Facts About Renewable Energy

Introduction

In the 1970s and early 1980s, there was great national interest in energy policy and energy conservation. This was primarily due to the huge increase in the price of oil, caused by reductions in oil supplies as a result of the OPEC oil embargo in 1973 and the Iranian hostage crisis in 1979. The higher price for oil spurred private and governmental development of renewable energy sources such as, solar power, wind, geothermal, and biomass. In the late 1980s, however, the national commitment to renewable energy waned as the price of oil plummeted. Neither the government, nor consumers, were willing to invest in more costly renewable energy sources and programs when nonrenewable fossil fuels were so inexpensive.

I wonder...

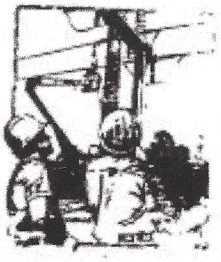
In recent years, there has been a greater interest in the issue of energy, especially renewable energy. This interest has *not* been the result of rapidly increasing energy prices –nonrenewable energy, including oil, is abundant and relatively inexpensive. Rather, the renewed interest has been because of *environmental* concerns, especially the burning of fossil fuels, which many believe contributes significantly to acid rain and global warming. Another factor contributing to the interest in energy issues is the realization of the United States' increasing dependence on foreign oil. This was highlighted by the war in the Persian Gulf.

I agree

Public policy issues involving energy have tremendous economic implications. To ensure wise public policy, citizens and decisiomnakers must not only understand basic facts about energy sources, but also must know how to apply basic economic concepts in their analysis of energy issues.

I agree

Energy Basics

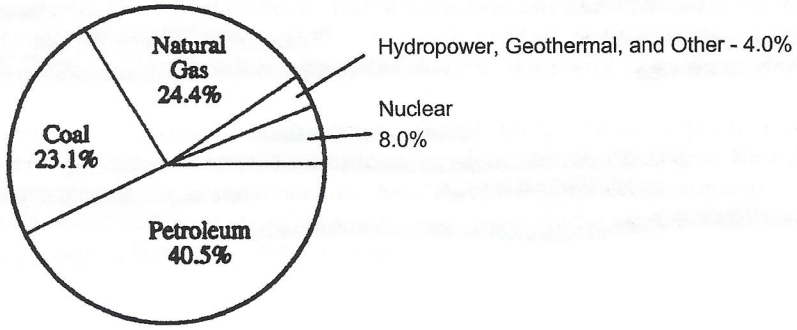


MEASURING ENERGY: **Energy** can be defined as the capacity to do work. The unit of measurement used to express the heat contained in energy resources is called a **British thermal unit** or **Btu**. One Btu is the heat energy needed to raise the temperature of one pound of water one degree Fahrenheit. A Btu is quite small. For example, if allowed to burn completely, a wooden kitchen match gives off one Btu of energy. A quad is used to measure very large amounts of energy. A quad is equal to one quadrillion (1,OOO,OOO,OOO,OOO,OOO) Btu's. The United States uses an enormous amount of energy –about one quad of energy eveiy 4.5 days!

Wow!

ENERGY SOURCES: There are many **primary energy sources** used in the United States, including petroleum, coal, natural gas, nuclear, hydropower, propane, geothermal, wind, solar, and biomass. Figure 3-1 shows the breakdown by energy source.

Figure 3.1
U.S. Consumption of Primary Energy (1991)
(Percent)



I understand this

These primary energy sources are classified as renewable or nonrenewable. **Renewable energy sources** are those that can be replenished quickly or that are nondepletable. Examples include solar, hydropower, wind, geothermal, and biomass. **Nonrenewable energy sources** are finite. If we continue to use them, at some point they will run out. Examples are fossil fuels such as coal, petroleum, and natural gas.

Cool!

ELECTRICITY: Electricity is a **secondary energy source**, which means that we must use primary sources to produce it. About 28 percent of all primary energy consumed in the United States is used to generate electricity. Coal, nuclear, hydropower, natural gas, and petroleum are the top five primary sources for producing electricity. Unlike the primary sources, electricity is not classified as renewable or nonrenewable.

TRENDS IN UNITED STATES ENERGY CONSUMPTION: As the economy and population of the United States have grown, so has energy consumption. However, this increase has been marked by remarkable increases in **energy efficiency**. For example, in 1989, the United States used about 9 percent more energy that it did in 1973; however, the value of the nation's real gross **domestic product GDP** (the total value of all the goods and services produced in the economy in a year) was 46 percent higher! The United States has improved its energy/GDP ratio as fast or faster than other developed countries. This improvement in energy efficiency was largely a response to the rapid increases in crude oil prices in the 1970s.

