Developing, Implementing, and Evaluating an Energy Education Unit for Sixth Grade Science at New London Middle School

By

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Abstract

Energy is an important part of all of our lives. We use energy everyday to run our automobiles, light our homes, and grow our food. Energy is necessary for how we live our lives however; we currently face an energy crisis. We now face problems of rolling blackouts and are predicted to run out of petroleum around the year 2080 (Martinez, 2002). Not only do we face energy shortages; we also are suffering the consequences of pollution from burning our nonrenewable energy resources. Acid rain, global warming, and mercury pollution are only just a few of the pollution problems. The pollution from burning fossil fuels has damaged the environment and caused health problems in people (Leon, 1992). A change is needed. A change in what we use to produce electricity and what we use to run our automobiles is needed for a sustainable future. And the first step toward a sustainable future is education.

To educate the next generations about energy needs of the future, we must begin now. According to Hanson (1993), "...students who participate in one of more Energy Source units during elementary school are substantially more knowledgeable about energy, more interested in it, and have better energy conservation habits." And this is the goal of the project, to have students participate in an energy education unit so that they will be more knowledgeable about energy, more interested in it, and have better energy conservation habits.

To accomplish this goal, an energy education unit needed to be developed, implemented, and evaluated for the researcher's sixth grade science class at the New London Middle School. Before developing the new energy education unit, energy workshops and courses were attended and work with energy experts and independent
research was done as well. Next, the unit was developed. In developing the unit, research done by Engleson and Yockers in *A Guide to Curriculum Planning in Environmental Education* was followed. According to Engleson and Yockers, as with other environmental education units, in an energy education unit students need to participate in activities that teach energy awareness, knowledge, values, citizen action skills, and citizen action as well as activities that use student-centered instructional strategies. Information learned from energy research and energy education experiences were used to develop a new energy education unit. In the spring of 2003, the control group received a pre-test, instruction from the current energy education unit, and then the post-test. Then in the spring of 2004, the experimental group received the pre-test, instruction from the developed energy education unit, and then the post-test. The results were as hypothesized and student energy knowledge increased and energy conservation values became more positive as a result of receiving instruction from the developed energy education unit.

The results of the research show that the developed energy education unit helps students gain a better understanding of energy knowledge and more positive energy conservation values. The developed energy education will be used and additions will be made as energy education evolves. The use and continued improvement of the developed energy education unit is necessary so that students are able to make educated energy decisions in their lives.


**Acknowledgments**

I began working on my Master's Degree at the University of Wisconsin- Stevens Point in the spring of 2001. In the course of my Master's Degree, I spent many long hours working on homework for my environmental education classes as well as on my energy education project. Along the way, my loved ones gave me the support and encouragement I needed. I also met others during my work on the energy education project that have helped me to complete my project with their expertise and assistance. I would like to acknowledge everyone who helped me on my energy education project journey.

First, I would like to thank my mom. As always, my mom was there to give me endless support and encouragement. There were many times that I asked her to listen to my energy lesson ideas as well as rough drafts of my project. She was always willing to make time to be my sounding board. Her enthusiasm and emotional support was integral in completing my project.

I would like to thank my boyfriend, Robbie, for his support and encouragement as well. He was always willing to look over my rough drafts of my project and listen to my frustrations. And during the long hours on the computer, he always made sure I had a good meal as well as his love and support to keep me going.

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Finally, I would like to thank a few other people who helped during the process of developing and completing my energy education project. First, I'd like to thank Dr. Yockers for his guidance, assistance, time, and expertise through all stages of my energy education project. Also, Jennie Lane for her help with finding energy education workshops to attend and for her help with the solar panel grant. And finally, Jerry Loker and the other staff members at the New London Utilities for the tour of the New London Utilities, the energy education teaching ideas, the energy education scholarship, and the use of the energy bike. Thanks again to Dr. Yockers, Jennie Lane, and Jerry Loker for their assistance with my energy education project.

Through support and assistance from loved ones and others, I was able to complete my energy education project. I feel that through the process of completing my energy education project, I have grown as a person and as an educator. The classes I took, the new experiences I gained, and the people I met have made me knowledgeable person and have helped me to develop leadership skills in energy education. I hope that by completing this project and continuing its use, will have life-long educational benefits for my students.
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Chapter 1

INTRODUCTION

Statement of the Problem

The purpose of this project is develop, implement, and evaluate an energy education unit for the researcher's sixth grade science class at the New London Middle School.

Significance of the Problem

Energy is an important part of all of our lives. People use energy everyday. We use energy to heat our homes, operate our vehicles, and manufacture a variety of products. Energy has allowed us to make medical advancements along with making our lives more comfortable. Energy is necessary for how we live our lives however; we currently face an energy crisis. We now face problems of rolling blackouts and are predicted to run out of petroleum by the year 2080 (Martinez, 2002). We are running out of the nonrenewable energy resources that we rely on. As our population continues to grow, more and more energy resources will be needed when less and less will be available. Not only do we face energy shortages; we also are suffering the consequences of pollution from relying on nonrenewable energy resources. Chemicals that are released from burning nonrenewable energy resources have caused many pollution problems such as acid rain, mercury contamination in our water supplies, and global warming. The
pollution from burning nonrenewable energy resources has caused widespread environmental damage. It also has caused human health problems (Leon, 1992). Pollutants released when burning fossil fuel cause asthma and other respiratory diseases. Also, as coal is burned mercury is released and ends up in bodies of water. Fish become contaminated with mercury and as a result, eating contaminated fish can cause brain damage and mental retardation in children unborn children. A change is needed. A change in the amount of energy we use and the types of energy resources that are used to produce electricity and run our automobiles is needed for a sustainable future. The first step toward a sustainable future is education.

To educate future generations about the energy needs of the future, we must begin with today's youth. We know how important energy is to all our lives. We are aware of predicted energy shortages and both the environmental and health effects of using nonrenewable energy resources. Knowing all of this brings the researcher to the conclusion that it is essential that students receive quality energy education. Quality energy education is the purpose of this project. This project will focus on the development, implementation, and evaluation an energy unit for sixth grade students at the New London Middle School. In the energy unit, the five subgoals of environmental education will be addressed as well as Wisconsin academic science standards and the environmental education standards. Students need to learn about the types of energy resources, the impacts of using each energy resource on the environment, and choices they can make to use energy responsibly. Students need to learn about past, present, and future energy needs and will hopefully begin making energy decisions for sustainable future.
Subproblems

1. The first subproblem is to design a pre-test and post-test that measures student knowledge of energy concepts and values on energy conservation.

2. The second subproblem is to expand the researcher's background knowledge on energy and energy education.

3. The third subproblem is to develop an energy education unit for sixth grade science.

4. The fourth subproblem is to apply for grants that will help fund solar panels for the new energy education unit.

5. The fifth subproblem is to administer the pre-test and post-test to the control and experimental class group and analyze data from the results.

Hypothesis

1. Through the use of the new energy education unit, students will increase their knowledge on energy resources.

2. Through the use of the new energy education unit, students' energy conservation values will become more positive.
Limitations

1. The project is limited to the researcher's sixth grade science classes at the New London Middle School.

2. The results of study are limited by the fact that the control group and experimental group will not be tested in the same school year.

Definition of Terms

1. **Develop** – research, collect, and create lessons and activities that teach energy concepts and teach sound environmental education.

2. **Energy education** – Energy education is any activity that teaches students about energy resources, energy conservation, and helps them to gain values toward energy conservation.

3. **Implement** – To teach energy lessons and students participate in the activities

4. **Evaluate** – Analyzing the results of the pretests and posttests

5. **New London Middle School** - New London Middle School is a 6-8 school located in New London, Wisconsin.
6. **New Energy Unit** – a six-week unit involving scope and sequence tied to science and environmental education standards, which would include games, field trips, outdoor experiences, labs, and other activities.

7. **Control group** - Students who are taught using the current energy education unit.

8. **Experimental Group**- Students who are taught using the developed energy education unit.

9. **KEEP** - KEEP stands for Wisconsin K-12 Energy Education Program. The KEEP program includes a workshop for teachers to attend and a binder filled with energy education activities.

**Assumptions**

1. **The first assumption** was that grants would be received to provide solar panels for the developed energy education unit.

2. **The second assumption** was that the control group and experimental group would have similar background knowledge and attitudes on energy.

3. **The third assumption** was that the pre-test and post-test developed would effective in assessing student energy knowledge and energy values.
LITERATURE REVIEW

Importance of Energy Education

Every day we use energy. We use energy to heat our homes, cook our food, and run our automobiles. And often we take this energy for granted. We assume that when we flip on the light switch, the lights will go on or when open the refrigerator door, the food inside will be cold. Despite the fact that the two main energy resources we use, coal and oil, are limited resources. Not only is energy taken for granted, the impact of depending on nonrenewable resources for energy has caused environmental damage and human health problems.

According to the Power House web-site, in 2002 the approximately 90.9% of the electricity generated for use in the United States came from nonrenewable energy resources and approximately 50.1% of the electricity form nonrenewable energy resources was coal (Power House, 2004). At our current consumption rate, it has been estimated that we have about 214 years of coal left and 78 years of petroleum left (Martinez, 2002). As the population grows and as our society becomes more dependent on technology, the demands for energy will increase. And as the supply of the nonrenewable resources becomes more and more limited, the cost of the resources will rise. In 2004, we are seeing this with the increase in the price of gasoline at the pumps and the higher cost of electricity on our electric bills. Not only have we been
experiencing a higher cost for electricity and fuel, but some states have experienced blackouts due to the high energy demands. "In the summer of 2001, California experienced "rolling blackouts" from imbalances between utility supply and demand" (NEETF, 2002).

There is a push for energy conservation, however at some point the nonrenewable resources will run out. And before that time comes, a solution is needed.

Energy shortages is not the only energy issue that we need to be concerned with, our dependence on nonrenewable resources has caused environmental problems. As fossil fuels are burned they release many pollutants into the air. These pollutants have caused environmental problems such as air pollution, acid rain, global warming, and mercury pollution. Even the transporting of fossil fuels have caused environmental damage. Oil spills kill animals and mining for coal damages the land and creates water pollution. Another nonrenewable energy resource we use to generate electricity is nuclear energy. Nuclear energy is a powerful source of electricity, however if anything goes wrong during the process of generating electricity or with the handling of nuclear waste, widespread death and disaster could occur. And the damaging effects of a nuclear catastrophe would last for thousands of years. This is important to consider, due to recent terrorist attacks. If we continue to rely on these nonrenewable resources, we will continue to further damage the environment.

These pollution problems not only affect the environment, but they have caused widespread health problems. As fossil fuels are burned they release particulate matter into the air which people breathe in. As people breathe in these fine particles, it causes health problems such as asthma and lung cancer. Children are especially at risk since their lungs are still developing; the damage done by breathing in the particulate matter
can cause permanent lung damage. Research has shown that children who live near area where there is a lot of particulate matter in the air, are 40 percent more likely to die of respiratory causes (Schneider, 2000). Pollution from burning fossil fuels has also caused death. "Fine particle pollution from U.S. power plants cuts short the lives of over 30,000 people per year" (Schneider, 2000). Along with respiratory diseases, burning coal has caused mercury pollution in our waters. The mercury has contaminated the fish that people use as a food source. Eating fish with high levels of mercury pollution can cause brain damage, mental retardation, and even death. Each year children and adults become sick and some even die as a result of current nonrenewable energy resource choices.

Environmental damage, health problems, and future energy shortages have resulted from the use of nonrenewable energy resources. Our energy situation is a crisis situation and a solution is desperately needed.

But how can a solution be found if adults and future adults don't have an understanding of energy and energy issues? In 2001, a nationwide study of 1,503 adults (18 years old and older) were interviewed for the NEETF/Roper Survey. The survey contained 10 multiple choice questions on energy. Questions on the test were things like, "How is most of the electricity in the United States generated?" and "Which of the following (household appliances) uses the most energy in the average home?" Only 12% of American adults passed this survey (NEETF, 2002). How can good energy choices be made when so few understand basic energy facts?

So, if a large portion of today's adults do not have an understanding of energy, we need to make sure future adults do. A solution to our current energy crisis is one that, "seeks to meet the needs and aspirations of the present without compromising the ability
to meet those of the future" (Engleson and Yockers, 1994). And to make sure that there are reliable energy resources to meet the demands of America without damaging the environment and human health, we need to educate today's youth. Children need to be educated on basic energy knowledge in order to be able to make educated energy choices as adults. According to a study done by Hanson (1993), “…students who participate in one or more Energy Source units during elementary school are substantially more knowledgeable about energy, more interested in it, and have better energy conservation habits.” Energy education is the first step to a sustainable future.

As educators we play a key role in solving current energy problems and inspiring future energy solutions. As educators we can teach students how their energy choices affect the environment, the economy, their health, and America's future. As educators, it is our responsibility to educate the youth of today, so that their future is one of sustainability.

Importance of Professional Development in Energy and Energy Education

The first step to educating students on current energy problems and future energy solutions, is to educate the educators. Teachers across the nation need to know energy concepts, issues, and energy solutions in order to effectively teach students. Teachers need to know where to get good energy resources and teachers also need to learn and use the most effective teaching strategies for energy education.

If teachers themselves do not have the knowledge and skills to teach environmental education, they can not effectively teach students. "According to the 1998
Baseline Study of the Wisconsin K-12 Energy Education Program (KEEP) by Hagler Bailly prepared for the Energy Center of Wisconsin, forty-seven percent of Wisconsin teachers surveyed do not teach their students about energy. This study indicated that the teachers did not include energy education for the following reasons: (1) teachers do not have the knowledge or background to teach this subject area, (2) they do not have enough class time, (3) there are not enough resources or funding available to them, and (4) energy concepts are unrelated to their subject area" (Koop, 1999). In order to increase energy education in the classroom, teachers need training and resources.

To make energy education successful, teachers need to have energy knowledge and energy-related teaching resources. "To provide students with valuable energy-related knowledge and skills, we must provide teachers with professional development opportunities and resources to become competent energy educators" (Koop, 1999). Teachers need to attend energy workshops and courses. The energy workshops and courses need to not only include information on energy concepts and issues, but also information on how to effectively teach students about energy. Energy education materials need to be provided to schools and teachers need to be made aware of the resources available to them and taught how to use them. One such program is the Wisconsin K-12 Energy Education Program (KEEP, 1999). The KEEP program provides teachers with an energy education in-service and with energy education resources. Along with attending a KEEP workshop, teachers need to reevaluate current curriculum and add energy education in logical places. Workshops, resources, energy infused curriculum, and self reflection will help make energy education successful.
Characteristics of an Effective Energy Unit

Incorporating energy education experiences in schools is an important step for students to be able to make positive energy choices. Energy education will give students the knowledge, values, and skills to make positive energy conservation choices. An effective energy education unit must contain the five subgoals of environmental education, use sound effective instructional strategies, and should address the Wisconsin academic standards for science and environmental education standards.

An effective energy education unit must contain the five subgoals of environmental education. The five subgoals of environmental education are: awareness, knowledge, values, action skills, and action. According to Hungerford, et. al. (1988), “Literacy...begins with knowledge and ends with action.” Knowing this, to gain energy literacy an effective energy unit would develop student understanding of energy concepts and values as well as an understanding of energy related issues and the actions that can be taken to help solve energy-related problems. Students also need to participate, at some level, in solving energy-related problems. Since energy a vital role in our lives, students need clearly understand how their decisions on energy use impact the environment and the future needs of others and be active in making good energy choices.

The unit needs to contain important instructional strategies to be successful. According to Engleson and Yockers (1994), sound environmental education units need to also contain the following. First of all, lessons need to be learner-focused. Learner-focused lessons are developed and taught based on students' age and developmental characteristics of that age. Second, lessons need to be taught in a way that is not gender biased. This would include making sure that both male and female energy scientists are
taught, male and female roles are not stereotyped, and both students and scientists are not
generalized as "he" instead, "he and she" are used. Third, lessons need to be experience-
based. Some experience-based activities would include the following strategies: inquiry
lessons, debates, simulations, games, field trips, hands-on activities. Fourth, the unit
needs to have students continually reflect upon the future. And fifth, the unit needs to be
holistic, contain economic, political, cultural, ethical, and aesthetic aspects. And finally,
the lessons need to include energy facts and energy issues that relate to the state in which
they live in. These instructional strategies maximize student learning.

Finally, Wisconsin academic science standards that relate to energy need to be
addressed. As a part of the Wisconsin academic science standards, students need to be
able to use various definitions of energy and explain the behaviors of various forms of
energy (Wisconsin Department of Public Instruction, 1997).

Also, the environmental education standards that relate to energy need to be
addressed. Some of the environmental education standards include: describe the flow of
energy in natural systems, illustrate how they use energy in their daily lives, and list and
distinguish between renewable and nonrenewable energy resources (Wisconsin
Department of Public Instruction, 1998). Meeting these standards will prepare students
for state testing and for life outside the classroom.

In summary, an effective energy education unit needs to address Wisconsin
academic standards, the five subgoals of environmental education, as well as incorporate
a variety of teaching strategies for students to maximize their understanding of energy.
An effective energy education unit will give students the energy knowledge they need to
be able to make sound energy decisions.
Chapter 3

METHODOLOGY

First Subproblem

The first subproblem was to design a pre-test and a post-test that measures student knowledge of energy concepts and attitudes on energy conservation.

The first subproblem is to design a pre-test and a post-test that measures student knowledge of energy concepts and attitudes on energy conservation. The first step will be to decide on important energy concepts. The energy concepts students need to know will be determined through the use of New London Middle School’s sixth grade curriculum objectives in combination with Wisconsin academic science standards, environmental education standards, and energy education objectives from the KEEP program. The chosen energy concepts will be used to make questions for the pre-test and post-test. Other related energy and environmental pre-tests and post-tests will be evaluated. The five energy conservation value statements that will be included on the pre-test and post-test also will be developed. The pre-test and post-test will be completed by the spring of 2003.
Second Subproblem

The second subproblem is to expand the researcher's background on energy knowledge and on energy education.

The second subproblem is to expand the researcher's background on energy knowledge and on energy education strategies. To begin with, energy-related workshops and classes will be attended to expand the researcher's knowledge on energy and energy education. The Midwest Renewable and Sustainable Living Fair will be attended during late June of 2002. At the Midwest Renewable and Sustainable Living Fair there will be several workshops and exhibits that will provide resources and activities for the energy education unit. Consultation from Jennie Lane, the KEEP director, will be sought in order to find other energy workshops and courses to attend as well as independently searching for energy workshops and courses. Another expert source of information will be the staff New London Utilities, the utility company that supplies electricity for the New London area. The researcher will try to set up a meeting with them at the end of August 2002 and discuss current energy issues and energy education opportunities.
Third Subproblem

The third subproblem is to develop an energy education unit for sixth grade science.

The third subproblem is to develop an energy education unit for sixth grade science. Resources from KEEP, the Internet, workshops, courses, and from other resources will be researched. From these sources, activities will be selected that best correlate with the energy education objectives that have been selected through the use of New London's school district standards, Wisconsin academic standards, and environmental education standards. The activities will address the five environmental education subgoals. The activities also will be student-centered and incorporate a variety of learning styles and higher level thinking skills.
**Fourth Subproblem**

The fourth subproblem is to apply for grants that will fund solar panels for the new energy education program.

The fourth subproblem is to apply for grants that will fund solar panels for the new energy education program. Research on grants will be done using the Internet, contacting local agencies, and working with Jennie Lane. A grant will be applied for to help fund solar panels for the energy education program. The search for grants will begin in the summer of 2002.

**Fifth Subproblem**

The fifth subproblem is to administer the pre-test and post-test to control and experimental class groups and analyze data from the results.

The fifth subproblem is to administer the pre-test and post-test to the control and experimental class groups and analyze data from the results. The control group will receive the pre-test and post-test in the spring of 2003 and will receive instruction from the current energy unit. The experimental group will receive the pre-test and post-test in the spring of 2004 and will receive instruction from the developed energy unit. The pre-test and post-test data from both the control and experimental group will be compared to determine if the students who received instruction from the developed energy education program had an increased understanding of energy and had more positive energy conservation values.
Chapter 4

PROJECT RESULTS

Subproblem One

The first subproblem was to design a pre-test and a post-test that measured student knowledge of energy concepts and values on energy conservation.

The first subproblem was to design a pre-test and a post-test that measured student knowledge of energy concepts and values on energy conservation. Before writing the pre-test and post-test, the researcher reviewed the New London Middle School's curriculum objectives and the Wisconsin academic science standards. Then in the summer of 2002, the researcher discussed developing pre-tests and post-tests with Dr. Yockers, a graduate program advisor. Several samples of other pre-tests and post-tests from the book, Are We Walking the Talk? were shared. In the fall of 2002, the designing of a pre-test and post-test to measure student knowledge of energy concepts and values on energy conservation for both the control group and experimental group was initiated. The test included 15 multiple choice questions relating to energy knowledge and 5 energy value questions. For the energy value questions, students were to read a statement and then mark one of the following choices: A. strongly agree, B. agree, C. undecided, D. disagree, and E. strongly disagree. A sample of the pre-test and post-test can be found in Appendix A. The questions chosen were related to the objectives of the energy education unit.
Subproblem Two

The second subproblem is to expand researcher's background on energy and energy education.

The second subproblem was to expand the researcher's background on energy and energy education. This was accomplished by attending energy workshops, energy classes, working with energy experts, and doing independent research. In the summer of 2002, the researcher attended the Midwest Renewable and Sustainable Living Fair in Custer, Wisconsin. At the Midwest Renewable and Sustainable Living Fair the following workshops were attended: Electrathon Vehicles, Watt about Wind, Greening Schools, Energy and Air Quality, Transportation Tribulation, Solar Cookers, Biofuel, Solar Energy, and Electric Basics. Various energy related booths were visited. The energy booths had information on a variety of energy topics such as compact fluorescent light bulbs, wind turbines, air pollution, transporting nuclear waste, and alternative fuel source vehicles. The Wisconsin Association for Environmental Education conferences in the fall of 2002 and the fall of 2003 were also attended. At both conferences the researcher focused on attending energy-related workshops. Some of the energy-related workshops included: the Energy and Society Workshop where a teacher resource kit was received, a fuel cell workshop, a Wisconsin energy statistics workshop, and a conservation of water and energy workshop. A KEEP course was taken in the fall of 1999 and the follow up course to the original KEEP course was taken in the fall of 2002. In the summer of 2002 and fall of 2002, the researcher met with Jerry Loker, a member of the New London Utilities Staff, to discuss energy education. A tour of the New London Utilities and an
explanation of how the utility is operated was given. The researcher learned about home
energy audits and was given some leftover energy audit equipment. Jerry Loker and the
researcher also designed a New London Utilities field trip. The field trip did not take
place in the 2003-2004 school year as planned, but hopefully will be included in the
2004-2005 school year. Energy lesson ideas were researched on the Internet and at the
Wisconsin Center for Environmental Education library at the University of Stevens Point.
Attending workshops, courses, working with energy experts, and doing independent
research helped expand the researcher's energy education knowledge.

Subproblem Three

The third subproblem is to develop an energy education unit for sixth grade science.

The third subproblem was to develop an energy education unit for sixth grade science. Information gained from attending energy workshops, energy classes,
discussions with energy experts, and independent energy research were used to develop
the new energy education unit. The lessons also were aligned with the Wisconsin
academic science standards, environmental education standards, and school district's
standards which can be found in Appendix B. The lessons incorporated the five subgoals
of environmental education: awareness, knowledge, values, citizen action skills, and
action experience. A variety of effective educational teaching strategies such as
simulations, experiments, and group work were incorporated within the energy education
The energy education unit was designed to be 6 weeks long and is separate from the electricity unit. The energy education unit was completed in the winter of 2004. The completed energy education unit can be found in Appendix C.

**Subproblem four**

The fourth subproblem is to apply for grants that will help fund solar panels for the new energy education unit.

The fourth subproblem was to apply for grants that would help fund solar panels for the new energy education unit. Students would use the solar panels to build and operate solar powered cars. The hands-on experience of using solar technology would help the students to see how solar energy can be used to generate electricity and as a possible fuel source to operate cars. After attending the Midwest Renewable and Sustainable Living fair in the summer of 2002, a solar panel grant was applied for. An essay was written on the importance of teaching students about solar energy and how solar panels would be effectively used in the classroom to teach about solar energy. The solar panel grant essay was submitted to Jennie Lane. The essay was selected and 8 solar panels with 3 motors were awarded for use in the classroom. After the control group completed the post-test in the spring of 2003, the students built solar powered cars and used them. In the spring of 2004 the experimental group built and operated solar powered cars as a part of the actual energy education unit.
Subproblem Five

The fifth subproblem was to administer the pre-test and post-test to the control and experimental class groups and analyze data from the results.

The pre-tests and post-tests covered a variety of energy concepts that related to the objectives of the energy education unit. The pre-test and post-test consisted of the same questions in the same order. The pre-test was given to the control and experimental group prior to receiving energy instruction. The control group consisted of 74 sixth grade students in the 2002-2003 school year. The experimental group consisted of 68 sixth grade students in the 2003-2004 school year. The control group did the pre-test and post-test in the spring of 2003 and the experimental group did the pre-test and post test in the spring of 2004. The pre-tests and post-tests were compared to see if there was a change in energy knowledge and energy conservation values between the control and experimental groups.

To begin with, the control group and the experimental group's energy knowledge scores were compared by looking at the number and percent of students in the following 4 categories: students with 0-3 questions correct, students with 4-7 questions correct, students with 8-11 questions correct, and students with 12-15 questions correct. The number of students who fit in each of these categories were tallied. Figure 4.1 shows the number of students in the control group who fit in each of the 4 categories for the pre-test and post-test. Figure 4.2 shows the number of students in the experimental group who fit in each of the 4 categories for the pre-test and the post-test.
**Figure 4.1**

**CONTROL GROUP**
Energy Knowledge: Pre-test and Post-test
N = 74

Number Of Students

---

**EXPERIMENTAL GROUP**
Energy Knowledge: Pre-test and Post-test
N = 68

Number Of Students

---

Number of Correct Responses
On page 24, figure 4.1 and figure 4.2 show the energy knowledge pre-test and post-test results for the control and experimental group. In comparing the data from the pre-tests and post-test, the experimental group had more students improve their energy knowledge scores for each category than the control group. However, since the control group contained 74 students and the experimental group contained 68 students, the number of students in each category were converted to percents of students to make a better comparison which can be seen in tables 4.1, 4.2, 4.3, and 4.4.

