Overview of Unit 3
The Issue of Renewable Energy

Introduction

There has been considerable interest recently in the topic of renewable energy. This is primarily due to concerns about environmental damage (especially acid rain and global warming) resulting from the burning of nonrenewable fossil fuels. However, investing in renewable energy is controversial for several reasons. First, not all scientists agree on the degree of environmental damage that can be attributed to fossil fuels. Second, fossil fuels are relatively abundant and cheap energy sources, and have contributed significantly to economic growth. Abandoning inexpensive fossil fuels for more expensive renewable ones will have major economic ramifications. Your students will enjoy analyzing this interesting and controversial topic.

Learning Objectives

After completing this unit, students will:

1. Learn to examine an energy/environmental issue using a five-step, decision-making model.

2. Explain basic facts about various renewable energy sources.

3. Identify the advantages and disadvantages of renewable energy sources.

4. Explain basic economic concepts used to analyze energy issues.

5. Understand that public policy decisions involve trade-offs among social goals.

Unit Outline

I. Facts about Renewable Energy

II. Renewable Energy Vocabulary

III. Teaching Activities

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Facts About Renewable Energy

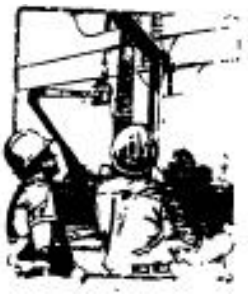
Introduction

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.

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.

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.

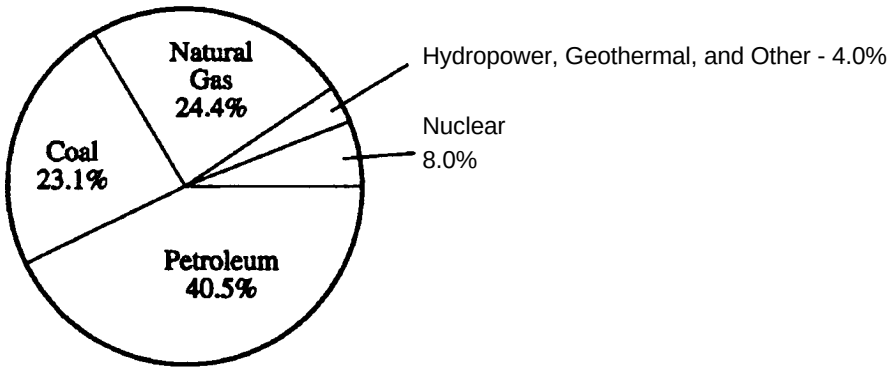
Energy Basics



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!

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)



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.

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.

Renewable Energy Sources

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.

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.

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.

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 • Causes no air or water pollution	• May not be cost effective • Storage and backup are necessary • Reliability depends on availability of sunlight

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.

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.

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.	

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.

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.

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	

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.

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

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.

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.

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.

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.

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?

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.

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)?*

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.

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.

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.

Renewable Energy Vocabulary

Btu
British thermal unit; the amount of energy needed to raise the temperature of one pound of water one degree Fahrenheit

Economic Efficiency
getting the most benefit from *all* of our scarce productive resources.

Energy
the capacity to do work

Energy Conservation
actions taken to get the most benefit from our scarce energy resources; promotes energy efficiency

Energy Efficiency
the amount of energy it takes to do a certain amount of work

Ethanol
a liquid, biomass fuel derived from crops, such as corn and wheat; ethyl alcohol

Gasohol
biomass fuel produced by mixing ethanol and gasoline, typically 10 percent and 90 percent respectively

Geothermal Energy
energy that comes from the heat within the earth

Hydropower
energy that comes from the force of moving water

Hydrothermal Energy
most common type of geothermal energy; consists of reservoirs of steam and/or hot water

Market Price
price of a good, service, or energy resource, as determined by its price in the marketplace

Methane
colorless, odorless gas formed from the decay of organic substances; identical to natural gas

Methanol
a liquid, alcohol fuel derived from wood, agricultural wastes, coal, and natural gas; methyl alcohol

Nonrenewable Energy
resources, such as fossil fuels, that are limited in supply

OPEC
stands for Organization of Petroleum Exporting Countries, a cartel that controls a large part of the world's oil reserves

Opportunity Cost
the value of the next best alternative when making a decision; every decision has an opportunity cost

Photosynthesis

process shared by all green plants by which solar energy is converted to cbemical energy. Combines carbon dioxide, water, and various minerals to form carbohydrates

Primary Energy Source
direct energy sources such as coal, oil, uranium, solar, and hydropower

