the farm, calculate:

(i) The number of kWh of electricity that can be produced in one year

(ii) The amount of money the farmer can save in one year, NOT counting the installation cost of the digester. (You may round your answer to the nearest $1,000.)

(iii) The amount of time, in years, that it will take to recover the cost of installing an anaerobic digester on the farm. (You may round your answer to the nearest whole number of years.)

(d) Calculate the minimum number of cows the farm would need to produce 800,000 kWh of electricity per year.

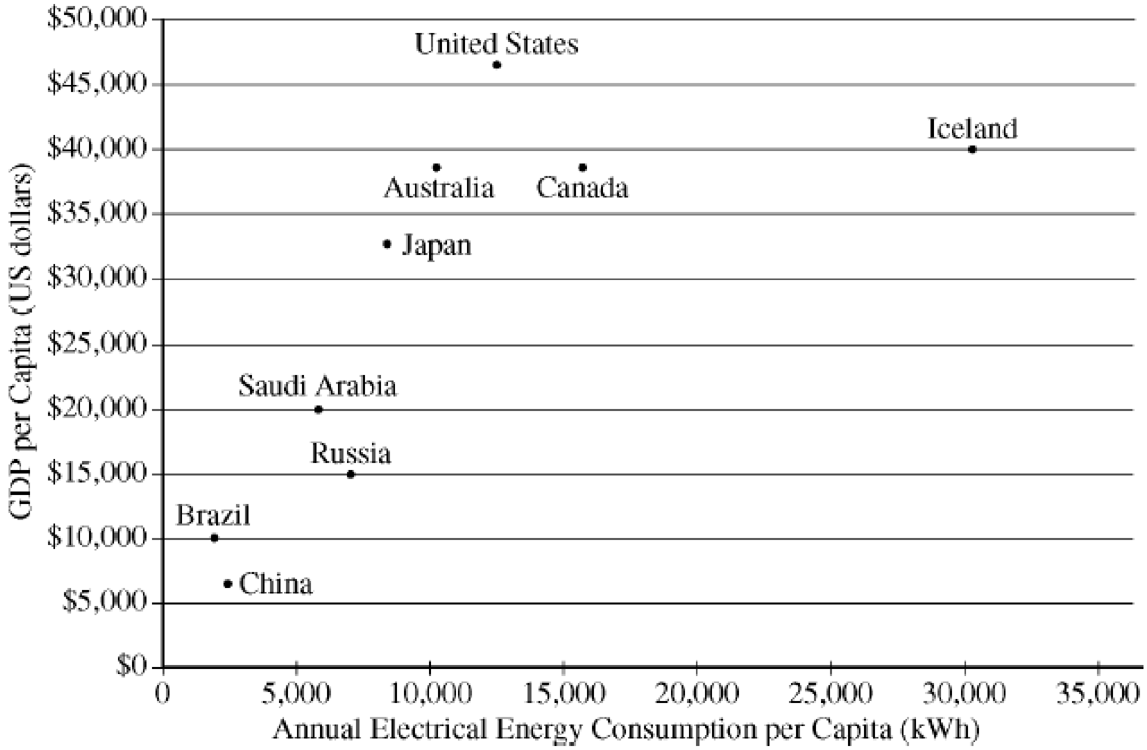
a.

b. benefit 1	Benefit 2

c. i. (how many days are in a year?)
ii.
iii.

d.

GDP VERSUS ANNUAL ELECTRICAL ENERGY CONSUMPTION (2009)



Shown above is a graph of the gross domestic product (GDP) per capita versus the annual electrical energy consumption per capita for nine countries in 2009.

(a) Iceland's position on the graph is due in part to its access to geothermal energy sources. Describe how electricity is generated from a geothermal source.

(b) Despite its low GDP per capita and low annual electrical energy consumption per capita, China has become the world's largest emitter of CO_2. Explain this apparent contradiction.

(c) In addition to contributing to increased atmospheric CO_2 concentrations, China is facing other air pollution issues related to the generation of electricity. Identify one such issue and describe the impact it has on human health.

(d) Two countries shown on the graph have developed domestic energy sources: sugarcane in Brazil and tar sands in western Canada.

(i) Choose EITHER sugarcane or tar sands, then briefly describe the process of fuel production from that energy source.

(ii) Describe TWO disadvantages of using the energy source that you chose in part (d)(i).

