SUSTAINABLE ENERGY:
HELPING THE "X" FAMILY MEET THEIR GOALS

Unit Overview

This unit introduces students to the costs and benefits of energy use and helps them to investigate alternative sustainable energy paths for the future by analyzing the energy consumption experiences of a typical family in Virginia. In the first part of the unit, students examine all aspects of the role of energy in the lives of the "X" family. They learn where energy for the home and transportation come from and how it is used. They then analyze the concrete environmental impacts of "X" family's energy use in one year. The second part of the unit introduces students to alternative ways that the "X" family might meet their energy needs now and in the future. Students are asked to focus on different aspects of the family's energy use and compare alternative sources and uses of energy for each. Students are then asked to seek the most sustainable means of providing the "X" family with their energy needs by comparing the relative economic and environmental impacts of various options. Students will learn through this exercise that there are many options and few "right" answers in the quest for sustainable energy.

Grade Levels: Middle School (6-8)

SOL's: Life Science 12; Earth Science 7; Math 8.4, 8.13; Computer/Technology 8.2, 8.4; English 8.4, 8.6, 9.8; Science 6.1, 6.2, 6.3

Skills: Analyzing, comparing, calculating, problem solving, researching, synthesizing information

Key Words/Concepts: Nonrenewable energy sources, renewable/alternative energy sources, energy consumption, environmental costs, energy choices

Using the Unit

This lesson is divided into two parts, the first presents an analysis of home energy use by a typical family in Virginia and highlights the environmental impacts of this use. This portion of the unit may stand alone and relies primarily on skills of comprehension and class participation from students. The second part of the lesson builds upon the first and requires that students actively engage in critical thinking, investigation and some library and Internet research.

This unit includes background information for teachers, learning objectives and takes the teacher through each portion of the unit step by step. The unit contains activity and handout pages to be copied and distributed to students.

Background for Teachers

The United States currently relies heavily on coal, oil and natural gas for its energy. Fossil fuels such as these are *nonrenewable,* that is, they draw on finite resources that will eventually dwindle, becoming too expensive or too environmentally damaging to retrieve and utilize. This presents a problem for current and future generations. Energy has become the life-blood of modern civilization. We use energy for hundreds of purposes in the course of a typical day, consuming nearly 90 quadrillion BTU's of energy per year in the United States alone. As U.S. and world populations grow and energy-consuming technologies become more widespread, the future demand for energy is expected to rise. How will future generations meet their energy needs on a sustainable basis? Although no one has the definitive answer, a wide range of

possible solutions do exist. What looks to be the most promising path to a sustainable energy future is a mix of two key strategies: vastly improved energy efficiency in everything from cars to industrial processes on the one hand and far greater reliance on alternative and renewable energy sources on the other.

It is important to note that no perfect solution to the problem of sustainable energy has yet been developed. All energy use affects the environment whether it is from renewable or non-renewable sources. Whatever choices we make will require trade-offs.

Fossil fuels provide a cheap and convenient source of energy which promoted tremendous economic growth and dramatic improvements in the basic standard of living of every American over the past century. Yet extraction and use of fossil fuels also caused a wide range of troubling environmental problems such as soil erosion, subsidence, soil and water pollution, release of toxic chemicals, oil spills, destruction of habitat, acid rain, smog, increased incidence of respiratory problems and an increase in atmospheric greenhouse gasses that may lead to global warming. The costs of these impacts on humans and the environment are difficult to measure in monetary terms, yet we know they are substantial. Some economists argue that if the market price of fossil fuels truly reflected all of these external or by-product costs, the price of electricity would be above 10 cents per kilowatt hour and more than a dollar per gallon would be added to the market price of oil.

Alternatives to fossil fuels include solar, wind, hydro, geothermal, biomass and nuclear energy sources. Each of these has advantages and limitations.

Renewable energy resources such as solar and wind are attractive in that they will not be depleted. Energy from these sources creates only a tiny fraction of the pollution caused by fossil fuel extraction and use; however, production of energy from wind and solar requires large amounts of space (a significant "ecological footprint") and since the sun does not shine constantly and wind does not blow constantly, advanced energy storage mechanisms are required to make their use effective. Wind energy comes close to competing with some fossil fuels in price but solar energy technology is not yet price competitive with fossil fuels. It is thought that the most promising way to utilize these energy sources in future will be in conjunction with the use of hydrogen as a key means of storage and transportation.

Biomass energy is produced from agricultural and forest products and waste and is either burned or transformed into fuel such as methanol or ethanol. Biomass can create less pollution than fossil fuels, but its use is not pollution-free. It requires large amounts of land, topsoil, water and energy resources in its production.

Geothermal energy depends upon heat trapped in and below the earth's crust. It produces very little pollution relative to fossil fuels but sources of geothermal energy are limited and not always renewable.

Hydroelectric power is renewable and harnesses the energy of moving water. It produces minimal pollution, but large scale hydroelectric plants require damming of rivers which disrupts ecosystems. Hydroelectric power can also be generated on the small scale by inserting turbines in waterways. These cause less ecological damage but cannot produce the same energy capacity as large hydroelectric plants.