WOW!!

Renewable Energy Sources

Wow!

RECENT TRENDS: In the 1970s, the federal government's renewable energy program grew rapidly to include not only basic and applied **research and development (R & D)**, but also participation in private sector initiatives. In the 1980s, this interest waned as the price of oil fell. In constant dollar (real) terms, government spending for R&D in renewable energy declined 90 percent from a peak of $875 million in 1979 to a low of $84 million in 1990. In 1990, this trend was reversed. Constant dollar R&D spending in 1992 was $146 million, and it appears likely there will be additional funding for additional renewable energy programs. This funding increase reflects fears of environmental damage from burning fossil fuels, especially acid rain and global warming.

To what extent the United States continues to subsidize the development of renewable energy will be a subject of much future debate.

RENEWABLE ENERGY SOURCES: The information below identifies basic facts about the different renewable energy sources, and lists some advantages and disadvantages of each source.

I Know this info

Solar Energy: **Solar energy** is produced in the core of the sun. In a process called **nuclear fusion**, the intense heat in the sun causes hydrogen atoms to break apart and fuse together to form helium atoms. A very small amount of mass is lost in this process. This lost matter is emitted into space as radiant energy. Less than 1 percent of this energy reaches the earth, yet it is enough to provide all of the earth's energy needs. The sun's energy travels at the speed of light, 186,000 miles per second, and reaches the earth in about eight minutes. Capturing the sun's energy is not easy, since solar energy is spread out over such a large area. The energy a specific land area receives depends on factors such as time of day, season of the year, cloudiness of the sky, and proximity to the equator.

New info, Wow!

One primary use of solar energy is **home heating**. There are two basic kinds of solar heating systems: active and passive. In an **active system**, special equipment (such as solar collectors) is used to collect and distribute the solar energy. In a **passive system**, the home is designed to let in large amounts of sunlight. The heat produced from the light is trapped inside. A passive system does not rely on special mechanical equipment.

I Know this info

Another primary use of solar energy is **producing electricity**. The most familiar way is using **photovoltaic (PV) cells**, which are used to power toys, calculators, and roadside telephone call boxes. The other primary way to produce electricity is using **solar thermal systems**. Large collectors concentrate the sunlight onto a receiver to superheat a liquid, which is used to make steam to power electrical generators.

Advantages of Solar Energy	Disadvantages of Solar Energy
• Unlimited supply	• May not be cost effective
• Causes no air or water pollution	• Storage and backup are necessary
	• Reliability depends on availability of sunlight

I Know this info

Hydropower **Hydropower** is energy that comes from the force of moving water. Hydropower is a renewable energy source because it is replenished constantly by the fall and flow of snow and rainfall in the **water cycle**. As water flows through devices such as a water wheel or turbine, the **kinetic** (motion) **energy** of the water is converted to **mechanical energy**, which can be used to grind grain, drive a sawmill, pump water, or produce electricity.

Wow!

The primary way hydropower is used today in the United States is to produce electricity. In 1991, hydropower provided 10 percent of the nation's electricity. Although a hydroelectric power plant is initially expensive to build, in the long run, it is the cheapest way to produce electricity, primarily because the energy source, moving water, is free. Recently, many people have built smaller hydroelectric systems that produce only enough electricity to power a few homes.

Detailed fact sheets for middle and high school students on all the renewable and nonrenewable energy sources are available from the National Energy Education Development Project (NEED), 102 Elden St., Suite 15, Herndon, VA 20170, telephone (703) 471-6263.

New info

Two lesser known forms of hydropower are **ocean thermal energy conversion** (OTEC), which uses the temperature difference between surface and deep ocean waters to boil and then recondense fluids, and **tidal power**, which uses the enormous power of ocean tides. Presently, these forms of hydropower are not veiy feasible, but they hold promise for the future.

Advantages of Hydropower	Disadvantages of Hydropower
• Abundant, clean, and safe	• Can have a significant environmental impact
• Easily stored in reservoirs	• Can be used only where there is a water supply
• Relatively inexpensive way to produce electricity	• Best sites for dams have already been developed
• Offers recreational benefits like boating, fishing, etc.	

I Know this info

Wind Energy: **Wind** is air in motion. It is caused by the uneven heating of the earth's surface by the sun. Wind power has been used for thousands of years to convert the wind's kinetic (motion) energy into mechanical energy for grinding grain or pumping water. Today, wind machines are used increasingly to produce electricity.

