Energy for the Future

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Introduction

The announcer voice comes over the radio in a deep, serious tone and begins the special report: "This just in: Energy sources will run out on July 1, 2025. The supplies of oil and natural gas are critically low. Uranium and plutonium mines have been exhausted. There will be no other available sources for electricity, heat, and transportation." While none of us has heard the news as frankly as the imaginary announcer, the evidence has been circulating for many years that unless consumers get serious about energy conservation and environmental protection including the reduction of harmful emissions from energy production and utilization, the Earth will at some point be no longer able to sustain us.

The focus of this curriculum unit on energy is to generate a consciousness in the minds of middle or high school science students that alternative energy sources are essential if our planet is to sustain life for future generations. It can be used in an environmental science class or as an extended topic in chemistry or physical science. The intended goal is for students to evaluate their energy usage, carbon footprint and their personal impact on the environment and consider ways that they might be reduce their "energy footprint". At the same time, students will explore alternative energy sources that can be used to reduce the usage of fossil fuels and produce cleaner energy and lessen the negative impact on the environment.

The duration of the unit is approximately 2 weeks if used as an extended topic project or 1 week if time constraints prevent longer. The unit can be divided into smaller portions as needed because each type of energy is addressed as a separate topic. Because some activities require computer access, the length of the unit may be extended if computers are not accessible in a classroom and computer labs must be booked. Some activities in the unit can be done as homework but the research portions are aimed at small groups so that students have the benefit of working as a team. The goal of the final product, a plan or model of an energy efficient home is for students to work in a small group to create a project that reflects content learned, collaborative effort and student generated design and presentation.

The world's energy resources have been primarily acquired from natural resources such as fossil fuels such as coal, oil and natural gas. This has been the way of the past for centuries with very little concern for the sustainability of these resources until perhaps the 1970's when the gasoline crisis put the issue in the forefront of many American's minds. Thus began a push to conserve energy resources and an increased awareness that our energy resources were not in infinite supply.

In the 21st century, the push for conservation of the environment, reduction of greenhouse gases and the awareness of the need for other resources for energy has spawned the research and development of renewable energy resources and clean energy technology that offer promise for future generations. Students will study and analyze energy resources such as bio-fuels, solar power, geothermal and wind power and the ability to utilize these energy resources to provide future generations with a cleaner, sustainable environment. Nuclear energy, while not considered renewable, is one option that alleviates the need for oil or natural gas to produce electricity. It is presented in the unit as an alternative energy resource because of its notoriety and as a means for students to evaluate it along with the other sources mentioned previously.

The world we live in today is very different from the world of our grandparents and generations that came before us. Energy use has soared as new gadgets such as the computer have been introduced. The amount of energy consumed in the United States associated with agriculture and food production from farm to table is very large with oil and diesel use being at the top.[1] Research has determined that resources such as oil and natural gas that were once perceived as infinite in supply are actually very limited due to the extensive, time intensive process of natural production and the increased rate of consumption. In other words, it's a supply and demand problem. The current supply is being consumed faster that it can be replenished. This coupled with the destruction of the environment and sensitive ecosystems by the increased greenhouse gases and other harmful emissions have pushed the need for research and development of alternative energy sources into the spotlight both nationally and globally.

As future decision makers, and voters, students need to be able to make informed decisions about laws and policies that affect their lives as well as the generations of people that will follow. As environmental protection and conservation awareness continues to increase, the need for knowledge increases. This unit seeks to engage students in exploring the alternative energy resources currently being developed and tested and increase their awareness of the impact that they as students, citizens, and

consumers have on the future of the planet as they utilize energy resources in their daily lives. One of the desired outcomes of the unit is for students to initiate strategies and develop habits that will reduce their carbon footprint and help to improve the sustainability of the planet for future generations

Alternative energy resource is a phrase that refers to sources that can be used to produce energy that are not fossil fuels such as oil, coal and natural gas or sources that can provide energy without the environment impact that fossil fuels create. The desired product is one that will produce energy in sufficient quantity as well as be economical to produce and be environmentally friendly. Much of the concern lies in reducing carbon dioxide emissions and greenhouse gas production that is associated with coal burning technology. As consumers of energy, students as well as their families need to be conscientious of the environment and cognizant of even small changes that can have cumulative large results such as switching light bulbs from traditional ones to light emitting diode (LED) or compact fluorescent types, turning off lights in rooms not in use, unplugging appliances not in use, and turning back the thermostat at home.