Nuclear energy does not contribute to air pollution or global warming but there are risks associated with its use including plant

malfunctions, radiation leaks and production of radioactive wastes which are potentially harmful to life forms for thousands of years. Nuclear energy depends upon uranium and plutonium which are non-renewable resources. Nuclear energy plants are extremely costly to build, operate and dismantle and the building of nuclear plants is so energy intensive that it takes many years for a plant actually make a positive contribution to the nation's energy balance.

Given that no perfect solution as yet exists, achievement of sustainable energy in the future depends upon finding a combination of technologies and energy sources that provide us with the energy we need at the *least* financial, environmental and social cost.

This unit provides students with information about economic and environmental costs and benefits associated with current patterns of energy use. It exposes students to the various alternatives that exist for the achievement of greater energy sustainability in the future and asks students to evaluate various options, developing their own suggestions and conclusions based on the given information and their additional research. Students should be reminded that there is no "right" answer in this case. Their goal is to develop and support arguments for a set of solutions based upon the available information and their own values in trading off one option against another.

Unit Context

In the context of our Soft vs Hard Green framework (see chapter 2), Soft Green enthusiasts advocate reliance on decentralized energy production to reduce loss of efficiency in long distance transmission systems and to disperse pollution. Hard Green thinkers tend to make the opposite argument, that large centralized power generation facilities are best because they have greater engineering efficiency than smaller scale plants, and offer more manageable pollution abatement and disposal strategies.

Learning Objectives

In this unit students will:

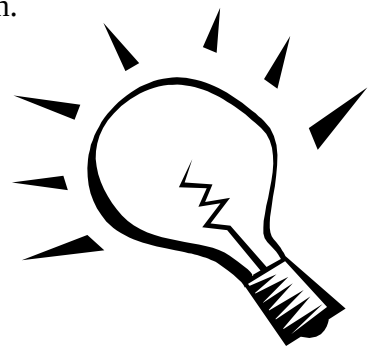
- Analyze energy consumption patterns of a typical family in Virginia.
- Compare and connect energy consumption with the environmental impacts that result.
- Investigate and compare various alternatives to current patterns of energy consumption in the home.
- Compare and contrast the relative merits of various alternative energy options.
- Develop recommendations for a combination of energy alternatives that promote greater sustainability.

Getting Ready

Make copies of:

- Introduction to the "X" Family (SE 1-4)
- "X" Family Causes & Environmental Effects (SE 5)
- Ideas for Sustainable Energy Fact Sheets (SE 6-12)
- Sustainable Energy Recommendations for the "X" Family (SE 13-14)

Make available some of the resources recommended for further reading in each of the fact sheets and allow time for Internet research.



LESSON 1:
Energy Consumption

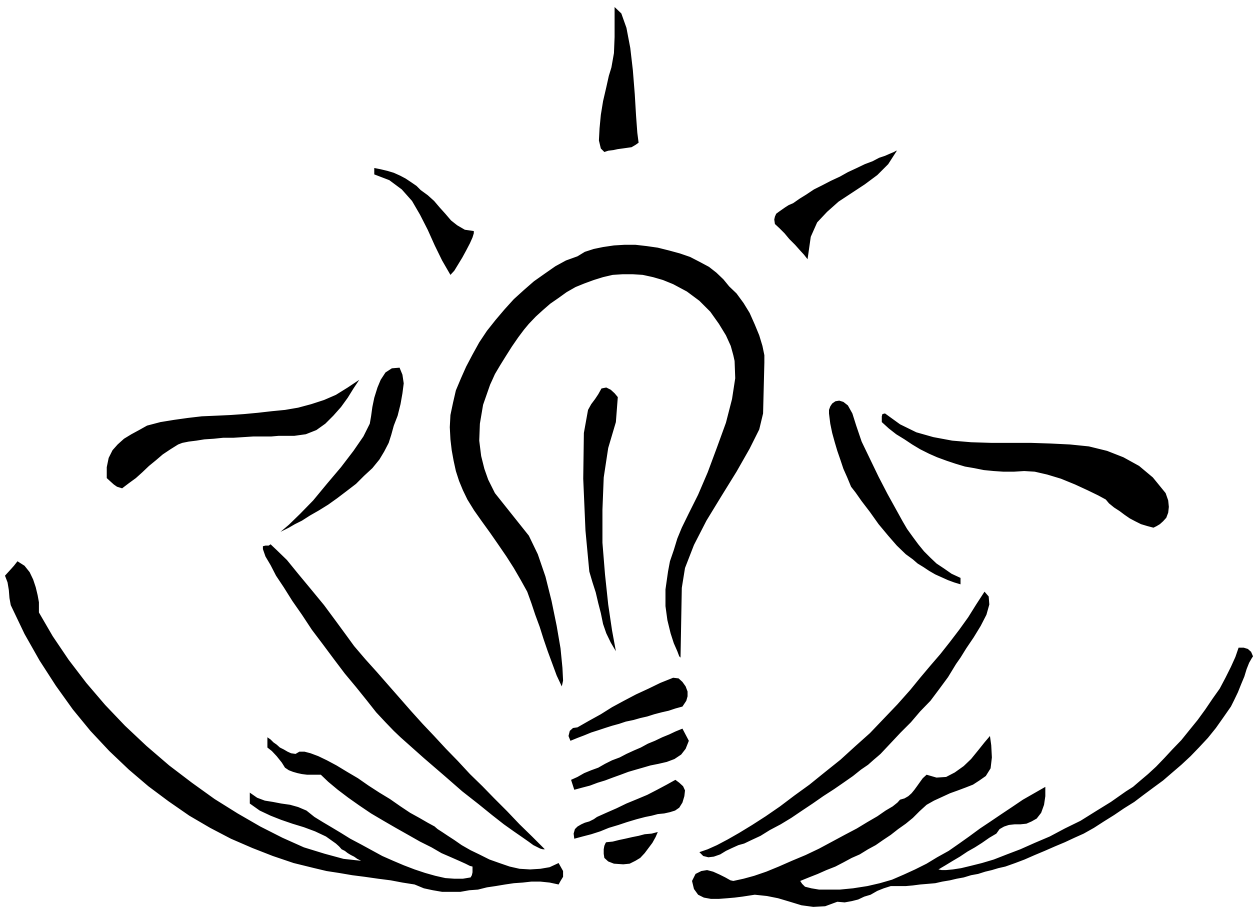
1. Give students Introduction to the "X" Family (SE 1). Explain that the "X" family is a typical family in Virginia that wants to make some changes in their energy consumption due to a growing awareness of effects that energy consumption has on our environment. The job of the class is to help the family go from being typical energy consumers to sustainable energy consumers as cheaply and efficiently as possible. In order to do this the class must first analyze the family's current energy consumption choices and see how these relate to environmental impacts and financial costs for the family. This information is given in the three parts of Introducing The "X" Family (SE 1-4).