Table 4.1

<table>
<thead>
<tr>
<th>12-15 questions answered correctly</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Control Group (N=74)</td>
</tr>
<tr>
<td>Experimental Group (N=68)</td>
</tr>
<tr>
<td>------------------------------------</td>
</tr>
<tr>
<td>Pre-Test</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>Post-Test</td>
</tr>
<tr>
<td>37.8%</td>
</tr>
<tr>
<td>57.3%</td>
</tr>
<tr>
<td>Change</td>
</tr>
<tr>
<td>37.8%</td>
</tr>
<tr>
<td>57.3%</td>
</tr>
</tbody>
</table>

Table 4.1 above shows the percent of students in the control and experimental group that answered 12-15 questions correctly. As shown in table 4.1, neither the control group nor experimental group answered 12-15 questions correct on the pre-test. On the post-test, 37.8% of the control group answered 12-15 questions correctly. On the post-test, 57.3% of the experimental group answered 12-15 questions correctly. The experimental group increased their score by 19.5 percent more than the control group.
Table 4.2.

8-11 questions answered correctly

<table>
<thead>
<tr>
<th></th>
<th>Control Group (N=74)</th>
<th>Experimental Group (N=68)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Test</td>
<td>32.4%</td>
<td>32.3%</td>
</tr>
<tr>
<td>Post-Test</td>
<td>35.1%</td>
<td>38.2%</td>
</tr>
<tr>
<td>Growth</td>
<td>2.7%</td>
<td>5.9%</td>
</tr>
</tbody>
</table>

Table 4.2 above shows the percent of students in the control and experimental group that answered 8-11 questions correctly. On the pre-test 32.4% of the control group answered 8-11 questions correct and on the post-test 35.1% of the control group answered 8-11 questions correctly. The control group showed an increase of 2.7% in the 8-11 questions correct category. 32.3% of the students in the experimental group answered 8-11 question correct on the pre-test and 38.2% of the experimental group answered 8-11 question correct on the post-test. The experimental group showed an increase of 5.9% in the 8-11 questions correct category. This seems to show that the experimental group had a greater increase in the percent of students who answered 8-11 questions correct from the pre-test to the post-test. The experimental group had a higher percent of students who answered 8-11 questions correct on the post-test.
Table 4.3

4-7 questions answered correctly

<table>
<thead>
<tr>
<th></th>
<th>Control group (N=74)</th>
<th>Experimental Group (N=68)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Test</td>
<td>56.7%</td>
<td>58.8%</td>
</tr>
<tr>
<td>Post-Test</td>
<td>21.6%</td>
<td>4.4%</td>
</tr>
<tr>
<td>Change</td>
<td>-35.1%</td>
<td>-54.4%</td>
</tr>
</tbody>
</table>

Table 4.3 above shows the percent of students in the control and experimental group who got 4-7 questions correct. On the pre-test 56.7% of the control group answered 4-7 questions correct and on the post-test 21.6% of the students answered 4-7 questions correct. There was a 35.1% drop in students who answered 4-7 questions correct for the control group. On the pre-test 58.8% of the experimental group answered 4-7 questions correct and on the post-test 4.4% of experimental group answered 4-7 questions correct. There was a 54.4% drop in students who answered 4-7 questions correct. The experimental group had a bigger change in the percentage of students who answered 4-7 questions correct. The experimental group also had a lower percentage of students who answered 4-7 questions correct on the post-test. This seems to show that the experimental group had a higher percent of students get more than 4-7 questions correct on the post-test than the control group.
Table 4.4

0-3 questions answered correctly

<table>
<thead>
<tr>
<th></th>
<th>Control Group (N=74)</th>
<th>Experimental Group (N=68)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Test</td>
<td>10.8%</td>
<td>8.8%</td>
</tr>
<tr>
<td>Post-Test</td>
<td>5.4%</td>
<td>0</td>
</tr>
<tr>
<td>Change</td>
<td>-5.4%</td>
<td>-8.8%</td>
</tr>
</tbody>
</table>

Table 4.4 above shows the percent of students in the control and experimental group who got 0-3 questions correct. On the pre-test 10.8% of the control group answered 0-3 questions correct and on the post-test 5.4% of the control group answered 0-3 questions correct. On the pre-test 8.8% of the experimental group answered 0-3 questions correct on the pre-test and 0% of the experimental group answered 0-3 questions correct.

The experimental group had a greater decrease in the percent of students who answered 0-3 questions correct from the pre-test to the post-test. Also, the experimental group had a lower percent of students who answered 0-3 questions correct on the post-test than the control group.
Average Test Scores

Average energy knowledge test scores are compared in figure 4.3 above. The average pre-test scores for both the control and experimental groups were very similar. The control group average score was 6.48 questions right and the experimental group average score was 6.5 questions right. However, the average post-test score for the control group was 9.3 questions right and the average post-test score for the experimental group was 11.3 questions right. This means that students in both the control and experimental groups did learn energy concepts, however the students in the experimental group, on average, answered 2 more questions right on the post-test than the control group.
The next section of the energy pre-test and post-test was an energy conservation values section. In this section students answered 5 energy conservation value questions. Students either answered strongly agree, agree, undecided, disagree, or strongly disagree. The questions are as listed below.

16. I walk or ride my bike places instead of asking for a ride.
17. I recycle paper and aluminum cans at school and at home.
18. I turn lights and appliances off when they are not being used in order to conserve electricity.
19. I feel saving energy is important.
20. I feel that reducing pollution is important.

In analyzing the data from the energy conservation values section of the test, changes in the percent of students who answered strongly agree and agree were studied.

Table 4.5
16. "I walk or ride my bike instead of asking for a ride."

<table>
<thead>
<tr>
<th></th>
<th>Percent of students from the control group who answered strongly agree or agree</th>
<th>Percent of students from the experimental group who answered strongly agree or agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Test</td>
<td>37.8%</td>
<td>50%</td>
</tr>
<tr>
<td>Post-Test</td>
<td>50%</td>
<td>73.5%</td>
</tr>
<tr>
<td>Change</td>
<td>12.2%</td>
<td>23.5%</td>
</tr>
</tbody>
</table>

For question 16 in table 4.5 above, "I walk or ride my bike instead of asking for a ride," the experimental group showed a 23.5% change in energy conservation values while the control group only showed change in energy conservation values of 12.2%. According to the results of the post-test, the experimental group seemed to have more positive energy conservation values as a result of receiving the developed energy education unit.
Table 4.6
17. "I recycle paper and aluminum cans at school and at home."

<table>
<thead>
<tr>
<th></th>
<th>Percent of students from the</th>
<th>Percent of students from the</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>control group who answered</td>
<td>experimental group who</td>
</tr>
<tr>
<td></td>
<td>strongly agree or agree</td>
<td>answered strongly agree or</td>
</tr>
<tr>
<td>Pre-Test</td>
<td>74%</td>
<td>80.8%</td>
</tr>
<tr>
<td>Post-Test</td>
<td>81%</td>
<td>88%</td>
</tr>
<tr>
<td>Change</td>
<td>7%</td>
<td>7.2%</td>
</tr>
</tbody>
</table>

For question 17 in table 4.6 above, "I recycle paper and aluminum cans at school and at home," the experimental group showed a 7.2% change in energy conservation values and the control group showed a 7% change in energy conservation values. According to the results of the post-test, it seems that the experimental group had more positive energy conservation values as a result of receiving the developed energy education unit.

Table 4.7
18. "I turn lights and appliances off when they are not being used in order to conserve electricity."

<table>
<thead>
<tr>
<th></th>
<th>Percent of students from the</th>
<th>Percent of students from the</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>control group who answered</td>
<td>experimental group who</td>
</tr>
<tr>
<td></td>
<td>strongly agree or agree</td>
<td>answered strongly agree or</td>
</tr>
<tr>
<td>Pre-Test</td>
<td>64.8%</td>
<td>68.9%</td>
</tr>
<tr>
<td>Post-Test</td>
<td>70%</td>
<td>86.7%</td>
</tr>
<tr>
<td>Change</td>
<td>5.2%</td>
<td>17.8%</td>
</tr>
</tbody>
</table>

For question 18 in table 4.7 above, "I turn lights and appliances off when they are not being used in order to conserve electricity," the experimental group showed a change in energy conservation values of 17.8% while the control group showed a change in energy conservation values of 5.2%. According to the results of the post-test, it seems that the experimental group had more positive energy conservation values as a result of receiving the developed energy education unit.
Table 4.8
19. "I feel saving energy is important."

<table>
<thead>
<tr>
<th></th>
<th>Percent of students from the control group who answered strongly agree or agree</th>
<th>Percent of students from the experimental group who answered strongly agree or agree</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-Test</strong></td>
<td>79.7%</td>
<td>92.6%</td>
</tr>
<tr>
<td><strong>Post-Test</strong></td>
<td>81%</td>
<td>98.5%</td>
</tr>
<tr>
<td><strong>Change</strong></td>
<td>1.3%</td>
<td>5.9%</td>
</tr>
</tbody>
</table>

For question 19 in table 4.8 above, "I feel saving energy is important," the experimental group showed an change in energy conservation values of 5.9% while the control group only showed a change in energy conservation values of 1.3%. According to the results of the post-test, the experimental group seems to have a more positive energy conservation values as a result of receiving instruction from the developed energy education unit.

Table 4.9
20. "I feel that reducing pollution is important."

<table>
<thead>
<tr>
<th></th>
<th>Percent of students from the control group who answered strongly agree or agree</th>
<th>Percent of students from the experimental group who answered strongly agree or agree</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-Test</strong></td>
<td>77%</td>
<td>82.3%</td>
</tr>
<tr>
<td><strong>Post-Test</strong></td>
<td>83.7%</td>
<td>92.6%</td>
</tr>
<tr>
<td><strong>Change</strong></td>
<td>6.7%</td>
<td>10.3%</td>
</tr>
</tbody>
</table>

And in question 20 in table 4.9 above, "I feel that reducing pollution is important," the experimental group showed a change in energy conservation values of 10.3% while the control group showed a change in energy conservation values of 6.7%. According to the post-test results, the experimental group seems to have more positive energy conservation values as a result of receiving instruction from the developed energy education unit.
For all the questions, the experimental group seemed to have more positive energy conservation values than the control group. From these results, it seems that the new energy unit seems to encourage more positive energy conservation values.

Also, in looking at the data, the experimental group had a higher percent of students with positive energy conservation values on both the pre-test and post-test. One contributing factor could be the fact that throughout the 2003-2004 school year all lessons that were taught had a strong environmental emphasis compared to prior years. Another contributing factor could be that the students in the experimental group had backgrounds in which they were exposed to stronger energy conservation values.
Chapter 5

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The purpose of the project was to develop, implement, and evaluate an energy education unit for sixth grade science at the New London Middle School. A pre-test and post-test were developed to measure energy knowledge and energy conservation values in the control and experimental groups.

In the spring of 2003 the control group received the pre-test and post-test and received instruction from the current energy education unit. Energy education knowledge was enhanced through taking energy workshops, classes, doing research, and working with energy experts. The information and resources gained from the variety of energy learning experiences were used to develop an energy education unit. The new energy education unit addressed the five subgoals of environmental education and used a variety of instructional strategies.

In the spring of 2004 the experimental group received the pre-test and post-test and instruction from the developed energy education unit. The change in energy knowledge and energy conservation values between the control and experimental groups were compared.

According to the data collected for the energy knowledge section of the post-test, both the experimental and control groups had a similar percentage of students answer questions correctly for the 12-15 questions correct category and the 8-11 questions right
category. However, 57.3% of the experimental group answered 12-15 questions correct on the post-test and 37.8% of the control group answered 12-15 questions correct on the post-test. On the post-test for the 8-11 questions correct category, 38.2% of the experimental group answered 8-11 questions correct and 35.1% of the control group answered 8-11 questions correct. The data shows that the experimental group had a higher percentage of students who answered 8-15 questions correct on the post-test than the control group.

According to the results on the energy conservation values section of the pre-test and post-test, the experimental group had more positive energy conservation values on the pre-test and post-test.

The project was a success for two main reasons. The first reason is due to the professional development that was done prior to developing the unit. Professional development in the areas of energy and energy education have allowed for the exposure to a wide variety of energy lessons and energy information. The second reason the project was a success was the design of the unit. The energy education unit was designed to address the five subgoals of environmental education and used a variety of learner-centered teaching strategies. The professional development experience and the incorporation of a variety of teaching strategies allowed the energy education project to be a success.
Recommendations

There are three main recommendations that should be considered from the results of this energy education project. First, the energy education unit should be continued in the researcher's classes and appropriate updates should be made when necessary. Second, the energy education unit also will be shared with the other 6th grade science teacher at the New London Middle School. Third, the pre-test and post-test should be reevaluated and redesigned.

Energy Education Unit Recommendations

The students who received instruction from the new energy education unit had increased their energy knowledge and had more positive energy conservation values than students who did not receive instruction from the new energy education unit. Improvements can still be made to the unit. The energy activity trunk from the KEEP program could be added to the energy education unit. Fuel cell activities could be added to the energy education unit when funding comes available for student fuel cell lab equipment. Also, improvements can be made in the lessons that are used to teach energy conversions and energy forms which seemed to be an area of difficulty for the experimental and control groups. The unit should be updated as energy information and teaching strategies change and evolve. So, continued professional development in the area of energy is important for the continued improvements to the energy education unit.
Infusion into the Sixth Grade Science Program Recommendations

There seemed to be an improvement in energy knowledge and more positive energy conservation values through the use of the new energy education unit. The new energy education unit that was developed should be used across the sixth grade curriculum. The research should be shared with the principal, the curriculum director, and the other sixth grade teacher. Professional assistance will be provided to the other sixth grade teacher.

Energy Education Assessment Strategies

Overall, the pre-test and post-test seemed to cover energy knowledge concepts and energy conservation values. The pre-test and post-test that was used was adapted from the book, Are We Walking the Talk, and reflected both Wisconsin academic science standards and New London Middle School standards. The questions covered concepts from across the energy standards. However, changes need to be made in the energy values section and the energy knowledge section should be lengthened and reevaluated. Also, further statistical analysis and research is necessary in order to find the most effective way to teach students about energy.

First, question 16 needs to be changed to better suit the student population. Question sixteen states, "I walk or ride my bike places instead of asking for a ride." This question was difficult for students because most of them live in the county. Over half of the student population at the New London Middle School rides the bus to school. The average bus ride, one way, is anywhere from 30 minutes to an hour. In discussing this question with the students, students who lived in the county felt that to get anywhere they
needed to ask for a ride because walking or biking would be too far and take too long. This question would need to be reworded to something like, "For short distances, I walk or ride my bike instead of asking for a ride." This would allow students who live in the country to be able to relate to the question.

Second, the energy knowledge section should be reevaluated and lengthened. In evaluating the results of the pre-tests and post-tests of the control and experimental groups, the energy conversions and energy forms questions seemed to be an area of difficulty for both the control and experimental groups. Using this observation, how energy conversions and energy forms are taught need to be changed. Also, the test length could be longer to get more thorough results.

Finally, further research is necessary in order to find the most effective way to teach students about energy. The pre-test and post-test will continue to be used with the students in the 2004-2005 school year and compared with the results with the 2002-2003 and 2003-2004 school year tests. The results will be analyzed by looking for a pattern in the questions answered correctly and incorrectly. Changes will be made to improve student understanding of energy concepts. Also, alternative assessment strategies regarding energy education should be implemented in addition to the written test.

Continued testing, continued improvements to the energy education unit, and continued professional development, are the steps to creating an effective energy education unit.
References Cited

Champeau, Randy. Are We Walking the Talk? Wisconsin Center for Environmental Education. 1997.


Wisconsin Department of Public Instruction. Wisconsin's Model Academic Standards for Environmental Education. Wisconsin Department of Public Instruction. Milwaukee, WI. 1998.

**Curriculum Resources Used in Energy Education Unit**


http://www.clargold.k12.ia.us/high/staff/jwilson/wind%20turbine/Generate%20Your%20Own%20Energy.pdf


<www.pbs.org/now/classroom/wind%20machine.pdf>


APPENDIX A

ENERGY PRE-TEST AND POST-TEST
1. Which of the following is an energy source used to generate electricity for human use?
   a. Light Bulbs
   b. Lightning
   c. Paper
   d. Wind

2. Petroleum products are all of the following except:
   a. Wax
   b. Gasoline
   c. Rayon
   d. Cotton

3. All of the following are forms of energy except:
   a. Chemical
   b. Charged
   c. Elastic
   d. Sound

4. The original source of energy for almost all living things is:
   a. sun
   b. water
   c. the soil
   d. plants

5. Acid rain is a problem because:
   a. it may break down the layer of ozone in the earth's atmosphere
   b. people may have to stay indoors when it's raining
   c. it may harm plants by affecting their leaves and changing the soil they grow in
   d. it may cause a slow change in the earth's temperature

6. One advantage to using nuclear power instead of coal or oil for energy is:
   a. Nuclear power plants are not expensive to build
   b. There is less air pollution
   c. It is totally safe
   d. The waste products are easy to store.

7. Which of the following is a renewable resource?
   a. oil
   b. nuclear
   c. solar
   d. gas

8. Which of the following is a conversion from chemical energy to thermal energy?
   a. Food is digested and used to regulate body temperature
   b. Charcoal is burned in a barbecue pit
   c. Coal is burned to boil water
   d. All of the above

9. In every energy conversion, some energy is always converted to
   a. kinetic energy
   b. potential energy
   c. thermal energy
   d. mechanical energy
10. Which of the following is not a fossil fuel
   a. gasoline
   b. coal
   c. firewood
   d. natural gas

11. Which of the following is NOT true about using fossil fuels.
   a. Fossil fuels are a convenient source of energy
   b. Fossil fuels do not pollute
   c. Fossil fuels create large amounts of heat
   d. Fossil fuels are easy to transport

12. Which of the following is true about using renewable energy.
   a. All renewable resources are inexpensive to use
   b. All renewable resources can be used anywhere
   c. All renewable resources do not pollute the air
   d. All of the above

13. Using which of the following energy resources harms human health the least?
   a. coal
   b. oil
   c. solar
   d. nuclear energy

14. Using which energy resource is causing Global Warming?
   a. Fossil fuels
   b. Solar
   c. Nuclear energy
   d. Water

15. Which of the following helps save energy?
   a. driving a large vehicle
   b. leaving lights and appliances on for a short time while not in use
   c. using a compact fluorescent light bulb instead of an incandescent light bulb
   d. leaving water run while you brush your teeth

16. I walk or ride my bike places instead of asking for a ride.  
   Strongly Agree  Agree  Undecided  Disagree  Strongly Disagree
   A       B     C       D       E

17. I recycle paper and aluminum cans at school and at home.  
   Strongly Agree  Agree  Undecided  Disagree  Strongly Disagree
   A       B     C       D       E

18. I turn lights and appliances off when they are not being used in order to conserve electricity.
   Strongly Agree  Agree  Undecided  Disagree  Strongly Disagree
   A       B     C       D       E

19. I feel saving energy is important.
   Strongly Agree  Agree  Undecided  Disagree  Strongly Disagree
   A       B     C       D       E

20. I feel that reducing pollution is important.
   Strongly Agree  Agree  Undecided  Disagree  Strongly Disagree
   A       B     C       D       E
APPENDIX B

WISCONSIN ACADEMIC SCIENCE STANDARDS
ENVIRONMENTAL EDUCATION STANDARDS
NEW LONDON MIDDLE SCHOOL STANDARDS
WISCONSIN ACADEMIC STANDARDS

Students will:

D. 8.7. Use commonly accepted definitions of energy
D.8.9. Explain the behaviors of various forms of energy

WISCONSIN ENVIRONMENTAL EDUCATION STANDARDS

Students will:

A.4.2 Collect information, make predictions, and offer explanations
A.8.1 Identify environmental issue questions
A.8.2 Collect information and conduct experiments

B.4.2 Illustrate how they use energy in their daily lives
B.4.3 List renewable and nonrenewable sources of energy
B.4.9 Distinguish between renewable and nonrenewable energy resources
B.4.12 Determine the cause of different types of pollution
B.8.15 Analyze how people impact their environment
B.8.18 Identify major air, water, or land pollutants and their sources

C.4.4 Identify some of the decisions and actions related to the issue
D.4.3 Identify ways to take positive environmental action
E. 8.1 Formulate a personal plan for environmental stewardship

NEW LONDON MIDDLE SCHOOL STANDARDS

Energy

The student will describe the formation of fossil fuels.

The student will summarize the generation of electricity using any power source.

The student will evaluate methods of conserving energy.

The student will compare and contrast alternative energy sources.

The student will choose the best alternative energy source and justify the choice.
APPENDIX C

ENERGY EDUCATION UNIT
ENERGY UNIT OBJECTIVES

Students will:

Define energy
Define potential energy
Define kinetic energy
Compare potential and kinetic energy
Explain energy conversions that occur on a roller coaster
Describe conversions between various forms of energy
Identify renewable and nonrenewable energy resources
Differentiate between nonrenewable and renewable energy resources
List benefits and drawbacks of each energy resource
Examine energy use in daily life
Summarize the generation of electricity using any power source
Simulate the formation on fossil fuels
Explain how fossil fuels are used to generate electricity
Simulate coal mining
Simulate an oil spill clean up
Conduct an acid rain experiment
Conduct a smog experiment
Conduct a global warming experiment
Design posters explaining pollution problems that result from using fossil fuels
Simulate the half-life of Uranium 235
Analyze nuclear waste storage options
Build and generate electricity by using hydropower
Build and generate electricity using wind power
Build and use a solar collector
Build and use a solar cooker
Build and use solar powered cars
Explore geothermal energy
Explore the potential of using tides to generate electricity
Explore different types of biomass
Choose the best energy resources for Wisconsin to use and justify choice
Use the energy bike to learn about CFL bulbs and the expense of using heat
Evaluate methods of conserving energy
Compare and contrast alternative energy resources
Identify and follow a plan of positive energy use
Energy Basics

1. What is energy?

2. Potential and Kinetic Energy

3. Forms of Energy

4. Energy Conversions
Characteristics of Potential and Kinetic Energy

Objectives
Students will define energy
Students will define potential energy
Students will define kinetic energy
Students will compare kinetic and potential energy

Background
Potential energy is stored energy
Kinetic energy is energy of motion
Kinetic energy depends on speed and mass
Gravitational potential energy depends on weight and height

Procedure
1. Define energy and give examples of energy
2. Define potential energy and give examples of potential energy
3. Define kinetic energy and give examples of kinetic energy
4. Have students complete both potential and kinetic energy labs

Assessment
1. Have students relate the terms energy, potential energy, and kinetic energy to their lives
Name ____________________ Potential and Kinetic Energy Lab A

Does the mass of an object effect its kinetic energy?

Lab set up

1. The mass of the large car is ________________
2. The mass of the small car is ________________
3. Now, roll the large car down the ramp. Measure in centimeters how far the milk jug moved.
4. Now roll the small car down the ramp. Measure in centimeters how far the milk jug moved.
5. Fill in chart

<table>
<thead>
<tr>
<th>Distance milk jug moved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large toy car</td>
</tr>
<tr>
<td>Roll small car slowly</td>
</tr>
</tbody>
</table>

6. How does mass effect kinetic energy?

Does speed effect kinetic energy?

1. Roll the small car down the ramp slowly. Measure how far the milk jug moves in centimeters.
2. Roll the small car down the ramp as fast as you can. Measure how far the small car moves.
3. Fill in chart

<table>
<thead>
<tr>
<th>Distance milk jug moved in centimeters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roll small car slowly</td>
</tr>
</tbody>
</table>

4. How does speed effect kinetic energy?
Name __________________________ Potential and Kinetic Energy Lab B

Lab set up

![Diagram of a ramp and milk jug](image)

How does height effect potential energy?

1. Use 2 cars that are the same weight.
2. Roll one car down a ramp that is 4 books in height.
3. Roll the other car down a ramp that is 6 books in height.
4. Fill in chart

<table>
<thead>
<tr>
<th></th>
<th>Ramp that is 4 books in height</th>
<th>Ramp that is 6 books in height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance milk jug moved</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. How does height effect potential energy?

How does weight effect potential energy?

1. Use 2 cars with different weights
2. Roll the heavier car down the ramp
3. Roll the lighter car down the ramp
4. Fill in the chart

<table>
<thead>
<tr>
<th></th>
<th>Heavy car</th>
<th>Lighter car</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance the milk jug moved</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. How does weight effect potential energy?
Roller Coaster Lab

Objectives
Students will design a roller coaster
Students will label areas on a roller coaster where there would be potential energy
Students will label areas on the roller coaster where there would be kinetic energy
Students will explain energy conversions that occur in their roller coaster

Background
Potential energy is stored energy. Kinetic energy is energy of motion.
Law of Conservation of Energy = Energy can not be created not destroyed; Energy can be converted from one form to another
During most energy conversions, some energy is converted to thermal energy as a result of friction.

Materials
BBs
10 sets of 6 foot pieces of clear plastic tubing
Tape

Procedures
1. Have students build their roller coasters
2. Roller coasters need to have at least 1 loop and at least 1 hill
3. The BB must be able to roll threw the roller coaster
4. The group with the fastest roller coaster gets a prize

Assessment
1. Students will draw their roller coasters and answer questions about them on the lab sheet
2. Students need to have the understanding of basic energy conversions, potential and kinetic energy, and thermal energy
Roller Coaster Sheet

Name ____________________________

1. Draw your roller coaster in the box below.

2. Label the spot where there is the most potential energy on your roller coaster. Use the letter P and circle it.

3. Label another spot on your roller coaster where there is potential energy. Use a lower case p.

4. Label 2 spots on your roller coaster where there is kinetic energy. Use the letter K.

5. Is the energy your roller coaster begins with ever destroyed?

6. As the BB rolls through the tube, some of the energy is changed into what type of energy?

7. What 2 things could you do to start your roller coaster with more potential energy?

Your Roller Coaster
Station Break

Objectives

Students will be able to
• provide examples of energy conversions; and
• explain that heat is a product of energy conversions.

Rationale

Recognizing energy conversions helps students appreciate the many ways that they depend on energy.

Background

Most of us don’t realize just how important energy is in our lives. Every facet of our life involves energy. One of the reasons we tend to take energy for granted is that it is constantly changing from one form to another. When this happens it is called an energy conversion. Examples of the different types of energy conversions are found on the Station Break Cards.

During these conversions, energy is changing between potential and kinetic forms of energy. Potential energy is the energy stored in matter because of its position or the arrangement of its parts. Kinetic energy is the energy of motion. For example, to operate a wind-up toy, kinetic energy from winding the toy is converted to elastic potential energy in the toy’s spring mechanism. After the spring is released, the elastic potential energy is converted back to kinetic energy when the toy moves. For more information about potential and kinetic energy, see the activity “Potentially Kinetic” on page N 42.