New info, Wow!

The two most common types of wind machines used for producing electricity are horizontal and vertical. **Horizontal machines** have blades that look like airplane propellers. **Vertical machines** look like giant egg-beaters. The vertical machines are easier to maintain, can accept wind from any direction, and don't require protective features to guard against high winds. However, horizontal machines produce *more* electricity, and for this reason are used far more than their vertical counterparts.

I Know this info

Most electricity production occurs on large wind farms. Most **wind farms** are not owned by public utility companies. Instead, independent producers, who operate the farms, sell electricity back to utility companies for distribution. The **Public Utility Regulatory Policies Act** (PURPA) requires utility companies to purchase electricity from independent energy producers at fair and nondiscriminatory rates. In 1990, wind energy

provided the United States with about .10 percent of its total electricity, with California producing 98 percent of this amount. Many predict that wind energy will provide much more of our future electrical production.

Advantages of Wind Energy	Disadvantages of Wind Energy
• Is a "free" source of energy	• Requires constant and significant amounts of wind
• Produces no water or air pollution	• Wind farms require significant amounts of land
• Wind farms are relatively inexpensive to build	• Can have a significant visual impact on landscapes
• Land around wind farms can have other uses	

I know this info

Geothermal Energy: **Geothermal energy** comes from the intense heat within the earth. The heat is produced by the radioactive decay of elements below the earth's surface. There is more than one kind of geothermal energy, but the only kind that is widely used is **hydrothermal energy.** Hydrothermal energy has two basic ingredients: water and heat. Water beneath the earth's surface contacts the heated rocks and changes into steam.

Depending on the steam's temperature, it can heat buildings directly or can power turbines to generate electricity.

New info

Using geothermal energy to produce electricity is a new industry in the United States. In a typical geothermal electric plant, steam is piped directly to a turbine, which then powers an electrical generator. A geothermal well can be one to two miles deep! In 1990, hydrothermal energy produced less than *0.5* percent of the electricity in the United States.

Advantages of Geothermal Energy	Disadvantages of Geothermal Energy
• Provides an unlimited supply of energy	• Start-up/development costs can be expensive
• Produces no air or water pollution	• Maintenance costs, due to corrosion, can be a problem

I know this info

Biomass: **Biomass** is any organic substance that can be used as an energy source. The most common examples are wood, crops, seaweed, and animal wastes. Biomass has been used for thousands of years and is the oldest known energy source. It is a renewable energy source because its supply is unlimited – more can always be grown in a relatively short time.

New info Wow!

All biomass is converted solar energy. The energy is stored in biomass through the process of **photosynthesis**, in which plants combine carbon dioxide, water, and certain minerals to form carbohydrates. The most common way to release the energy from biomass is burning. Other less used ways are bacterial decay, fermentation, and conversion.

There are four main types of biomass: (1) wood and agricultural products, (2) solid waste, (3) landfill gas, and (4) alcohol fuels. Wood is by far the most common form, accounting for about 90 percent of all biomass energy. Burning solid waste is a common practice, and people have done it for thousands of years. What iv new is burning waste to produce electricity. **Waste-to-energy** power plants operate like a traditional coal plant, except garbage is used to produce steam to run the turbines. Although it typically costs more to produce electricity using biomass, the great advantage is that is reduces the amount of waste entering landfills. Some people have environmental concerns about waste-to-energy plants, but because it is becoming increasingly difficult to find sites for landfills, these plants are an increasingly attractive option.

New info

Wow!

The **methane** produced in landfills by the decay of organic matter is another source of biomass energy. Because of today's low natural gas prices, the methane ("biogas") produced in landfills is usually burned at the site. However, some individuals have devised more efficient uses. A landfill owner in Indianapolis uses the methane to heat his

greenhouse, thus reducing the operating costs of his on-site nursery business. I agree

Corn, wheat, and other crops can be used to produce a variety of liquid fuels. The most common are ethanol and methanol. Today these are relatively high cost fuels, and the price of oil would have to double to make them a cost effective option. However, a mixture of 10 percent ethanol and 90 percent gasoline produces a fuel called **gasohol**. Gasohol is much more cost competitive and can be used in a traditional gasoline engine. It also has a higher octane rating than gasoline and is cleaner burning.