Nuclear Energy

Einstein was instrumental in the development of modern atomic theory. The development of his famous mass-energy equivalent equation led to the idea that if the energy in the nucleus of the atom could be somehow obtained and harnessed, a whole new source of energy would be available for future generations. The famed Manhattan project used this as the basis for the development of the atomic bomb in the late 1930's and early 1940's.

Nuclear energy is produced from the fission or splitting of an atomic nucleus of uranium. The energy released can be used to heat water to provide steam that in turn runs the turbines to produce electricity. Unlike the steam generated from coal or natural gas burning which produce greenhouse gases that are harmful to the environment, nuclear reactors do not produce carbon emissions. The reaction must be carefully controlled in the reactor chamber or the amount of energy and heat released can result in the meltdown of nuclear fuel rods and the release of dangerous amounts of radiation. Concerns about accidents and radioactive waste disposal have kept further expansion of nuclear power technology at a standstill in the United States for nearly 30 years. Only 20 percent of the power currently produced in the U.S. is from nuclear sources[2].

Nuclear energy is receiving a second look as countries like the United States seek to reduce dependence on foreign oil suppliers and work toward a better environment. President Obama's energy policy includes plans to develop safer, cleaner nuclear power technology and the Energy Department is working to build reactors in Georgia, South Carolina, Texas and Maryland.[3] Countries like Japan and France depend heavily on nuclear power generators but only about 15% of the world's electricity is generated using nuclear sources.[4] In some arenas, nuclear energy is being promoted as a clean, renewable energy alternative. However, the renewable claim is a misconception as uranium and plutonium that are mined as the fuel source are not infinite in supply and the resources will eventually be depleted at some point.

Wind Power

Wind power is generating much interest in the clean energy technology arena. The source of wind power is obviously from wind currents that flow across the Earth's surface. The kinetic energy from wind current is harvested and used to turn turbines to generate electricity similar to hydroelectric technology that uses moving water. It is an efficient and clean source of energy as it produces no harmful waste products. This technology is capable of producing electricity on both a residential scale and a commercial scale. The technology is efficient and maximizes land use. " An acre of corn land in Iowa used to house wind turbines would produce $300,000 worth of electricity per year as opposed to the same site producing corn for ethanol production which would only yield about $960 per year".[5]

Today's wind mills are not likes the ones we picture dotting the countryside in Denmark years ago. The windmill of today is modern, tall, and best of all, less noisy. It stands about 300 feet tall and has 3 to 5 blades. Small turbines can produce enough power to service up to 6 homes. The larger turbines can be linked on a grid and are capable of supplying power to large communities. The United States has substantial amounts of land-based wind energy, according to Brown, which can supply the national power needs with leftovers.[6] Backyard systems are also available which are capable of producing 2-10 watts of power which can provide electricity to ¼ to 6 homes.[7] For homeowners considering this investment, cost effectiveness should be evaluated as well as the location because in some areas it may be difficult to generate electricity because of wind availability. Research should be conducted regarding rebates and government incentives and compare the initial investment with future return.

According to the North Carolina Wind Energy at Appalachian State University site, wind technology is being considered in the state because the current technology has reduced the cost and wind technology is now competitive with oil and gas.[8] Research is currently underway to determine the impact of wind farms on the coastal regions of North Carolina and South Carolina as this is the area where a sustainable wind source is found. California, Texas and South Dakota are leading the way in wind generators with anticipation that when the current projects are finished, a surplus of electricity will allow the export of electricity.[9] While much of the wind technology is concentrated in the Plains, developers are looking at the east coast of the United States as a viable option for locating wind farms as well. The United Kingdom seeks to produce 15% of its energy from renewable resources by 2020 and wind technology is leading the way.[10] The Thanet windfarm which began operating off the coast of Kent, has bolstered Britain into the spotlight as the top producer of wind power from offshore wind in the world.[11]

Wind turbines are not favored by all consumers. Opponents cited turbulence, noise, aesthetics and bird safety as reasons not to build wind farms. Some of the windfarms in the United States are located in areas close to military installations. The Department of Defense has raised concerns about wind turbines interfering with radar systems raising issues about national security.[12]