In all energy conversions, the useful energy output is less than the energy input. This is because some energy is used to do work, and some energy is converted into heat (which escapes into the environment). For example, the chemical energy in food is converted to mechanical energy (moving our muscles) by a process similar to burning called respiration. Energy is needed to break apart the food molecules, and during the process, heat energy is generated. Feel your arm; this warmth is the heat energy that is produced by respiration within your cells. Let’s say you are using the energy you gained from food to operate a pair of scissors. Heat is lost during this activity, too. There is friction when the blades of the scissors slide against each other to cut paper. Friction is the resistance to sliding, rubbing, or rolling of one material against another, which requires extra work to overcome and results in energy loss through heat. This heat energy escapes into the environment.

So, everywhere you look there are energy conversions. As energy is being converted, heat is being generated all around you (and inside you). Both of these make life on Earth what it is, full of diverse and interesting creations and changes.
### Question/Answer Sheet for Game 3

<table>
<thead>
<tr>
<th>Game 3</th>
<th>Game 3</th>
<th>Game 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jumping on a diving board temporarily gives it what kind of energy?</td>
<td>Use your pencil to demonstrate gravitational potential energy.</td>
<td>What form of potential energy is present in a bouncing ball? (There are two, but you need to list only one.)</td>
</tr>
<tr>
<td><em>Suggested answer:</em> Elastic potential energy.</td>
<td><em>Suggested answer:</em> Pick the pencil up off the table.</td>
<td><em>Suggested answers:</em> Gravitational (when it is held above the floor) and elastic (when it hits the floor).</td>
</tr>
<tr>
<td>Name three examples of kinetic energy.</td>
<td>What type of energy is present in food?</td>
<td>What form of energy is demonstrated by water in a dam?</td>
</tr>
<tr>
<td>Which has more gravitational potential energy, a rock held three feet above the ground or the same rock held three feet higher?</td>
<td>Define potential energy.</td>
<td>How was chemical potential energy released when the baking soda was mixed with the vinegar?</td>
</tr>
<tr>
<td><em>Suggested answer:</em> The rock held six feet (1.8 m) above the ground.</td>
<td><em>Suggested answer:</em> The energy of position or the energy stored in a material.</td>
<td><em>Suggested answer:</em> The baking soda reacted to the vinegar causing molecules to break apart, rearrange themselves and release chemical potential energy.</td>
</tr>
</tbody>
</table>
Special considerations for the materials are found below each card. Different materials can be used as long as they meet the objective of the station.

- Copies of the Summing Up Student Page
- Index cards (optional)

Getting Ready:

Set up seven different stations (tables or investigation areas) around the room. Put one Station Break Card and the materials listed on that card at each station. Have the radio operating for some time prior to class so that it feels warm.

---

**Procedure**

**Orientation**

Do the following: drop a ball, turn on a flashlight, bend your arm, and twist a rubber band and let it go. Ask students what all these actions have in common. Explain that each involves energy being changed or converted from one form to another. Review the definition and forms of energy.

Forms of energy used in this activity include the following:

- Chemical energy
- Elastic energy
- Electrical (electromagnetic) energy
- Light energy
- Heat energy
- Mechanical energy (motion)
- Sound energy

**Steps**

NOTE: This activity orients students to a variety of energy conversions by having groups rotate around the room to portray each type of conversion. An alternative is to demonstrate one energy conversion at a time, allowing time for groups to conduct investigations and further explore that conversion before moving on to the next demonstration. See Related KEEP Activities for additional investigation ideas.

1. Tell students they will be gaining experience with energy conversions. Show them the stations set up around the classroom. Inform them that their job is to visit each station for five minutes. At each station they should:
   - read the written directions for the investigation found on the card at that station;
   - perform the investigation as directed;
   - read and discuss the Summing Up Questions (try to make a group decision in answering the Summing Up Questions); and
   - use the Summing Up Student Page to record their answers.

2. Divide students into groups of three or four and provide each group with a Summing Up Student Page. Each group member can have a specific task or role at the stations. For example, one student is the Reader and Director, leading discussions and making sure the others know what to do. Another student can be responsible for conducting the experiment. Another student, the Recorder, records responses to the Summing Up Questions. Students may want to alternate roles with each station.

3. Assign each group to a station and have them begin, moving to the next station after five minutes.

4. After students have been to all the stations and completed the Summing Up Questions, hold a class discussion. Students will likely give a wide variety of answers.
Station 7: Plug It In!

Materials
Hair dryer, fan, electric pencil sharpener

Let's Investigate
1. Experiment with each object.
2. Determine which form of energy is needed to get each object to work.
3. Observe each object in action; then discuss with your partners which form of energy the working object is displaying.

Summing Up
1. What form of energy was needed to make each object work?
2. Into what form or forms of energy was this converted in each working object?

Special Consideration for Materials at the Plug It In! Station
Materials could include any devices that need to be plugged in to operate. This station must be located near an electrical outlet. Each device should produce motion and/or heat.

Sample Answers to Plug it In! Summing Up
1. Each device needs electrical energy to make it operate.
2. Each of the working devices produces mechanical energy or sound energy or both, and heat.

Conversion Diagrams

**Electrical Energy → Mechanical Energy → Heat Energy**

[Diagram for Hair Dryer]

**Electrical Energy → Heat Energy**

[Diagram for Toaster]
Station 1: The Radiometer

Summing Up Questions
1. Describe what you did and what results were observed in testing the radiometer. Be sure to discuss methods that did not work as well as those that were successful.

2. What form of energy was needed to make the radiometer spin?

3. Into what form of energy was this converted?

Station 2: Quiet Please!

Summing Up Questions
1. What form of energy was needed to make each object work?

2. Into what form or forms of energy was this converted in each object?

Station 3: Stretching It

Summing Up Questions
1. What form of energy was needed to stretch the rubber bands?

2. What form of energy caused the rubber bands to return to their original shapes?

3. What other form of energy was involved in this experiment?
Station 4: Toyland

Summing Up Questions
1. What form of energy was needed to make each toy work?

2. What form or forms of energy were displayed by the working toys?

Station 5: Bring in Da Noise!

Summing Up Questions
1. What form of energy was needed to make each object work?

2. Into what form or forms of energy was this converted in each working object?

Station 6: PB & J

Summing Up Questions
1. What form or forms of energy were needed to produce each of the items in the sandwich?

2. What form of energy is present in the sandwich now?

3. Into what form or forms of energy does the sandwich change after it's eaten?

Station 7: Plug It In!

Summing Up Questions
1. What form of energy was needed to make each object work?

2. Into what form or forms of energy was this converted in each working object?
Energy Resources

I. Energy Awareness
   A. Energy collage
   B. Nonrenewable vs. renewable
   C. Energy resource use in the USA

Energy Knowledge

II. Nonrenewable Energy Resources
   A. Fossil Fuels
      1. Fossil fuel introduction
      2. Fossil fuel formation
      3. Transporting fossil fuels
      4. Environmental effects of burning fossil fuels
   B. Nuclear Energy
      1. Nuclear energy introduction
      2. Nuclear waste
      3. Nuclear waste poster

III. Nonrenewable Energy Resource Booklet

IV. Renewable Energy Resources
   A. Water
   B. Wind
   C. Biomass
   D. Geothermal
   E. Ocean Tides
   F. Solar
      1. Solar Cooker
      2. Solar Collector
      3. Solar Powered Cars

V. Renewable Energy Book
Energy Use Collage

Objectives
Students will be able to:
B.4.3. Illustrate how they use energy in their daily lives

Background
Energy is an important part of our daily lives. We use energy to grow our food, light and heat our home, and run our automobiles. From the time we get up in the morning until the time we close our eyes at night, we are constantly using energy. It is important for students to understand how important energy is in their everyday life.

Procedure
1. Think-pair-share. Have the students discuss and list as many ways as possible that they used energy that day. Then have the students share their ideas.
2. Have the students make a "How We Use Energy" collage. Have the students work in groups of 2 or 3 and cut out different pictures of how they use energy out of magazines. Have the students glue the pictures on a piece of construction paper and title the paper, How We Use Energy.
3. Have students share collages
4. Display student work

Assessment
1. Collages should include several different ways students use energy.
2. Have students trace the energy they use back to its source.
Energy Resources

Objectives
1. Students will name several energy resources used in the United States
2. Students will define nonrenewable energy resource and list all 4 examples of nonrenewable energy resources
3. Students will define renewable energy resources and list all 5 examples of renewable energy resources
4. Students will graph the distribution of energy resources used by the United States.

Background
An energy resource is a natural resource that can be converted by humans into other forms of energy in order to do useful work. Nonrenewable energy resources include fossil fuels and nuclear energy and renewable energy resources include solar, water, wind, biomass, and geothermal. These resources are used to generate electricity.

Procedure
1. Teach students the following facts:
   a. Our electricity and automobile fuel come from energy resources
   b. There are 2 types of energy resources, nonrenewable and renewable
   c. Nonrenewable resources are coal, petroleum, natural gas, and nuclear energy
   d. Renewable resources are solar, water, wind, biomass, and geothermal
   e. Nonrenewable means that once the resource is used, it can not be reused.
   f. Renewable means that the resource can be used over and over and will not run out.
2. Show examples of each energy resource
3. Show students how electricity is generated by each of the energy resources
4. Have students predict which energy resource they think the United States uses to generate most of our electricity
5. Tell the students that the United States relies on coal for most of its electricity
6. Hand out the sheet on energy resources statistics to the students
7. Have the students create their own pie chart to represent the distribution of energy resources used to generate electricity in the United States.

Assessment
1. Have students discuss and answer the following questions
   a. Define nonrenewable energy resource and list all 4 examples of nonrenewable energy resources
   b. Define renewable energy resource and list all 5 examples of renewable energy resources
   c. List the energy resources used to generate electricity in the United States in order from the most used to the least used
   d. Which resources does the United States use the most of to generate electricity, nonrenewable or renewable?
   e. Hypothesize why the United States has chosen nonrenewable energy resources to rely on for electric power
Objectives
Students will identify coal, petroleum, and natural gas as fossil fuels
Students will identify coal, petroleum, and natural gas as nonrenewable resources
Students will illustrate and explain the formation of fossil fuels

Background
Coal, petroleum, and natural gas are fossil fuels. Fossil fuels are nonrenewable energy resources used to generate electricity as well as other uses. Fossil fuels formed from the buried remains of plants and animals that lived millions of years ago. These plants stored energy form the sun by photosynthesis. These animals used and stored energy by eating the plants or by eating animals that ate plants. So, fossil fuels are concentrated forms of the sun's energy. The fossil fuels can be burned and used in the process of generating electricity.

Procedure
1. Show students examples of coal, petroleum, and natural gas.
2. Explain the uses of fossil fuels
3. Explain the formation of fossil fuels
   a. dead plants and animals
   b. heat
   c. pressure
   d. millions of years
4. Tell students that dead plants and animals have carbon in them
5. Tell students that the human body is 18% carbon
6. Tell students that as fossil fuels form, they are reduced to their carbon form
7. Tell the students they will use the carbonization process to form fossil fuels

Assessment
1. Students should understand how fossil fuels are formed.
*See attached sheet for lab and assessment questions
Question: How can organic matter be reduced to carbon?

Hypothesis: ____________________________________________

Procedure:

Step 1
Measure and record the weight of the sugar.

Step 2
Place the sugar in the pan. Place the pan on a hot plate and slowly heat the sugar. Record the time needed to convert the sugar to its black carbon form on the chart to the right.

Step 3
Save the carbonized sugar on a piece of foil. Weigh it. How much weight was gained or lost?

Step 4
Wash the pan. Then repeat steps 1–3 for the flour and salt.

<table>
<thead>
<tr>
<th></th>
<th>Sugar</th>
<th>Flour</th>
<th>Salt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight Before</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight After</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Needed for Carbonization</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Materials
- sugar, flour, and salt (1/2 cup each)
- spoon
- saucepan
- stove or hot plate
- aluminum foil
- balance scale
Results and Conclusions:

1. How were the three substances similar before and after the experiment?

2. Which of the three contained the least carbon? How do you know?

3. Speculate about other kitchen supplies. What else could you carbonize?

4. Coal and oil were created from plant and animal matter under pressure over a long period of time. From what you have learned, what else might cause carbonization?

5. What other questions do you have about carbonization?

Science Challenge: Set up an experiment to test this question:
How are coal and sugar related?

Write your question, hypothesis, procedure, and materials list on another sheet of paper. Then test the hypothesis and record your conclusions.
Digging for Coal

Objectives

Students will be able to
• describe how coal is formed;
• identify where coal deposits are found and show that they are unevenly distributed throughout the United States;
• identify how coal is used in Wisconsin and the United States;
• simulate coal mining and its effects using chocolate chip cookies; and
• state the benefits and problems associated with mining and using coal.

Rationale

By learning how coal is formed, where it is found, how it is mined, and how it is used, students gain an understanding of the important role it plays in providing energy to Wisconsin and the rest of the United States.

Background

See “Facts about Coal” on page A97 in Appendix.

Procedure

Orientation

Ask students if they know how coal is used. They may answer based on previous knowledge or experience, or they may recount stories they’ve heard (the characters in Charles Dickens’s A Christmas Carol use coal to heat their homes and workplaces; locomotives mentioned in a number of stories are powered by coal). List students’ responses on the board.

Point out to students that nowadays coal is mostly used by power plants in Wisconsin and the United States to generate electricity. It is rarely used to heat homes or drive locomotives and ships anymore. Briefly mention other uses of coal (see “Facts about Coal” in Appendix).

Show students how coal is formed using the following demonstration. Fill the bottom of the aquarium (or glass loaf pan) with about 2 inches (5 cm) of fine-to-medium-grained sand. Add water, plant leaves, and twigs to create a “swamp.” Then place another 2 to 3 inches (7.5 cm) of sand on top of the leaves and twigs. Repeat the following passage to students as you finish adding the top layer of sand:

“You take plants found in a swampy area, bury them under many layers of sand and silt, and compress the layers over millions of years until all but the layers on the top turn into rock. What do you get?”

(Continued on next page)
Have students guess the answer. After students have guessed, show them a sample of coal (if available) or a picture of coal. If additional samples of coal are available, distribute them to students and have them describe the samples in terms of color, weight, and hardness. If you only have one or two pieces of coal available, have students pass the samples around. You may also have students look at the coal samples under a microscope in order to see the sedimentary layers. If known, tell students what type of coal they are looking at (anthracite, bituminous, etc.) and where it came from.

**Steps**

1. Review the different types of coal with students. Discuss how coal is mined out of the ground, and how it is used in Wisconsin and elsewhere in the United States. Tell students that they will be doing a coal mining simulation using chocolate chip cookies.

2. Place the **Summary Table** on the blackboard or on a large piece of butcher paper posted on a wall.

3. Give each student a cookie, a napkin, and a paper clip. They are not to eat the cookies until the exercise is over.

4. Ask students to suggest what the whole cookie, the tan parts of the cookie, the chocolate chips, and the paper clip represent in the simulation.
   (Answers: cookie = country or state; tan parts of the cookie = Earth's crust; chocolate chips = coal; paper clip = mining machinery.)

5. Have students count how many visible chunks of coal are in their country or state. Students should count only the chips they can see on the top of the cookie. Record their responses on the **Summary Table**.

6. Have students predict the total number of coal deposits in their country or state (the total number of chips they think the cookie has). Record this number for each student on the **Summary Table**.

---

**Resources:**

**For Teachers**


(Continued on next page)
7. Students can begin “mining” their coal deposits.

8. Have students place their coal deposits in one pile and Earth’s crust in another. Have students continue “mining” until most appear finished. When students finish, record the total number of coal deposits mined in their country or state (the total number of chips found in the cookie) on the summary table.

9. Have students compare the number of coal deposits they predicted they would find to the actual number they “mined” in their country or state. Ask students how they arrived at their prediction, and whether or not their method was an accurate way to determine the number of coal deposits that were underground.

10. Before students are allowed to eat their cookie, instruct them to put their “Earth” back together. Encourage them to try, even if their cookie looks like a pile of crumbs.

11. Allow students to eat their cookie.

12. Hand out copies of U.S. Coal Deposits and U.S. Coal Production by State, 1993. Discuss with students the concept that coal deposits (as well as all fossil fuel resources) are unevenly distributed throughout the United States and the world. Relate this point to the lack of coal deposits in Wisconsin, and how we have to get coal from other parts of the nation to meet part of our energy needs.

Closure
Discuss the following points with the class and have students answer the questions.

- Compare the way chips were mined on the cookie’s surface and interior with the process of surface and underground coal mining. In what ways are they the same? In what ways are they different? Also compare the effort it took to mine the chips inside the cookie mining chips on the surface. What does this suggest about the energy needed to mine coal?
- Were students able to put their cookies back together? How difficult was it? How does this compare to the difficulty of reclaiming land after coal mining has taken place? Explain.
- Relate coal mining to the uses of coal. How do we use coal in Wisconsin and in other parts of the United States? What benefits do we get from using coal? What problems arise from using coal?

**Summary Table**

<table>
<thead>
<tr>
<th>Student Name</th>
<th>Number of Chocolate Chips Found before Mining</th>
<th>Predicted Number of Chocolate Chips in the Cookie</th>
<th>Actual Number of Chocolate Chips Mined</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>
5. Go through each station and discuss the energy conversions that took place for each device. Get the class to reach a consensus on the conversions. Using an overhead transparency, diagram the changes involved (see information associated with the Station Break Cards). Unless mentioned by students, do not identify heat in the conversions yet.

6. Ask students if there were any stations in which more than one energy conversion took place. Any station in which batteries were used had more than one energy conversion involved. The batteries converted chemical energy to electrical energy. This electrical energy was then used to produce sound or motion, and heat.

7. Ask students if anyone noticed any other forms of energy being converted at the stations. Instruct one of the students to feel the radio that has been operating for some time. They should notice that the radio is warm. The warmth illustrates that heat energy was also formed in this conversion.

8. Challenge students to comment on other instances where they observed heat being given off. Point out that during any transformation of energy from one form to another, heat is also given off; however, it is less apparent in some conversions than others. Revise the energy diagrams to reflect the formation of heat in the conversion.

Closure
Have students define the term “energy conversion.” Challenge students to do the following:
- Locate at least five devices or objects around the school or at home that convert energy
- List the forms of energy needed to operate each item
- Identify the form or forms of energy into which it is converted
- Note the type of device or object involved

Resources:

For Teachers
Creative Collectibles,
Division of Duro-Test
Corporation, 9 Law Drive,
Fairfield, N.J. 07004.
Phone: (201) 808-1800.
(One source for radiometers)

Complementary Activities
Gartrell, Jack E., and Larry E. Schafer. Evidence of Energy: 
An Introduction to Mechanics, 

University of Northern Iowa, 
Center for Energy and 
Environmental Education, 
Energy Education Curriculum 
Project. “Station Break” pp. 7-
17, and 78-86 in Energy 
Education Curriculum Project: 
Energy Conversions: Middle 
School Module 2. Cedar Falls, 
Iowa: University of Northern 
Iowa and Iowa Energy Center, 
1995.

For Students
Adler, David. “Energy Can 
Never Be Used Up?” pp. 13-
14 in Wonders of Energy: The 
Question and Answer Book. 
Mahwah, N.J.: Troll 

Wiese, Jim. Rocket Science:
Fifty Flying, Floating, Flipping, 
Spinning Gadgets Kids Create 
Themselves. New York: John 
Related KEEP Activities:

Prior to this activity, students should be able to identify the different forms of energy. See activities such as “Evidence of Energy” and “Potentially Kinetic.” To have students further investigate the forms of energy, see the activity “Exploring Heat” and K-5 Energy Sparks for Theme I: Exploring Sound, Exploring Light Energy, and Exploring Movement. More advanced students may be interested in participating in “People Power” and doing calculations described in Energy and Power Conversion Factors in the Appendix.

Credits:

Activity adapted from University of Northern Iowa Center for Energy and Environmental Education, Energy Education Curriculum Project. “Station Break” pp. 7-17, and 78-86 in Energy Education Curriculum Project: Energy Conversions: Middle School Module 2. Cedar Falls, Iowa: University of Northern Iowa and Iowa Energy Center, 1995. Used with permission. All rights reserved.

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Assessment

Formative

• Did students follow the directions at each station?
• How accurately did they respond to the Summing Up Questions?
• Are they able to identify other energy conversions in their lives?

Summative

Have students work in small groups or individually. Instruct each group to write down the different forms of energy used during this activity on index cards or pieces of paper (one form per card). Have students randomly select two cards at a time and lay them on the table. Their task is to try to identify a conversion process that can change energy from the form stated on one card to the one listed on the second. For example, if the two cards they draw are electricity and sound, their answer could be when you turn on the radio (electricity) you can hear it (sound). Assign each student to select five combinations of cards and record their responses. For more of a challenge, students can draw three cards each time.

Extensions

Introduce students to the Energy Bike and investigate the various energy conversions. For information about obtaining and using an Energy Bike, see page A 58.
Station 1: The Radiometer

Materials
Radiometer, hair dryer, flashlight or lamp, paper fan

Let's Investigate
Use each of the materials available at this station one at a time to rotate the blades of the radiometer.

Summing Up
1. Describe what you did and what results you observed in testing the radiometer. Be sure to discuss methods that did not work, as well as those that were successful.
2. What form of energy was needed to make the radiometer spin?
3. Into what form of energy was this converted?

Special Consideration for Materials at The Radiometer Station
A radiometer is a light bulb-shaped device that contains an object that looks like a weather vane (wings arranged in a circle like spokes of a wheel that can move). See Resources for ordering information.

Sample Answers for The Radiometer Summing Up
1. Light from the flashlight does the best job of rotating the radiometer wings. Heat from the hair dryer causes the wings to rotate for a few seconds. Fanning has no effect on the radiometer wings.
2. Light energy was needed to rotate the radiometer.
3. Light energy was converted to mechanical energy as the wings moved.

Additional Information:
The original radiometer was invented by Sir William Crookes in the mid-nineteenth century. The device was developed to measure the intensity of radiant energy or heat.

What makes the radiometer work? The atmosphere inside a radiometer is a nearly perfect vacuum. More than 99 percent of the air has been removed, leaving only thousands of air molecules inside the radiometer in comparison with the trillions in the atmosphere outside it. This means that each molecule of air inside the radiometer is able to move about more freely.

The opposing sides of each vane or wing of the radiometer are alternately dark and light in color. When light energy—infrared radiation—strikes these wings, it transfers heat to each one, but not to the same degree. The lighter side of the wing reflects light, and the dark carbonized side absorbs light. When the freely moving air molecules inside the radiometer strike the light colored side of the wing, they take on very little energy and do not bounce off very fast. However, when the molecules strike the dark side, they take on a great deal of energy and "kick" away at terrific speed. This causes the vane to spin in the direction it has been kicked (away from the dark carbonized side of the wing). In other words, the temperature difference between the two sides causes the vane to move due to convection currents and momentum transfer.

Conversion Diagram

Light Energy \[\rightarrow\] Radiometer \[\rightarrow\] Mechanical Energy + Heat Energy

N54 Station Break

THEME 1: WE NEED ENERGY

KEEP Activity Guide
Station 2: Quiet Please!

Materials
Battery-operated portable radio, battery-operated portable tape recorder, battery-operated toys

Let's Investigate
1. Experiment with each object at this station.
2. Determine which form of energy is needed to get each object to work.
3. Observe each object in action; then determine which form of energy the working object has.

Summing Up
1. What form of energy was needed to make each object work?
2. Into what form or forms of energy was this converted in each object?

Sample Answers for Quiet Please! Summing Up
1. Each object tested is powered with batteries. Batteries convert chemical energy into electrical form. See Anatomy of a Battery in the “Circuit Circus” activity on page D 8 to help understand how batteries make this conversion.
2. Mechanical and sound energy were produced in all of the devices. All of the devices produced heat as well (although the heat may not have been felt or detected).

Conversion Diagrams

Toys
Chemical Energy  $\rightarrow$ Electrical Energy  $\rightarrow$ Mechanical Energy + Heat

Radio
Chemical Energy  $\rightarrow$ Electrical Energy  $\rightarrow$ Sound Energy + Heat
Station 3: Stretching It

Materials
Rubber bands of various thicknesses

Let's Investigate
1. Experiment with each of the different rubber bands at this station.
2. Stretch each of them back and forth quickly.
3. After several pulls, test the temperature of each rubber band by touching them, individually, to your upper lip.
4. Test to see which thickness of rubber band gets the warmest.

Summing Up
1. What form of energy was needed to stretch the rubber bands?
2. What form of energy caused the rubber bands to return to their original shapes?
3. What other form of energy was involved in this experiment?

Sample Answers for Stretching It Summing Up
1. Mechanical energy was needed to stretch each of the rubber bands.
2. Elastic potential energy caused the rubber bands to return to their original shape.
3. Heat energy was produced by the rubber bands as they were stretched and unstretched.

Conversion Diagram


Person
(stretching rubber band)
Station 4: Toyland

Materials
Wind-up toys that move forward, jump, or spin

Let’s Investigate
1. Experiment with each of the toys.
2. Determine which form of energy is needed to get each of the toys to work.
3. Observe each toy in action, then determine which form of energy the working toy is displaying.

Summing Up
1. What form of energy was needed to make each toy work?
2. What form or forms of energy were displayed by the working toys?

Sample Answers for Toyland Summing Up
1. Each toy had to be wound up to move. This means that mechanical energy was added to each toy, since your hand wound each toy.
2. Each of the working toys has mechanical energy, shown by their motion. Sound and heat were also given off by the toys, but the heat may not have been noticeable.

Conversion Diagram

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Person (winding up toy)</td>
<td>+ Heat</td>
<td>Toy (unwinding)</td>
<td>+ Heat</td>
<td></td>
</tr>
</tbody>
</table>
Station 5: Bring in Da Noise!

Materials
Party noisemaker, bell, wind or percussion instruments (e.g., tambourines, triangles, kazooos)

Let's Investigate
1. Experiment with each object.
2. Determine which form of energy is needed to get each object to work.
3. Observe each object in action, then determine which form of energy the working object is displaying.

Summing Up
1. What form of energy was needed to make each object work?
2. Into what form or forms of energy was this converted in each of the working objects?

Special Consideration for Materials at the Bring in Da Noise! Station
If you use a wind instrument such as a kazoo, you may want to have one clean kazoo for each group.

Sample Answers for Bring in Da Noise! Summing Up
1. Each instrument worked by either blowing on it or by hitting it. Both of these actions involve mechanical energy.
2. Each of the working objects produced sound energy.