Wow, I agree

Advantages of Biomass	Disadvantages of Biomass
Abundant and "renewable"	Burning biomass can result in air pollution
Can be used to burn waste products	May not be cost effective

Economic Implications

Energy policies have many economic implications. Two somewhat controversial issues concern the distinction between energy efficiency and economic efficiency, and the role of market prices in guiding decisions about energy resources.

ENERGY EFFICIENCY VERSUS ECONOMIC EFFICIENCY: Economists are concerned with the overall economic efficiency of the economic system. This means getting the greatest benefit from *all* of our scarce productive resources. **Energy efficiency** is a narrower concept, and means getting the greatest benefit from our *energy* resources. Sometimes these goals conflict. A goal of maximizing energy efficiency puts no value on the other scarce resources. For example, we could make automobiles today that average more than 100 miles per gallon. This would result in better **energy conservation**, but would we be willing to pay the cost in terms of lack of power, crash protection, and payload?

Wow!

THE ROLE OF PRICE IN GUIDING DECISIONS ABOUT ENERGY: In market economies resource allocation is guided by market prices. They help society determine answers to the crucial questions of what, how, and for whom to produce. However, in the area of energy policy, many advocate significant levels of government intervention in energy markets. The intervention often takes the form of **subsidies** for the development of renewable energy sources.

New info

For example, the **market price** of oil is currently about $20 a barrel. This price is high enough for oil producers to make a profit. At this price, oil is also relatively inexpensive for consumers and producers of other goods and services, who enjoy many benefits from this valuable source of energy. The relatively low market price of oil indicates that oil is an abundant source of energy at this time. *Should the government subsidize more expensive forms of renewable energy given the low price of oil (and other fossil fuels)?*

I agree

Proponents contend that subsidies are necessary to help reduce our dependence on finite fossil fuels. Proponents also point out that relying more on renewable energy will reduce our dependence on foreign oil suppliers, and will result in less pollution of the environment.

New info

Subsidy opponents argue that we will never run out of fossil fuels. As fossil fuels become more **scarce**, their market price will rise, encouraging consumers to use less. The higher price also will make it cost effective for energy companies to invest in new fossil fuel production technologies and to invest in alternative energy sources, including renewable energy. This simultaneous *decrease* in the quantity of energy demanded and *increase* in the quantity of energy supplied, occurs automatically, without costly and inefficient government intervention. Opponents of subsidies agree that the environmental costs of fossil fuels should be reflected in their price, and this should be an important consideration when dealing with this issue. They believe that the best way to lessen the danger of a cut-off in foreign supplies is to build a strategic petroleum reserve.

I agree

The issue of the development of renewable energy sources is a complicated one. The key point to remember is that there is an opportunity cost to every economic decision. Using tax revenues to subsidize renewable energy means giving up some other valuable use for those revenues. In energy policy, as in all public policy, decision makers must consider all the opportunity costs when determining trade-offs among different policy goals.