Profit
the amount of sales revenues remaining after subtracting all the costs of production

PURPA
Public Utility Regulatory Policies Act; requires utility companies to purchase electricity from independent energy producers at fair and nondiscriminatory rates

Quad
One quadrillion (1,000,000,000,000,000) Btu's

Renewable Energy
energy resources that are "unlimited" in supply because they can be replenished

Scarcity
in economics, the situation that exists whenever wants are greater than the resources available to satisfy the wants; scarcity requires people to make choices

Secondary Energy Source
an energy source, such as electricity, that is produced using a primary energy source

Solar Energy
energy that comes from the sun

Subsidy
financial assistance given by government to encourage the production of a good, service, or resource; production would be uneconomical without the subsidy

Waste-to-Energy Plant
a plant that burns solid waste to produce usable energy

Wind Energy
energy that comes from the movement of air

Teaching Instructions

Overview

These specific teaching activities, like those in the other units, do not have to be done in order. It may be best, however, to do the Case Study toward the end of the unit, after students have mastered much of the basic information. Although some basic information is given in the Facts About Renewable Energy section, your students will need to research other resources to investigate the broad area of renewable energy adequately. The "Resources" section on page 152 identifies a variety of excellent sources. The "Further Investigations" activity suggests a variety of research activities.

Some of the key economics concepts in this unit are described below in the "Important Concepts to Emphasize" and "Facts About Renewable Energy" sections. Teachers may also wish to review the basic economic concepts relating to energy and the environment explained in the htroduction of this curriculum.

Important Concepts To Emphasize:

1. **Subsidies are not always stated explicitly in dollars**. They can be hidden and hard to measure in money terms. A subsidy exists whenever one person or group receives something of value from another person or group without charge or expectation of compensation. A subsidy can take various forms, such as cash gifts, special tax credits to reduce tax liability below that of others in similar circumstances, or transfer of tangible or intangible property. For example, until recently, Congress provided an income tax credit for homeowners who took certain actions to increase the energy efficiency of their homes, or used renewable energy sources to reduce their dependence on fossil fuels.

2. **There are no free sources of energy**. Everything has an opportunity cost. Even sources such as wind and solar power, which are readily available, cannot be developed without diverting resources from other social priorities. As an example, wind generators in California produce renewable energy, but also kill eagles and other endangered birds of prey that occasionally fly into the equipment.

3. **Conservation means more than just not using our natural resources**. It means making sure that society gets the most out of all its scarce productive resources, including natural resources. For example, we want to conserve petroleum so that we get the maximum benefit from our finite supplies; however, if we never use it, it has no value to us. We should manage our scarce natural resources to provide the greatest net benefit to present and future generations combined, after considering all of the costs and benefits involved, including the environmental costs.

4. **We will never run out of petroleum and other nonrenewable resources**. This is not to say that we can continue to use these energy sources without thought for tomorrow. Rather, it means that as an energy source becomes increasingly scarce, its market price will rise, discouraging consumption and encouraging production of alternative energy sources. During the 19th century, whalers nearly drove some species of whales to extinction. As this happened, the market price of whales and whale products inevitably rose. Eventually, whale oil became so expensive that petroleum became commercially feasible as an energy source, and whale oil lamps were phased out in favor of cheaper kerosene. The whales were actually saved by the free market response to their increasing scarcity.

5. **When people do not bear all of the costs of their actions, their decisions tend to be socially inefficient**. We implicitly subsidize fossil fuels today whenever producers and consumers do not pay the full environmental costs of their actions. As an example, without environmental regulations, consumers in Indiana would not pay the full social cost of producing electricity. To the extent that fossil fuel-burning power plants in the midwest may contribute to acid rain in the northeast, consumers in Indiana receive a subsidy from the northeast by not paying the full environmental costs of their electricity. The economic reasons for restricting the use of high-sulfur coal is that producers and consumers who can shift the environmental damage to others have no incentive through the free market to use more expensive low-sulfur coal to generate power. Most of the benefits of using low-sulphur coal would go to other regions (the northeast and Canada), while the costs would be borne by midwesterners. Restricting the use of high sulphur coal would also have a very detrimental impact on the economics of states like

Indiana, which have important coal mining industries.

Teaching Suggestions:

ACTIVITY 1: RENEWABLE ENERGY BASICS. Have the students research the renewable sources and complete the chart. Discuss the advantages and disadvantages of each.