2. Have students read through the information given in the handout and ask the following questions to ensure comprehension. Make sure to explain that kilowatt hours and BTU's (British Thermal Units) are common measures of energy use. One kilowatt hour is the amount of electricity used in one hour at a rate of 1,000 watts. One BTU is the heat energy needed to raise the temperature of one pound of water one degree Fahrenheit.

- How much energy does the family use in a year? (*88,299 Kwh or 305 million BTU's*)
- What are the three major areas where the energy goes? (*Towards automobile transportation, heating the home and providing electricity for water heating and electrical appliances*)
- How much total money does the family spend each year on energy use? ($3, 630)
- Which of the three areas uses the most energy? (*Automobiles*)
- The least? (*Electricity)*
- Which uses of electricity consume the most energy? (*Water heating, Lights and Cooking*)
- What are some of the environmental impacts of energy use for automobile transport? *(Production of emissions that create smog, acid rain and contribute to the green house effect from burning of gasoline in the cars' engines. Other effects come from extraction, refinement and transportation of oil from wells to the gas pump such as oil spills, toxic by-products of refinement and leaks in oil pipelines.)*
- What are some impacts of energy use for home heating? (*Production of emissions from burning of natural gas, especially Carbon Dioxide which contributes to the green house effect and possibly global warming.*)
- What are some impacts of energy use in producing the family's electricity? (*Most of the family's electricity comes from burning coal in power plants. The remainder comes from nuclear energy and a small quantity of hydroelectric power and natural gas. Coal produces the greatest amount of toxic emissions and Carbon Dioxide gas of any fossil fuel. Extraction and mining of coal also creates serious problems of soil erosion, water contamination and subsidence.*

Nuclear energy creates no emissions of toxic gasses but gives off a great deal of thermal waste heat and the radioactive by-product of nuclear energy are toxic for thousands of years.)

3. Give students "X" Family Causes and Environmental Effects (SE 5) and ask them to fill out the table and answer questions based on the information they have about energy consumption by Family "X'.



LESSON 2:
Sustainable Energy Option & Alternatives

1. Completion of Lesson 1 of the unit prepares students to now analyze the various options and alternatives that are available to the "X" family in becoming more sustainable energy consumers.

Students may work alone or in groups of three to complete Lesson 2 of the unit. Each group or individual should be given the three sets of Sustainable Energy Fact Sheets (SE 6-12), each providing information on sustainable alternatives in one of the three areas of home energy consumption: Transportation, Home Heating and Electricity use.

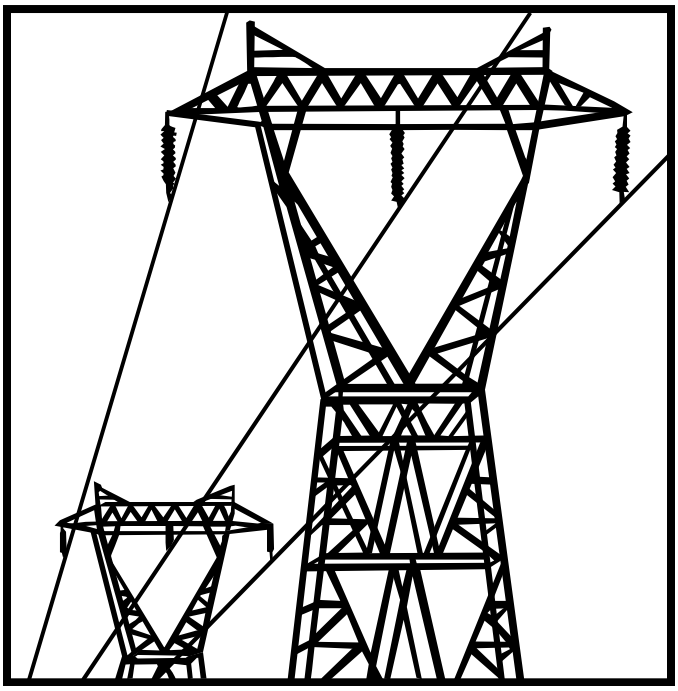
2. Prepare students for this part of the activity by first reviewing the background information given in the beginning of the unit. Explain that each fact sheet contains a range of options the family may choose to adopt in improving their level of energy sustainability. The students will examine the given alternatives and will come up with their own recommendations for the "X" family in becoming sustainable energy consumers. The goal should be to create the most energy efficient combination that provides the least amount of environmental impact for the least estimated cost to the family. Stress that there is no one "right" answer for the family. Each student or group should feel free to come up with whatever combination of strategies that they feel provides the most improvement at the least cost. However they need to develop arguments which support their choices.