I agree

Activity 3

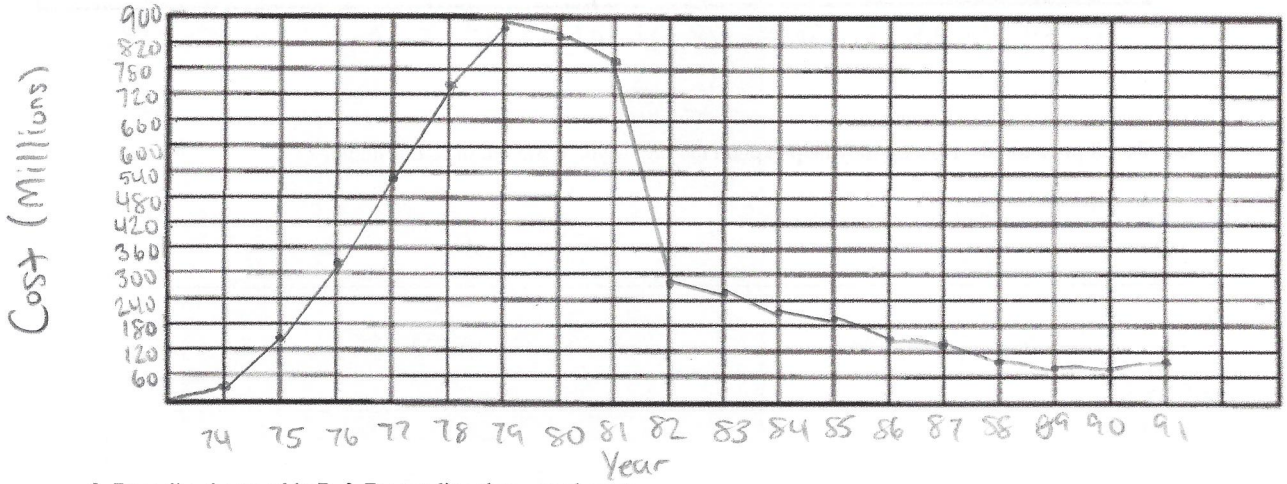
Trends In R & D Spending

1. The United States Department of Energy (DOE) subsidizes research and development (R & D) in renewable energy. The data below show R & D spending since 1974 in **constant 1982 dollars.** The FY stands for fiscal year. Construct a line graph showing R & D funding by year. (Put R & D funding on the vertical axis and Fiscal Year on the horizontal axis.)

DOE Renewable Energy R & D Funding

($ millions, 1982 dollars)

FY74	40	FY80	850	FY86	149
FY75	132	FY81	759	FY87	123
FY76	324	FY82	279	FY88	98
FY77	513	FY83	244	FY89	88
FY78	747	FY84	192	FY90	84
FY79	875	FY85	181	FY91	114

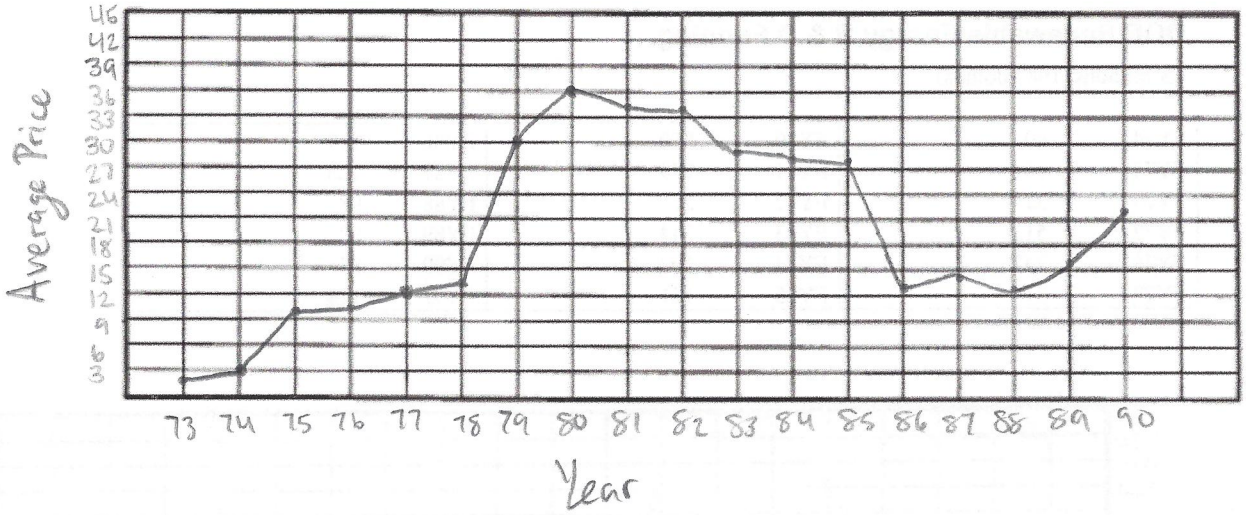


2. Describe the trend in R & D spending that you observe.

The R & D Funding ranges from $40 to $875.
Each year, there is usually a constant change.

3. The data below give average current dollar price per barrel of oil since 1973. Price is rounded to the nearest dollar. Construct a line graph showing this data. (Put Price on the vertical axis and Fiscal Year on the horizontal axis.)

Average Price of Oil (Current Dollars)					
FY73	$2	FY79	$30	FY85	$28
FY74	$3	FY80	$36	FY86	$13
FY75	$10	FY81	$34	FY87	$17
FY76	$11	FY82	$32	FY88	$13
FY77	$12	FY83	$29	FY89	$16
FY78	$13	FY84	$28	FY90	$22



4. Describe oil price trends. How do they help explain the trends you observed in R&D funding?

As the price increases, the R&D funding increased. This is because higher oil prices mean that more people want to find cheaper energy.