Solar Power

Harnessing the energy from the sun through photovoltaic cell or solar thermal collector technology is a means of providing an alternative energy resource that is clean and free of harmful emissions such as carbon dioxide and sulfur dioxide which are harmful to the environment. Photovoltaic cells which use silicon semi-conductors capture the sun's energy and convert it directly to electricity. This concept has been used in calculators for many years and in more recent years in landscape lighting and billboard signs. In the United States, rebates and tax incentives as well as the Federal tax credit have helped to reduce the consumer's investment and have contributed to an increased growth in the market for photovoltaic technology.[13] Feed-in or energy buy back opportunities where utility companies are required to purchase energy from qualified projects have made this technology more attractive.

According to Lester Brown, the explosion of interest in renewable energy is not limited to industrialized countries.[14] Countries that have exported oil in the past are now

looking to harness energy from renewable resources such as solar power and export excess electricity in the future. Germany enacted a law requiring utility companies to purchase green power at premium prices under fixed contracts. Today Germany gets more than 16 percent of its power from green sources and has reduced its carbon dioxide emissions significantly.[15]

Solar energy has many applications especially in the area of farming where oil and natural gas are used. In commercial dairy farming, solar water heating systems can be used to provide hot water for cleaning animal areas and equipment. Gas and oil heaters can be replaced with solar air and space heaters reducing energy needs for ventilation and heating of barns as well as for generating electricity for lights and fences. Commercial greenhouses use the sun as a source for lighting but rely on oil heaters to maintain temperatures in the winter. Solar technology advancements have led to the development of solar greenhouses that utilize thermal mass to collect and store solar heat energy and provide heat for use at night or on cloudy days.[16]

Biomass/Biofuels

Interest in biofuels has increased over the last decade especially after Hurricane Katrina and the exorbitant fuel prices that resulted due to the damage to oil refineries in the region. This coupled with terrorism fears and the Gulf War has refueled the search for alternatives to reduce dependency on foreign oil. Plant based energy sources have become a popular consideration. These sources include yard waste, by-products of sugar production, forestry by-products, animal waste, and left-over crop material such as stalks and stems. Ethanol is probably the most common biofuel produced. Ethanol mixed with gasoline (referred to by many as gasohol) became a household name during the oil embargo crisis in the 1970's.

Ethanol is a product of grain fermentation with the most widely used grain being corn. Farmers are offered subsidies to grow corn for ethanol production but the overall energy output is lower compared to other sources like solar. Farming for ethanol production requires land and this could lead to more deforestation to create cleared land to grow corn. This seems to negate ethanol production as an environmentally sound energy source.

Another area getting some attention and appears to be more popular in Europe is burning of animal waste and garbage to generate heat. These are referred to as waste-to-

energy plants and France and Germany lead the way in this effort[17]acquired. Methane gas which is harmful to the environment can be collected from landfills and converted to electricity. In 2009, Durham County, North Carolina began using this technology.

Geothermal

Geothermal energy is probably the least thought of source of energy yet the Earth's crust contains a vast amount of energy stored right under our feet. Despite its slow growth, it has a great potential as a renewable, environmentally sound resource. Tapping into geothermal energy works very much like tapping into oil. Current drilling technology can be adapted to drill into the Earth's rock layer, fill the crack with water, then pump the hot water out to turn a turbine to produce electricity. The water condenses and is pumped back underground for heating.

In California, some cities are pumping cleansed wastewater from treatment facilities underground into geothermal fields (geysers) where it is used to generate steam and subsequently electricity. "Generating 200 megawatts of electricity from wastewater has displaced two billion pounds of greenhouse gas emissions annually".[18] This approach has its drawbacks as well including aesthetics and increased risk of earthquakes in areas around the plants.

Objectives:

1. Students will determine their individual carbon footprint and track their energy usage for a 48 hour period. The goal is for students to individualize the experience and evaluate the impact that they have on the environment.
2. Students will use computer and Internet technology conduct research and analyze information from scholarly journals and websites to determine current developments in alternative and renewable energy resources.
3. Students will evaluate the advantages and disadvantages of each type of alternative or renewable energy resource and complete a written recommendation with supporting information from research and present it during a class debate.
4. Students will create a personal plan for efficient energy consumption and create a one to two minute video commercial promoting energy conservation.
5. Students will research and create a presentation for an energy efficient home outlining specific amenities, appliances, and construction materials that are currently available with the projected cost and savings.