ACTIVITY 2: GRAPHING ENERGY FACTS. In Part I and Part II, make sure students do an accurate job estimating the particular parts of the pie graphs. This involves correctly estimating angles of a circle. Also insist on graphs that are neatly drawn and labeled. You may wish students to construct larger graphs for a bulletin board display.

ACTIVITY 3: TRENDS IN RESEARCH AND DEVELOPMENT (R & D) SPENDING. This activity shows the correlation between R & D funding and oil prices. In question one, explain that to compare spending levels of different years accurately we must use constant dollars, from a particular base year, in this case, 1982. If we do not use constant dollars, the comparisons are distorted due to inflation.

In question 2, explain that oil prices are quoted in current year dollars. Using constant dollars would give a truer picture of the *real* (inflation adjusted) changes in oil prices. Have some of your students determine the constant dollar prices of these oil prices. To do this they must use the implicit price deflator (IPD), an index number used by economists to figure constant dollar (real) price changes. The IPD for each year since 1973 is given below, using 1987 as the base year (IPD = 100). To determine the real constant dollar price of oil for any year, use this formula:

Constant Dollar Price = (Current Price/IPD) x 100

For example, in 1973 the current dollar price was $2 a barrel. The constant dollar (real) price is $2/41.3 x 100 = $4.84. In other words, the $2 price in 1973 is equivalent to $4.84 using inflated 1987 dollars. Have students figure and graph the *real* oil prices. Discuss how this graph differs from the graph of current dollar prices.

Implicit Price Deflators (1973-1990)

1973	41.3	1979	65.5	1985	94.4
1974	44. 9	1980	71.7	1986	96.9
1975	49.2	1981	78.9	1987	100.0
1976	52.3	1982	83.8	1988	103.9
1977	55.9	1983	87.2	1989	108.5
				1990	113.2

ACTIVITY 4: ENERGY EFFICIENCY. In question 4c. discuss why it is important to use real (constant dollar) GDP when analyzing changes in energy efficiency. (Answer: One should consider *actual* increases in goods and services, not increases caused only by inflation.)

ACTIVITY *5:* FURTHER INVESTIGATIONS. Encourage students to do research on their own. If time permits, let students share information they have learned with their classmates.

ACTIVITY 6: DEBATING THE ISSUES. Students can debate orally or present their views as a written assignment.

ACTIVITY 7: EEE ACTIONS. Encourage students to implement some of the suggested activities.

ACTIVITY 8: CASE STUDY: THE CASE OF THE RENEWABLE RESOURCES
This case study deals with a hypothetical congressional debate over an energy bill that would provide federal support for energy firms willing to increase their R & D spending for renewable energy sources such as solar, wind, biomass, and hydropower. The case uses role playing to encourage students to look at the trade-offs involved in energy policy and to recognize the role of values and self-interest in determining the appropriate public policy. Suggested steps to

implement the case study are as follows:

1. Ask all the students to read background materials on energy: Assign half of the students to serve as Senators who will listen to testimony and then vote on the bill to give tax breaks to developers of renewable energy sources. The other half of the class should be divided into small groups representing some or all of the following groups: (1) fossil fuel producers and consumers, (2) developers of solar, wind, and geothermal power, (3) environmental groups, and (4) consumers in areas such as New England, which has good potential for hydro power, but depends on midwestern coal and OPEC petroleum.
2. Each special interest group should fill out a Decision Worksheet and Decision Grid reflecting its perspective on the problem. Each group should then elect a spokesperson to provide testimony in the Senate Hearings.
3. After hearing from the affected groups, members of the Senate should develop a consensus decision worksheet and vote on the energy bill.
4. In a debriefing session, ask students to defend their positions as either special interest groups or Senators voting on the issue.

Key Questions to Ask Students:

1. *What is a subsidy?* (financial assistance provided by a person or group to another person or group, in the form of cash, tax breaks, or the transfer of something of value without payment)
2. *What is a tax credit?* (a tax break or rebate in the form of a special reduction in taxes that otherwise would have been due by an individual taxpayer or class of taxpayers)
3. *Why are there not free sources of energy?* (nothing is free, in the sense that everything has an opportunity cost, represented by the next best alternative that was given up in making a choice)
4. *Why should solar energy companies care that fossil fuels can damage the environment?* (solar companies feel that getting to use the environment for free represents a subsidy for fossil fuels that lowers their price below the full social cost, making it hard for nonpolluting energy sources to compete)
5. *What is the difference between a renewable and a nonrenewable energy resource?* (unlike renewable energy resources such as sunlight, water power, and wind, nonrenewable energy resources exist in finite quantities that cannot be replaced when they are used up)
6. *If petroleum is a nonrenewable resource, how can it be that we will never run out?* (as oil gets harder to extract from increasingly less productive deposits, the price will rise, and both consumers and producers will have incentives to find cheaper alternatives)

Activity 1

Renewable Energy Basics

Complete the chart below about the basic types of renewable energy resources.