Conversion Diagram

Mechanical Energy → Sound Energy → Heat Energy

Instrument
Station 6: PB & J

Materials
Peanut butter, jelly, bread, plastic knives, warm soapy water, sponge or washcloth

Let's Investigate
1. Make sure the station is clean.
2. Use a clean knife to make a peanut butter and jelly sandwich.
3. Divide it into thirds or quarters.
4. Your teacher will tell you whether to eat the sandwiches.
5. Clean up the station when finished.

Summing Up
1. What form or forms of energy were needed to produce each of the items in the sandwich?
2. What form of energy is present in the sandwich now?
3. Into what form or forms of energy does the sandwich change after it's eaten?

Special Consideration for Materials at the PB & J Station
If sanitation is a concern, do not allow students to eat the sandwiches.

Sample Answers to PB & J Summing Up
1. Students should know that these products require the sun's energy, or light, to grow. If processed foods are used, students may list some of the forms of energy required during the processing phase, such as chemical energy in fossil fuels and electricity.
2. Food stores energy in the form of chemical energy.
3. Once eaten, the chemical energy stored in the sandwich is converted into heat and mechanical energy (muscle movement). Many students will not realize that heat energy is formed also.

Conversion Diagram

Chemical Energy ➔ Mechanical Energy ➔ Heat Energy

Food (respiration)
Name ____________________  -Mining for Coal Lab

1. Predict how many pieces of coal are in your cookie. __________

Dig our your coal!

2. How many pieces of coal were in your cookie? __________

3. How is mining for chocolate chips similar to mining for coal?

4. Is it hard to get remove all the coal residue from the soil?

5. If it rains, where will the coal residue go?

6. How do you put the land back together?

7. Does mining for coal harm the soil?

8. Does mining for coal harm rivers and streams?

9. Does mining for coal wreck animal homes?
1. Put the feather in the oil. How do you think oil spills affect birds?

2. How do you think oil spills affect fish?

3. Are oil spills harmful to plants and animals? Why?

Which material cleaned up the oil spill the best?
Describe how each of the following materials clean oil spills.

<table>
<thead>
<tr>
<th>Material</th>
<th>How well did the material clean up the oil? What did the material do?</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Twine</td>
<td></td>
</tr>
<tr>
<td>5. Eye dropper</td>
<td></td>
</tr>
<tr>
<td>6. Sand</td>
<td></td>
</tr>
<tr>
<td>7. Detergent</td>
<td></td>
</tr>
<tr>
<td>8. Paper towel</td>
<td></td>
</tr>
</tbody>
</table>

9. Which material cleaned up the oil spill the best? ________________

10. Describe what the material did to the oil.

11. What do you think is used to clean up oil spills in the ocean?

12. Do you think cleaning oil spills is difficult?

13. What do you think could be done to reduce the number of oil spills?
Crude oil is found in five different geological structures—seepages, anticlines, stratigraphic traps, faults, and salt domes. Have students design and illustrate their own oil wells. Ask them to show their oil wells drilling into one of the five types of geological structures. Invite students to share their models with the class.

**Removing Oil**  
(Science Experiment)

Students investigate the most efficient way to use pumps to remove oil from reservoirs. Students make oil pumps by using clear plastic bottles with spray-pump attachments. Plastic tubing should extend from the pump attachment to the bottom of each container. Invite students to follow these steps:

1. Place 1–2 cups of clean, small pebbles in the bottle.
2. Pour 100 mL of corn oil into each bottle.
3. Carefully start pumping as much oil as possible out of the container into a 100-mL graduated cylinder.
4. Measure and record.
5. Clean the bottle and cylinder and repeat the steps using the following combinations: 50 mL cold water/50 mL oil; 50 mL hot water/50 mL oil/10 drops of detergent.
6. Allow the boiled water to cool.
7. Compare the taste of the salty water in the pan with the distilled water in the cup.

Have students respond to the following questions in their science journals:

- What do you notice about the difference in tastes?
- Does the distilled water taste less salty? What did this experiment demonstrate?
- How is distillation like fractioning?

**Refining Oil**  
(Science Experiment)

Petroleum products such as gasoline, kerosene, diesel oil, and lubrication oils are distilled or separated from crude oil in refineries. Oil pumped through tubes is boiled and then travels from bottom to top in a fractioning tower. Gasoline vaporizes first, since it has the lowest boiling point. Kerosene vaporizes second and diesel fuel third. Gasoline is drawn off at the top of the tower. Lubricating oils are distilled at the bottom. The following steps illustrate the distillation process:

1. Dissolve one-quarter cup salt in two cups of water.
2. Boil it in a saucepan with a too-large lid hanging over the edge. Place a cup under the lid to catch the distilled water droplets as shown.
3. Allow the boiled water to cool.
4. Compare the taste of the salty water in the pan with the distilled water in the cup.

Have students respond to the following questions in their science journals:

- What do you notice about the difference in tastes?
- Does the distilled water taste less salty? What did this experiment demonstrate?
- How is distillation like fractioning?
# Understanding Acid Rain

**Purpose:** Determine the effects of acid rain on different types of rocks.

**Hypothesis:** What do you think will happen when the rocks are exposed to plain water and to acid?

**Materials/Procedure:** Place each of the two types of rocks in the liquids—one in the cup of vinegar and one in water. List the types of rocks on the chart below.

**Observation:** Observe the rocks after 24 hours and again after seven days. Describe any changes in the rocks (or in the liquids) on the chart below.

<table>
<thead>
<tr>
<th>Kind of Rock</th>
<th>In Water</th>
<th>In Acid (Vinegar)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>After 24 Hours</td>
<td>After 7 Days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Conclusion:**

**Purpose:** Determine the effects of acid rain on plants.

**Hypothesis:** What do you think will happen to the plant spritzed with acid compared to the plant spritzed with water?

**Materials/Procedure:** Daily, for seven days, use the spray bottle marked “water” to spritz the plant marked “water” and the spray bottle marked “acid rain” to spritz the plant marked “acid rain.”

**Observation:** Observe the plants after 24 hours and again after seven days. Describe any changes in the plants, especially differences in size, number of leaves, color, or appearance. Also sketch a picture of each plant after 24 hours and then after seven days in the space provided.

<table>
<thead>
<tr>
<th>Plant</th>
<th>After 24 Hours</th>
<th>Picture</th>
<th>After 7 Days</th>
<th>Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spritzed With Water</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spritzed With “Acid Rain”</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Conclusion:**
The Greenhouse Effect

In a greenhouse, sunlight passes through the glass or plastic of the greenhouse, warming the surfaces inside. When the surfaces become warm, they give off heat waves. Because this kind of heat energy cannot easily pass through glass or plastic, it remains in the greenhouse and warms the air.

The sun's energy enters Earth's atmosphere as radiant energy, most of it in the form of light rays. Some of these rays are reflected back into space by clouds and the surface of Earth, and some are directly absorbed by clouds. About half of the light rays are absorbed by the surface of Earth (including the oceans), which heats up. Earth's heated surface in turn gives off heat waves. Most of these heat waves, instead of passing back out into space, are absorbed by certain kinds of molecules, especially carbon dioxide and water vapor, which themselves heat up and give off heat waves that travel back toward Earth's surface. Because this effect is similar to how a greenhouse works, in that the heat waves are kept from escaping, scientists call it the "greenhouse effect."

Greenhouse gases are needed to keep Earth warm enough for living things. But some scientists believe that the recent increase in greenhouse gases might be causing Earth to warm more quickly than the rate at which living things can adapt. They warn that the polar ice could melt enough to raise the sea level, thus flooding coastal areas, or that vast forests could die out because of the warming climate. But no scientist can predict for sure what will happen.
Greenhouse Lab

<table>
<thead>
<tr>
<th></th>
<th>Temperature of Greenhouse Jar (jar with plastic wrap cover)</th>
<th>Temperature of jar without cover</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In Celsius</td>
<td>In Celsius</td>
</tr>
<tr>
<td>Start</td>
<td>Celsius</td>
<td>Celsius</td>
</tr>
<tr>
<td>End</td>
<td>Celsius</td>
<td>Celsius</td>
</tr>
</tbody>
</table>

Questions

1. Which jar held on the most heat? The greenhouse jar or the jar without the cover?

2. Name the major greenhouse gas.

3. Does the greenhouse effect happen if there are no clouds? Yes or No?

4. Name two things that humans have done to increase the amount of greenhouse gases there are today.

5. What will happen if people keep polluting greenhouse gasses?

6. Name two things you can do to reduce the amount of greenhouse gasses released into the atmosphere.

7. What is global warming?
Catching tiny particles of air pollution at school will really be an eye-opener for your students! Provide each student with an index card. Inform your students that the index cards will be used in an experiment to see if air pollution exists in different areas of your school. On one side of the card, have each student write his name and a specific location at school where he will test for pollution. (Indoor locations might include the classroom, cafeteria, and gym. Outside locations might include the bus-loading area, the playground, and the area just outside your classroom.) On the other side of the card, have the student spread a layer of petroleum jelly. Explain that the petroleum jelly will "catch" the pollution. Direct each student to place his card in its assigned location. (Students may need tape to secure their cards to a wall, chair, or other item in the chosen location.)

After several days, have the students retrieve their cards and compare their results. Ask your students questions, such as "Did some locations produce more pollution than others?" and "Did it make a difference if the card was outside or inside?" Record their responses on chart paper. Then have each student write a brief description of the location that contained the most pollutants and an explanation of why the location may be more polluted. Your students will be wide-eyed with wonder at the pollution they hadn't noticed before.
Poster Project

Requirements
1. Names
2. Colored
3. Titles
4. Neat
5. Pictures
6. Description of problem
7. Description of solution

Choice A
Global Warming
1. Causes
   A. Burning fossil fuels
   B. Fossil fuels release carbon dioxide. Extra carbon dioxide traps extra heat
2. Consequence
   A. Polar ice caps melt = floods
   B. Drought

Ways you can reduce Global Warming

Choice B
Acid Rain
1. Causes
   A. Burning coal releases sulfur
   B. Sulfur dioxide mixes with water in clouds and makes acid rain
2. Consequences
   A. Takes nutrition out of soil
   B. Damages building/statues
   C. Harms plants and animals

Ways you can reduce acid rain

Or

Choice C
Smog
1. Causes
   A. Burning fossil fuels
   B. Burning fossil fuels release sulfur dioxide and nitrogen oxide which pollute the air.
2. Consequences
   A. Damages lungs
   B. Causes more respiratory illnesses in children

Ways you can reduce smog
Summary:
Students simulate a nuclear chain reaction and read about how a nuclear reactor works.

Grade Level: 6-8 (9-12)

Subject Areas: Language Arts/English (Reading), Science (Physical [Chemistry, Physics])

Setting: Classroom, outdoors, or large space

Time:
Preparation: one hour
Activity: two 50-minute periods

Vocabulary: Atom, Boiling water reactor, Chain reaction, Containment building, Control rod, Coolant, Element, Enrichment, Fission, Fuel assembly, Isotope, Kinetic energy, Moderator, Neutron, Nuclear energy, Nucleus, Plutonium, Potential energy, Pressure vessel, Pressurized water reactor, Radiation, Radioactive decay, Radioactivity, Reactor, Uranium

Major Concept Areas:
• Development of energy resources

Materials:
• Copies of Nuclear Fission and Nuclear Chain Reactions
• Scrap paper or small, light biodegradable objects such as popcorn
• Stopwatch or clock with second hand
• Copies of How a Nuclear Power Plant Operates

Objectives
Students will be able to
• explain how energy is obtained from nuclear fission;
• compare controlled and uncontrolled nuclear chain reactions;
• describe how a nuclear reactor uses nuclear energy to produce electricity; and
• formulate an opinion about using nuclear energy.

Rationale
Understanding how energy is obtained from nuclear fission and how it is used to produce electricity in a nuclear power plant teaches students how some of the electricity they use is produced.

Background
See the background information in Nuclear Fission and Nuclear Chain Reactions and How a Nuclear Power Plant Operates. Additional information may be found in “Facts about Nuclear Energy” in Appendix.

Procedure
Orientation
Ask students what they know about nuclear energy. Some students may respond with accurate statements about it, while others may say they don’t know much about it at all. A few might joke about its explosive nature and say things like “it blows things up.” Ask if they have seen or heard about nuclear energy in the media (cartoons or television characters associated with nuclear energy or nuclear power plants), or have used idiomatic phrases recently, such as “We nuked the dinner leftovers in the microwave.” Record their comments on the chalkboard or elsewhere. Ask students to label each comment as “fact” (true), “fiction” (false), or “don’t know.”

Review basic atomic terms such as atom, nucleus, neutron, radioactivity, and molecule with the class. Draw a diagram of an atom on the chalkboard and have students identify its parts. You may want to draw a simplified version of a uranium-235 ($^{235}\text{U}$) atom, showing its nucleus surrounded by electrons. List the number of protons (92) and neutrons (143) by the nucleus, and the number of electrons (92) by the area where they orbit the $^{235}\text{U}$ nucleus (see example diagram).

Harnessing Nuclear Energy

(Continued on next page)
Steps
1. Divide the class into pairs and have them read Nuclear Fission and Nuclear Chain Reactions (see "Read and Explain Pairs" in the Appendix for a suggested reading comprehension strategy). Select pairs to share their answers with the class. Encourage students to raise other questions about the readings.

2. Tell students they are going to model a nuclear chain reaction. Take the class outside or to a large open area. Inform students they each represent a U^{235} nucleus. Provide each student with two pieces of scrap paper and tell students to wad the paper into small balls (or give each student two kernels of popcorn). The paper balls represent neutrons.

3. Have students stand in three or four rows about an arm's length from each other. Tell them that you will start by throwing your paper wads into the air. Students who are hit by a paper wad have been bombarded with a neutron, and they must split off their own neutrons by immediately tossing their two balls of paper into the air. Students are to throw the paper wads randomly (not aiming at anyone).

4. Note the time and throw your papers into the air. When the paper balls stop flying, note the time again. Also count the number of students that did not "react" or who were not hit with paper.

5. Discuss controlled and uncontrolled chain reactions.
   • Uncontrolled reactions occur when fissionable material is concentrated and all of it reacts very quickly. This reaction produces a very high temperature all at once and results in an action much like an atomic bomb.
   • Controlled reactions last longer than uncontrolled reactions. They usually start small, speed up slowly, and reach a constant, sustained level of reaction.

Resources:
For Teachers


Complementary Activities


(Continued on next page)
6. Ask students if they think their paper-throwing demonstration represented a controlled or uncontrolled reaction. How would they arrange themselves to simulate a more controlled reaction? Have them collect the papers and try out their suggestions, and compare the results to the previous demonstration.

7. After students have returned to the classroom and to their seats, have them read How a Nuclear Power Plant Operates (see “Read and Explain Pairs” in Appendix). Select pairs to share their answers with the class.

Closure
Ask students to review their earlier comments about nuclear energy and to reclassify their comments as “fact,” “fiction,” or “don’t know.” Discuss whether their initial understanding was based on popular misconceptions about nuclear energy. Ask them how they would respond to such misconceptions in the future (see Assessment).

Assessment

Formative
- Did students work cooperatively to read the material?
- How accurately did students answer questions from the reading assignments?
- Can students demonstrate an uncontrolled and a controlled nuclear chain reaction using wads of paper?

Summative
- Have students identify reasons why they would or would not want their electricity generated from nuclear energy. What else would they need to find out before making their choice?

Extensions

An alternative to the paper-throwing activity is to have students set up dominoes. Dominoes that are arranged close together when knocked over illustrate an uncontrolled reaction. Challenge students to set up the dominoes so that they simulate a controlled reaction.

Have the class tour one of Wisconsin’s three nuclear power plants. The first two, Point Beach Units 1 and 2, are owned by Wisconsin Electric Power Company and are located on Lake Michigan north of Two Rivers. The other is the Kewaunee Nuclear Plant, operated and partly owned by Wisconsin Public Service Corporation and located on Lake Michigan near the town of Kewaunee. Contact Wisconsin Electric or Wisconsin Public Service for further information about nuclear power plant tours. If a tour is not possible, a utility representative may give a presentation about the nuclear power plants to the class.
Related KEEP Activities:

Conduct the appliance survey in the activity “At Watt Rate?” to orient students to the ways they use electricity in the home. Students can learn more about nuclear power plants in Wisconsin through the activity “Fuel That Power Plant.” Some power plants offer tours; see the Appendix for contact information. The activity “Advertising Energy” can be used to analyze public relations strategies employed by electric utilities and the nuclear industry. Follow this activity with “Dealing with Nuclear Waste.” Further investigations of different types of resources can accompany this activity. Have students experiment with procedures described in “Electric Motors and Generators” to simulate electricity generation. The Appendix contains information about the Energy Bike. This unique teaching aid teaches students about generating electricity, energy efficiency, and other concepts while riding a stationary bicycle.
Introduction
One of the greatest scientific discoveries of the twentieth century is that nuclei of uranium atoms can be split by neutrons to produce large quantities of energy. This process, called nuclear fission, brings to mind the large-scale production of electricity by nuclear power plants and large-scale destruction by nuclear weapons. In order to understand how nuclear fission can produce such large amounts of energy, we must begin by looking at uranium.

Characteristics of Uranium
Uranium is one of the elements found in nature. An element is a substance made entirely of the same kind of atoms, with each atom having the same number of protons and electrons. Every uranium atom has 92 protons in its nucleus and 92 electrons orbiting the nucleus. However, not every uranium atom is completely alike. Different uranium atoms have different numbers of neutrons in their nuclei. These variations of uranium atoms are called isotopes. Many other elements besides uranium have isotopes as well. The isotope of uranium used to produce nuclear energy is uranium-235 (abbreviated as U\textsuperscript{235}). It is called U\textsuperscript{235} because each atom has 92 protons plus 143 neutrons in its nucleus, which totals 235 protons and neutrons. Another important uranium isotope is uranium-238 (U\textsuperscript{238}), which has 92 protons and 146 neutrons in its nucleus (92 + 146 = 238). An atom of U\textsuperscript{238} has three more neutrons in its nucleus than an atom of U\textsuperscript{235} does. The forces that hold protons and neutrons together in uranium isotopes are unstable. When the forces that hold an isotope together are broken energy in the form of radioactive gamma waves, similar to x rays, are released. Therefore, another characteristic of uranium is that it is radioactive.

Energy from Nuclear Fission
For nuclear fission to occur, the nucleus of a uranium atom has to be split somehow. This splitting is done with neutrons. Most neutrons travel at low speeds. Such neutrons have the right amount of energy needed to split U\textsuperscript{235}. On the other hand, only neutrons traveling at very high speeds have enough energy to split U\textsuperscript{238} nuclei, and they are rare. Therefore, fission occurs much more easily with U\textsuperscript{235} than it does with U\textsuperscript{238}.

A neutron colliding with a U\textsuperscript{235} nucleus splits it into two smaller nuclei of other elements and, depending on the nuclei that are formed, releases two or three neutrons. For example, a U\textsuperscript{235} nucleus might be split into the nuclei of the elements barium and krypton, and release three neutrons. Splitting another U\textsuperscript{235} nucleus might produce the elements lanthanum and molybdenum and only two neutrons. These and other elements produced by fission are radioactive.
When the total mass of the U\textsuperscript{235} nucleus before fission, plus the neutron that splits it, is compared to the total mass of the two smaller nuclei and the neutrons after fission, a small amount of mass is missing. This finding is true no matter what combination of nuclei and neutrons is produced. Where did the missing mass go? Einstein’s famous equation $E = mc^2$ solves the mystery—the missing mass was converted into energy (see \textit{E=mc\textsuperscript{2}: How Nuclear Fission Produces Energy}). The energy stored in the form of mass in the nucleus, plus energy stored in the bonds that hold neutrons and protons together, is called nuclear energy. This is a form of potential energy. The energy released after fission occurs is observed as motion of the split nuclei and neutrons (kinetic energy) and released heat (thermal energy).

\textbf{E=mc\textsuperscript{2}: How Nuclear Fission Produces Energy}

To see how nuclear fission produces energy, let’s look at one of the possible fission reactions for a single U\textsuperscript{235} nucleus. The reaction can be written as follows:

$$^{1}_{0}n + ^{235}_{92}U \rightarrow ^{141}_{56}Ba + ^{82}_{36}Kr + 3^{1}_{0}n + \text{energy}$$

A neutron ($^{1}_{0}n$) hits a U\textsuperscript{235} nucleus, splitting it into a barium nucleus ($^{141}_{56}Ba$) and a krypton nucleus ($^{82}_{36}Kr$). Three neutrons ($3^{1}_{0}n$) plus a certain amount of energy are also released. When the total mass of the neutron and the U\textsuperscript{235} nucleus before fission is compared to the total mass of the barium, krypton, and three neutrons after fission, a small amount of mass turns out to be missing.

The amount of missing mass and the energy released by this reaction can be calculated. Since atomic nuclei are very small, it is more convenient to express their mass in units called atomic mass units (amu) rather than in pounds or kilograms (one amu is equal to one-twelfth of the mass of C\textsuperscript{12}, the most common form of carbon atom).

The total mass of the neutron and the U\textsuperscript{235} before fission is

- $^{235}_{92}U = 235.04393$ amu (atomic mass units)
- $^{1}_{0}n = 1.00867$ amu
- total = 236.05260 amu

The total mass of the barium, krypton, and the three neutrons after fission is

- $^{141}_{56}Ba = 140.91436$ amu
- $^{82}_{36}Kr = 91.92627$ amu
- $3^{1}_{0}n = 3.02601$ amu
- total = 235.86664 amu

To find the decrease in mass, subtract the total masses of the barium, krypton, and three neutrons from the neutron and the U\textsuperscript{235}.

Decrease in mass = total mass before fission - total mass after fission
= 236.05260 amu - 235.86664 amu
= 0.18596 amu

(Continued on next page)
Next, use Einstein’s equation $E=mc^2$ to calculate the amount of energy equal to the decrease in mass. To do this, the mass must first be converted from amu to kilograms.

$$0.18596 \text{ amu} \times \frac{1.66 \times 10^{-27} \text{ kg}}{1 \text{ amu}} = 3.09 \times 10^{-28} \text{ kg}$$

The amount of energy produced is equal to $m$, the decrease in mass (in kilograms), multiplied by $c^2$, the square of the speed of light (in meters per second).

$$E = mc^2$$

$$= (3.09 \times 10^{-28} \text{ kg}) \times (3 \times 10^8 \text{ meters/sec})^2$$

$$= 2.78 \times 10^{11} \text{ joules of energy per } ^{235}U \text{ nucleus, or}$$

$$= 2.64 \times 10^{11} \text{ Btu of energy per } ^{235}U \text{ nucleus}$$

Splitting one $^{235}U$ nucleus produces $2.64 \times 10^{14} \text{ Btu}$ of energy, an amount that can barely be measured. On the other hand, the amount of energy released by fission of one pound of pure $^{235}U$ is extremely large. One pound of pure $^{235}U$ contains $1.18 \times 10^{24} \text{ atoms of } ^{235}U$. Assuming every atom undergoes fission according to the reaction given earlier, the energy released is

$$\frac{2.64 \times 10^{14} \text{ Btu}}{\text{atom of } ^{235}U} \times \frac{1.18 \times 10^{24} \text{ atoms of } ^{235}U}{\text{pound of } ^{235}U} = 3.11 \times 10^{10} \text{ Btu per pound of } ^{235}U$$

This is equal to the energy contained in 1,244 tons (1,264 metric tons) of bituminous coal, 249,000 gallons (942,565 liters) of gasoline, or 2,600 tons (2,642 metric tons) of wood.

This amount is slightly smaller than the average amount of energy released by fission of one pound of $^{235}U$. Other fission reactions may produce nuclei like germanium, lanthanum, strontium, xenon, and zirconium instead of barium and krypton, along with only two instead of three neutrons. Producing different fission products yields slightly different amounts of energy per split $^{235}U$ nucleus. When averaged, the energy produced by fissioning one pound of pure $^{235}U$ is equal to $3.5 \times 10^{10} \text{ Btu}$.

**Nuclear Chain Reactions**

The energy released by a single $^{235}U$ nucleus is too small to have any practical purpose. To produce a large amount of energy, a large number of $^{235}U$ nuclei have to be split. This happens when neutrons released from a split $^{235}U$ nucleus go on to fission other $^{235}U$ nuclei. This reaction produces additional neutrons, which cause more fissions, which release still more neutrons to cause even more fissions, which release even more neutrons, and so on. The result is known as a chain reaction.

An uncontrolled chain reaction releases large amounts of energy quickly. This kind of chain reaction allows nuclear weapons to create large explosions. A controlled chain reaction releases energy more slowly and steadily. Nuclear power plants are designed to produce controlled chain reactions that release steady amounts of energy for producing electricity.

The average concentration of uranium in ore mined from Earth is about 0.11 percent; the rest of the ore is made up of other minerals. Of the total amount of uranium, 99.3 percent is $^{238}U$ and 0.7 percent is $^{235}U$. 

*KEEP Activity Guide*  
THEME II: DEVELOPING ENERGY RESOURCES  
Harnessing Nuclear Energy
A chain reaction is not possible with such low concentrations of U\textsuperscript{235}, so the percentage of U\textsuperscript{235} needs to be increased. This is done by first using chemical processes that remove the uranium from the ore after mining, and then increasing the percentage of U\textsuperscript{235} in the uranium using a process called enrichment. In nuclear power plants, a mixture of three percent U\textsuperscript{235} and 97 percent U\textsuperscript{238} is used to produce controlled chain reactions. To produce uncontrolled chain reactions like those that occur in nuclear explosions, a mixture of 90 percent U\textsuperscript{235} and ten percent U\textsuperscript{238} is used.

Comparing the Energy from Combustion and from Nuclear Fission
The energy released by nuclear fission is much larger than the energy released by burning wood or fossil fuels such as coal, oil, and natural gas. For instance, one pound (.45 kg) of uranium with three percent U\textsuperscript{235} — the mixture used in nuclear power plants — has an amount of energy equal to about 41 tons (36.9 metric tons) of bituminous coal, 8,300 gallons (31,5401 liters) of gasoline, or 87 tons (78.3 metric tons) of wood.

Why is the energy from nuclear fission so much greater than from burning wood or fossil fuels? The nuclear bonds holding the neutrons and protons in the nuclei together are much, much stronger than the chemical bonds that hold the molecules in wood and fossil fuels together. The stronger the bonds, the more energy is stored in them. In addition, breaking nuclear bonds changes a small amount of the mass in a uranium nucleus into energy. Therefore, the nuclear energy stored in a uranium nucleus is much greater than the chemical energy stored in wood and fossil fuel molecules.