3. Give each group or individual Sustainable Energy Recommendations (SE13-14) for the "X" Family to fill out with their specific recommendations for the family.

4. Students should be encouraged to access the web sites and additional resources listed at the end of each fact sheet to enhance their understanding of the options available in making their recommendations.

5. Once the recommendations sheets are completed, ask individuals or teams to share their list with the class, explaining why they made the choices they did. Discuss some of the difficult tradeoffs that students faced in making their recommendations.

6. In summing up the unit, ask students if they are willing to follow the advice they gave to the "X" family. Which of the options would they like to see their own families adopt? Which ones do not seem realistic? Why or why not?



INTRODUCING

THE "X" FAMILY

Father: Michael X, Computer technician
Mother: Sandra X, School counselor
Son: Mark X (Age 13), Middle school student
Daughter: Angela X (Age 7), Elementary school student

The family lives in suburban Virginia. Sandra and Michael both commute to work by car. He commutes 30 miles each day and she commutes 3 miles to the school where she works. Mark and Angela both take the school bus and get rides to their many after school activities from Sandra in the family's SUV.

The family owns a single-family home in a quiet neighborhood. The house is two stories and was built in the 1980's. They have been living here for 9 years and like the location which is less than a mile away from shopping and not far from parks and Angela's school. The house is attractive but the family has noticed that it feels a bit drafty in the winter and they are paying high heat bills.

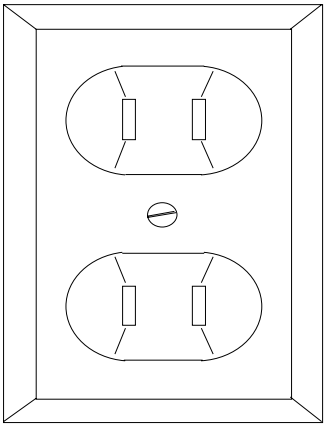
In the last few years Sandra and Michael have become more concerned about environmental issues. They never paid much attention in the past to how their own actions might affect the environment and never factored in environmental impacts when making decisions about home, car or appliance purchases. But now they want to better understand how those decisions affect the environment and what they might do to reduce their impacts.

They know that energy use is one of the key areas where they can make a difference but don't know where to start or what choices will have the most benefit for the least cost. Their goal is to cut down on the negative environmental effects of family energy use by at least one third but they can't afford to spend a lot of money to do so. They are willing to make some investments now to save energy but they would like any additional costs to be offset by lower energy bills that will pay back the investment in 10 years or so.

Your job is to help the X family meet their goal. You will first analyze the family's typical energy consumption patterns and costs during one year, examining the environmental impacts of their energy use. Then you will look at some of the options for reducing home energy consumption and the negative environmental impacts of energy consumption. You will examine the tradeoffs of the various alternatives and finally will make your recommendations to the family on what *you* think they should do to meet their goal.

Annual "X" Family

Energy Consumption



All energy consumption is given in terms of kilowatt hours and BTUs so amounts of energy can be compared across different uses.

Total energy use per year: 88,299 Kwh
(305 million BTUs)

Annual cost of energy use:	$3,630
Share for auto fuel:	$1,980
Share for home energy use:	$1,650

Breakdown of Energy Consumption for Home and Automobile Transportation

1. ENERGY USED IN TRANSPORTATION:

Car 1: 1998 Sport Utility Vehicle.
Drives an average of 14,000 miles/yr.
Energy equivalent: 33,489 Kwh

Costs: $1,235 for gas each year
Consumes 915 gallons of gas/yr.
(143 million BTUs)

Car 2: 1997 Mid-sized Passenger Car.
Drives an average of 12,500 miles/yr.
Energy equivalent: 20,130 Kwh

Costs: $ 745 for gas each year
Consumes 550 gallons of gas/yr.
(69 million BTUs)

2. ENERGY USED TO HEAT THE HOME:

The family uses **natural gas** to heat the home. They have a typical natural gas furnace heating system (which has an efficiency of about 70%) and have never done anything to upgrade the efficiency of their current system.