Type	Definition	Examples	Advantages	Disadvantages
Solar				
Hydropower				
Wind Energy				
Geothermal				
Biomass				

2. List those energy sources that are fossil fuels. _____

_____

3. What main *advantage* do fossil fuels have over the renewable energy resources? _____

_____

_____

4. What are two main *disadvantages* of fossil fuels compared to renewable energy?

_____

_____

Activity 2

Graphing Energy Facts

Part A: The table below lists United States primary energy consumption by source in 1973 and 1991.

Primary Energy Consumption (percent)

	1973	**1991**
Petroleum	46.9	40.4
Nuclear Power	1.2	8.0
Hydropower/OtherRenewable	4.1	4.0
Natural Gas	30.3	24.4
Coal	17.5	23.2

1. Draw two pie graphs showing this data. Use different colors to identify each energy source and neatly label your graphs. Then answer the questions that follow.

2. What is a primary energy source? Explain how it differs from a secondary source.

_____

_____

3. Which source decreased the most from 1973 to 1991? _____

Why do you think this happened? _____

_____

_____

_____

4. Which source increased the most from 1973 to 1991? _____

Why do you think this happened? _____

_____

_____

_____

5. Sunlight, wind, and running water are essentially “free”. Yet renewable energy sources are a very small part of our energy consumption. Why is this? Explain. _____

_____

_____

_____

PART B: The data below shows the amount of electricity generated in the United States in 1990 by various renewable energy sources.

1990 United States Renewable Electric Generating Capacity (Gigawatts)

	Gigawatts	Percent of Total
Hydropower	75.1	
Geothermal	2.6	
Biomass — (Municipal Waste to Energy)	2.0	
Biomass (other)	6.0	
Solar Thermal	0.4	
Wind	1.4	
TOTAL RENEWABLE	87.4	

Draw a bar graph below showing the generating capacity. On the vertical axis, put Electrical Generating Capacity/Gigawatts. On the horizontal axis, put the energy sources. Use different colors and neatly label your graph.

2. Compute the percent of the total that each resource provides and put the percent in the blanks. Then make a pie graph of the percent data. Use different colors and neatly label the graph.