Strategies

The nature of the unit allows for the use of varied strategies to engage students in the learning process. The aim is for much of the unit to be student centered. Strategies for improving literacy and technology skills will also be included in various activities.

As an introduction to the unit, student's prior knowledge will be assessed using an anticipation guide, student readiness survey or K-W-L activity. This will give an overview of what students already know about energy and help to adjust teaching based on prior knowledge and level of expertise with the content. Students can be grouped in pairs or small groups of 3-4 to discuss their ideas about energy and then share in a whole group discussion. Vocabulary will also be stressed as many terms may be new to students. Students will keep a new vocabulary log in which they record unfamiliar words as they complete reading and research assignments. Students will define these terms along with a picture representation if appropriate to help them understand and remember the definition. Vocabulary will be shared with the class. Students will also be asked to record daily journal entries with ideas, reaction, or thoughts about the information they are learning throughout the unit.

Instruction will be delivered using PowerPoint presentations. Brainstorming sessions will jump start each energy topic to generate student interest and assess prior knowledge. Computer labs will be utilized for students to conduct guided research on each type of energy presented as well as investigate energy efficient technology for home use. Students will engage in class discussion and collaborative work as a means to share ideas, information and create a final product.

Through lab investigation, students will create a "biodiesel" product similar to the cooking oil biodiesel that some local refineries are producing for cars. This will give students a real world glimpse at how cooking oil from restaurants can be recycled to produce a viable alternative to gasoline.

Other resources that are available include videotape/DVD presentations on alternative energy and energy conservation. Video clips from United Streaming, Discovery Learning or other sites will be incorporated into instruction to give a visual component to the unit. Several nuclear reactor stations offer a virtual tour online which students will be able to utilize for information.

For each section or type of energy, students will be engaged in activities that focus on that particular topic. Some activities will be completed individually and others with partners or in small groups. A culminating student generated product will allow students to process, analyze, evaluate and present information learned during the unit.

Unit Outline

Day 1: Introduction and Activity 1 and 2. Ask students to begin 48 hours of energy use tracking and bring in power bill from home for next class (Activity 3).

Day 2: Nuclear, solar and wind energy. Students will move to computers to research alternative energy resources and take notes. Following the research, students will share research and compile notes for their group. Research may be continued as a homework assignment.

Day 3: Complete activity 5. Introduce geothermal and biomass. Give students a copy of the biodiesel lab to read for homework.

Day 4: Activity 4: Biodiesel lab and post lab discussion

Day 5: Student research

Day 6: Students will divide into groups and discuss research information. The group will compose a letter to the President of the United States outlining a recommendation from the group. This will allow students to analyze, evaluate and synthesize the information learned into a written format. It will strengthen their persuasive writing techniques.

Day 7: Students will work in groups to design an energy conservation awareness campaign for school or home. Depending on format chosen by the students, this may take multiple class periods if students choose to shoot a video commercial. Access to video production equipment will be needed if students are to complete this in the classroom.

Day 8 and 9: Students will work in groups to create a final presentation outlining the specifications for an energy efficient home. Students can choose a slide show proposal or create a model for display in the class.

Day 10: Student Presentations

Classroom Activities

Activity 1: Unit Vocabulary Foldable®

Students will create a foldable to record vocabulary terms and definitions for the unit by folding a sheet of paper in half (long). Students can use plain while paper or construction paper. Flaps for each term will be created on the top by cutting from the edge of the paper to the center fold so that the flap can be opened and the definition of each term viewed underneath. Students will define terms on the inside portion. This tool will enable students to familiarize themselves with terms that are used in the content and provide a method for them to study terminology independently.

Essential vocabulary includes: geothermal, photovoltaic cell, kilowatt, feed-in, sustainable, greenhouse gases, biomass, renewable resource, non-renewable resource, energy, turbine, and generator. Students will be asked to add terms that are unfamiliar from their research as well so that a comprehensive and personalized vocabulary list is formed for each student.