(iii) Which of the two energy sources is more sustainable? Justify your answer with an explanation.

a.Describe geothermal energy production

b. Explain contradiction

c.ID air pollutant	Health issue

d. Tar sands		sugarcane	
i.		i.	
ii.		ii.	
iii. more/less sustainable	Justification	More/less sustainable	justification

The Fremont School District uses oil to heat school buildings. Go Green! is a new project the district will implement. The superintendent has declared that the district will dedicate itself to reducing its carbon footprint. In addition to taking serious energy-conservation measures, the district is planning to help offset its carbon dioxide emissions by raising money to help conserve a portion of a large tract of forest land adjacent to the high school campus.

(a) Describe one alternative energy source that would reduce the carbon footprint of the school district. Discuss one environmental benefit (other than reduced CO_2 emissions) and one environmental drawback of using the alternative source instead of fuel oil.

(b) Identify TWO ecological benefits provided by intact forest ecosystems (other than reducing CO_2 levels in the atmosphere).

(c) Use the assumptions below to answer the questions that follow. For each calculation, show all work.

The biomass of the forest increases at an annual rate of 2.7×10^5 kg/ha.
The forest biomass is 50 percent carbon by mass.
Each year the district uses 3.0×10^5 gallons of fuel oil for heating and hot water.
10 kg of CO_2 is produced when 1 gallon of fuel oil is burned.
1.0 kg of CO_2 contains 0.27 kg of carbon.
The cost of putting 1 ha of the forest into conservancy is $12,000.

(i) Calculate the mass of carbon, in kg, that is accumulated and stored in 1.0 ha of forest in one year.

(ii) Calculate the mass of carbon, in kg, that is emitted by the school as a result of its fuel-oil consumption in one year.

(iii) Calculate the number of hectares of forest the school district needs to conserve in order to offset the carbon released in one year by the school burning its fuel oil.

(iv) Calculate the amount of money the school district must raise for the conservation project.

a.Describe alternative (how get energy from it)	Environmental benefit (not reduced CO_2)	Environmental drawback

b. ecological benefits of forests

1	2

c.

i.
ii.
iii.
iv.

Read the article below and answer the questions that follow.

The Fremont Plaindealer May 1, 2013

Last night the county council discussed a motion to support the construction of a new nuclear power plant on the Fremont River to address the rising demand for electrical power in Fremont County. Councilperson Pamela Kull spoke in support of the plant, remarking that "nuclear power plants produce no dangerous solid waste" and "using nuclear power avoids the release of greenhouse gases."

Councilperson Chinh Serach said that Dr. Kull's remarks were incorrect and then introduced a different motion to provide funding to help Fremont homeowners and businesses reduce electricity use. He stated that such steps could make building the nuclear plant unnecessary.

(a) State whether you agree or disagree with each of the following remarks made by Dr. Kull. For each remark, provide one justification for your position.

(i) "Nuclear power plants produce no dangerous solid waste."

(ii) "Using nuclear power avoids the release of greenhouse gases."

(b) If the plan for a nuclear power plant in Fremont is approved, it will take several years for the plant to be built. **Describe** TWO environmental problems that could result from the construction of the plant (i.e., prior to operation).

(c) Suppose that the nuclear power plant is constructed on the Fremont River site.

(i) **Identify** the most likely pollution threat that the plant will pose to the Fremont River as a result of the plant's normal daily operation.

(ii) **Discuss** one potential ecological consequence of the pollution threat that you identified in part (i).

(iii) **Identify** a system often used in nuclear power plants to reduce the pollution you identified in part (i).

(d) **Describe** TWO specific steps that Fremont residents and/or businesses could take to reduce the use of electricity.

(e) **Identify** a specific nuclear power plant at which a major accident has occurred. **Explain** one environmental consequence (other than effects on human health) of a nuclear power plant accident.

Nuclear Power FRQ Answer Sheet

i. Agree/disagree	Justification: (evidence, example, or quote)
ii. Agree/disagree	Justification: (evidence, example, or quote)

b. 2 problems with construction of the plant

Problem 1
Problem 2

c.

i.
ii.
iii.

d.

e.ID	Explain environmental consequence (not health)