3. Which renewable source is used the most for producing electricity?_____

Why?_____

_____

_____

4. Which renewable energy source above is used the least? _____

5. Which renewable source do you think *should* be used the most? Why? _____

_____

_____

_____

Activity 3

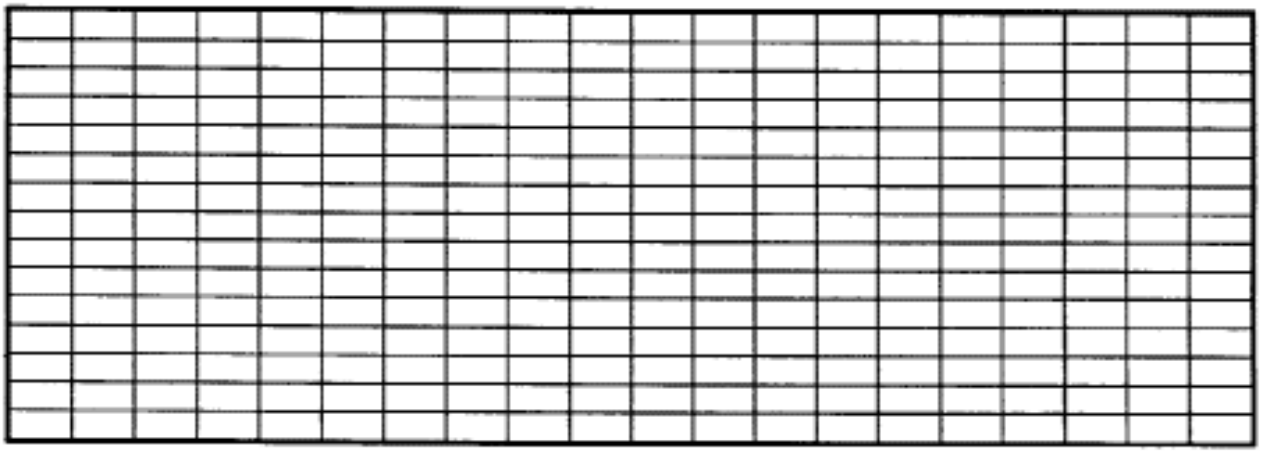
Trends In R & D Spending

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



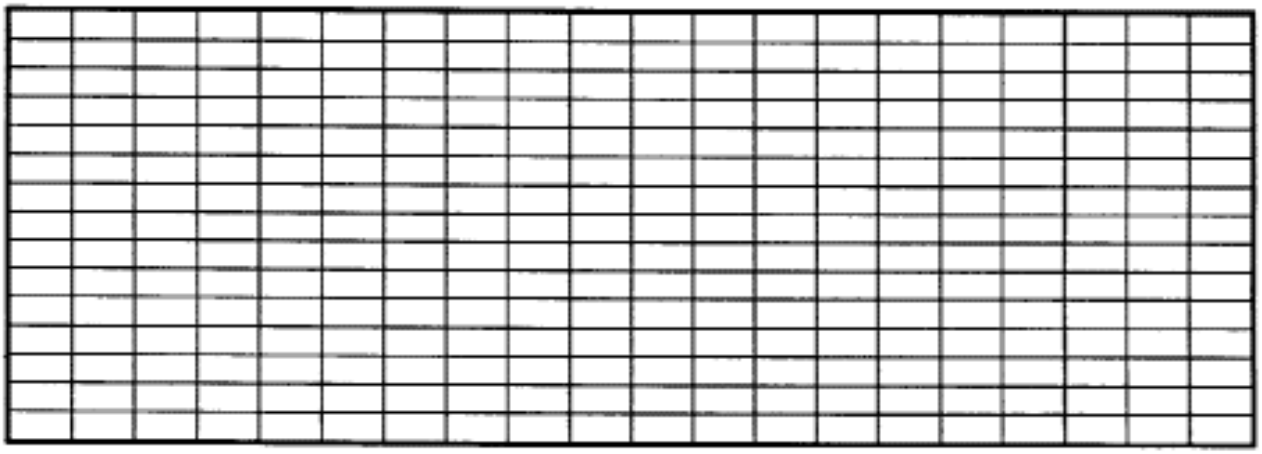
2. Describe the trend in R & D spending that you observe.

_____

_____

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?

_____

_____

_____

_____

Activity 4

Energy Efficiency

1. Define **energy efficiency**. _____

2. List four ways you can be more energy efficient at *home?* _____

_____

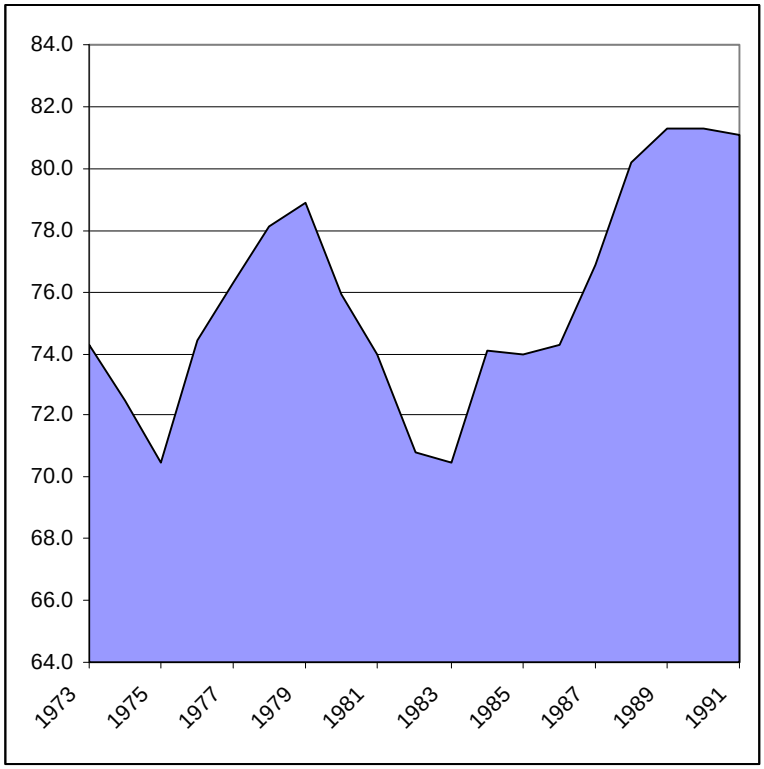
3. What are ways that a *business* can be more energy efficient? _____

_____

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
l974 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? _____

b. Compute the *percentage* increase from 1973 to 1991. _____

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?

_____

_____

_____

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

_____

_____

_____

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

company and find out how PURPA has affected its operation.