Activity 2: Carbon Footprint/Energy Footprint

This activity is intended to create awareness of individual environmental impact and to initiate student engagement and reflection. Using the Internet, students will access the energy calculator at http://www.csgnetwork.com/elecenergycalcs.html and determine their estimated energy usage for various activities. Students will also determine their carbon footprint using the calculator at www.nature.org/initiatives/climatechange. Each student will evaluate his/her impact and write a short refection in their journal addressing the following questions:

1. Describe the results of your carbon footprint calculation and your initial reaction.
2. Were you surprised by your results?
3. What aspect was most surprising?
4. What do the results tell you about your impact on the environment as an individual?
5. How do you think your footprint compares to others around you? To your parents?
6. If everyone in your class were to have the same footprint as yours, what do you think the impact on the environment would be in 10 years? In 50 years?
7. List the areas that you are most concerned about and at least one way that you think might reduce your footprint?

Activity 3: Energy Analysis

Students will analyze energy bills to determine estimated monthly per person energy usage in their household. Electricity, natural gas and gasoline usage will be used. Students will also track their personal energy usage for a 48 hour period and record results in a data table. (see appendix for example)
In class, students will break into groups of 4 and share their data with other member. The group will create a composite table of data and generate a list of ideas addressing the activities that use the most energy. By making this more personal, students will be able to see how their daily activities utilize energy as well as reflect on ways in which they can reduce energy consumption and costs.

Activity 4: Biodiesel—Using Renewable Resources

Activity is available at www.greeningschools.org.
Review lab safety rules prior to beginning the lab.
Recycling of restaurant cooking oils is one way to create biodiesel fuel that can be used in diesel automobiles. Recycling companies pick up the oil and refine it for resale. In this experiment, students will generate biodiesel on a small scale from household cooking oil.

Activity 5: Wind Generation and Fuel Cell Technology

This is available as a kit from Horizon Fuel Cell Technologies. Students will construct a model of a wind mill and use it to generate electricity. Included is a mini fuel cell and assembly for generating electricity from the electrolysis of water. The goal of this activity is for students to investigate the operation of fuel cell technology on a small scale and apply it to other areas of study. Students will analyze the benefits of this technology as they make observations.

Activity 7: Letter to the President of the United States

Each group will create a letter to the President making a recommendation regarding the use of tax dollars on energy research and outline which energy technologies the money should be used to develop. In the letter, students will cite examples and supporting material from their research. This activity will demonstrate the student's ability to formulate ideas and disseminate them through written expression.

Activity 8: Energy Conservation Awareness Campaign

Students will decide what format to use—visual, audio, video or a combination. Drawing from their research and their personal energy tracking, students will create a campaign to raise awareness in the school or community about conserving energy or to promote a specific type of energy technology studied. The product will capture attention of an intended audience similar to how commercial advertising generates interest in a specific product. If time or availability of equipment does not permit video production, an alternative product would be a skit written and performed for the class. It will strengthen student skills in the areas of technology, visual and/or performing arts and language arts.

Notes

[1]Lester Brown. "Dwindling Fossil Fuels and Our Food Supply." *Mother Earth News*, Aug.- Sept.2010. http://sks.sirs.com (accessed November 2, 2010).

[2]Matthew Wald. "A Comeback for Nuclear Power? ." *New York Times Upfront*, May 10, 2010, unknown edition, sec. Upfront. http://sks.sirs.com (accessed October 4, 2010).

[3]Ibid.

[4]Unknown. Our Energy. "Facts about Nuclear Energy." http://www.ourenergy.com (accessed November 30, 2010).

[5]Lester Brown. "Dwindling Fossil Fuels and Our Food Supply." *Mother Earth News*, Aug. – Sept. 2010. http://sks.sirs.com (accessed November 2, 2010).

[6] Ibid.

[7]NC Wind Home Page. "Introduction to Wind Power". .http://www.wind.appstate.edu (accessed November 2, 2010).

[8] Ibid.

[9]Lester Brown. "Dwindling Fossil Fuels and Our Food Supply." *Mother Earth News*, Aug. – Sept. 2010. http://sks.sirs.com (accessed November 2, 2010).

[10] Juliette Jowit and Steverin Carrell. "Welcome to the Megafarm of the Future". *The Guardian,* Sept. 24, 2010. p.5. http://sks.sirs.com (accessed November 2, 2010).