Energy use: 21,500 Kwh per year (74 million BTUs) **Costs**: 4 cents per Kwh $860 per year

3. ENERGY USED IN THE FORM OF ELECTRICITY:

(for Lights, Refrigeration, Appliances, Water Heating etc.)
The following are the major uses of electricity in the family home and the annual energy consumption for each (Kwh):

Water heating	6,060	Lights	1,960
Stove	1,160	Refrigerator	870
Air conditioner	580	Televisions (2)	574
Clothes Dryer	480	Dishwasher	420
Computer	270	Hair Dryers (2)	240
Coffee maker	96	Microwave oven	89
Stereo system	73	Vacuum cleaner	48
Clocks (4)	48	Printer	45
Toaster	36	Clothes washer	31
Other	100		

Energy Use Total: 13,180 Kwh **Costs:** 6 cents per kilowatt hour $790 per year

Energy Use of the "X" Family

Environmental IMPACT

Environmental costs of current energy use include increased medical expenses for health problems caused by pollution, costs of cleaning up water, soil and air and repairing damage done to land, plants, animals and people. There are also many less tangible costs, such as loss of beautiful views, faltering ecosystems and the potential costs of global warming which need to be accounted for. We know these costs exist but it is very difficult to measure them accurately.

The Department of Energy, recently attempted to put values on the health and environmental costs associated with each energy type. Although we know that these numbers are imperfect measures at least they give us some basis for comparison of relative environmental impacts.

According to these estimates the *environmental costs* of producing energy from various sources is as follows. (Note that environmental costs are **not** at this time included in the price we pay for energy)

Electricity from Coal:	5.7 cents per Kwh
Electricity from Nuclear:	5.0 cents per Kwh
Energy from Oil:	2.7 cents per Kwh
Energy from Natural Gas:	1.0 cent per Kwh
Energy from Biomass:	0.7 cents per Kwh
Energy from Solar cells:	0.4 cents per Kwh
Energy from Geothermal:	0.1 cents per Kwh
Energy from Wind:	0.1 cents per Kwh

1. Impacts from Family Cars:

Burning gasoline in automobiles produces pollution which is released into the air. This contributes to smog, asthma and accumulation of warming greenhouse gasses in the atmosphere. The major pollutants from auto exhaust are Hydrocarbons, Nitrogen Oxide, Carbon Monoxide and Carbon Dioxide.

Evaporation of gasoline from the fuel tank, especially on hot days and when refueling the car, gives off hydrocarbons which contribute to smog. Oil leaks from automobiles contaminate ground water when washed from roadways or parking lots by rain.

The pollutants produced by the "X" family's cars each year are as follows:

Car 1: Sport Utility Vehicle

Hydrocarbons (smog and air toxics)	114 lbs
Carbon Monoxide (poisonous gas)	894 lbs
Nitrogen Oxide (smog and acid rain)	59 lbs
Carbon Dioxide (global warming)	16,800 lbs

Estimated environmental costs:
98.7 cents per gal. $903 per year

Car 2: Mid-size Passenger Car (1)

Hydrocarbons	80 lbs
Carbon monoxide	606 lbs
Nitrogen Oxide	41 lbs
Carbon Dioxide	10,000 lbs

Estimated environmental costs:
98.7 cents per gal. $543 per year

"X" Family Environmental IMPACT

2. Impacts from Home Heating with Natural Gas:

Natural Gas is generally less polluting than other fossil fuel energy sources like oil and coal. The biggest environmental impact from use of natural gas is release of Carbon Dioxide into the atmosphere which is thought to contribute to the greenhouse effect and global warming.

Using natural gas to heat the X family home releases 9,030 lbs of Carbon Dioxide into the atmosphere each year.

Estimated Environmental costs: 1 cent per Kwh. ($215 per year created by family consumption.)

3. Impacts from Electricity Use:

The electricity for most Virginia households comes from two main sources: coal fired power plants and nuclear electric plants.

Coal is a cheap and plentiful source of locally mined energy but it is also the dirtiest fossil fuel energy source, producing more pollutants per Kwh than either oil or natural gas. Coal mining also takes its toll on land and water systems. It disrupts large land areas, destroying the existing ecosystems. Leaking of toxic chemicals from coal mining operations into groundwater is also a common problem. Coal is a non-renewable resource although by some estimates we are not likely to face coal scarcity for several hundred years.

Nuclear energy produces very little air pollution but it does produce large amounts of thermal pollution (waste heat). The main environmental impacts associated with nuclear energy are the risks associated with using radioactive materials, possibility of plant failure or meltdowns and storage or disposal of nuclear wastes from plants.

Estimated environmental costs:

5.7 cents per Kwh for coal
5.0 cents per Kwh for nuclear

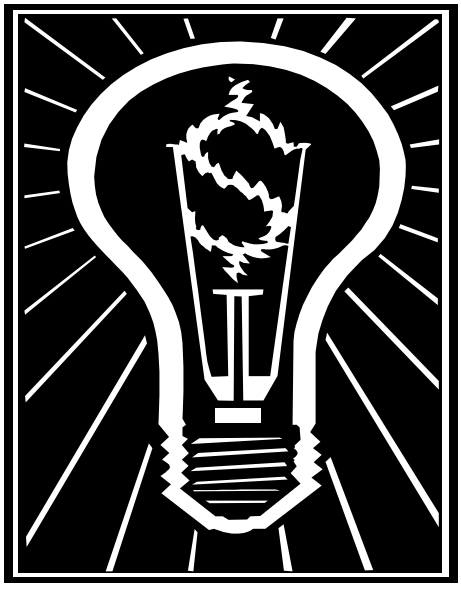
($751 per year total from family consumption).