10. Explain and diagram how a hydroelectric power plant operates. Label your diagram carefully. Identify some of the environmental concerns about constructing this type of power plant. Research the kilowatt hours (kWh) cost of electricity produced in these plants. How does the cost compare with electrical production using other forms of energy?

11. Research how tidal power and ocean thermal energy conversion can be used to generate electricity.

12. Diagram and explain the operation of a waste-to-energy power plant. If possible, visit a plant in operation. The Indianapolis Resource Recovery Facility, a waste-to-energy plant operated by Ogden Martin Systems, provides teachers with information and also schedules free tours. The address is 2320 South Harding Street, Indianapolis, IN 46221. The telephone number is (317) 634-7367.

13. Research these four basic methods of capturing geothermal energy: dry steam systems, wet steam systems, geopressurized hot water systems, and hot dry-rock systems.

14. Research how geothermal energy can be used to heat homes. Diagram how such a geothermal system works. Investigate the costs compared to other types of home heating systems.

15. Research current developments in alternative fuels, especially ethanol, methanol, and gasohol. How are they made? What are the advantages and disadvantages of each type of fuel? What states lead in the production and consumption of these fuels?

16. Research the advantages and disadvantages of using wood as a fuel. Be sure to examine how wood is used for fuel in other countries of the world.

17. Investigate the topic of superconductivity. Find out how this development has the potential to change, or even revolutionize, the electronic, electric power, and transportation industries.

18. As you study energy, put information on a timeline made of paper. Stretch the timeline across one wall. Mark important discoveries, inventors, and places related to energy.

19. Plan a trip to a local power plant. Prepare questions beforehand to ask plant officials. Prepare a report of your visit, including diagram of the energy production process.

20. Assign a research paper in which students address how the United States should react to another energy crisis. Identify what policies should be encouraged and/or avoided.

Activity 6

Debating the Issues

Debate and discuss these statements:

1. To help lessen our dependence on foreign energy, especially oil, the United States should *increase* funding for renewable energy substantially, even though this will *reduce* funding for other important programs.

2. United States car companies should be required to produce a solar-powered car, since this will help reduce our consumption of polluting fossil fuels.

3. The government should quit subsidizing R & D in renewable energy. When the price of nonrenewable sources

becomes high enough, it will then be profitable for private energy to invest in renewable energy technology. Until then money spent on R & D is being wasted, and should be used for more urgent needs, such as cancer research, toxic waste clean-up, and better roads.

4. To lessen our dependence on foreign oil and to spur development in alternative energy sources, including renewable energy, the United States should impose a gasoline tax of $1 per gallon.

5. To reduce the consumption of fossil fuels, we should develop hydropower as much as possible. We should build more dams and reservoirs, even if it means somewhat disrupting the ecological balance of certain rivers and streams. Reservoirs also provide many valuable recreational benefits.

6. We should encourage communities to develop environmentally safe waste-to-energy power plants. Not only does this reduce what is put into our landfills, but it also uses our solid waste to produce energy.

Activity 7

EEE Actions: You Can Make A Difference!

1. Do an energy audit in your home. Check ways to make your home more energy efficient. Make energy saving changes if possible, such as improving insulation, installing storm doors and windows, stopping drafts under doors and around windows, and installing devices that reduce hot water consumption.

2. Plant shade trees around your house. This will make your house cooler and lessen the need for air conditioning.

3. Investigate the possibility of installing a passive solar heating system in your house.

4. Recycle where feasible. Recycling certain items such as aluminum cans can save enormous amounts of energy. Txy to buy recycled products, and buy products that use minimum packaging.

5. Use your appliances efficiently. For example, run dishwashers and washing machines when you have full loads, wash clothes in cold water, don’t overheat your hot water, use a clothes line instead of the dryer, and buy energy efficient appliances.

6. Dress for the season! In the winter, wear warm clothes inside your house and turn down the thermostat a bit! In the summer, wear cool, loose clothes. Try not to turn on air conditioning until it gets really hot.

7. If feasible, walk or ride a bike to school or around town. It’s good exercise and it saves energy!

8. Ask your principal if your school has a plan for reducing energy consumption. If not, ask if your class can conduct an energy audit. Discuss possible improvements and draft a letter with suggestions for reducing your school’s energy consumption.

9. Design energy conservation awareness posters and place them in the hallways at school.

10. Be sure that your family car has a regular tune-up. Keep the tires inflated properly.

Activity 8

Case Study
The Case of the Energy Subsidy

Student Directions:
1. The Senate is considering energy policies to give tax breaks to renewable energy sources and to increase taxes on fossil fuels. You will be asked to take part in public hearings involving these issues.