Questions
1. Two isotopes of the element carbon are carbon-12 (C\textsuperscript{12}) and carbon-14 (C\textsuperscript{14}). In what ways are the carbon isotopes the same? In what ways are they different?

2. Using marbles to represent protons and neutrons, describe what happens when a neutron splits a U\textsuperscript{235} nucleus.

3. Explain how energy is obtained from nuclear fission.

4. Why is a chain reaction needed to produce large amounts of energy from nuclear fission?

5. Why might a uranium mixture of 60 percent U\textsuperscript{235} and 40 percent U\textsuperscript{238} not be suitable for use in a nuclear power plant?

6. How many pounds of uranium are in one ton (2,000 pounds) of uranium ore? How many pounds of U\textsuperscript{235} are in one ton of uranium ore?

7. Why is the energy produced by nuclear fission of uranium so much greater than the energy produced by burning wood?
Introduction
Nuclear power plants, like power plants that burn fossil fuels, produce electricity by first boiling water to produce steam. The main difference between a nuclear power plant and other kinds of power plants is that at a nuclear power plant, the heat used to make the steam is produced by fissioning atoms, not by burning fossil fuels.

Nuclear Reactors
At a nuclear power plant, fission takes place in the reactor. The reactor is basically a machine that heats water. A reactor has four main parts: (1) the uranium fuel assemblies; (2) the control rods; (3) the coolant/moderator; and (4) the pressure vessel. The fuel assemblies, control rods, and coolant/moderator make up the reactor's core. The core is surrounded by the pressure vessel.

The Fuel Assemblies
Uranium made up of a mixture of three percent $^{235}$U and 97 percent $^{238}$U is the fuel used in a nuclear power plant. But we cannot just throw uranium into the reactor the way we can shovel coal into a furnace. Uranium must be enriched and formed into fuel pellets that are about the size of your fingertip. The fuel pellets are then stacked into hollow metal tubes called fuel rods, which keep the pellets in the proper position.

Each fuel rod contains about 200 fuel pellets and is 12 to 14 feet (3.6 to 4.2 m) long. However, a single fuel rod cannot generate the heat needed to make a large amount of electricity. So fuel rods are carefully bound together in fuel assemblies, each of which contains about 240 rods. The assemblies hold the fuel rods apart so when they are submerged in the reactor core, water can flow between them.
The Control Rods
Another important part of the reactor are the control rods. They are inserted from the top of the reactor core, and slide up and down between the fuel rods or fuel assemblies in the reactor core. Control rods regulate or control the speed of the nuclear reaction. These rods contain materials such as cadmium and boron. Because of their atomic structure, cadmium and boron absorb neutrons, but do not fission. The control rods work like sponges by absorbing extra neutrons. When the control rods absorb neutrons that could otherwise hit uranium atoms and cause them to split, the chain reaction slows down.

The temperature in the reactor core is carefully monitored and controlled. When the core temperature goes down, the control rods are slowly lifted out of the core, and fewer neutrons are absorbed. Therefore, more neutrons are available to cause fission. This releases more energy and heat. When the temperature in the core rises, the rods are slowly lowered and the energy output decreases because fewer neutrons are available for the chain reaction. To maintain a controlled nuclear chain reaction, one neutron from each U\textsuperscript{235} atom that splits will cause another U\textsuperscript{235} atom to fission, while other neutrons are absorbed. Therefore, the number of fissioning atoms stays constant.

Temperature changes in the core are usually gradual. But if monitors detect a sudden change in temperature, the reactor would immediately shut down automatically by dropping all the control rods all the way into the core to absorb neutrons. A shutdown of this type takes only a few seconds and stops the nuclear chain reaction. This shutdown happens because the neutrons necessary to keep a chain reaction going are absorbed by the control rods.

The Coolant/Moderator
A third essential part of the reactor is the coolant/moderator. At most nuclear power plants in the United States, the coolant/moderator is nothing more than purified, treated water. Any material used for cooling is called a coolant. In nuclear power plants, the cooling water is also used to move the reactor's heat to places where it can be used to generate electricity. If the reactor is not cooled, the heat inside could damage the core. So it is necessary always to have coolant in the reactor core to keep it from getting too hot.

A moderator is a material that slows down neutrons. Just as a ball is more likely to be caught when it is thrown softly, neutrons are more likely to be captured and cause fission in U\textsuperscript{235} atoms when they are not moving too fast. Water is a moderator because it slows down the neutrons. Using water as the moderator allows enough neutrons to be captured by the uranium to permit a chain reaction to occur.

The Pressure Vessel
The fourth part of the reactor is the pressure vessel. The pressure vessel is enormous. Its walls are 9 inches (22.5 cm) thick, and it often weighs more than 300 tons (270 metric tons). The pressure vessel surrounds and protects the reactor core. It provides a safety barrier and holds the fuel assemblies, the control rods, and the coolant/moderator. The pressure vessel is located inside the containment building, which is made of thick concrete reinforced with thick steel bars.

How a Nuclear Power Plant Produces Electricity
The reactor in a nuclear power plant converts nuclear energy into thermal energy (heat). The purpose of the other parts of the nuclear power plant is to convert the thermal energy produced by the reactor into electrical energy.

Because of the heat produced by the fission reaction, the coolant/moderator water that is circulated through the core becomes extremely hot. Generally, when water reaches 212 degrees F (100 °C), it boils and turns into a gas
called steam. Gas takes up more space than liquid. But inside certain kinds of reactors, there is only a limited amount of space, and the water cannot turn into steam. As a result, the water is under pressure, and it can be heated to 600 degrees F (316 °C) and still remain a liquid. Because the water in the core is under enough pressure to remain a liquid, this type of reactor is called a pressurized water reactor, or PWR.

Pressurized Water Reactor

Pressurized water reactors have three separate systems of pipes, or loops, for moving heat. Water in these loops never mixes together. However, heat energy from one loop moves to another. In the first loop, pressurized water is pumped through the reactor and then moved through extremely strong pipes that lead to several steam generators. Inside the steam generators, the coolant/moderator water in the first loop flows through hundreds of pipes. Water from the second loop flows around these pipes. The first loop carries water that is 600 degrees F (316 °C). Because heat flows away from heated surfaces toward cooler surfaces, the heat in the first loop transfers to the second loop. When water in this second loop takes on the heat from the first loop, it turns to steam. This is because water in the second loop is under less pressure.

The second loop carries the steam to the turbine. A turbine is basically a pinwheel with many blades that are spun by steam. At power plants, turbines are attached to generators, which change the mechanical energy of the spinning turbine into electrical energy.

After turning the turbine, the steam in the second loop has lost most of its heat energy. It is cooled and turned back into water so that it can be used again in the second loop. This operation takes place in the condenser, which is located under the turbine. In the condenser, the steam in the second loop transfers some of its heat to the third
loop. Again, heat is transferred from a heated substance to a cooler one. The third loop contains cooling water drawn from a large body of water such as a large river, lake, or ocean. The purpose of the third loop is to remove heat from the steam in the second loop. This heat is removed by placing the heated water back into the river, lake, or ocean. In cases where heated water may adversely affect the river or lake environment, or if a large body of water is not available, the heat is dissipated into the air by using large cooling towers.

**Boiling Water Reactor**

Another common type of light water reactor is the boiling water reactor, or BWR. The main difference between a PWR and a BWR is that PWRs have three loops, while BWRs only have two loops. BWRs do not have steam generators. Instead, the water in BWRs boils inside the pressure vessel, and the steam is used directly to turn the turbine. In BWRs, the control rods come from the bottom instead of the top. It is important to remember that in both a PWR and a BWR, the water from one loop never mixes with water from another loop. Only the heat is transferred.

**Nuclear Power Plant Safety**

The new elements formed in the nuclear reactor due to fission are radioactive and therefore potentially dangerous to human health. Preventing their release to the public is the most important part of reactor safety. Because of the danger that could result from overheated uranium fuel, there is great concern about the possibility of an accident in which coolant is lost. This is known as a loss of coolant accident, or LOCA. To handle a LOCA, reactors are designed to work in the following ways:

- The temperature of the uranium fuel is kept well below its overheating point.
- In PWR and BWR reactors, the coolant is the moderator (water), so any loss of coolant also means a loss of moderator. If the moderator is not there to slow the neutrons down, they cannot continue the chain reaction. When the reaction stops, heat is reduced.
• The control rods automatically move into place to absorb neutrons and stop the chain reaction when any abnormal situation is detected.
• An emergency core cooling system (ECCS) turns on to replace lost coolant by rapidly injecting cooling water.
• The reactor building itself (the containment structure) is designed to withstand high pressure inside and to contain the energy released during a LOCA from steam and hot gases.

Accidents have occurred in nuclear power plants in the United States, the most widely publicized one being the LOCA at the Three Mile Island (TMI) power station on March 28, 1979. The TMI accident seems to have been due to a faulty valve, a design error in a water level indicator, and human error. But the control rods did automatically shut down the chain reaction, or "scram" the reactor; the emergency core cooling system (ECCS) also operated as planned. The results were a damaged reactor core and a small release of radioactive gases into the atmosphere.

The accident at TMI did nothing to end the nuclear debate. Opponents of nuclear power said that TMI proved that nuclear technology is fundamentally unsafe and unsound. Advocates of nuclear power replied that the accident showed that even when a great deal goes wrong, a nuclear reactor's redundant safety systems prevent the loss of control.

Questions
1. Explain how a nuclear reactor converts nuclear energy into electricity.

2. Give two reasons why the fuel assemblies hold the fuel rods apart.

3. Compare the three-loop system of the pressurized water reactor (PWR) to the two-loop system of the boiling water reactor (BWR). Suggest advantages and disadvantages of using each system.

4. How is a nuclear reactor designed to keep uranium fuel from overheating?

5. Suppose a problem occurs in which some of the control rods in the reactor get stuck and won't go into the core when they are supposed to. The rest of the control rods are working properly but are only in the core part way. What can be done to keep the uranium fuel from overheating?

6. Using everyday objects, design or build a model of a nuclear reactor that includes fuel assemblies, control rods, a coolant/moderator, and a pressure vessel. (Hint: a coffee can could be used to represent the pressure vessel.) Use the model you designed or built to explain to the class how a nuclear reactor works.
Answers to Selected Questions

1. Both carbon-12 (C\textsubscript{12}) and carbon-14 (C\textsubscript{14}) have the same number of protons and electrons in their atoms. Carbon-14, however, has two more neutrons in its nucleus than carbon-12 does.

4. The energy released by splitting a single U\textsubscript{235} nucleus is too small. A chain reaction produces neutrons that can be used to split a large number of U\textsubscript{235} nuclei, which results in a large amount of energy being produced.

5. A mixture of 60 percent U\textsubscript{235} and 40 percent U\textsubscript{238} would most likely lead to an uncontrolled chain reaction inside a nuclear reactor. Controlling the chain reaction produced by this mixture would be much more difficult than controlling the chain reaction produced by three percent U\textsubscript{235} and 97 percent U\textsubscript{238}.

6. 2,000 pounds of uranium ore multiplied by 0.11 percent (0.0011) equals 2.2 pounds (.99 kg) of uranium (U\textsubscript{235} and U\textsubscript{238} combined). 2.2 pounds (.99 kg) of uranium multiplied by 0.7 percent (0.007) equals 0.0154 pounds (.00693 kg) of U\textsubscript{235}. The other 2.1846 pounds (.98307 kg) of uranium is U\textsubscript{238}.

Answers to Selected Questions

2. One reason that the fuel assemblies hold the fuel rods apart is so that water can flow between them and be heated. Another reason is so that control rods can slide between the fuel rods to regulate the speed of the nuclear reaction.

3. In the three-loop system of the pressurized water reactor (PWR), the pressurized water that acts as the coolant/moderator is more isolated from the rest of the power plant and the surrounding environment than the coolant/moderator water in the two-loop system of the boiling water reactor (BWR). The additional isolation is important because the coolant/moderator water can become radioactive. If this water were to somehow leak out of the first loop of the PWR, it would stay inside the containment building. Although it is unlikely, a coolant/moderator water leak in the first loop of the BWR could result in the release of contaminated water into other parts of the power plant or possibly into the surrounding environment.

The advantage of the BWR over the PWR is that only two loops are needed instead of three. Fewer loops means that fewer parts of the power plant system need to be maintained or could fail, which may also make nuclear power plants that use BWRs cheaper to build.

5. Dropping the control rods that are working properly further into the core could keep the uranium fuel from overheating and allow operators time to fix the control rods that are stuck. If enough of the control rods were working properly, dropping them into the core might even shut down the nuclear reactor completely so that it could be repaired.
Dealing with Nuclear Waste

Objectives

Students will be able to
- identify three types of nuclear waste and their sources;
- describe the decay pattern of radioactive isotopes using the concept of half-life; and
- assess different options for disposing of high-level nuclear waste and select the disposal option they think is best.

Rationale

By investigating nuclear waste and the issues surrounding its disposal, students recognize that disposing of nuclear waste is a difficult problem and that choosing a disposal option involves judging its risks and assessing its advantages and problems.

Background


Procedure

Orientation

Survey students’ knowledge of nuclear waste by asking the following questions:
- What happens to nuclear fuel after it has been used in a reactor?
- Are there other kinds of nuclear waste besides used nuclear reactor fuel?
- Is nuclear waste hazardous? Why?
- What do you think should be done with nuclear waste?

Record their comments on the chalkboard or elsewhere.

Steps

1. Divide the class into pairs. Have each pair read What Is Nuclear Waste? (see “Read and Explain Pairs” in the Appendix for a suggested reading comprehension strategy). Have selected pairs share their answers with the class.

Encourage students to raise other questions about the reading.
2. Have each pair of students read the “Introduction” and carry out the shoe box experiment titled “Modeling Radioactive Decay” in The Half-Life of Radioactive Material. Hand out a Radioactive Decay Graph to each pair of students and have them graph the results of their experiment.

3. Have selected pairs share their graphs with the class. As an option, post the graphs produced by the class to show the variations and similarities of the half-life curves.

4. Have each pair of students answer the questions listed under “Modeling Radioactive Decay” in The Half-Life of Radioactive Material and complete the section titled “How Long Do Radioactive Materials Have to Decay before They Are Safe?” in Radioactive Decay Graph. Have selected pairs share their answers with the class. Encourage students to raise other questions about the reading.

5. Hand out the Summary of High-Level Nuclear Waste Disposal Options to each student. Have students review and briefly discuss the different options. Encourage students to come up with their own ideas for disposing of nuclear waste.

6. Instruct students to write a two- to three-page position paper on which option they think should be used to dispose of high-level nuclear waste from spent fuel. Remind students to include their own ideas. The paper may be done as a homework or research assignment outside of class, if desired. Papers should address the following points:

- The disposal option they chose
- The reasons why they chose a particular disposal option over other options
- Whether or not spent nuclear fuel should be reprocessed, and why

Direct students to the resources listed in the Summary of High-Level Nuclear Waste Disposal Options or to other resources that provide additional information on nuclear waste issues. As an option, have resources available for students (see Getting Ready).

Closure

When students have finished their position papers, re-create the following table on the blackboard. Tabulate which of the disposal options students chose under each column and, for each disposal option, whether or not students think spent nuclear fuel should be reprocessed before disposal.

Select students to read their position papers to the class. Allow them time to answer other students’ questions and defend their positions before the class.

<table>
<thead>
<tr>
<th>Disposal Options</th>
<th>Should Spent Fuel Be Reprocessed Before Disposal?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bury Waste Underground</td>
<td>Yes</td>
</tr>
<tr>
<td>Bury Waste beneath the Ocean Floor</td>
<td></td>
</tr>
<tr>
<td>Place Waste in a Specially Constructed Facility above Ground</td>
<td>Yes</td>
</tr>
<tr>
<td>Shoot Waste into Space</td>
<td></td>
</tr>
<tr>
<td>(Other disposal option ideas)</td>
<td></td>
</tr>
</tbody>
</table>

• Small candies (each pair of students will need 100 pieces of two different types of candies, such as M&M’s and Skittles—the candies should be blank on one side and have a letter or decal on the other)
• Copies of Radioactive Decay Graph
• Copies of Summary of High-Level Nuclear Waste Disposal Options

Getting Ready:

Either ask students to bring shoe boxes and candies from home or provide them on your own. You may give students copies of the resources listed in the Summary of High-Level Nuclear Waste Disposal Options. Answers to questions in What Is Nuclear Waste? and The Half-Life of Radioactive Material are located after the student pages.

Resources:

(Also see Resources listed in Summary of High-Level Nuclear Waste Disposal Options.)

For Teachers


(Continued on next page)
Assessment

Formative
- Did students work cooperatively in “Read and Explain” pairs?
- Can students describe the difference between high-level nuclear waste, low-level nuclear waste, and radioactive tailings?
- Can students explain where the different types of nuclear waste come from?
- Are students able to graph and interpret the half-life of a radioactive isotope using candies?
- Can students accurately describe the pattern of radioactive decay using the concept of half-life?
- How accurately did students answer questions associated with the readings?

Summative
Consider how well students promoted and defended their choice of a disposal option for high-level nuclear waste.

Solid low-level waste is safely disposed of in shallow trenches. When the trench is full, a protective covering for erosion control will be placed on top.

Related KEEP Activities:
Precede this activity with “Harnessing Nuclear Energy.” Other waste issues associated with energy use are found in “Dirty Half Dozen” and “Don’t Throw Energy Away.” Students can use the activity “Advertising Energy” to analyze public relations strategies employed by electric utilities and the nuclear industry.
Encourage students to research the following topics related to nuclear waste disposal:

- How radiation affects human health
- How nuclear waste and other nuclear materials are transported
- How a high-level nuclear waste disposal site would be constructed at Yucca Mountain in southern Nevada
- The reasons surrounding local opposition to proposed nuclear waste sites, sometimes called the NIMBY (Not In My Back Yard) syndrome
- How other nations plan to dispose of their nuclear wastes
- Who is responsible for nuclear waste disposal in the United States

Have students investigate how the nuclear waste produced by Wisconsin’s three nuclear plants (Point Beach Units 1 and 2 and Kewaunee) is currently being disposed. This investigation could be tied in with a tour of one of the nuclear plants or a presentation on Wisconsin’s nuclear plants given by a utility representative.
Introduction
Waste that results from the use of radioactive materials is called nuclear waste (or radioactive waste). Nuclear waste comes primarily from the following sources:
- All the steps involved in using nuclear energy to produce electricity
- Defense activities, including the manufacture of nuclear weapons
- Hospitals, universities, and research laboratories
- Industry
- Mining and milling of uranium ore

Nuclear Waste and Human Health
The radioactive isotopes found in nuclear waste emit radiation while undergoing radioactive decay (see The Half-Life of Radioactive Material for more information about radioactive decay). This radiation, in the form of alpha particles, beta particles, and gamma rays, can disrupt living cells and interfere with the health of humans and other living things, depending on the amount of radiation received. All humans and living things are exposed to small amounts of background radiation from natural and human-made sources in the environment. Humans directly exposed to higher levels of radiation may suffer health effects such as cancer, genetic disorders, and other degenerative diseases.

Types of Nuclear Waste
Nuclear waste is classified in terms of how radioactive it is, where it comes from, and how harmful it may be to human health. The categories of classification are high-level waste, low-level waste, and radioactive tailings.

High-Level Waste
This is the most radioactive form of nuclear waste. It includes spent fuel (used fuel) from nuclear power plants and some waste from defense activities, including the manufacture or disassembly of nuclear weapons and spent fuel from nuclear submarines. High-level nuclear waste is extremely hazardous to humans and other living things. This waste must be stored in a place of maximum safety until it undergoes radioactive decay and loses enough radioactivity to be considered safe. Some radioactive isotopes in high-level waste lose radioactivity rather quickly, while others remain radioactive for thousands of years.

In addition, the initially high levels of radioactivity in spent fuel produce large amounts of heat that must somehow be absorbed or removed. For example, the fuel rods containing spent fuel from nuclear power plants are stored in large pools of water located in facilities next to the power plant. The water absorbs the heat produced by the spent fuel.

High-level waste is handled by operators using remote control equipment behind heavy protective shielding. They transport the waste in heavily shielded containers called casks. Storage of high-level waste is addressed in Summary of High-Level Nuclear Waste Disposal Options.

Low-Level Waste
Low-level waste usually contains only a small amount of radioactivity within a relatively large amount of material. It is less hazardous than high-level waste. Most low-level waste does not require extensive shielding. However, for certain low-level waste, some shielding may be necessary.

Hospitals, nuclear power plants, research labs, and many industries produce low-level waste. Also, some of the waste produced by defense activities is low-level waste. Low-level waste from research, medical activities, and
nuclear power plants may include commonly used equipment such as empty containers, rags, papers, filters, broken tools, and used protective clothing that has been exposed to radioactive materials.

Low-level waste is placed in containers and then buried at special landfills licensed by the federal government. Two major burial sites are located at Barnwell, South Carolina, and Hanford, Washington.

Radioactive Tailings
The fuel used at a nuclear power plant comes from uranium ore, which is mined from the ground. After mining, the uranium ore is milled, a process that separates and removes the uranium from the rest of the ore by crushing and chemically treating it. The leftover rocks and soil from mining and milling are called tailings. The tailings contain radon-222, a radioactive gas, which can be harmful to human health if the exposure is in concentrated amounts. To prevent the release of radon-222 into the air, the tailings are usually covered with a layer of soil.

Questions
1. Name two sources that produce both high-level and low-level waste.
2. Why does high-level nuclear waste need more shielding than low-level waste?
3. Does low-level waste need to be placed in casks before it is transported? Explain.
4. How is the disposal of low-level nuclear waste similar to the disposal of radioactive tailings?

Reprocessing Spent Fuel from Nuclear Reactors
Nuclear fuel used in nuclear power plants in the United States contains a mixture of uranium-235 (U\textsuperscript{235}) and uranium-238 (U\textsuperscript{238}). The U\textsuperscript{235} nuclei undergo fission, releasing energy that is used by the power plant to produce electricity. While the fuel is being used, some of the U\textsuperscript{238} in the fuel will absorb neutrons and change into a new radioactive element called plutonium. Plutonium is a special element because it is not found in nature; it is created as part of the nuclear fission process only. Like U\textsuperscript{235} nuclei, the nuclei of certain plutonium isotopes easily undergo fission, which means that plutonium can be used in nuclear power plants and nuclear weapons.

After a period of time, most of the U\textsuperscript{235} in nuclear fuel has undergone fission, and the fuel is no longer able to produce enough energy to run the power plant. However, this spent fuel still contains some leftover U\textsuperscript{235} and plutonium. The leftover U\textsuperscript{235} and plutonium can be removed from spent fuel and made into new nuclear fuel through a procedure called reprocessing. One advantage of reprocessing is that it puts the remaining U\textsuperscript{235} and plutonium to further use rather than disposing of it. Another advantage is that since U\textsuperscript{235} and plutonium stay radioactive for many thousands of years, removing them from spent fuel leaves radioactive waste that decays more quickly. However, the remaining waste is still considered high-level waste. Reprocessing also creates a greater amount of low-level waste than does disposal of spent fuel without reprocessing.
Questions

2. How might reprocessing spent fuel reduce the amount of uranium that has to be mined?

Nuclear Proliferation and the Potential for Theft
One concern over the use of nuclear energy is that a quantity of U\textsuperscript{235} or plutonium of sufficient concentration can be extracted from nuclear fuel and used to make nuclear weapons. This may happen if other countries using nuclear power try to use a portion of their fuel for making weapons. Small quantities of nuclear fuel may also be stolen and sold to other nations for the same purpose or can be used by terrorists, whether or not they actually wish to create a weapon. The potential spread of nuclear weapons throughout the world is called nuclear weapons proliferation.

Extracting U\textsuperscript{235} or plutonium from spent fuel to make a nuclear weapon is a difficult process that requires specialized equipment costing millions of dollars. Extracting these isotopes from reprocessed nuclear fuel is somewhat easier because their concentrations are higher in reprocessed fuel than they are in spent fuel.

Because of concerns over nuclear weapons proliferation, President Carter halted commercial nuclear fuel reprocessing in the United States in 1977. The ban was lifted by President Reagan in the 1980s. However, currently, none of the spent fuel from nuclear power plants is being reprocessed, although the defense department reprocesses some of its spent fuel.

The likelihood of nuclear fuel being stolen in the United States is low, given the high degree of security present in our nation's nuclear power plants, fuel production sites, and defense operations. The security of nuclear fuel in other nations may vary and is of particular concern in the former Soviet Union, where mismanagement and economic hardship have led to lowered security.

Questions
1. Why would it be easier to build a nuclear weapon using plutonium from reprocessed nuclear fuel than from spent fuel?

2. What would security personnel at a nuclear power plant be guarding against?
**Introduction**

All radioactive isotopes, including those found in nuclear waste, undergo radioactive decay. The decay process releases radiation that can be hazardous to humans and other living things. However, the amount of radiation released by these isotopes is not constant. Instead, the isotopes' radioactivity decreases over time to a point where they produce little or no radiation and are no longer hazardous. But how much time must pass before this happens?

How long it takes a single atom of a radioactive isotope to decay cannot be predicted; it is a random process. On the other hand, the rate of decay of large numbers of these atoms can be accurately measured. This rate, called the half-life, is defined as the time it takes for one-half of a radioactive isotope sample to decay into another isotope.

Each radioactive isotope has its own half-life, which may range from fractions of a second to billions of years. Also, the shorter the half-life, the greater the intensity of the radioactivity produced by the isotope. This relationship makes sense because in order for a radioactive isotope to decay quickly, its atoms must release large amounts of radiation. The amount of radioactivity released by an isotope is known as its specific radioactivity and is measured in curies per gram of material.

Many of the isotopes contained in high-level nuclear waste (see *What Is Nuclear Waste?*) have short half-lives and high specific activities. High-level waste also contains isotopes such as americium and plutonium that have long half-lives. High-level nuclear waste contains a mixture of large amounts of radioactive isotopes with short and long half-lives that release large amounts of radiation, thereby making this waste hazardous.

Here is a list of selected radioactive isotopes, their half-lives, and their specific radioactivities.