Energy Resources and Consumption REVIEW

1) Energy Concepts
   (Energy forms; power; units; conversions; Laws of Thermodynamics)
   a) What are the 2 forms of energy? ________________ and ___________________
   b) What are 2 units for energy? __________________ and ___________________
   c) What are the 2 Laws of Thermodynamics?
      i) ____
      ii) ____
2) Energy Consumption
   a) History
      (Industrial Revolution; exponential growth; energy crisis)
      i) How did we change energy consumption after the industrial revolution? What is the major source of energy now?
         ____
         ____
      ii) How has exponential population growth changed our energy consumption?____
         ____
      iii) Describe how our current use of energy and population growth has created an energy crisis.
         ____
         ____
         ____
   b) Present global energy use
      i) What are the 3 major sources of energy globally? _______________________________
      ii) What is the main energy source in France? ____________________________________
      iii) What is the main energy source in Iceland? ___________________________________
   c) Future energy needs
      i) As population grows, how will our future energy needs change?
         ____
         ____
3) Fossil Fuel Resources and Use
   (Formation of coal, oil, and natural gas; extraction/purification methods; world reserves and global demand; synfuels; environmental advantages/disadvantages of sources)
   a) What are the four stages of coal formation?
      i) ________________________
      ii) ________________________
      iii) ________________________
      iv) _________________________
   b) How did oil form? What is it made out of?
      ____
      ____
   c) What is Oil Shale? ____
   d) What is Oil Sand or Tar Sand? ____
   e) Where can we find natural gas reserves? ____
   f) How do we purify or refine crude oil into oil (hint, it has to do with heating it up).____
   g) What countries have the most coal? ____

h) What countries have the most oil? ____
i) What countries are increasing their demand for fossil fuels? _________________________
j) List 3 disadvantages of using fossil fuels:
   i) ____
   ii) ____
   iii) ____
k) List 3 advantages of using fossil fuels:
   i) ____
   ii) ____
   iii) ____

4) Nuclear Energy
(Nuclear fission process; nuclear fuel; electricity production; nuclear reactor types; environmental advantages/disadvantages; safety issues; radiation and human health; radioactive wastes; nuclear fusion)

a) Describe nuclear fission chain reaction.
   ____
   ____
   ____
b) What are the two elements used in a nuclear power plant? _____________ and __________
c) Describe how a nuclear power plant converts a nuclear reaction into electricity.
   ____
   ____
   ____
d) What are the types of nuclear reactors? ____
e) List 2 advantages of nuclear power:
   i) ____
   ii) ____
f) List 3 disadvantages of nuclear power:
   i) ____
   ii) ____
   iii) ____
g) Identify and describe 3 nuclear disasters that have occurred in the past.
   i) ____
   ii) ____
   iii) ____
h) Describe 2 ways that nuclear power plants pose a safety risk.
   i) ____
   ii) ____
i) Describe how radiation exposure can be harmful to human health.
   i) ____
j) Where is all nuclear waste stored now? ____________________________
k) What is the proposed site of nuclear waste storage? ________________________
l) Why is nuclear waste so harmful? ____
m) What is the amount of years required to legally store nuclear waste? __________________
n) What is the ½ life of Plutonium? __________________________
o) After 10 half lives, Plutonium will be safe. In how many years will Plutonium be safe?

p) What is nuclear fusion?
____
____

q) Where do we find nuclear fusion in nature? _______________________________

5) Hydroelectric Power
(Dams; flood control; salmon; silting; other impacts)
a) Describe how hydroelectric power is generated.
____
____

b) List 5 disadvantages of dams.
i) ____
ii) ____
iii) ____
iv) ____
v) ____

c) List 5 advantages of dams.
i) ____
ii) ____
iii) ____
iv) ____
v) ____

d) Where and what is the largest dam in the world? ____________________________

6) Energy Conservation
(Energy efficiency; CAFE standards; hybrid electric vehicles; mass transit)
a) What is the formula for energy efficiency? ________________________________
b) If you use 2000BTU of coal and your furnace is 70% efficient, what is the amount of heat that will be given off by the furnace? ___________________________________
c) What are the CAFÉ standards? ____
d) List 4 ways to conserve energy:
i) ____
ii) ____
iii) ____
iv) ____

7) Renewable Energy
(Solar energy; solar electricity; hydrogen fuel cells; biomass; wind energy; small-scale hydroelectric; ocean waves and tidal energy; geothermal; environmental advantages/disadvantages)
a) Describe high heat solar energy
(mirrors).____
____

b) Describe photovoltaic solar energy (solar panels)
____
____

c) Identify and describe 2 advantages and 2 disadvantages of solar energy
i) ____
ii) ____
iii) ____
iv) ____

d) Describe biomass from burning material, ethanol, and methanol.

____

______________________________ ________________________

e) Describe wind energy.