[11]Ibid.

[12] Unknown. "Wind Farm Turbulence." *Los Angeles Times*, September 7, 2010 morning edition, sec. A. http://sks.sirs.com. (accessed November 1, 2010).

[13] Charles Kubert. "The Sun Also Rises as a New Energy Source." *Captial Ideas* 53,

No. 3 (2010): 14. http://sks.sirs.com. (accessed November 2, 2010).

[14] Lester Brown. *Plan B 4.0: Mobilizing to Save Civilization*. New York. Norton. 2009.

[15] Evan Schwartz. "The German Experiment." *Technology Review.* 113, no.4(2010): http://sks.sirs.com (accessed November 2, 2010).

[16] Unknown. "EERE: Energy Savers Home Page." EERE: Energy Savers Home Page. http://www.energysavers.gov (accessed October 28, 2010).

[17] Lester Brown. "Dwindling Fossil Fuels and Our Food Supply." *Mother Earth News*, Aug. – Sept. 2010. http://sks.sirs.com (accessed November 2, 2010).

[18] Jane Little. "Clean Energy from Filthy Water." *Scientific American.* July 2010. http://scientificamerican.com. (accessed November 2, 2010).

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Author discusses the advantages of solar energy and renewable standard portfolios.

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Teacher Resources

www.greenenergychallenge.us
www.eia.doe.gov
www.consumerspower.org
www.awea.org/pubs/documents/swslides/toc.htm
www.methanepower.net
http://www.wind.appstate.edu
http://www.csgnetwork.com/elecenergycalcs.html

Equipment and Supplies

Wind Turbine Kit from Horizon Fuel Cell Technologies.
Supplies for biodiesel lab from www.greeningschools.com
Computers with Internet access and presentation software

Student Web Resources and Readings

http://www.wind.appstate.edu
www.hes.lbl.gov/consumer
www.nature.org/initiatives/climatechange/calculator
www.eia.doe.gov
Plan B 4.0: Mobilizing to Save Civilization by Lester Brown ISBN: 978-0-393-33719-8.

Implementing District Standards

This unit addresses the following North Carolina Standard Course of Study goals and objectives for Earth and Environmental Science.

Objective 2.06: Analyze the sources and impacts of society's use of energy.

The content of the unit and the activities included therein allows students to research sources of renewable energy as well as to compare the implementation and use of these sources. Students will also evaluate their individual impact on energy usage and propose solutions to the problems that arise.

This unit addresses the following goals and objectives for the Advanced Placement Environmental Science course:

Objective 4.05: Analyze and compare conventional and alternative energy sources.

Objective 7.04: Develop an awareness of environmental options: conservation.

Through the research and exploration of alternative energy resources in the unit, students will be able to compare them to current energy or conventional resources such as coal, oil and natural gas. During the course of the unit, students will be asked to consider their own energy usage and investigate conservation methods that can be implemented to reduce their impact.

48 Hours of Energy
Personal Energy Usage Tracking Chart

Directions: You will track your energy usage for a 48 hour period. List each device that you use, length of time, etc. in the chart below. You may attach additional sheets if needed.

Start date: _____ End date: _____
Start time: _____ End time:_____

Type of appliance or device
Total time used
Type of Energy
(battery, solar, electrical, gas)
If battery operated, size and type of battery.
Did you leave the appliance plugged in?
Does the appliance run 24 hours a day such as a refrigerator?
Estimated energy usage for the device or appliance (example: a 40 watt light bulb uses 40 watts of energy)

Analysis Questions:

1. According to your data, which device or appliance do you use the most in a 48 hour period?

2. What is the estimated amount of energy consumed by the device in question 1?

3. Ask your parents for a copy of your household's monthly power, natural gas, and hot water usage bills. Find the total units used by your household for each bill. Record below.

Electricity (in kilowatts): _____ Amount per kilowatt: _____

Natural gas: _____ Amount per unit: _____

Water (gallons) _____ Amount per gallon: _____

Automobile gasoline: _____average/month

4. Calculate the estimated amount for each person in your house if the totals were divided evenly.

Electricity: _____
Natural gas: _____
Water: _____
Gasoline: _____

5. List all energy saving tools strategies that are used by you and your family.

6. Create a personal plan for reducing your energy consumption.