<table>
<thead>
<tr>
<th>Radioactive Isotope</th>
<th>Half-Life</th>
<th>Specific Radioactivity (curies/gram)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molybdenum-99</td>
<td>66.7 hours</td>
<td>474,000</td>
</tr>
<tr>
<td>Iodine-131</td>
<td>8 days</td>
<td>123,500</td>
</tr>
<tr>
<td>Krypton-85</td>
<td>11 years</td>
<td>392</td>
</tr>
<tr>
<td>Strontium-90</td>
<td>28 years</td>
<td>141</td>
</tr>
<tr>
<td>Cesium-137</td>
<td>30 years</td>
<td>86.4</td>
</tr>
<tr>
<td>Americium-243</td>
<td>7,370 years</td>
<td>0.200</td>
</tr>
<tr>
<td>Plutonium-239</td>
<td>24,400 years</td>
<td>0.0613</td>
</tr>
<tr>
<td>Uranium-235</td>
<td>700 million years</td>
<td>0.00000241</td>
</tr>
<tr>
<td>Uranium-238</td>
<td>4.5 billion years</td>
<td>0.000000334</td>
</tr>
</tbody>
</table>

**Modeling Radioactive Decay**

What you'll need:
- A shoebox
- 100 pieces of Candy A (such as M&M's)
- 100 pieces of Candy B (such as Skittles)

(Note that each of the candies is blank on one side and has a letter on the other; the side with the letter is the "heads" side of the candy).

The process of radioactive decay and the concept of half-life can be modeled by putting candies into a shoebox, shaking the box, and removing the candies that come up heads. Heads means the side of the candy with a letter or logo on it (compared to the blank side of the candy, which is tails).
This model helps illustrate the random nature of radioactive decay. A candy that comes up heads is a radioactive isotope that has decayed. The heads up candies are replaced by another type of candy that represents the decayed atom. Candies that come up tails after each shake represent atoms that are still radioactive.

**Directions**

1. Put 100 pieces of Candy A in the box and put the lid on.

2. Holding the lid on firmly, shake the box several times.

3. Open the box and remove all the candies that are heads up.

4. Count the candies that are left and enter this number in the table below.

<table>
<thead>
<tr>
<th>Shake</th>
<th>Candies Left</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start</td>
<td>100</td>
</tr>
<tr>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>13</td>
</tr>
<tr>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>6</td>
<td>16</td>
</tr>
<tr>
<td>7</td>
<td>17</td>
</tr>
<tr>
<td>8</td>
<td>18</td>
</tr>
<tr>
<td>9</td>
<td>19</td>
</tr>
<tr>
<td>10</td>
<td>20</td>
</tr>
</tbody>
</table>

5. Replace the removed pieces of Candy A with Candy B.

6. Repeat Steps 2-4 nineteen more times, or until all the pieces of Candy A are replaced by Candy B (whichever comes first).

**Graphing Radioactive Decay**

To see what the pattern of radioactive decay looks like, plot the data from the table above on the **Radioactive Decay Graph**. Draw a line that connects all the points.

**Questions**

1. According to the graph, what is the half-life of Candy A (the number of shakes needed for half of the candies to “decay,” or to change from Candy A to Candy B)?

2. If you started with 50 pieces of Candy A instead of 100, would the half-life change? Explain.

3. How is the flipping of candies similar to the decaying of a radioactive isotope? How is it different? (Hint: Consider the probability of a flipped candy coming up heads or tails.)
4. How many shakes did it take to get rid of all the candies? How many half-lives is this equal to?

5. What would you do with the candies and the shoebox to increase the length of the half-life?

6. Cesium-137 has a half-life of 30 years. If there were 10 grams of cesium-137 in 1995, how many grams of cesium-137 were there in 1875?

7. The half-life of uranium-238 is 4.5 billion years. How much of the uranium-238 originally on earth has decayed if the earth was formed 4.5 billion years ago?

**Challenge Question**

8. You may have noticed that you were not asked to carefully put all 100 candies into the shoebox tails up (or heads down) before doing the first shake. You could have done this if you wished, but it was not necessary. Explain why. (Hint 1: What are you assuming about the candies before the first shake? Hint 2: Does putting the candies carefully in the box or throwing them in the box beforehand affect whether the candies come up heads or tails after the first shake?)

---

**How Long Do Radioactive Materials Have to Decay before They Are Safe?**

Many radioactive materials in nuclear waste give off dangerous amounts of radiation even after one half-life has passed. Nuclear scientists generally believe that the radioactivity of such waste reaches a safe level after 20 half-lives, where safe means no more hazardous to health than the radiation received from the surrounding environment. Given the different half-lives of these isotopes, clearly some elements will become safe much sooner than others.

**Questions**

1. Four of the radioactive isotopes that are found in spent nuclear fuel are listed below. For each of the isotopes, compute the time required for the isotope to reach a level of radioactivity that is considered safe. Write the time periods in the space to the right.

<table>
<thead>
<tr>
<th>Radioactive Isotope in Spent Fuel</th>
<th>Half-Life</th>
<th>Time Needed to Become Safe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iodine-131</td>
<td>8 days</td>
<td></td>
</tr>
<tr>
<td>Strontium-90</td>
<td>28 years</td>
<td></td>
</tr>
<tr>
<td>Cesium-137</td>
<td>30 years</td>
<td></td>
</tr>
<tr>
<td>Americium-243</td>
<td>7,370 years</td>
<td></td>
</tr>
</tbody>
</table>

2. Which of the isotopes listed on the table requires the most stable and secure means of isolation and storage? Why?

3. Cesium-137 and strontium-90 are readily taken up by green plants. How might this pose a health hazard to human beings?
Radioactive Decay Graph

Number of Candies Remaining

Number of Shakes
Summary of High-Level Nuclear Waste Disposal Options


Introduction
Because of its hazardous nature, great care must be taken to isolate high-level nuclear waste from the environment. Thousands of years may need to pass before this waste is considered safe. Most of the high-level waste produced in the United States is in the form of spent fuel from nuclear power plants, which is being temporarily stored at facilities near the power plants themselves.

A Summary of Temporary Spent Fuel Storage
Description:
Currently, all nuclear plants in the United States, as well as the Kewaunee and Point Beach nuclear plants in Wisconsin, store their spent nuclear fuel in facilities located at the power plant site. Most spent fuel is stored in pools of water that absorb the heat released by the fuel. However, some spent fuel is stored in dry casks. For example, dry casks are used to store the older spent fuel from the Point Beach nuclear plant.

Advantages:
Waste is stored in facilities near nuclear power plants and does not have to be transported. Power plant personnel can monitor the waste and take action if problems occur. Spent fuel is available for reprocessing.

Problems:
Spent fuel storage facilities at nuclear power plants were designed only to store waste temporarily until a permanent disposal option was available. Many sites are becoming crowded and need to be expanded. Loss of water in pools could lead to overheating of spent fuel and the possibility of a major accident. Many spent fuel storage sites, like nuclear plants themselves, are located near populated areas.

Permanent Disposal Options
Presently, no permanent disposal site or method of disposal exists in the United States for high-level nuclear waste. A number of permanent disposal options have been proposed over the years. The United States and other countries are seriously studying some of the options, while others are not being considered at all. The following summaries describe different permanent disposal options and address their advantages and problems.

Bury Spent Fuel Deep Underground
Description:
Place spent fuel in casks and bury it in a mined repository deep underground. The ideal underground site would be geologically stable (no earthquakes or volcanic activity) and would not come in contact with groundwater or with surface water filtering into the ground. Once the repository is filled, it would be permanently sealed.

Advantages:
This option provides greater isolation from living organisms than storing it above ground. High-level waste would be stored in one location instead of at each nuclear power plant.

Problems:
The geologic stability of a site cannot be predicted with certainty. Earthquakes may occur and groundwater levels may change. Location markers and warning signs may not be understood by future residents or those considering mining the area. Once the waste is buried, it would be difficult to retrieve if problems developed or if reprocessed...
nuclear materials were needed in the future. Local residents may be strongly opposed to having a disposal site near where they live.

Status:
Geologic burial is the leading option being considered by the United States. Specific sites have been extensively studied, with Yucca Mountain in southern Nevada being the leading candidate for permanent disposal of spent fuel. If an underground site is finally chosen, it is not likely to begin accepting nuclear waste until the year 2020.

---

**Bury Spent Fuel beneath the Ocean Floor**

**Description:**
Place spent fuel in casks and bury it by placing it in holes drilled 30 to 300 feet beneath the ocean floor.

**Advantages:**
Certain ocean floor sites may be more geologically stable and may provide greater isolation than many underground sites on land. Clay material found beneath the ocean floor can potentially absorb radioactive materials should leakage occur.

**Problems:**
Burial of waste beneath the ocean floor may violate current international laws. Persuading countries to change the laws may take a great deal of time and effort. Transporting the waste overseas to the disposal site may also pose risks. Once the waste is buried, it would be nearly impossible to retrieve it if problems developed or if reprocessed nuclear materials were needed in the future.

**Status:**
The United States is not considering this disposal option, although other countries are studying it.

---

**Store Spent Fuel in Specially Constructed Facilities above Ground**

**Description:**
Special facilities would be built above ground to permanently store spent fuel and other high-level nuclear waste. The facilities would be guarded and managed by a permanent staff of workers who might even live near the site.
Advantages:
Like underground burial, the high-level waste would be stored in one location instead of at each nuclear power plant. Personnel would monitor the waste and take action if problems occur. Spent fuel would be available for reprocessing.

Problems:
It is not clear whether such a site could be managed for the thousands of years that need to pass before the radioactivity level in the waste is considered safe. Society may experience many changes in the future, some of which may be disruptive (such as war or a plague). Local residents may be strongly opposed to having a disposal site near where they live.

Status:
This option is not actively being studied at this time.

Bury Spent Fuel in the Antarctic Ice Cap
Description:
Bury waste in the Antarctic ice cap.

Advantages:
Antarctica is one of the most remote and isolated places on Earth. Little life exists there, and it is practically uninhabited by humans. Antarctica is also far away from most human settlements and most of Earth's other ecosystems.

Problems:
The Antarctic ice cap may not be as stable as an underground location, since ice sheets move on occasion. Heat from nuclear waste could melt the ice and possibly cause an ice sheet to move. Burying waste in the Antarctic ice cap may violate current international laws. Persuading countries to change the laws may take a great deal of time and effort. Once the waste is buried, it would be difficult to retrieve if problems developed or if reprocessed nuclear materials were needed in the future. Transporting the waste to Antarctica may pose risks.

Status:
This option is not being considered at this time.

Place Spent Fuel in Rockets and Shoot It into Space
Description:
Shoot nuclear waste into space where it would either orbit the sun or be captured by it.

Advantages:
Ideally, the best way to isolate high-level nuclear waste from the environment is to remove it from Earth entirely.

Problems:
An accident or explosion during launch could spread hazardous high-level waste over a wide area of Earth. Shooting waste into space is very expensive because of the high cost of rocket launches and the limited amount of waste each rocket could hold. Retrieving the waste would be nearly impossible and very risky.

Status: This option is not being considered at this time.
#1. Include on cover:
1. Title = Nonrenewable Energy Resources
2. Definition = Energy resources that can NOT be reused
3. 2 types of nonrenewable energy resources - fossil fuels and nuclear energy

#2 - Page 1
Formation of fossil fuels
1. dead plants and animals
2. pressure
3. heat
4. millions of years

Nuclear energy information
1. Nuclear energy comes from splitting a nucleus of an atom which releases heat.

#3 - Page 2
Generating electricity using fossil fuels
1. Burn fossil fuel
2. Heat from burning fossil fuels boils water
3. Water turns to steam
4. Steam spins turbine
5. Turbine spins magnet in generator
6. Generator makes electricity

Making electricity using nuclear energy
1. Split Uranium 235 nucleus
2. Heat is released from splitting nuclei
3. Heat boils water
4. Water turns to steam
5. Steam spins turbine
6. Turbine spins magnet in generator
7. Generator makes electricity

#4 - PAGE 3

Fossil Fuels

Positives Negatives
1. Electricity 1. Acid Rain
2. Fuel for 2. Smog
automobiles 3. Global Warming
4. Oil spills
5. Water pollution
6. Land pollution

Nuclear

Positives Negatives
1. more powerful than fossil fuels
2. Electricity
3. No air pollution which means:
   NO smog,
   No Acid Rain, and
   No Global Warming
4. Oil spills
5. Water pollution
6. Land pollution
1. Nuclear waste causes cancer, deformities, and death
Water

Moving water can be used to generate electricity. Power plants that use water to make electricity are called hydroelectric plants. Hydroelectric plants do not pollute and are renewable. Wisconsin has many hydroelectric plants. However, water can only be used to make electricity where there are flowing bodies of water and hydroelectric plants disrupt a river's ecosystem.

** Answer the following questions

1. Can flowing water be used to make electricity?

2. Do we have hydroelectric plants in Wisconsin?

3. Does using water to make electricity cause pollution?

4. Is using water to make electricity nonrenewable or renewable?

5. How do hydroelectric plants affect the river's ecosystem? Are they helpful or harmful to fish and other river animals?
GENERATE YOUR OWN HYDROPOWER

OBJECTIVES

The student will do the following:

1. Build a water wheel.
2. Build a simple galvanometer.
3. Build a simple hydropower generator.
4. Detect the electricity generated.
5. Demonstrate how water power is converted to electricity.

BACKGROUND INFORMATION

The model hydropower generator made in this activity works much like hydropower plants for generating electricity. When the propeller (water wheel or turbine) spins, the magnet whizzing past the nail head generates a tiny amount of alternating current (AC) in the coil wound the nail. The small germanium diode connected across the two nail terminals converts the AC into DC (direct current). The galvanometer will indicate that a small current has been produced by the generator.

PROCEDURE

1. The day before the activity is to be done, introduce it to the class.

   A. Define and describe a turbine. A turbine is a device that has a central drive shaft fitted with curved vanes or blades that cause it to whirl when force is exerted on it by water, steam, or gas. A water wheel is a simpler, less efficient predecessor of a turbine; it can use only water. Modern turbines were developed from early water wheels.

   B. Define and describe a galvanometer. A galvanometer is an instrument that measures minute electric currents. It is made of a compass wound with magnetic wire. As current is passed through the wire, the compass needle will be deflected toward the east-west axis.

   C. Define generator. A generator is a machine that converts mechanical energy into electrical energy.
D. Define hydrogenerator. A hydrogenerator is a machine that converts the mechanical energy of water power into electrical energy.

II. Give each student a copy of "GENERATE YOUR OWN HYDROPOWER" (included). Assign the building of water wheel (turbine) as homework. (You may choose to have the students build these in class.)

III. Explain the activity, then carefully supervise the students work. The directions must be followed closely.

IV. Continue with the follow-up below.

FOLLOW-UP

I. Ask the students these questions.
   A. Describe how the apparatus used in this activity qualifies as a generator.
   B. How do you know electricity is being generated?
   C. What type of electricity (AC or DC) does your generator produce? (AC)
   D. What type of electricity does a galvanometer detect? (DC)
   E. What feature of the galvanometer you built allows it to detect the current produced? (the diode)
   F. If your generator did not produce detectable current, what are some possible explanations?
      How can you test your hypotheses?

II. Extension: The following are suggestions for building upon this activity. Some are especially appropriate as enrichment.
   A. Different types of water wheels may be built and their effectiveness tested. Check reference books for other designs.
   B. Change certain variables and repeat the exercise. Compare the results when the water's velocity is changed, when suspended solids (like silt) are added to the water, or when the water's temperature is changed.
   C. Build a model town complete with tiny electric lights. (Perhaps a model train set's town models could be used.) Check to see if the hydrogenerator will supply enough electricity for the model town. How must the system be modified to make this work?
GENERATE YOUR OWN HYDROPOWER

DIAGRAM 1: HYDROPOWER GENERATOR

1. Build a hydropower generator (see Diagram 1).
   
   a. Warp 1,000 turns of magnetic wire around one of the large nails. The coil should be 2 inches long, measured from the head end. Leave a few inches of wire for the connections. Twist them so they will not unwind.
   
   b. Drive this nail into the center of the wooden block.
   
   c. Drive in the 2 smaller nails. (Refer to the diagram for their placement.)
   
   d. Scrape the enamel insulation off the ends of the coil wires.
   
   e. Wrap the ends around the heads of the 2 nails.
   
   f. Hook the diode across the nails and make all connections secure. (Soldering is optional.)
GENERATE YOUR OWN HYDROPOWER

(continued)

g. Fix the bar magnet on the head of the other large nail. The magnet should be centered on the head of the nail. If using glue, give it plenty of time to set. This nail will be the water wheel shaft.

h. Support the shaft with the 2 tin can strips. Fold them in half lengthwise for added stiffness. Bend out about an inch at the ends for the base. Nail them to the wooden block in line with the large nail.

i. Decide how high the shaft holes should be. Locate the holes so the magnet end of the shaft is close to the upright nail head but so that the shaft is not prevented from spinning freely. Make the holes for the shaft.

j. Insert the shaft in the supports until the magnet is directly over the nail head. Two collars of electrical tape (applied to the shaft just inside the supports) will keep the shaft in place.

k. Using the tinker toys and paper cups, construct the water wheel. Cut the cups as shown in the diagram and glue the bottoms to the spokes.

l. Fit the water wheel onto the shaft, making sure that the wheel fits snugly on the nail.

DIAGRAM 2: GALVANOMETER

2. Build a galvanometer (see Diagram 2).

   a. Build a base for the compass by folding the ends of each of 2 squares of stiff cardboard and stacking them back to back as shown in the diagram.

   b. Place a compass on the base and wind magnetic wire around the north-south axis about 100 turns.
c. After winding the coils of wire, twist the free ends a few times to prevent unwinding.

d. Connect the free ends to the two alligator clips. (This step is optional. You may connect the wires directly to the nails where the diode is located on the hydropower generator apparatus.)

e. The galvanometer is now complete. Whenever electricity flows through the coil, the compass needle will be deflected toward the east-west axis.

3. Test the hydrogenerator.

a. Connect the galvanometer’s alligator clips (or wire if not using alligator clips) to the 2 nail terminals.

b. Keep the compass about a foot away from the magnet.

c. Line the galvanometer compass needle up with the coil.

d. Hold the water wheel at the edge of the sink and run a stream of water over the wheel. As the wheel turns, it will power the generator. A small current will be detected by the galvanometer. When the shaft turns, the compass needle will be deflected. This demonstrates that electricity is being produced by the hydrogenerator.
The natural energy of wind is tremendous. In the past windmills were used to pump water. Today, windmills, now called wind turbines, are used to generate electricity. One large wind turbine can generate enough electricity for one small town. Wind is a renewable source of energy and does not pollute at all! And it is cheap to use! However, wind turbines can only generate electricity where there is wind. Currently, wind turbines are being used in Wisconsin. Wisconsin is perfect for using wind energy!

*Answer the following questions

1. Wind can be used to generate what?

2. Is using wind to generate electricity a nonrenewable or renewable energy resources?

3. Does using wind to generate electricity cause pollution? Yes or No?

4. Is using wind to generate electricity expensive or cheap?

5. What is the only draw back of using wind to generate electricity?

6. Can wind be used to generate electricity in Wisconsin?
WIND MACHINE INSTRUCTIONS

This sheet tells you how to build your own wind machine for generating electricity.

First, get a small motor and a ruler or piece of wood from your teacher. Attach the motor to the end of the ruler by wrapping it with a rubber band.

Second, cut two 30-cm pieces of electrical connecting wire. With a pair of scissors, take off 2 cm of rubber insulation from both ends of the two wires. Do this by pinching softly with the scissors on the rubber casing, cutting it slightly; then pull the scissors towards the wire's end, pulling off the casing.

Next, attach one end of each wire to one of the motor's outlets. Tape the wires to the molding, at the end without the motor. Attach the other two ends of the wire to alligator clips. We will use these later to attach to the voltmeter.

Now you're ready to build the actual wind propellers. Take six paper clips. Snip off part of each clip with pliers or wire cutters. Straighten out the bottom part of each clip.

Then cut out six pieces of cardboard 1 cm x 3 cm. Glue / or tape central part of each paper clip to the bottom of a cardboard piece. Leave time for glue to dry (20 min.). Here is where you can vary the size, shape, weight and alignment of the blades. You can change the number as well.

Take a cork and poke the wind blades into it. Insert the blades at about 5 mm from the end, spaced equally around the circumference of the cork. To loosen up a hole, you may want to stick a pin in beforehand.

Place the cork end furthest away from the wind blades on the motor's shaft. Make sure the shaft goes in the exact center of the cork and do not wiggle it (this will loosen its hold on the motor). Connect to the voltmeter and test your design. Be sure to wear goggles to protect your eyes.

Source: Adapted from the booklet found at
What is geothermal energy?

Geothermal means heat from the earth. This heat comes from magma, hot molten substances deep within the earth. Magma, usually miles beneath earth's crust, sometimes creeps up near the surface and makes hot spots. When underground water comes in contact with these hot spots, the water turns to steam. The steam rushes out of the earth as geyser. This steam can be used to spin turbines that drive electric generators. One geothermal field in Northern California can generate enough electricity to serve a city the size of San Francisco. The U.S. has 1.8 million acres (720 thousand hectares) of land where geothermal energy exists. Some experts think that geothermal energy will provide one-third of our electricity by the 21st century. One problem of geothermal energy is that the steam must be used near its source.

How does geothermal energy work?

Materials:
hot plate, pan, funnel, balloon

Procedure:
a. Fill a pan halfway with water.
b. Place a collapsed balloon over the funnel tube.
c. Place the funnel upside down in the pan of water.
d. Heat the pan over the hot plate.

1. What happens? ______________________________________

Water vapor needs four times as much space as water. Much pressure is produced, and the steam looks for a way out. Steam that is underground seeks escape through the cracks in Earth's surface. The results are geyser.

2. What forms of transportation have used steam?

Science at home:
Make a pinwheel from light plastic or acetate paper. Attach it to a long stick. Boil water in a pan and place the pinwheel above it. Use the pinwheel as a turbine. Do not let your skin come in contact with the steam. What do you notice? Can you think of ways that geothermal energy could be used? (Do this with an adult present.)
What power can we get from the oceans?

Scientists are exploring how oceans can provide energy for the future. If you have visited a seacoast you may have noticed that the level of the water changes. These changes, called high and low tides, are caused by the gravitational pull of the moon on our Earth. Energy from tides can produce electricity at a tidal power station. These power stations are positioned near beaches so the incoming tides are pumped behind a dam. As the tide falls, the water is released through turbines which generate electricity.

Scientists are also exploring ocean thermal energy. The sun warms the surface waters of the ocean as it shines. The water deep below the surface stays very cold. There can be a difference of 72°F (40°C) between the surface water and the deep water. The differences in water temperatures are used to drive the electric generators.

Do cold and warm water mix?

Materials:
Large, clear plastic cup, test tube, red and blue food coloring

Procedures:
a. Fill the cup with cold water and add a few drops of blue coloring.
b. Fill a test tube with hot water and add a few drops of red coloring.
c. Put your finger over the end of the test tube and turn it upside down in the cup.
d. Remove your finger. What happened?

e. Repeat the experiment, but make these changes. Fill the cup with hot water and add a few drops of red coloring.
f. Put cold water in the test tube with some blue coloring.
g. Place the test tube upside down in the cup.
h. Remove your finger. What happened?

1. ________________ water is heavier.

2. What would happen if warm water was heavier than cold water?

3. Read about tides. How many high and low tides happen in 24 hours?
Biomass Types

1. Trash - Americans throw away about 94 million tons of solid waste each year. Farm and industrial waste increase the amount to 850 million tones per year. This garbage can be burned and used to make electricity.

2. Corn, sugar beets, and soybeans - Corn, sugar beets, and soybeans can be fermented to produce ethyl alcohol which can be added to gasoline or can be used as gasoline.

3. Methane gas - Bacteria can be used to break down garbage which produces methane gas. This methane gas can be used in generating electricity or converted into a liquid fuel for automobiles.

Positives and Negatives:
   1. Positive = Minimal air pollution and Renewable energy resource
   2. Negative = Need large areas of land and produces smoke

**Answer the Questions below

1. What is biomass?

2. Give 3 examples of things that would be examples of biomass.

3. Name 2 things that biomass can used for?

4. Is biomass nonrenewable or renewable?

5. Does biomass cause major air pollution problems such as global warming and acid rain?

6. Does using biomass to make electricity or run automobiles need a lot of space?

7. Collect your trash for 1 whole day. Please do not include food items for sanitary reasons. Bring your trash to class.
Can trash make energy?

Americans throw away about 94 million tons of solid waste each year. Farm and industrial waste increase the amount to 850 million tons per year. Making fuel from organic waste products (materials made from plants such as wood, corn, and algae) is expensive. But bioconversion, or the process of making organic fuel, helps to conserve our natural resources while it gets rid of waste products.

There are three methods of bioconversion. Organic materials can be heated to produce oil and gas. Corn and sugar beets can be fermented to produce ethyl alcohol which can be added to gasoline. Bacteria can also be used to break down materials to produce methane gas which can be burned or changed to a liquid fuel (methanol). All of these fuels can be used to heat buildings and produce electricity at a power plant.

Make a fuel that burns from trash.

**Materials:**
gloves, paper products, bucket, aluminum pan, warm water

**Procedure:**
a. Wearing gloves, collect paper products from the garbage can at school or home. (Don't forget wrappers, labels, empty cardboard containers.)
b. Cut the paper into 3 inch (8 cm) squares and soak them in a bucket of warm water.
c. Layer the pieces in a shallow aluminum pan.
d. Press the layers together and squeeze the water out of the paper.
e. Pour the extra water out after you have made a ¾ inch (2 cm) layer.

f. Let the paper dry outside or bake in a 200°F (93°C) oven for 1 hour.
g. Lift the pile of paper out of the dish and let it dry completely.
h. Try burning chunks of this paper in a fireplace or campfire. Does it burn like wood?

1. Start a recycling center at your school or in your home. Save newspapers, aluminum cans, and glass bottles. Sell them to a local recycling company.

2. Contact local sewage treatment plants and trash collection agencies. Find out if they are using any bioconversion methods.
**Shoebox Solar Cooker**

### Objectives

Students will be able to
- construct an effective solar oven;
- explain how a solar oven works; and
- discuss the benefits and challenges of using a solar oven.

### Rationale

Operating a solar oven helps students learn about solar energy and heat-related principles and appreciate the importance of energy-related technologies.

### Background

Did you ever hear the expression, "It's hot enough to fry an egg on the sidewalk?" Sidewalks don't really get quite hot enough to cook on, but you could build a solar box cooker, place it on a sidewalk, and allow it to collect the sun's heat energy and cook many different kinds of food. Commercial solar cookers are also available (see Resources). To work properly, a solar box cooker (also called a solar oven) must hold heat energy long enough for the food to absorb the heat and cook.

Making a solar oven can be both simple and difficult. Collecting energy from the sun is easy. When sunlight strikes a surface and is absorbed, it gets converted to heat energy (or infrared radiation). A glass or Plexiglas cover works like a greenhouse window to let sunlight in but not let the infrared radiation out. Solar cookers usually include some kind of reflector that increases the amount of energy the cooker receives by reflecting light inside the box onto the cooking container. Keeping the heat energy in the oven is more difficult. Solar box cookers must be carefully insulated and tightly sealed so the captured heat cannot escape.