____

____

f) Identify and describe 2 advantages and 2 disadvantages of wind turbines.

i) ____

ii) ____

iii) ____

iv) ____

g) Describe geothermal energy.

____

____

h) Identify and describe 2 advantages and 2 disadvantages of geothermal energy.

i) ____

ii) ____

iii) ____

iv) ____

Questions 5-9 refer to the locations indicated on the diagram below.

5. Large quantities of methane hydrates are located in this region and if released will contribute significantly to global climate change.

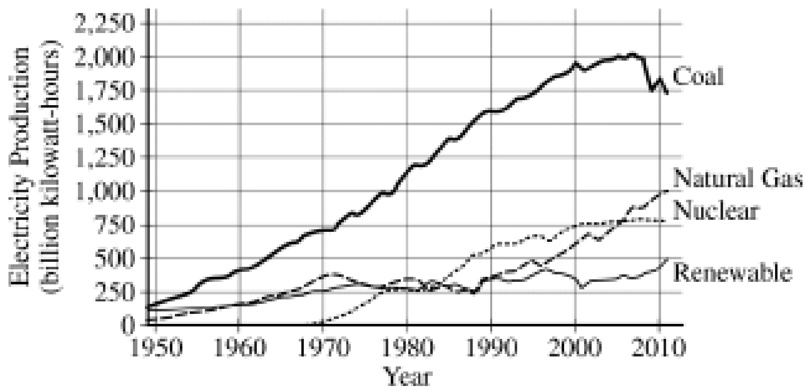
6. This region of the world is currently experiencing the largest average annual temperature increase because of anthropogenic climate change.

7. Damaging tornadoes occur most frequently in this area.

8. Fragmentation of tropical forests due to human activities is leading to a significant loss of biodiversity in this area.

9. This region has been the largest petroleum exporter for the past four decades.

SOURCES OF ELECTRICITY IN THE UNITED STATES, 1950–2010



40. Which of the following is the most valid inference regarding electricity production, based on the graph above?

(A) Electricity production from coal began to decrease in 2008 because of shortages in coal supplies.
(B) Electricity production from coal began to decrease in 2008 because of the increasing use of natural gas and renewable energy.
(C) The use of nuclear energy increased from 1970 to 2010 because of the low cost of constructing nuclear power plants.
(D) The use of nuclear energy increased from 1970 to 2010 because of shortages in coal supplies.
(E) Renewable energy has not increased as much as nuclear energy has since 1970 because of federal laws restricting construction of wind farms.

44. Which of the following is considered an advantage of using nuclear power to generate electricity?

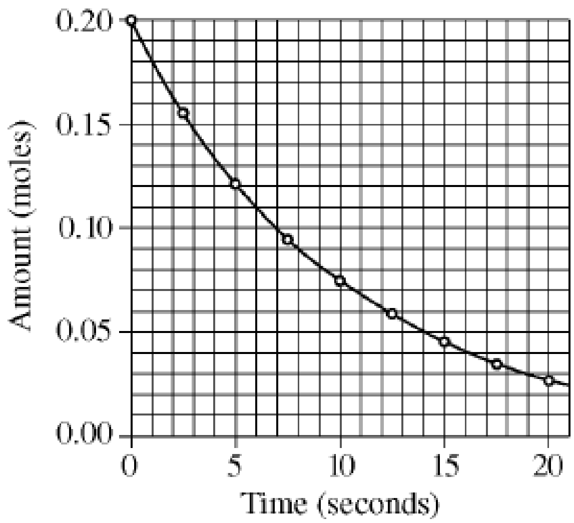
(A) No waste is generated.
(B) There is a limitless supply of the raw material needed for the process of generating energy.
(C) Nuclear power plants are inexpensive to build and maintain.
(D) There is no potential for thermal pollution.
(E) There is no CO_2 emitted from the nuclear reaction.

57. Hydraulic fracturing, or fracking, is the pumping of highly pressurized water with a mixture of sand and chemicals into boreholes to

(A) create cracks within the rock in order to provide pathways for the release of gas and oil
(B) pulverize the rock in order to let gas and oil rise through the soil horizons
(C) reopen old mine shafts, from which gas and oil can be collected
(D) create seismic movement and artificial earthquakes in order to liberate gas and oil
(E) supersaturate the rock with the fracking fluid, which scrubs gas and oil from the rock by abrasion

56. A family of five recently replaced its 5-gallon-per-minute showerheads with water-saving 2-gallon-per-minute showerheads. Each member of the family averages 8 minutes in the shower per day. In a 30-day period, how many fewer gallons of water will the family use with the new showerheads?