"X" Family Causes & Environmental Effects

1. What are the top five home and transportation energy consumers for the "X" Family?

Energy Consumer:	How much energy is consumed in one year?
1.	
2.	
3.	
4.	
5.	

2. What are the major environmental impacts of energy produced from fossil fuels such as coal, oil and natural gas?



Ideas for

Sustainable Energy for Transportation

Hybrid-electric Cars

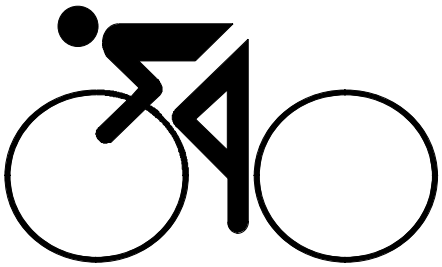
Hybrid vehicles blend the power of a combustion engine and an electric motor. Current models run on gasoline but can get as much as 70 miles to the gallon with the added power of the electric motor whose battery is recharged every time the driver uses the brakes. Hybrid car makers include Honda, Toyota and GM. The high mileage per gallon and a special catalytic converter combine to create a big cut in pollutants - 84% fewer hydrocarbons and 50% less nitrogen oxide than a typical car. Since the cars get from twice to three times the gas mileage of typical cars - owners save significantly on gasoline costs.

Drawbacks are that they are smaller and lighter than many conventional cars. Thus, they provide less protection in collisions and the initial price is somewhat higher than comparably sized conventional cars.

Fuel Cell Cars

Researchers hope that within 20 years fuel cells will replace internal combustion engines in powering vehicles. Fuel cells generate electricity directly from a chemical reaction between hydrogen and oxygen. If hydrogen is used as the original fuel then the only emission is pure water. Right now, although hydrogen is the most abundant element in the universe, it is not readily available in pure form and is difficult to store and transport. It is possible to draw hydrogen from fuel sources such as gasoline, ethanol or methanol using fuel "reformers" built into the engine of the car. Even if fossil fuels are used as the source of hydrogen, fuel cells are cleaner than internal combustion engines because they create two to three times as much energy and thus get more mileage out of every gallon. The auto companies Ford and Daimler-Chrysler both hope to market fuel-cell cars in the near future that will match the performance and cost of today's cars.

Eventually solar energy may be used to extract hydrogen from water, which can then be used as a completely pollution-free fuel but this may not be practical for some time.



Muscle Power

Bicycles as a primary form of transport are not practical for every situation but there are many advantages to using bikes (or walking) in place of cars whenever possible. For much of the world bikes outnumber cars ten to one as a primary source of transportation. Bikes are not only low cost and easy to repair, but they use no fuel except the food you put in your body and they provide numerous health benefits to the rider.

A new invention called the E-bike uses an electric motor to help the rider on steep hills or long rides. It has a rechargeable battery and can run at 15 miles per hour. The energy used by the E-bike is only a tiny fraction of that required to power an automobile yet can replace the car for quick trips to the store and commuting to nearby school or work. The current cost of the E-Bike is about $1,000, while more conventional bikes cost anywhere from $50 to $2,000.

Ideas for Sustainable Energy for Transportation

Energy Conservation through Sharing and Other Measures

Saving on energy used for transportation can be as simple as finding ways to share rides with others. Carpooling to work or after-school functions cuts down on the number of trips made, saving fuel and wear on the automobile. Commuting in heavy traffic uses more fuel and creates more wear on cars than other kinds of driving. If workers share rides it has a significant impact on cutting pollution and easing rush-hour congestion of the roads.

Cars start to lose fuel efficiency at speeds above 60 miles per hour thus, energy is wasted when drivers exceed speed limits.

Choosing smaller, fuel-efficient cars is a better bet for saving energy than light trucks or Sport Utility Vehicles. Smaller, fuel-efficient cars can get twice as much mileage to the gallon as larger cars and trucks.

Ethanol fuel

Ethanol is fuel produced from corn, wood and other agricultural products and wastes. It can be used in place of gasoline in typical automobiles. Ethanol produces less pollution than gasoline in automobiles and in fact, you can buy gasoline/ethanol mixes at many fuel stations today. Increasing the use of ethanol fuel tends to help farmers in the United States since it increases demand for their crops and gives them higher revenues. Some drawbacks of ethanol are that it is more expensive than gasoline, it requires land and soil to produce which contributes to soil degradation, and a great deal of energy is used to produce, harvest and process the agricultural products into fuel for automobiles.

Alternative forms of Transportation

Public transportation such as bus or light rail systems provide a good energy saving alternative for many families. A full bus uses only a fraction of the energy needed to transport its occupants individually by car and cities such as Chattanooga, Tennessee provide low-emissions busses to serve the public. Light rail uses electricity to transport passengers, and although the electricity was generated in power plants which cause pollution, the trains themselves release no emissions and can transport many people using the same amount of energy used by a single family car.

You can find out more about these sustainable transportation options and others by searching the following web sites and other resources.

Center for Renewable Energy and Sustainable Technology
www.crest.org

U.S. Environmental Protection Agency
www.epa.gov

U.S. Department of Energy
www.doe.gov

SE 7

Ideas for

Sustainable Home Heating

A key to providing sustainable heat for the home is to cut out as much unnecessary waste of energy as possible. Energy is lost, not only in the home itself through leaky windows and poor insulation, but also in the process of extracting, transporting, generating and transmitting the energy that is used to provide home heat.