The key to a successful solar oven is making sure it faces the sun. To keep the solar cooker hot all day, it must be continually turned to follow the path of the sun. For a gradual heating process, place food in an oven and direct it toward the sun's midday position. The food cooks slowly, reaching its peak heat by mid-afternoon. The food is ready to eat by early evening.

Solar box cookers reach between 140 degrees F (60 °C) and 266 degrees F (130 °C) depending on their construction and intensity of the sunlight. Clear, sunny days provide the best results. However, as long as the cooker faces the sun and is well-insulated, the temperature outside the cooker should have little effect on the cooking rate. So solar cookers can be used in December as well as in July.
The choice of ovenware can affect the cooking time in a solar cooker. Ovenware can be made from glass, ceramic, earthenware, or metal. Each material conducts and retains heat differently. Often dark-colored ovenware is best for solar cookers because it absorbs light energy better than light-colored materials.

What can be cooked in a solar oven depends on the quality of the cooker. Any conventional recipe suitable for a slow cooker works well, because the solar cooker will get hotter than a slow cooker. Baking should be done on clear, sunny days as it requires higher temperatures. Cutting the ingredients into small pieces will help the food cook faster. The foods, especially liquids and moist meals such as stews, need to be sealed in the solar box cooker so water does not condense on the glass cover.

Simple solar cookers, such as those made from a shoebox, should be able to do the following:
- Heat water for hot chocolate, tea, or instant soup
- Warm canned soups, vegetables, and stews
- Prepare hot dogs
- Melt cheese, chocolate, or marshmallows
- Make simple pizzas (cheese and tomato sauce sprinkled on prepared crust)
- Bake chocolate chip cookies

Better built solar cookers can cook regular meals. With a well-constructed or commercial oven you can prepare foods, such as vegetables and grains, that need to be cooked more thoroughly. For example, summer squash, fresh peas, green beans, spaghetti, noodles, instant potatoes and rice cook relatively quickly. White rice, rolled oats, pearl barley, and squash should cook in two hours. Lentils, black-eyed peas, black beans, and potatoes will need about three hours.

Frying eggs may not be the best use for a solar oven, but you can cook eggs in breads, casseroles, and cakes. Whether you decide to make a warm drink on a cold day in December or a complete meal, solar box cooking is fun and delicious.

**Procedure**

**Orientation**
Ask if any students have ever been in a car that has been parked in the sun. Have a student describe what it feels like inside the car. Students may have also heard warnings about not leaving pets and children in parked cars because of the risk of heat exhaustion or stroke.

Discuss how sunlight passes through the glass windshield and windows in a car. When the light strikes the interior surfaces of the car, it is absorbed and converted to heat energy. The heat can not escape through the glass and causes the interior temperature of the car to increase.

**Steps**
1. Ask students if they think heat from the sun can be used to melt things such as chocolate or cheese. Tell students that by applying what they know about heat collecting in a parked car, they can design an oven that uses the sun’s energy to cook food.
Complementary Activities
Florida Middle School
Energy Education Project.
Energy Bridges to Science,
Technology and Society.
Tallahassee, Fla.: Florida
Solar Energy Center for the

Hawai‘i Extension Service.
Making Shoe Box Cookers.
Contact: Energy, Resources,
and Technology Division.
Department of Business,
Economic Development, and
Tourism, 99 Aupuni Street,
#101B, Hilo, Hawai‘i 96720.

For Students
Arizona Energy Office. A
Day in the Sun. Phoenix,
Ariz.: Arizona Energy Office,

Gurley, Virginia Heather.
Solar Cooking Naturally.
Sedona, Ariz.: Sun Light
Works, n.d.

Halacy, Beth, and Dan
Halacy. Cooking with the Sun.
Lafayette, Calif.: Morning

Pease, Tom. “Getting Our
Energy from the Sun” on
Daddy Starts to Dance.
Madison, Wisc.: Tomorrow
River Music, 1996.
Audiocassette.

Rickard, Graham. Alternative
Milwaukee, Wisc.: Gareth
Stevens Children’s Books,

2. Divide the class into working groups. Hand out and discuss Building a
Shoebox Cooker, Materials and Procedure for Variation #1, #2, or #3. NOTE:
Variation #1 involves cutting and placing foam trays in the box for insulation.
Younger students may have a difficult time handling the pieces of foam and will
get frustrated when they try to line the shifting trays with foil. Shifting can be
minimized by cutting the trays to fit tightly against each other. Small hands may
find Variation #2, the two-shoebox method, easier. Variation #3 is the easiest but
may not be as effective.

3. Provide students with copies of Using a Shoebox Cooker and have them
prepare the food they want to cook. Have students test and use their cookers. The
Solar Cooking Record can be used to document observations, and this data can
also be used to make graphs. NOTE: For younger students, it may be enough to
observe that the sun heats food and to note temperature changes.

Closure
Have students share the results of their cooking experiments. Do they think they
would regularly use solar ovens? Remind students that the ovens they constructed
are simple, and that there are more technical and efficient models available.
Inform students that there are companies that sell commercial solar cookers that
are very effective at heating food. If available, show pictures or overhead trans­
parencies of some of these cookers. Students can compare qualities of these cook­
ers to their own.

Discuss ways students can test or improve the cookers. Questions to explore
include:
• How well does the cooker work on cloudy days?
• What effect does outside temperature have on the cooking rate?
• Is there any difference when the cooker is used in December than when it
  is used in June?
• Would a bigger box, more reflectors, or different types of insulation
  improve the effectiveness of the cooker?
Assessment

Formative
- How well did students construct the ovens?
- Can students explain how a solar oven works?
- How effectively do the solar ovens heat food?

Summative
- Have students plan a party for another class or their parents in which food is cooked in the solar ovens. The event can begin with students explaining how they made the solar ovens and how they work. During the presentation, students can discuss the potential and practicality of solar oven use in their own future.
- Students can research the many different designs for solar cookers and experiment with different properties and adaptations. For example, try placing a thicker piece of metal, such as a piece of a cookie sheet or baking pan, in the bottom of the solar oven to increase heat transfer and storage.

Extensions

Students may be interested in exploring how solar cookers are currently being used worldwide, especially in places where electricity is unavailable and traditional fuel sources, such as wood, are being depleted (see Resources).

Purchase a commercial solar oven or invite a guest speaker (such as a vendor) who regularly uses a solar oven to show and discuss more sophisticated models and methods of solar cooking (see Resources). Students can also see solar ovens in use at the Midwest Renewable Energy Fair (see Appendix).

Credits:
Activity adapted from “Now You’re Cooking—With the Sun” pp. 68-81 in Florida Middle School Energy Education Project: Energy Bridges to Science, Technology and Society. Tallahassee, Fla.: State of Florida for the Florida Energy Office, 1994. Used with permission. All rights reserved.


Related KEEP Activities:
Use this activity as part of a unit on solar energy or heat. See K-5 Energy Sparks for Theme II: Suninvestigations or K-5 Energy Sparks for Theme I: Exploring Heat. A solar cooker can also be used to enrich investigations in “Taking Temperatures.” Older students can apply concepts from solar cooking to activities such as “So You Want to Heat Your Home?” and “Siting for Solar and Wind Energy.” Other uses of solar energy such as those found in “The Miracle of Solar Cells” could be done with younger students.
Materials for Variation 1 and 2

- Shoeboxes with lids (one per student or one per group) **Variation 2:** two boxes per student or team, one being roughly one inch (2.5 cm) larger than the other in all dimensions
- Foam produce trays, well washed (approximately four per shoebox) **Variation 2:** insulating material such as Styrofoam packing material, crumpled newspaper, cardboard, etc.
- Overhead transparencies (one per shoebox)
- White glue (optional)
- Duct tape (Masking tape is an alternative, but it won't last as long.)
- Heavy-duty aluminum foil (approximately two feet (60 cm) per shoebox)
- Chopsticks or twigs (one stick per shoebox)
- Rulers
- Pencils
- Single-hole punch
- Scissors, knife, or razor cutters
- Oven thermometers (one per group)
- Small food containers made of heat-conducting material such as glass or metal (Make sure food containers will fit inside the cookers! Examples include baby food jars, pot pie pans, petri dishes and Pyrex custard cups, or containers made from aluminum foil.)
- Food that is easy to heat (Try melting cheese on chips, chocolate on graham crackers, etc.)
- Plastic wrap
- Pot holders
- Sunglasses
- Decorating materials and paint (optional)
  NOTE: High-temperature spray paint works best as it won't crack when heated.

NOTE: For a larger solar cooker, use bankers' boxes instead of shoeboxes and acrylic plastic sheets instead of overhead transparencies. Using bankers' boxes will work best with **Variation 2** (see Procedure).

You may decorate or paint your solar ovens. Take care not to paint the overhead transparency or the reflector flap. Painting the exterior of the box is a matter of aesthetics; it doesn't affect the box's ability to absorb heat. Experts vary in their opinions of whether the interior of solar ovens should be reflective (to direct more sunlight onto the cooking food) or black (to absorb more heat to help cook the food). If you paint the foil-covered interior, use high-temperature black paint. CAUTION: **Painting the interior can expose the food to volatile gases.** Set the oven outside in the open with the lid open for a day to allow the gases to escape. An alternative is to line the interior with black construction paper. You may want to conduct an experiment where half the class has a black interior and the other half has foil to discover which method is more effective.
Procedure: Variation 1

1. Remove and save the lid from the shoebox. Line the inside of the shoebox with foam produce trays. The trays should be placed so that their raised edges are touching the shoebox floor and walls, forming an insulating air space. You may be able to fit trays in the shoebox with minimal cutting. If you have lots of trays, make two layers. If necessary, use white glue to hold the trays in place.

2. Line the interior of the insulated shoebox with aluminum foil, bringing the edges of the foil up and over the rim of the box. Use only one piece of foil (if possible) to help seal the interior of the cooker. If more than one piece of foil is necessary, overlap the edges to reduce heat loss. It may be easier to use two pieces of foil, one sized to the length of the box and one sized to the width. The two pieces of foil can then be laid in the box across each other (crisscrossed).

3. Using duct tape, tape the loose edges of the foil to the outside of the shoebox. This step completes the body of the cooker.

4. Using a ruler and pencil, draw a rectangle on the inside of the shoebox lid 3/4-inch (1.88 cm) from the edges of the lid. Mark one of the long sides “fold.”
Procedure: Variation 1 (Continued)

5. Using the scissors, knife, or razor cutter, cut carefully along the other three sides of the marked rectangle, so that the shoebox lid has a flap in it. Fold the flap up along the last edge of the rectangle. This flap will be your cooker’s reflector.

6. Carefully smooth a piece of foil over the underside of the flap. The smoother, the better! Secure the foil with glue or tape; if tape is used, fold the foil onto the top of the flap and tape it on that side, so as not to cover the shiny bottom of the flap with any tape.

7. Cut a piece of overhead transparency to fit inside the shoebox lid. If at all possible, use a single piece to reduce heat loss. If you have to fit two pieces together, overlap them by at least one inch (2.5 cm).

8. Tape the overhead transparency to the inside of the shoebox lid, completely covering the cut opening. Make sure that the tape is securely fastened to the 3/4-inch (1.88 cm) border around the opening. The overhead transparency lets sunlight into the cooker.

9. Securely place the lid onto the shoebox. Raise the reflector flap. Near one of the top corners, punch a hole in the lid with the single-hole punch. Insert the narrow end of a chopstick in this hole, so that the thick end is resting on the shoebox lid, but not on the overhead transparency. You may need to make a “nest” for the thick end of the chopstick with a bit of tape. The chopstick is your reflector support.

10. Your shoebox cooker is complete!
Procedure: Variation 2

1. Remove the lid from the smaller of the two shoeboxes. Line the smaller shoebox neatly with aluminum foil.

2. Remove and save the lid from the large shoebox. Insulate the bottom of the large shoebox by putting in a layer of insulating material. Pieces of foam trays, crumpled paper, corrugated cardboard, sand, or soil can be used. (You may want to set up an experiment: Which type of insulation works best?) Make the layer no deeper than the difference in height between the two boxes, so that when the small box is set on the insulation inside the big box, the boxes’ rims are even.

3. With the small box inside the large box, carefully fill in the air spaces between their four walls with more insulation. The insulation should come up to the rims of the boxes.

4. Cover the top of the insulation with a strip of aluminum foil, securing it on the outside of the large box and inside of the small box with tape. The aluminum foil will keep the insulating material isolated from the cooking chamber within the small box. Try to minimize the amount of tape used on the inside of the small box, to avoid covering large areas of the reflective foil.

5. Using a ruler and pencil, draw a rectangle on the inside of the shoebox lid 3/4 inch (1.88 cm) from the edges of the lid. Mark one of the long sides “fold.”

6. Using the scissors, knife, or razor cutter, cut carefully along the other three sides of the marked rectangle, so that the shoebox lid has a flap in it. Fold the flap up along the last edge of the rectangle. This flap will be your cooker’s reflector.
Procedure: Variation 2 (Continued)

7. Carefully smooth a piece of foil over the underside of the flap. The smoother, the better! Secure the foil with glue or tape. If tape is used, fold the foil onto the top of the flap and tape it on that side, so as not to cover the shiny bottom of the flap with any tape.

8. Cut a piece of overhead transparency to fit inside the shoebox lid. If at all possible, use a single piece to reduce heat loss. If you have to fit two pieces together, overlap them by at least one inch (2.5 cm).

9. Tape the transparency to the inside of the shoebox lid, completely covering the cut opening. Make sure that the tape is securely fastened to the 3/4-inch border around the opening. The overhead transparency lets sunlight into the cooker.

10. Securely place the lid onto the shoebox. Raise the reflector flap. Near one of the top corners, punch a hole in the lid with the single-hole punch. Insert the narrow end of a chopstick in this hole, so that the thick end is resting on the shoebox lid, but not on the overhead transparency. You may need to make a “nest” for the thick end of the chopstick with a bit of tape. The chopstick is your reflector support.

11. Your shoebox cooker is complete!

NOTE: Use larger boxes, such as bankers’ boxes, to make a bigger solar cooker. Follow Steps 1-4 of the procedure. Use the lid of the larger box as the reflector (see Step 7 and 10). You may want to tape one long end of the lid to the box. It may also help to cut the corners so the lid lifts up and down like a door. Use an acrylic plastic sheet instead of overhead transparencies, cutting it so that it rests on the insulation layer. Make handles to put in and remove the glass by using rolls of tape or by drilling holes into the acrylic sheet and inserting knobs. You will need sticks that are at least two feet long to support the reflective lid.

Variation 3

Materials:
• Shoebox
• Aluminum foil
• Tape
• Clear plastic wrap
• Food that is easy to heat (Try melting cheese on chips, chocolate on graham crackers, etc.)
• Pot holders
• Sunglasses

Procedure:
1. Line the shoebox with aluminum foil and tape in place if necessary.
2. Place food on aluminum foil.
3. Cover shoebox with plastic wrap and tape in place.
4. Set box in the sun.
CAUTION: The solar oven can get very hot, so use pot holders. Do not stare at the sun or the sun's reflection in the aluminum; it can damage your eyes. Sunglasses are recommended.

1. Make sure that your food container will fit inside the cooker. Prepare the food you want to cook. For example, sprinkle cheese on nacho chips, make a simple cookie recipe, place pieces of chocolate and marshmallows on graham crackers, etc.

2. Locate a sunny area for the cookers. Watch out for trees, buildings, and other structures that may cast shadows on your cookers. Your cookers will be outside at least an hour, and they must not be shaded. Remember that as the Earth rotates, shadows move and change lengths throughout the day.

3. Put a thermometer in each cooker (or in selected cookers if you don't have enough thermometers). Make sure that the lids are set securely on each cooker and that the reflective flaps are raised. Aim the cookers toward the sun. You can tell when the cookers are aimed correctly by adjusting their orientation until the cookers' shadows are as small as possible.

4. Adjust the reflective flap by moving it up and down and observing the reflected light within the cooking chamber. At the point when the interior is brightest, insert the chopstick support into the hole on the flap, to secure the flap at that angle. NOTE: Because Earth rotates, the cookers' orientation and reflective flap angle may need to be adjusted during the cooking period.

5. Preheat your cooker by letting it sit in the sun. On a sunny day, shoebox cookers can easily reach 200 degrees F (93 °C) in 30 or 40 minutes. Check the thermometers periodically.

6. When the cookers are hot enough (at least 150 degrees F [66 °C]), place your foods in the cooking containers, cover the containers with plastic wrap (optional) and as quickly as possible put the containers in the cookers. The less time the lids are off, the less heat you'll lose. It may help to have one student lift a lid while the other quickly puts the food in.

7. Let it cook! You may wish to keep recording temperatures and weather observations at set intervals.
Solar Cooking Record

Name(s): ..............................................................................

Date: ..............................................................................

What is the weather like today?
  Temperature: ____ Cloud cover: _______ Wind speed: _______
  Other: ..............................................................................

Draw or describe where you are placing your solar cooker and why you think this is a good location.

What are you cooking?

Shake down the thermometer to its lowest reading and note this below (the lowest reading of many oven thermometers is 100 degrees F). Put the thermometer in the box, marking the time next to the first temperature reading. Record the temperature every 15 minutes (continue recording on back if you need more space). Put a box around the time when the food was placed in your cooker. Describe any changes you see in the food.

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<th>Changes in food after placed in solar cooker</th>
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What does your food look like after cooking for at least one hour? Describe if you think it cooked thoroughly or not.

What does it taste like? Does it taste like it’s cooked thoroughly?
Can solar power heat a home?

Everyone uses solar energy. The sun's light and heat help to grow green plants that are necessary to all living things. The sun is the biggest and best producer of energy, and yet we use only 1 percent of its power.

The most practical and least expensive way to use solar energy is through solar collectors. Some are made of glass and trap heat in the roof. This heat is circulated around the house with electric fans. Other roofs may have a flat black solar collector with a pipe of cold water pumped into the front of the black plate. The cold water is heated and returned to the house for washing, cooking, or heating the rooms. Some collectors move and follow the sun's rays all day long. Solar collectors that cool a house are now being developed.

1. What areas of the United States would use more solar energy collectors? Why?

Make a solar collector.

Materials:
aluminum pan, black paper, 10 ft. (3m) of black tubing, sheet of glass, can of water, paper clip, empty can

Procedure:
a. Cover the inside of a shallow aluminum pan with black paper.
b. Loop about 6 ft. (1.8 m) of the black tubing inside the pan.
c. Keep the two ends hanging outside the pan.
d. Tape a piece of glass over the top of the pan.
e. Put one end of the tube in the can of water.
f. Suck on the other end to pull the water through.
g. Put a paper clip over the end of the tube to slow the flow of water.

2. What happens to the temperature of the water after it slowly moves through the collector?
Is the sun turned into electricity?

There are several ways the sun's energy can be changed into electricity.

One: a parabolic is a dish which collects the sun's rays on a mirror. The mirror bounces the sunlight back through a hole at the base of the dish. This light heats a liquid (oil, salt water, or sodium) in a boiler which makes steam. The steam moves a turbine to generate electricity. New Mexico has built a giant power station with 1,776 mirrors!

Two: solar cells are tiny slivers of silicon, an element found in the Earth's crust. Huge panels of solar cells can collect the sun's rays and turn them directly into electricity. The sunlight releases the cells' energy which flows across a chemical surface to make an electric current. Solar cells can be used to power boats, bicycles, and aircraft.

Three: the sun can make electricity with a solar pond. Solar ponds are painted black and filled with salt water. When the sun shines, the hot water is pumped into a boiler that heats fresh water. The fresh water produces steam which moves a turbine that makes electricity. When the steam cools, it condenses back into water which is returned to the pond.

1. Paint the inside of one juice can black and fill it with ½ cup (120 ml) salt water. Place it in the sun next to a regular juice can filled with ½ cup (120 ml) salt water. Which heats up faster? Try this experiment with tap water.

2. List 3 advantages and 3 disadvantages of solar energy.

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   Solar cells can be used to help power spacecraft. Why do solar cells work so well in space?

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   once at home:
   Design a transportation vehicle that uses solar cells for energy.
Solar Powered Cars

Objectives
Students will build and use solar powered cars

Background
Solar panels convert the sun's energy directly into electricity.

Materials
Solar panes
Motors
Extra wires
Alligator clips
Have students bring in materials that they wish to build the car with
Cardboard works well for wheels
Styrofoam works well for car body

Procedures
1. Demonstrate how solar panes work
2. Go over material handling procedures to make sure students don't damage equipment
3. Have students build cars
4. Have students use their solar powered cars outside on a sunny day

Assessment
1. Have students explain how solar panels can be used to power a car
2. Have students decide what other uses solar panels have
Renewable Energy Booklet – Grade Sheet

1. Title
2. Your Name
3. Cover is colored and deals with renewable energy only
4. Each page needs to have – Total 5 pages – Each page is worth 7 points
   A. Title
   B. Describe how the resource is used to make electricity
   C. 2 positive reasons to use this resource
   D. 2 reasons why this resource may not want to be used
   E. a colored picture of the resource
   F. Correct spelling – all words must be spelled correctly.
   G. Accurate information

Wind – Wind spins a turbine, which spins a generator to make electricity.
Positive – Renewable and does not pollute
Negative – Wind turbines do not work if there is not enough wind or if there is a storm.

Water – Water from a river turns a turbine in a dam, which spins a generator that makes electricity.
Positive – renewable and does not pollute
Negative – harms the fish environment and only works if a river is near by

Geothermal – Heat from the magma in the Earth’s crust is used to heat water. The water is turned to steam and the steam spins the turbine, which spins a generator.
Positive – Does not pollute and is renewable
Negative – Only works where there is magma and the heated water harms the soil

Biomass – Plants, trees, or wastes are burned. The heat is used to change water into steam. The steam spins a turbine, which spins a turbine to make electricity.
Positive – Renewable
Negative – The smoke from burning pollutes the air and requires a large amount of farmland.

Solar – There are three ways to use the sun’s energy to make electricity.
1. Parabolic dish – reflective dish
2. Solar ponds – salt ponds
3. Solar cells – silicon chips break off electrons from the sun’s light energy and electricity is instantly made.
Positive – renewable and does not pollute
Negative – only works when there is sun
Energy Conservation

I. Energy Values
A. WI energy resource use
B. Energy Divide

II. Energy Citizen Action Skills
A. Energy bike
B. Household appliance energy cost
C. Carbon Dioxide emissions
D. Home Energy Audit
E. Why Recycle?
F. Gas Guzzler?

III. Energy Action
A. Home Energy Reduction Plan
Wisconsin Resource Energy Consumption by Type of Fuel

1997

- Petroleum (30%)
- Coal (32%)
- Natural Gas (24%)
- Renewables (4%)
- Electric Imports (8%)
- Nuclear (2%)
Write one paragraph explaining which energy resource you feel Wisconsin should primarily use to generate electricity? Include 3 reasons to support your opinion.
Energy resources: coal, petroleum, natural gas, nuclear, wind, water, solar, and biomass.
Summary:
Students play a competitive game to simulate consumption of energy resources and explore how energy conservation (reduction of use and waste) can help to sustain future energy supplies.

Grade Level: 6-8 (3-8)

Subject Areas: Science (Environmental), Social Studies

Setting: Classroom

Time:
Preparation: 30 minutes
Activity: 50 minutes

Vocabulary: Conservation, Efficiency, Finite, Nonrenewable energy resource, Renewable energy resource

Major Concept Areas:
• Consumption of energy resources
• Quality of life
• Management of energy resource use
• Future outlooks for the development and use of energy resources

Materials:
• Copies of Energy Source Illustrations on page D 60-61 (optional)
• Each group of students will need a bag of candy, containing about 200 pieces of candy (butterscotch) in wrappers

Objectives
Students will be able to
• explain why they might concern themselves with the needs of future energy users;
• demonstrate how conservation practices can promote the long-term availability of a resource;
• appreciate how increased population places a strain on energy resources; and
• distinguish between renewable and nonrenewable resources.

Rationale
By analyzing their response as energy consumers, students learn how consumption patterns and choice of resource affect the availability of future resources.

Background
“IT’s mine!”
“No! It’s mine!”
“Now, kids, what have I told you about sharing?”

How many times have we heard or even participated in similar conversations? There are many things we share in life, including energy resources. When something in common is shared without consideration of other people, problems or tragedies may arise. This “Tragedy of the Commons” idea—expressed in a writing by William Forster Lloyd in 1833—was expanded by Garrett Hardin to illustrate challenges to sustaining our natural resources.

In terms of modern energy use, the “Commons” is energy resources, primarily fossil fuels such as coal, natural gas, and petroleum. The “Tragedy” is that although energy resources are developed and used for the good of society, these practices often involve inefficient use and overconsumption. These practices can lead to environmental problems and depletion of the resource. Over the past hundred years, our use of fossil fuels has increased significantly. Projections of when these fuels will run out vary from 50 to 200 years. Regardless of the depletion date used, the fact is, there is a limited amount of fossil fuels and eventually there will not be enough to meet our growing demands.

In the early 1970s, in response to increasing concern about environmental quality, government agencies such as the Department of Energy and the Department of Natural Resources launched many energy efficiency programs. There are indications that these programs have been effective. Overall, the amount of energy
use per capita (residential) in 1995 was 8.2 percent less that it was in 1970. In 1994, commercial energy use per employee had fallen 15 percent since 1975. In 1993, Wisconsin ranked 13th lowest in the nation in per capita energy consumption. This ranking was 10.8 percent below the United State’s average. Each individual using less energy now makes more energy available for future users.

Despite these conservation efforts, there are threats to their continued success. Wisconsin’s per capita energy consumption increased 3.1 percent in 1995, after a 1.4 percent increase in 1994. Since its low point in 1982, per capita energy use in Wisconsin has risen nearly 16 percent. The increases are due to larger use of coal to generate electricity, a growing economy, increased use of air conditioning, and continued increased use of petroleum for transportation. The number of miles Wisconsin citizens drove was 34 percent higher in 1994 than in 1982.

Another threat to achieving sustainable or reduced energy consumption is increasing population. In 1970, Wisconsin’s population was 4,418,000. In 1995 it was 5,101,581. In the year 2020 the population is projected to be around 5,677,000. Wisconsin’s population growth will increase overall energy consumption and may outweigh attempts to save energy through conservation.

Since most of the energy we use in Wisconsin comes from finite resources and, despite our best efforts, the demand for these resources will continue to grow as our population increases, the need to find alternative resources is becoming more and more apparent.