(A) 60
(B) 800
(C) 2,400
(D) 3,600
(E) 7,200



63. The half-life of a radioactive substance with the decay rate shown in the graph above is closest to

(A) 5 seconds
(B) 7 seconds
(C) 14 seconds
(D) 18 seconds
(E) 21 seconds

76. Consumers who get their electricity from coal-fired power plants are not paying the true cost of energy production in their monthly utility bills. Which of the following is true about utility bills for these consumers?

(A) The bills do not include public health costs, such as those associated with air pollution.
(B) The bills do not include the cost of power distribution.
(C) The bills do not include the cost of marketing electricity.
(D) The bills include the cost of environmental damage associated with transporting coal.
(E) The bills include the cost of cleaning up acid mine damage.

77. Which of the following is an example of a carbon sink?

(A) Deposition of organic matter on the deep ocean floor
(B) Clearing of trees in the Amazon forest
(C) Combustion of fossil fuels in power plants
(D) Decomposition of food waste by bacteria
(E) Nutrient uptake by the roots of grasses in a suburban lawn

67. A major limitation of using photovoltaic cells to generate electricity is that they

(A) do not produce as much CO_2 as other energy sources do
(B) do not produce as much electricity on cloudy days
(C) have no moving parts
(D) present a danger to birds and bats
(E) cannot be connected to the electrical grid

68. Major anthropogenic sources of nitrogen pollution include commercial fertilizers, vehicle exhaust, industrial air pollution, and

(A) disposal of refrigeration units
(B) discharge of sewage to surface waters
(C) ocean dumping of trash
(D) use of persistent pesticides
(E) oil spills like those in the Gulf of Mexico

69. Burning one gallon of gasoline in a car releases approximately 20 pounds of CO_2 into the atmosphere.

One person drives 60,000 miles in a car that averages 30 miles per gallon (mpg), while another person drives 60,000 miles in a car that averages 20 mpg. Over the course of the 60,000 miles, how many fewer pounds of CO_2 are released by the 30 mpg car than by the 20 mpg car?

(A) 2,000
(B) 8,000
(C) 20,000
(D) 80,000
(E) 100,000

91. Carbon dioxide and particulates are emitted by volcanoes. Particulates form stratospheric aerosols that reflect sunlight. Which of the following best describes the impact of atmospheric carbon dioxide and stratospheric aerosols?

(A) Carbon dioxide contributes to global warming, and aerosols cause cooling.
(B) Both carbon dioxide and aerosols contribute to global warming.
(C) Carbon dioxide contributes to global warming, and aerosols have no effect on global climate.
(D) Carbon dioxide reacts to form aerosols, leading to decreased global warming.
(E) UV radiation causes carbon dioxide to break down, leading to increased stratospheric cooling.

92. Recent studies have found that fine particulate matter with a diameter of 2.5 μm or less can have negative human health effects. Which of the following correctly links a negative human health effect to an anthropogenic source of fine particulate matter?

(A) High rates of respiratory disease from power plant emissions
(B) High rates of skin cancer in urban areas with sewage treatment plants
(C) High rates of asthma from salt spray in coastal communities
(D) High rates of genetic deformities from additives in food supplies
(E) High rates of obesity from exposure to waste from meatpacking

93. Water vapor is a greenhouse gas and is produced by burning fossil fuels. However, anthropogenic water vapor does not contribute significantly to global warming because water vapor

(A) is naturally occurring and therefore will not harm the environment
(B) does not absorb energy
(C) has a short residence time in the atmosphere
(D) does not contain carbon
(E) has no global-warming potential (GWP)