Activity 4

Energy Efficiency

1. Define **energy efficiency.** Goal to reduce amount of energy used.

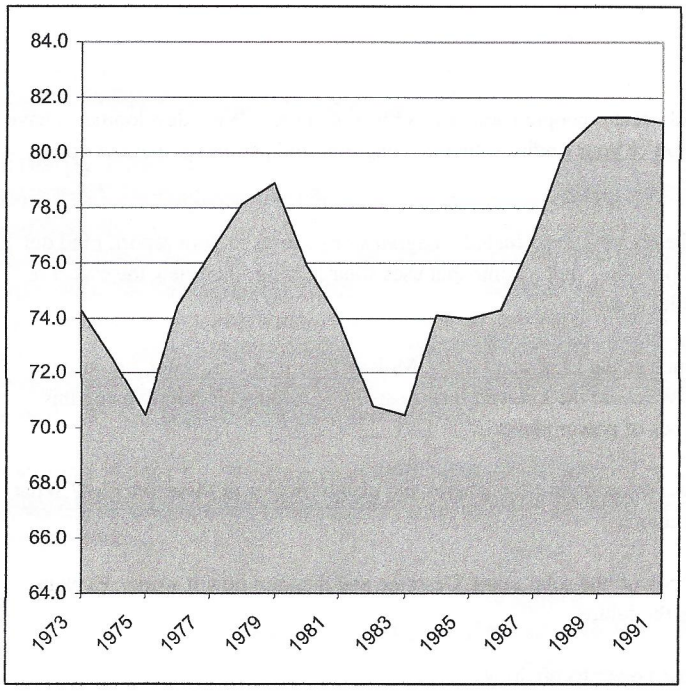
2. List four ways you can be more energy efficient at *home?* Don't leave the faucet on, don't leave lights on, keep all appliances well maintained, and do one load of laundry.

3. What are ways that a *business* can be more energy efficient? Good amount of maintenence, don't leave electricity running at night.

4. The graph and chart below show total United States energy consumption from 1973 to 1991.

United States Energy Consumption (Quadrillion Btu's)

1973 Total	74.3
1974 Total	72.5
1975 Total	70.5
1976 Total	74.4
1984 Total	74.1
1985 Total	74.0
1986 Total	74.3
1987 Total	76.9
1988 Total	802
1989 Total	81.3
1990 Total	81.3
1991 Total	81.1



a. What was the increase in consumption from 1973 to 1991? 96.24

b. Compute the *percentage* increase from 1973 to 1991. 9.15%

c. The Gross Domestic Produce (GDP) measures the value of all the goods and services produced in an economy in a year. Since 1973, the **real** (constant dollar) **GDP** of the United States has increased over 48 percent. Given this fact and your answer in b. above, what can you conclude about the **energy efficiency** of the United States from 1973 to 1992? The energy efficiency has increased.

The energy efficiency has increased since 1973 because the GDP went up greatly.

5. The United States consumes more energy per unit of GDP than Japan or Italy (In 1988: United States — 18.0 thousand Btu's, Japan —11.2, Italy 13.6). Give at least two reasons for this difference

The US requires more energy because of the large population and there is a variety of climates, needing heating and cooling.

Activity *5*

Further Investigations

1. Research the history of solar energy. How did ancient people harness this form of energy. What developments have taken place in the past 100 years? Prepare a report of your findings. Include diagrams and pictures of various solar energy systems.

2. Prepare a report on passive and active solar heating systems. Include diagrams or pictures in your report. Find out the cost difference between the two systems. If possible, visit a home that uses solar heating. Interview the owner to identify advantages and disadvantages of the solar system.

3. Research how a solar thermal power plant, such as the LUZ plant in the Mojave Desert in California, produces electricity. Diagram how such a system works. What are the kilowatt hour costs of producing electricity using this method? What does the future hold for these types of power plants?

4. Research developments in solar powered cars. What are the advantages and disadvantages of these vehicles? What does the future hold for solar powered transportation?

5. Research another new form of solar thermal power: the solar pond. Describe and diagram how it works. Explain what promise this type of solar power holds for the future.

6. Investigate developments in photovoltaic solar power technology.

7. Research the history of wind energy. Investigate how people in earlier times and in different cultures have harnessed the wind's energy. What developments have taken place in the past hundred years? How is wind energy being used today? Include diagrams and pictures in your report.

8. Prepare a report on how electricity is generated on wind farms. Describe types of wind generators, types and sizes of wind farms, the economics of electricity production on wind farms, and the locations of currently operating wind farms in the United States. Include diagrams.

9. Public Utility Regulatory Policies Act (**PURPA**) of 1978 requires utilities to buy electricity at reasonable rates from independent electricity producers. Research other specific requirements of the law. Contact your local electrical utility