In seeking the most sustainable method of heating the home, look for ways to minimize *energy waste* and the *life-cycle costs* of the heating system. Life cycle costs include both the cost of installing the heating system and the costs of operating the system over its lifetime.

1. Cut out the Waste

No matter what the family's source of heat, energy consumption can be reduced by as much as one third simply by making the following changes and improvements to the home. The costs of these improvements will be paid for in two or three years by the increased energy savings.

- Lowering the thermostat just 5 degrees in winter will save about 231 therms of gas and 2798 lbs of CO2 emissions per year.
- Seal up leaky windows with caulk or weather stripping or replace old windows with more energy efficient ones.
- Check the attic and crawlspace for insulation. If there is none, insulate these areas.
- If the walls are not insulated, have an insulation contractor blow cellulose into the walls.
- Seal up the largest air leaks in the house. Look for areas that feel drafty on cool days. The worst areas are often hidden: holes made in the walls for pipes, gaps around chimneys and recessed lights and unfinished space behind cupboards and closets.

2. Geothermal Heat Pump

This technology uses the relatively constant temperature (50-70 degrees year round) of the ground to reduce the amount of energy needed to heat and cool the home. The system does not convert electricity to heat, instead it uses electricity to move heat between the house and the ground which reduces the amount of energy required to provide comfortable indoor temperatures. This system reduces consumption of electricity 30-60% over conventional heating systems and these reductions bring cost savings on electric bills that pay off the installation costs in 2 to 10 years. Geothermal heat systems can be installed in existing homes or built into new ones.

Ideas for Sustainable Home Heating

3. Super Insulated House

Perhaps the most efficient way to sustainably heat the home is to build a super insulated house. These houses are so heavily insulated and airtight that heat from sunlight, appliances and human bodies warms them, requiring only a minimum amount of heat from other sources. These homes use extremely heavy insulation and insulated glass windows which are placed mostly on the south side of the house. This is the best direction for absorbing the heat of the sun in winter. Few windows are placed on the north side of the home to keep out cold winter winds. An air to air heat exchanger is used in these homes to prevent buildup of indoor air pollution.

These homes cost about 5% more to build than a typically insulated home but the extra cost is paid back by energy savings usually within 5 years and can save a homeowner $50,000 to $100,000 over a 40 year period.

4. Passive Solar Heating

Passive solar heating requires that homes be designed from the outset to take advantage of the natural warmth that comes from the sun in winter. Passive solar heat for the home works on the same principle as how a car interior will heat up so much more than the outside air when left in the sun. Windows allow solar energy to enter the home, this energy is absorbed by floor and wall materials during the day and released slowly back into the house at night. A home designed to take advantage of passive solar heat orients many windows on the south facing side of the home which receives the best exposure to sunlight in winter. Windows are minimized on the north side of the house to add additional insulation to the home. Designing and building a passive solar home is not necessarily more expensive than a conventional home, but careful planning must go in to placement, orientation and building materials if maximum solar gain is to be accomplished.

Passive solar heat does not typically replace other, more conventional sources of heat for the home but it cuts down significantly on the amount of energy needed from those conventional sources.

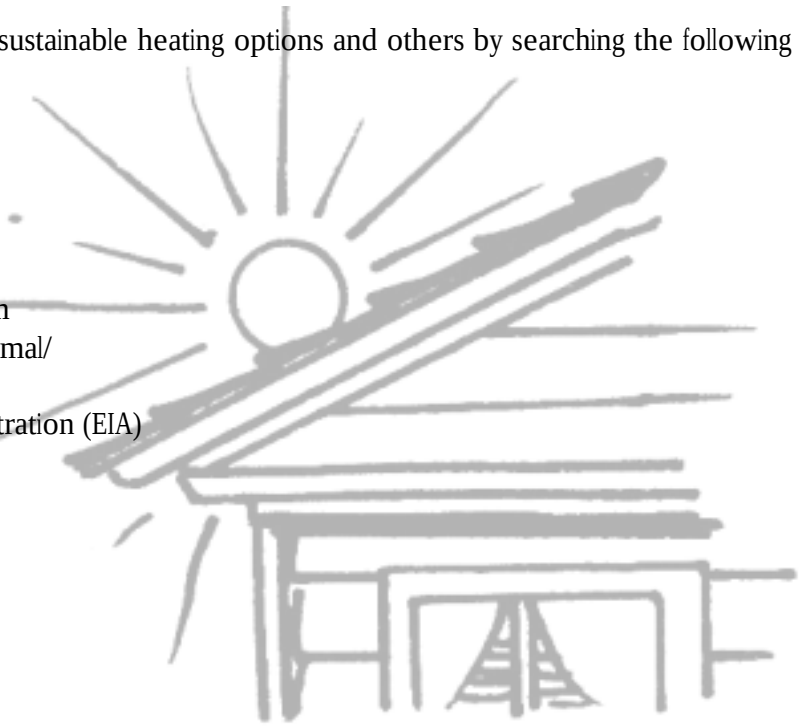
You can find more about these sustainable heating options and others by searching the following web sites and other resources:

ENERGYguide.com
www. energyguide.com

Geothermal Energy Program
www.eren.doe.gov/geothermal/

Energy Information Administration (EIA)
www.eia.doe.gov

ECONET
www.econet.org



SE 9

Energy

Ideas for

Sustainable Electricity

1. Improve the energy efficiency of appliances.

Reduce electricity consumption by replacing old appliances with the most energy efficient ones on the market. The benefits of more energy efficient appliances that will save money over time in electric bills must be weighed against the initial costs of buying the appliances.