Essential Knowledge

Nonrenewable energy sources are those that exist in a fixed amount and involve energy transformation that cannot be easily replaced.
Renewable energy sources are those that can be replenished naturally, at or near the rate of consumption, and reused.
The use of energy resources is not evenly distributed between developed and developing countries.
The most widely used sources of energy globally are fossil fuels.
As developing countries become more developed, their reliance on fossil fuels for energy increases.
As the world becomes more industrialized, the demand for energy increases.
Availability, price, and governmental regulations influence which energy sources people use and how they use them.
The global distribution of natural energy resources, such as ores, coal, crude oil, and gas, is not uniform and depends on regions' geologic history
Peat is partially decomposed organic material that can be burned for fuel.
Three types of coal used for fuel are lignite, bituminous, and anthracite. Heat, pressure, and depth of burial contribute to the development of various coal types and their qualities.
Natural gas, the cleanest of the fossil fuels, is mostly methane.
Crude oil can be recovered from tar sands, which are a combination of clay, sand, water, and bitumen.
Fossil fuels can be made into specific fuel types for specialized uses (e.g., in motor vehicles).
The combustion of fossil fuels is a chemical reaction between the fuel and oxygen that yields carbon dioxide and water and releases energy.
Energy from fossil fuels is produced by burning those fuels to generate heat, which then turns water into steam. That steam turns a turbine, which generates electricity.
Humans use a variety of methods to extract fossil fuels from the earth for energy generation.
Hydrologic fracturing (fracking) can cause groundwater contamination and the release of volatile organic compounds.
Cogeneration occurs when a fuel source is used to generate both useful heat and electricity
Some of the methods for conserving energy around a home include adjusting the thermostat to reduce the use of heat and air conditioning, conserving water, use of energy-efficient appliances, and conservation landscaping.
Methods for conserving energy on a large scale include improving fuel economy for vehicles, using BEVs (battery electric vehicles) and hybrid vehicles, using public transportation, and implementing green building design features.
Nuclear power is generated through fission, where atoms of Uranium-235, which are stored in fuel rods, are split into smaller parts after being struck by a neutron. Nuclear fission releases a large amount of heat, which is used to generate steam, which powers a turbine and generates electricity
Radioactivity occurs when the nucleus of a radioactive isotope loses energy by emitting radiation.
Uranium-235 remains radioactive for a long time, which leads to the problems associated with the disposal of nuclear waste.
Nuclear power generation is a nonrenewable energy source. Nuclear power is considered a cleaner energy source because it does not produce air pollutants, but it does release thermal pollution and hazardous solid waste.

Three Mile Island, Chernobyl, and Fukushima are three cases where accidents or natural disasters led to the release of radiation. These releases have had short- and long-term impacts on the environment.
A radioactive element's half-life can be used to calculate a variety of things, including the rate of decay and the radioactivity level at specific points in time.
Wood is commonly used as fuel in the forms of firewood and charcoal. It is often used in developing countries because it is easily accessible.
Burning of biomass produces heat for energy at a relatively low cost, but it also produces carbon dioxide, carbon monoxide, nitrogen oxides, particulates, and volatile organic compounds. The overharvesting of trees for fuel also causes deforestation.
Ethanol can be used as a substitute for gasoline. Burning ethanol does not introduce additional carbon into the atmosphere via combustion, but the energy return on energy investment for ethanol is low.
Hydroelectric power can be generated in several ways. Dams built across rivers collect water in reservoirs. The moving water can be used to spin a turbine. Turbines can also be placed in small rivers, where the flowing water spins the turbine.
Hydroelectric power does not generate air pollution or waste, but construction of the power plants can be expensive, and there may be a loss of or change in habitats following the construction of dams.
Photovoltaic solar cells capture light energy from the sun and transform it directly into electrical energy. Their use is limited by the availability of sunlight.
Active solar energy systems use solar energy to heat a liquid through mechanical and electric equipment to collect and store the energy captured from the sun.
Passive solar energy systems absorb heat directly from the sun without the use of mechanical and electric equipment, and energy cannot be collected or stored.
Solar energy systems have low environmental impact and produce clean energy, but they can be expensive. Large solar energy farms may negatively impact desert ecosystems.
Wind turbines use the kinetic energy of moving air to spin a turbine, which in turn converts the mechanical energy of the turbine into electricity.
Wind energy is a renewable, clean source of energy. However, birds and bats may be killed if they fly into the spinning turbine blades.
Geothermal energy is obtained by using the heat stored in the Earth's interior to heat up water, which is brought back to the surface as steam. The steam is used to drive an electric generator.
The cost of accessing geothermal energy can be prohibitively expensive, as is not easily accessible in many parts of the world. In addition, it can cause the release of hydrogen sulfide.
Tidal energy uses the energy produced by tidal flows to turn a turbine.
Hydrogen fuel cells are an alternate to nonrenewable fuel sources. They use hydrogen as fuel, combining the hydrogen and oxygen in the air to form water and release energy (electricity) in the process. Water is the product (emission) of a fuel cell.
Hydrogen fuel cells have low environmental impact and produce no carbon dioxide when the hydrogen is produced from water. However, the technology is expensive and energy is still needed to create the hydrogen gas used in the fuel cell.