2. After you research the various energy sources, you will be assigned a role as either a senator or one of the lobbyists representing various special interests and geographic regions.

3. Fill out a Decision Worksheet and Decision-Making Grid to help you come to a decision. Much depends on you. Good luck.

SCENARIO

The year is 1998. United States dependence on foreign petroleum, which became a problem in the early 1970s, continues to grow. In addition, concern rises over the environmental costs associated with the use of fossil fuels. Renewable energy sources are an option in some regions, but they have been slow to develop commercially. Connecticut, for example, has access to hydroelectric power, but usage has actually declined during the past century, because of relatively cheap fossil fuels. To help change this trend, Connecticut Senator Jonathan Barnhart has sponsored a bill to provide special tax breaks, or subsidies, for developers of renewable energy sources, including solar, wind, geothermal, hydropower, and biomass. These tax subsidies would take the form of tax credits, or rebates, for qualifying energy projects.

Senator Barnhart's proposal received mixed reviews in the Senate. Senators from the five top oil producing states—Texas, Alaska, Louisiana, California. and Oklahoma – expressed concern that the bill would put oil producers at a disadvantage that could result in serious job losses in their states. Three of those states, Texas, Louisiana, and Oklahoma, are also the top producers of natural gas, leading their senators to argue even more strongly against a subsidy for competing renewable fuels. Noting that renewable fuels are not yet competitive in price without tax subsidies, they argue that consumers would get the best product at the lowest price by letting the market determine what type of energy to produce and in what quantities. In addition, they object to any programs that would increase the size of the federal budget deficit at a time when program cuts and tax hikes are being proposed to deal with the out-of-control federal budget.

Environmental groups and developers of renewable energy sources disagree. They claim that fossil fuels already receive a subsidy from the general public in the form of environmental damage that does not get charged back to those who are responsible. They assert that fossil fuels would cost a lot more if the environmental costs to society were included. According to the environmentalists, we tend to be short-sighted in dealing with nonrenewable resources by not taking into account their finite nature until it is too late.

Oil company representatives respond that it was the free market that developed petroleum back in the mid-nineteenth century when whales became relatively scarce and there was concern that they might be driven to extinction. Oklahoma Senator Susan Phillips reminds Senator Barnhart that we avoided a whale oil crisis a century ago not through special subsidies, but through the free market responding to a shortage of whale oil by raising its price. Says Senator Phillips, "The higher price of whale oil actually created a market for petroleum and other energy sources by encouraging both consumers and producers to look for cheaper alternatives."

The president of the Sierra Club, Belinda Arbuckle disagreed. "For free markets to operate effectively, people need to pay the full cost of their actions. Our failure to take into account the full long-run costs of fossil fuels to society makes it difficult for producers of renewable energy sources to compete. I proposed new taxes on fossil fuels reflecting the

environmental damage associated with their production and use. This would tend to increase the cost of fossil fuels reflecting their environmental impact and making it easier for renewable energy sources to compete on the basis of price."

The fossil fuel industry response is that we do not need another tax on energy to clean up the environment, especially in light of the mixed scientific evidence on the damaging effects of sulfur dioxide and other pollutants from fossil fuels. The industry also reminds the Senators that an energy tax would have negative effects on jobs and growth throughout an economy dependent on fossil fuels.

The Senate is undecided about what to do, and is calling for special hearings. Should the Senate, 1) support the Barnhart proposal to grant subsidies to producers of renewable energy, 2) support the Sierra Club proposal to tax fossil fuels, or 3) do neither and let free markets determine energy use?

Answers To Selected Teaching Activities

Activity 1: Renewable Energy Basics

1. Definitions, examples, and specific advantages and disadvantages are listed in the Facts About Renewable Energy section.

2. The primary fossil fuel energy sources are petroleum, natural gas, and coal.

3. The main advantage of fossil fuels is that they are relatively abundant, and therefore, relatively inexpensive.

4. The primary disadvantage of fossil fuels is that they are more polluting than renewable energy sources. The burning of fossil fuels also produces carbon dioxide, which some fear is causing global warming. This, however, is only a theory, and has not been confirmed by scientific evidence.

Activity 2: Graphing Energy Facts

Part A

1. Make sure students have neatly labeled, colored graphs.

2. Primary energy sources are basic sources of energy, such as coal, natural gas, hydropower, wind, petroleum, etc. Secondary sources, such as electricity, require primary sources of energy to generate power.