Lights: Replacing standard incandescent light bulbs with compact fluorescent bulbs saves energy. These bulbs typically cost between 18 and 25 dollars each, but last much longer than a typical light bulb. For every 10% of lights replaced in the home each year the family will save:

440 Kwh of electricity
696 lbs of CO2 emissions
$25 dollars on electricity

Refrigerator: Refrigerators with freezers on top are more energy efficient than those with side freezers. Currently Maytag and Jenn-Air make the most efficient models on the market. If the X family replaces theirs with one of these, every year they will save:

385 Kwh of electricity.
608 lbs CO2 emissions
$22 on electricity

Dishwasher: If the family replaces their dishwasher with the most energy efficient one currently on the market (made by Asko), each year they will save:

76 Kwh of electricity
120 lbs CO2 emissions
$4.25 on electricity

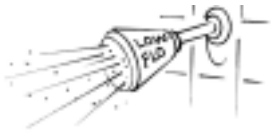
Water Heaters: If the current water heater is replaced with the most efficient electric model on the market today (made by A.O. Smith), each year they will save:

1,436 Kwh of electricity
2,268 lbs CO2 emissions
$80 on electricity

If they change to a **solar water heating** system in their home, each year they will save:

3,983 Kwh of electricity
6293 lbs CO2 emissions
$223 on electricity

Ideas for Sustainable Electricity



2. Implement electricity conservation measures in the home.

There are many simple things that can be done in the home to cut down on waste of energy without spending much time or money.

- Turn down water heater to warm setting (120 degrees) and put an insulating blanket around it.
  Cost: $10
  Savings: 1,600 Kwh per year
  2544 lbs CO2 reduction
  $89 on electricity

- Replace or clean filters for furnace, air-conditioner and heat pumps.
  Cost: $30
  Savings: 300 -500 Kwh per year
  $18 - $28 on electricity

- Install low flow shower heads which cut down on amount of hot water used.
  Cost: $20 (two)
  Savings: 1,700 Kwh per year
  $95 of electricity

- Reduce need for air-conditioning by planting shade trees and shrubs around house - especially on south and west sides.
  Cost: $ 50 -500
  Savings: Variable

- Turn down thermostat in winter. For every degree turned down they save:
  47 therms
  574 pounds of Co2 emissions
  $32 per year on gas

3. Buy electricity from a supplier of green or renewable power.

Green power is electricity generated from renewable resources such as solar, wind, geothermal, small hydro, and biomass. These "environment friendly" resources provide the consumer with an alternative to power generated by coal, oil, natural gas and nuclear sources.

Keep in mind that the electricity supplied to the X family home is part of the power grid which mixes all power sources in a regional pool. There is no way to physically separate green power from that generated by non-renewable sources. But by selecting the green power option the family is sending a message to its energy supplier to buy a greater percentage of its power from renewable sources. If everyone were to purchase the green power option it would drastically increase the demand and use of electricity produced by renewable resources and decrease demand for non-renewables. It is important to note that the option to buy green power is not yet available to all consumers but this option is becoming more widespread over time.

By choosing the green power option each year the family would save:

18,383 lbs of CO2 emissions

At present, green power costs more than regular power so electricity bills might increase $3-5 per month for the same amount of power used.

Ideas for

Sustainable Energy Options

You can find out more about sustainable energy options by searching the following websites:

U.S. Environmental Protection Agency
www.epa.gov

U.S. Department of Energy
www.doe.gov

Energy Efficiency and Renewable Energy Network (EREN)
www.eren.doe.gov

EPA's Energy Star Program
www.epa.gov

Rocky Mountain Institute
www.rmi.org

Solstice
www.solstice.crest.org

Center for Renewable Energy and Sustainable Technology
www.crest.org

Top Rated Energy-Efficient Appliances:
www.aceee.org/consumerguide/

ENERGYguide.com
www.energyguide.com

Geothermal Energy Program
www.eren.doe.gov/geothermal/

Energy Information Administration (EIA)
www.eia.doe.gov

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Sustainable Energy Recommendation for the "X" Family

TRANSPORTATION

Action:	Effect on Energy Consumption:	Effect on Environment:	Economic Costs:	Reasons for Choice:
1.				
2.				
3.				

HOME HEATING

Action:	Effect on Energy Consumption:	Effect on Environment:	Economic Costs:	Reasons for Choice:
1.				
2.				
3.				

Sustainable Energy Recommendation for the X Family

ELECTRICITY CONSUMPTION

Action:	Effect on Energy Consumption:	Effect on Environment:	Economic Costs:	Reasons for Choice:
1.				
2.				
3.				

Questions:

1. What were some of the tradeoffs you faced in making your choices?

2. If the family follows all of you recommendations, how much energy will they save in one year?

3. How much money (if any) will they save over 10 years?

4. How much air pollution and CO2 emissions will be reduced in one year? Over 10 years?