3. Petroleum (46.9 percent to 40.4 percent). This large decrease occurred because the price of oil increased significantly in the 1970s. As price increased, consumers bought less, switched to substitutes, etc.

4. Nuclear power. Nuclear power is clean and relatively cost effective. While much of the increased capacity in nuclear power prior to the 1970s was already planned, the oil price increases certainly encouraged the increased use of nuclear power. However, the Three Mile Island incident in 1979 caused much public opposition to nuclear energy. Since then no new plants have been ordered. The growth in the amount of nuclear generated electrical power has tapered off in recent years and could possibly diminish in the future, as older power plants are retired. The future looks brighter for coal, although the current fear of global warming is causing second thoughts about relying more and more on coal.
5. The major reason is that, compared to other sources of energy, renewable sources are relatively more expensive.

Part B:

1. Make sure student graphs are neatly labeled and use several colors.

2. Hydropower: 85.9 percent, Geothermal 3.0 percent, Biomass (Municipal Waste to Energy) 2.3 percent, Biomass (Other, especially wood and wood waste) 6.7 percent, Solar Thermal 0.5 percent, Wind 1.6 percent.

3. Hydropower. It is relatively cost effective compared to the other sources.

4. Solar Thermal

5. Answers will vary.

Activity 3: Trends In R & D Spending

1. Make sure students label the axes correctly. You may have to help students determine the range of R & D on the vertical axis. A workable range is $0 to $900.

2. R & D increases rapidly until 1980, then decreases rapidly throughout the 1980s. In 1991, it increases again.

3. Make sure students label the graph correctly and put a workable range of prices on the vertical axis ($0 to $40). You can have students graph the *real* price changes in oil, too, using 1987 dollars. See teacher directions for this activity.

4. Oil prices rose sharply in the 1970s. They then plunged in the mid-1980s, before increasing again at the end of the decade. The increase in R & D is explained by the observed dramatic rise in oil prices in the 1970s; the decrease in R & D parallels the fall in oil prices. Increases in R & D spending in FY91 can be partly explained by environmental concerns of burning fossil fuels.

Activity 4: Energy Efficiency

1. Energy efficiency measures the amount of energy it takes to do a certain amount of work or do a certain task.

2. Answers will vary. Examples: add insulation, install energy efficient appliances, turn down the thermostat, run dishwashers and washing machines only when fully loaded.

3. Answers will vary. Examples: Improved energy management such as better maintenance, improved insulation, conservation goals, lower thermostats, routine energy audits, use of computers to monitor energy consumption, heat recovery and heat exchange, improvements in electricity cogeneration, investment in energy efficient production technologies.

4. a 6.8 (81.1 - 74.3)
   b. 6.8/74.3 = 9.15 percent
   c. Energy efficiency has increased greatly.

5. “Energy efficiency” is a commonly used statistic to make comparisons among countries; however, it can be misleading since it does not take into account differences in life styles, population density, industry mix, and other factors. For example, Japan and Italy are small countries with high population densities. This makes energy-saving mass transit more practical. Italy and Japan also tax energy much more heavily (In Italy gas costs about $4 a gallon, of which $3 is tax!), which reduces energy consumption. The United States has a more extreme climate, which requires large amounts of energy for heating and cooling. Living standards also are higher in the United States, and it takes more energy to heat our larger homes. When corrected for differences in living space, the United States is among the most efficient of the other developed countries in residential heating. Another factor is that because energy is relatively abundant in the United States compared to Japan and Italy, we have developed industries that rely on high energy usage (“energy intensity”) in production.

Activity 8: Case Study: The Case of the Energy Subsidy

The Decision Worksheets for the various special interest groups will reflect the biases of the constituencies represented. Nevertheless, the consensus Decision Grid is likely to look something like the sample below.

Suggested Answer Key
The Case of the Energy Subsidy

Criteria					
Alternatives	**Fairness**	**Environmental Impact**	**Deals with Spillover Costs**	**Growth and Jobs**	**Budget Deficit**
Free market only	- Pollution hurts others	- Benign neglect	- Does not deal with spillover	+ Growth continues	0 No direct impact
Tax credits	+/- Why single out this industry?	+ Encourages cleaner fuels	? Could level playing field with fossil fuels, but hard to measure	+ Growth continues	- Reduces tax revenues
Fossil fuel tax	+ Those responsible would pay	+ Incentive to develop cleaner fuels	+ Would internalize spillover costs	- Energy costs would rise, slowing the economy	+ Increases tax revenues

Source: Indiana Department of Education, Energy Environment & Economics