**Wisconsin Resource Energy Consumption by Type of Fuel**

(Trillions of Btu and Percent of Total)

1995

- **Nuclear**
  - 119 (8%)
- **Renewable**
  - 67 (4%)
- **Coal**
  - 470 (31%)
- **Petroleum**
  - 479 (32%)
- **Natural Gas**
  - 386 (25%)
Many residents and companies in Wisconsin have already begun to locate and use renewable resources as alternatives to fossil and nuclear fuels. Renewable resources are those that can be replaced relatively quickly by natural processes. Some of these resources, such as wood, can be replenished. Replenishable resources can be depleted if their rate of use exceeds their rate of replacement. Other resources, such as wind and solar, are essentially inexhaustible and will be available as long as the sun continues to shine (which it is expected to do for a few billion more years). NOTE: There are environmental impacts from using renewables as well that affect sustainability; see Energy Resources Fact Sheets.

Currently about four percent of the energy we use in Wisconsin comes from renewable resources. The primary renewable resource used in Wisconsin is wood. It is burned for space heating in homes and to provide energy to run industrial machinery. Hydroelectric power currently ranks second. Hydroelectric power production comes from approximately 130 sites, and production is closely tied to annual rainfall. Other renewable resources used in Wisconsin include biogas energy from landfills and wastewater treatment plants that have installed collection and conversion equipment, fuel derived from municipal solid waste, and active solar and wind systems. In the absence of government support (for example, tax incentives, subsidies) and because conventional energy prices have remained low, installation of active solar and wind systems in Wisconsin has remained slow.

The amount of energy we obtain from renewables is projected to increase, but by how much varies. The following table compares the current and potential use of renewable energy resources.

Both conservation practices and investments in renewable resources can help Wisconsin promote sustainable energy generation and use, and thereby avoid the tragedies of overconsumering and wasting our common energy. Modern technologies and advances have afforded most Wisconsin citizens with lifestyles our grandparents would only have dreamed of. We, in turn, need to consider how our consumptive practices will affect future energy users. Each of us should consider using energy today with the needs of tomorrow’s energy users in mind.

<table>
<thead>
<tr>
<th>Resource</th>
<th>Potential</th>
<th>Current</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood</td>
<td>200</td>
<td>44.7</td>
</tr>
<tr>
<td>Solar</td>
<td>125</td>
<td>3.8</td>
</tr>
<tr>
<td>Ethanol</td>
<td>63</td>
<td>0.0</td>
</tr>
<tr>
<td>Hydropower</td>
<td>30</td>
<td>26.7</td>
</tr>
<tr>
<td>Wind</td>
<td>18</td>
<td>0.01</td>
</tr>
<tr>
<td>Combustible waste</td>
<td>20</td>
<td>3.4</td>
</tr>
<tr>
<td>Biogas</td>
<td>10</td>
<td>2.5</td>
</tr>
<tr>
<td>Total</td>
<td>467</td>
<td>81</td>
</tr>
</tbody>
</table>
Orientation
Have students list ways they use energy during a typical day. Remind them that products they use also require energy during the manufacturing process. Ask students if they have ever had problems getting enough energy to meet their needs (like running out of gasoline in a car or boat, needing wood for a fire). If any of them have experienced a power outage, have them share their feelings. Point out that, although there have been shortages, most power outages are caused by storms or technical problems.

Have students list different sources of energy. Write their responses on the board or post copies of the Energy Source Illustrations. If necessary, review the different resources and what is involved in developing them for various end uses (for example, coal is mined and transported to a power plant where it is burned to generate electricity).

Steps
1. Divide the class into groups of five or six students each. Tell them they are going to be participating in an activity called “Energy Divide.” Scatter a bag of candy on a table or a designated spot on the floor in front of each group.

   NOTE: An alternative is to have one group come to the front of the class and demonstrate the game to the rest of the class.

   Ground Rules for the Energy Divide
   - The candies represent Energy Units.
   - Each of you in this group represents a different energy consumer (this can be a large consumer, such as a country, or small one, such as an individual or a household).
   - You are not allowed to talk to each other.
   - The object of the game is to obtain enough energy resource units to support your basic life or operational functions. The minimum number of Energy Units needed by each consumer is five units for every 20 years. Anything above this minimum goes toward additional energy uses; anything below means the consumer does not have enough energy.
   - You will have four 5-second rounds in which to collect energy. Each round represents 20 years of energy use. You will be notified when to start and stop each round.
   - When the game begins, and during each round, you may try to collect the Energy Units you need (five per round), as many as you want, or none. If you do not get any or enough Energy Units during one round, you may participate in the next round if Energy Units are still available. If not, you cannot sustain your current living standards and must step out of the game.
   - At the end of the rounds, each group member can keep one piece of candy (optional).
**Related KEEP Activities:**

Have students use the survey “At Watt Rate?” to analyze the ways they use energy. Follow this activity by showing them ways they can conserve energy (see Action Ideas: Energy Efficiency Measures). Students can learn more about each of these resources through teaching ideas in K-5 Energy Sparks for Theme II: Introducing Energy Resources, Introducing Renewable and Nonrenewable Energy Resources, Fossil Fuel Products, Suninvestigations, Windy Wonders, and Water Fun and activities such as “Digging for Coal,” “Get That Gasoline!” and “Harnessing Nuclear Energy.” Enrich this activity with concepts found in 6-12 Energy Sparks for Theme II: Human Population Growth and Energy Use. Use activities such as “Energy Futures” to have students envision how scenarios developed during this activity could be applied to future societies.

2. Tell the class the basic rules (see Ground Rules for the Energy Divide). Begin the first round, and call time after 5 seconds. Wait a few seconds and begin the second round, and so forth. Continue with all four rounds even if they run out of candy. When the last round is over, instruct the groups to return the candy.

3. Discuss the results of the game. For example, what does it mean if they ran out of candy? Request explanations for why Energy Units were used up or left over. If some Energy Units were left over, are there enough units for 20 or 40 more years of energy use?
   - Have students identify the problems caused by not having enough energy. Refer students to the discussion during the Orientation. Point out that for the most part, people in Wisconsin have the energy they need for anything they want to do. Tell students that “Energy Divide” simulated that future users may not have enough energy if current energy use practices continue. Elicit students’ opinions about why they think they should or should not be concerned about future energy users.
   - Ask students about things they share with other people (a bathroom, television, pizza). Have students describe arguments or problems that may arise over sharing a common item and discuss how they resolve such issues.
   - Challenge students to compare their sharing experiences to “Energy Divide.” Briefly provide students with information about the “Tragedy of the Commons,” helping them to identify the tragedy and the commons. Discuss why it is better to share than to hoard resources. Explain that sharing in this simulation is even more difficult because the resource—the Energy Units—represent nonrenewable energy resources. These are resources that are no longer available after one use.

4. Ask students to provide suggestions on what they would do if they were to participate in the “Energy Divide” again. Have the class develop a set of recommendations that would ensure that each member of the group had enough energy to last through the four rounds. For example, they might recommend that consumers take no more than ten Energy Units in each round.

5. Have the groups play “Energy Divide” again, incorporating their suggestions to ensure that the energy will last. If the groups worked cooperatively, at the end of each round each group member should have enough energy and there should be some Energy Units left over. Although at the end of the fourth round there may not be enough Energy Units for many more rounds, at least this cooperative strategy is more promising. NOTE: If any students do not work cooperatively, you can insist that they do (playing the role of a law enforcement agency) or stop the game to further explore reasons people behave the way they do. You can also discuss how our society tries to promote or force cooperation (laws, regulations, incentives).

Inform the students that the more cooperative version of “Energy Divide” simulated energy conservation practices. Conservation involves wise use and careful management of resources (reducing waste, using only what is needed), so that current users will have enough to meet their needs while ensuring that resources will be available for future users. Ask students to share ways they avoid wasting energy. NOTE: See Extensions for ways to use the “Energy Divide” to illustrate challenges with population growth and to simulate renewable energy resources.
Closure
Have students review the results of the two different ways “Energy Divide” was demonstrated. They may want to devise a chart or table to record the number of Energy Units collected by all the students during the different versions. Ask them to compare the outcome of the game when they worked cooperatively to when they were unaware of each other’s intentions. Review reasons why current users of energy should care about future consumers.

If students could design the parameters for a new set of rounds, what would they suggest as the best case scenario for the game? How would they adjust the number of players, the amount of energy used, and the proportion of renewable energy to make energy supplies last longer? List each suggestion students make. If time allows, have them implement the strategies in a new version of “Energy Divide.”

Have students analyze whether their proposed adjustments to the activity could be applied realistically to real-life energy use policies. Challenge students to develop a plan of how energy resources should be developed and used (see Assessment).

Assessment

Formative
- Were students able to relate this simulation to a “Tragedy of the Commons” (problems with sharing a common resource)?
- What are the reasons students think they should or should not be concerned about future energy consumers?
- How effective were the conservation strategies suggested by the students to help conserve the amount of Energy Units each member of the group consumed?
- Can students explain why increased population challenges even the best conservation plans?
- Are students able to provide a definition for renewable and nonrenewable resources?

Summative
Have students develop a personal energy use plan for today and for 20 years from now (an alternative is to create a plan for their own or a fictional community). Both the current and 20-year plan can include ways students will conserve energy. For the 20-year plan they should envision what energy resources (renewable and nonrenewable) they would like to see used. They can also investigate ways they can begin using renewable resources more today (lighting with sunlight vs. electricity, biking or walking vs. driving a car). Have students evaluate each other’s plans, identifying things they do and do not like, providing justifications for their comments.

Extensions

Energy Use and Population Growth
To use “Energy Divide” to illustrate population growth, have one group begin the game, but pause at the end of the second round. Ask several students to come up and join the group. Explain that these additional students also need to get enough Energy Units. When the last two rounds are completed, ask the class what adding students to the demonstration represents. Do students think the number of people in Wisconsin 40 years from now will be the same as it is today? Inform students of Wisconsin’s projected population in 2020 (5,677,000) and point out that this projection is just over 20 years away.

Have students suggest how the “Energy Divide” activity could be further adjusted to allow more people to use the same amount of energy resources. For example, appliances are becoming more efficient so they need less energy; therefore, the game could be adjusted so that each member only needs three Energy Units instead of five.
**Energy Bike**

**Objectives**
Students will use the energy bike to light incandescent and compact fluorescent light bulbs and compare and contrast the amount of energy incandescent and compact fluorescent light bulbs use.

Student will use the energy bike to run a blow dryer and a fan. They will compare the energy use of a hair dryer to the fan.

**Background**
An energy bike is a bicycle with a generator connected to the back tire. As someone pedals the bike, electricity is generated. A cord connects the generator to a board with different outlets so, as students pedal the bike, they can light different things such as light bulbs, hair dyers, fans, boom box, and etc. Many different power companies have energy bikes for schools to use.

**Procedures**
1. Have students use the energy bike to light the incandescent light bulbs
2. Have students use the energy bike to light the compact fluorescent bulbs
3. Compare energy used by incandescent light bulbs and compact fluorescent bulbs
4. Have students use the energy bike to run a hair dryer
5. Have the students use the energy bike to run a fan
6. Compare the energy used by the hair dryer and the fan

**Assessment**
1. Have the students calculate how much energy using compact fluorescent light bulbs saves
Name

Formulas

Watts \times \text{Hours used per month} \quad 1000 = \text{KWh (kilowatt-hours) per month}

\text{KWh per month} \times \text{cost per kWh ($0.06)} = \text{approximate cost per month}

Part 1

<table>
<thead>
<tr>
<th>Lights in your room</th>
<th>Watts for 1 light bulb</th>
<th>Hours per day</th>
<th>Hours per month</th>
<th>KWh per month</th>
<th>Approximate cost per month</th>
</tr>
</thead>
</table>

Part 2

What would the cost per month be if you switched to 15watt compact fluorescent bulbs?

<table>
<thead>
<tr>
<th>Lights in your room</th>
<th>Watts for one CFL bulb</th>
<th>Hours per day</th>
<th>Hours per month</th>
<th>KWh per month</th>
<th>Approximate cost per month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light in your room</td>
<td>15 watts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Name ________________________________

Answer

1. What are the 2 parts a generator is made of?

2. What does a generator make?

3. What is electricity made of?

Read — *60 Watt Incandescent Light bulb and a 15 Watt CFL bulb = same brightness*

<table>
<thead>
<tr>
<th>Incandescent Light Bulbs = 30 cents</th>
<th>Compact Fluorescent Light Bulbs = $5.00 (CFL bulb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1- 60 watt bulb lasts 1000 watts</td>
<td>1- 15 watt bulb lasts 10,000 watts</td>
</tr>
<tr>
<td>90% of energy used = heat</td>
<td>40% of energy used = heat</td>
</tr>
<tr>
<td>10% of energy used = light</td>
<td>60% of energy used = light</td>
</tr>
</tbody>
</table>

Answer

1. What is the cost of 1 incandescent bulb? _________

2. What is the cost of 1 CFL bulb? _________

3. You need 10 incandescent bulbs to last as long as 1 CFL bulb. What is the cost of 10 incandescent bulbs?

4. If the cost of electricity is 1 cent per watt, how much will it cost to use a 60 watt incandescent bulb for 10 hours?

5. If the cost of electricity is 1 cent per watt, how much will it cost to use a 15 watt CFL bulb for 10 hours?

6. Which is cheaper to use in the long run, incandescent light bulbs or CFL bulbs?

   Cost of 10 incandescent bulbs + cost of electricity = ________________

   Cost of 1 CFL bulb + cost of electricity = _________________________

7. What percent of the energy used in an incandescent bulb is light? __________

8. What percent of electricity used in a CFL bulb is light? __________

9. Which bulb is safer to use if there are small children around? __________
## “Watt’s” a Kilowatt?

Follow the directions below to find out how much electricity your family uses in a month.

### Directions
Read the chart below. Estimate the number of hours each appliance is used in your home each month. Then, using the formulas shown, calculate the cost to use these appliances each month.

\[
\text{wattage} \times \text{hours of use} + 1,000 = \text{kWh (kilowatt-hours) per month}
\]

\[
\text{kWh per month} \times \text{cost per kWh (about$0.06)} = \text{approximate cost per month}
\]

<table>
<thead>
<tr>
<th>Appliance</th>
<th>Watts</th>
<th>Hours per Day</th>
<th>Hours per Month</th>
<th>kWh per Month</th>
<th>Approximate Cost per Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>television</td>
<td>200</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>refrigerator</td>
<td>780</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lightbulb</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>water heater</td>
<td>4,500</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>dishwasher</td>
<td>1,200</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>washing machine</td>
<td>1,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>clothes dryer</td>
<td>5,600</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>microwave oven</td>
<td>1,400</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>regular oven</td>
<td>2,400</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Approximate total cost per month:**

### Bonus Box
Reread the chart above. On the back of this sheet, list two appliances you feel you could use less each month. Then write two goals for conserving energy in your home. Share and implement your goals with your family.

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36 Note to the teacher: Use with “Watt’s a Kilowatt?” on page 32.
Home Energy Audit

1. During the day, instead of turning on the lights, curtains are opened to let in sunlight.
   a. Never  b. Rarely  c. Sometimes  d. Most of the time  e. Always

2. You turn off the water while brushing your teeth.
   a. Never  b. Rarely  c. Sometimes  d. Most of the time  e. Always

3. The TV is turned off when no one is watching it.
   a. Never  b. Rarely  c. Sometimes  d. Most of the time  e. Always

4. The lights are turned off when no one is using them.
   a. Never  b. Rarely  c. Sometimes  d. Most of the time  e. Always

5. The length of an average shower is.
   a. 5 minutes  b. 10 minutes  c. 15 minutes  d. 20 minutes

6. Full loads of laundry are done instead of small loads.
   a. Never  b. Rarely  c. Sometimes  d. Most of the time  e. Always

7. Windows have.
   a. Double-pane, either gas-filled or with reflective coating.
   b. Single-pane with storm windows or double-pane windows.
   c. Single-pane windows with no storm windows.

8. Thermostat is set at.
   
   Winter
   a. 70 degrees or lower
   b. 71-73 degrees
   c. 74 degrees or higher
   Summer
   a. 74 or lower
   b. 75-77
   c. 78 or higher

9. The weather stripping on your front and back door is.
   a. In good condition
   b. Worn out
   c. There is no weather stripping

10. Using the energy-efficiency rating on your water heater, does your water heater use.
    a. The least energy
    b. An average amount of energy
    c. The most energy

11. How many compact fluorescent light bulbs do you have in your house?
    a. 5 or more  b. 1-4  c. None

12. How often were your furnace filters changed or cleaned this last year?
    a. 4 or more times  b. 1-3 times  c. Not at all

13. How thick is your attic insulation?
    a. 12 inches or more
    b. 7-11 inches
    c. 6 inches

14. Check which of your appliances are energy efficient models.
    _______ Clothes dryer     _______ Washing Machine
    _______ Refrigerator      _______ Dishwasher
    _______ Stove
Dear Parent or Guardian,

Students will be doing their own home energy reduction plan. In this activity students will design a plan to reduce the amount of electricity used at home. The plan will include realistic changes that the student and other interested family members will do to conserve electricity. Students will begin designing their plan this week, and will put the plan into action beginning next week and continue through April.

Also, I was hoping that parents or guardians could help with this activity. I would like the students to be able to compare an electric bill from a prior month with April’s electric bill. By doing this, the children will see how doing little things to save to electricity can help save money too.

Hopefully, by seeing how saving electricity will save money too, the students will continue to make good energy choices.

Thanks,

Ms. Hermes
Home Energy Reduction Plan  
March 22, 2004 – April 30, 2004

I will save energy at home from March 22, 2004 through April 30, 2004 by doing the following:

1. 

2. 

3. 

4. 

5. 
Did you know that each person in the United States produces more than three pounds of garbage each day? Increase your students' understanding of just how much trash they produce by having a trash weigh-in. Give each student a large paper bag to collect all his dry, inorganic (no food!) trash for a day. Have each student write his name on his bag. During school, have him place the bag near his desk to collect his trash items throughout the day. At the end of the day, send the bag home with the student to continue collecting trash until bedtime. The following day, weigh each student's bag of trash on a scale. Next, give each student a copy of page 19. Then have the student fill in the first column of the reproducible with the weight of his trash. Ask students to share whether the collected garbage weighed more than they expected or less. As a group, talk about how to estimate the weight of the trash for one week and one month. Guide the students to use the estimates to complete the rest of the bar graph on page 19. Then read aloud the "Bonus Box" at the bottom of page 19. Help each student figure out how much trash he might throw away in one year. Next, discuss with the class the weight of the entire class's trash and remind the students how much more their trash would weigh if all the food that they threw away were included. Using page 19 as a guide, make a large graph of the entire class's trash and label it "Tons of Trash!"
Tons of Trash!

1. How much did one day's trash weigh? ______________ pounds of trash
2. How much would one week's trash weigh? ______________ pounds of trash
3. How much would one month's trash weigh? ______________ pounds of trash

Complete the graph to show the weight of your trash for one day, one week, and one month.

<table>
<thead>
<tr>
<th>Pounds of Trash</th>
<th>1 Day</th>
<th>1 Week</th>
<th>1 Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>140</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>130</td>
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<td></td>
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<tr>
<td>120</td>
<td></td>
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<td></td>
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<td>110</td>
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<td>100</td>
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<td>90</td>
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<td>70</td>
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<td>20</td>
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<tr>
<td>10</td>
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</tr>
</tbody>
</table>

Bonus Box: How much would one year's trash weigh? _______________
Recycling to the Rescue
(Reading, Sorting)

To further explain the concept of recycling, read *Recycle! A Handbook for Kids* by Gail Gibbons (Little, Brown and Company; 1996). Discuss with your students the different kinds of recyclable materials—such as paper, glass, aluminum, and plastic—and the importance of separating them from nonrecyclable trash. Explain that recycling helps protect and save the earth’s natural resources. To check for understanding of the various types of recyclables, give each student a copy of page 21 to complete as directed. Also supply each student with scissors and glue.

Junk Mail Jamboree
(Experiment)

One way to reduce the large amount of trash that is thrown away is to eliminate junk mail. How much junk mail do your students’ families receive each day, each week, or each month? Find out with a junk mail jamboree! A few days in advance, send a note home explaining to parents that your class will be collecting junk mail. Ask them to send any appropriate junk mail to school with their child daily for one week. Place several junk mail collection boxes near the door of the classroom. At the end of the week, weigh the junk mail for a grand total. Based on the junk mail’s total weight, help your students figure out how much the junk mail would weigh if collected for one month and then for one year. Brainstorm solutions for cutting down on junk mail and what to do with it once you have it. Solutions might include using the junk mail to make your own paper.
What a Waste!

Every day Americans throw away about 907,000 metric tons of solid waste. That’s about 9 pounds of trash per person! Follow the directions below to find out what types of trash get thrown out the most.

Directions: Look at the pie chart and the key below. Write each trash amount (percentage) in the correct pie piece on the chart. Color the key; then color each pie piece to match. Finally, use the chart to answer the questions below.

Waste by Weight

- Paper: 41%
- Yard debris: 18%
- Metals: 9%
- Glass: 8%
- Food: 8%
- Rubber, wood, leather, textiles: 8%
- Plastics: 7%
- Other: 1%

1. Nearly half of all the waste shown on the graph belongs in which category? __________
   List five types of materials that could be found in this category and could be recycled. ______

2. What percentage of the total waste is not included in the paper category? ______

3. The second largest category contains items that are usually found in nature. List five items that might be found in this category. __________________________

4. How much more of the total waste comes from yard debris than from rubber, wood, leather, and textiles? ____________________________

5. Twenty-four percent of the waste shown on the graph comes from three categories, each with the same amount of waste. What are the categories? List an example of two items that might be thrown away in each of these categories. ____________________________

6. Some categories on the graph represent common recyclable materials that are often thrown away. What are these categories and what is their total percentage? __________

Bonus Box: On the back of this page, make a list of 25 items that you throw away at home. Divide these items into the categories above. Then make a bar graph estimating the amount of trash you throw away in each category.
Another approach to generating less household waste is to throw less away. But what do you do with something after you use it? Use it again! This component of waste reduction, called Reuse, is often overlooked, but is perhaps the best alternative for saving energy and protecting resources. When you reuse something, that means energy is not needed to create a new product to replace the one that was thrown away. Here is a list of ideas to try:

- Buy products in returnable containers
- Reuse plastic or paper grocery bags (or buy a canvas bag and reuse it)
- Give old furniture, clothes, and household items to charities
- Buy furniture, clothes, and household items from thrift shops, charities, and yard sales
- Fix something instead of throwing it away
- Make creative crafts (bird feeders out of milk cartons, magazine storage containers out of cereal boxes)
- Carefully remove gift wrapping and reuse (or use the Sunday comics from the newspaper to wrap gifts)
- Use both sides of a sheet of paper

Illustrating the Waste Alternative

1. Share The Throwaway Bottle with students. Discuss energy sources needed to complete each step (petroleum for digging machines and trucks, natural gas or electricity from coal in the glass factory).

2. Have students identify the energy-consuming steps required at each stage of producing and throwing away the bottle. Help students identify the steps that probably use nonrenewable resources such as coal or oil. Students may also identify other energy uses not included in the diagram (such as the consumer driving to and from the store).

3. Propose to students that this bottle can be reused instead of thrown away. Some stores sell liquids in bulk, so the bottle can be taken to the store and refilled. What percentage of the energy use indicated in the diagram could be saved if the bottle were reused? If the consumer refills the bottle, 97 percent of the energy could be saved. If the consumer returns the bottle to the factory and they refill it, 88 percent of the energy would be saved.

4. Have students discuss advantages and disadvantages of throwaway containers. Record their suggestions in a two-column chart on the chalkboard. The chart might look like the one below:

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do not need to remember to bring container with you when you go to the store. Do not have to keep items clean for reuse.</td>
<td>Extra energy is needed to produce new containers. Extra resources are consumed and environment polluted during production process. Adds more material to the waste stream.</td>
</tr>
</tbody>
</table>

Don't Throw Energy Away
Figures show energy costs at each step.

1. Mining sand and other materials (7%)
2. Transporting raw materials (17%)
3. Manufacturing (60%)
4. Transporting bottle (4%)
5. Filling bottle at the bottling plant
6. Transporting filled bottle to the store (2%)
7. Buying bottle at the store (<1%)
8. Taking bottle home and drinking contents (<1%)
9. Putting empty bottle in garbage can (<1%)
10. Taking empty bottle to garbage dump (1%)
There is a way for people to throw away things without adding materials to the landfill. This is to throw things into a different stream: the recycling stream. Recycling is another one of the Three Rs listed as a solution for dealing with solid waste. Recycling involves taking discarded items and transforming or remanufacturing them into similar or different products.

Items that are commonly recycled include paper, steel, glass, aluminum, and plastic containers. Recycling saves energy because energy is not needed to locate, obtain, and process raw materials. However, there are alternative energy costs. The basic steps of recycling are separation of recyclable from non-recyclable materials, collection of materials, processing (breaking or melting materials into their basic material, such as paper into pulp), and remanufacturing. These steps, along with transportation to retailers, all use energy. Although recycling has its own energy costs and there are some pollution issues with recycling, there is evidence that recycling paper can save energy.

<table>
<thead>
<tr>
<th>Recycling 1 ton of</th>
<th>Saves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass</td>
<td>10 gallons of oil</td>
</tr>
<tr>
<td>Plastic</td>
<td>1,000 to 2,000 gallons of gasoline</td>
</tr>
<tr>
<td>Newspaper</td>
<td>100 gallons of gasoline</td>
</tr>
<tr>
<td>Aluminum</td>
<td>2,350 gallons of gasoline. This is equivalent to the amount of electricity used by the typical Wisconsin home over a period of ten years.</td>
</tr>
<tr>
<td>Iron</td>
<td>1 ton of coal</td>
</tr>
</tbody>
</table>

From Wisconsin Department of Natural Resources. Recycling Facts and Figures. Madison, Wisc.: Wisconsin Department of Natural Resources, n.d.

Many states, including Wisconsin, are concerned about finding space to store solid waste and want to promote better use of our resources. Below is data on proportions of solid waste the United States generates and recovers through recycling and composting.

**Products Generated and Recovered in 1994**
(in thousands of tons)

<table>
<thead>
<tr>
<th>Product</th>
<th>Generated</th>
<th>Recovered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper and Paperboard</td>
<td>81,300</td>
<td>28,730</td>
</tr>
<tr>
<td>Steel cans</td>
<td>2,920</td>
<td>1,550</td>
</tr>
<tr>
<td>Aluminum cans</td>
<td>1,710</td>
<td>1,120</td>
</tr>
<tr>
<td>Plastic packaging</td>
<td>9,490</td>
<td>710</td>
</tr>
<tr>
<td>Glass bottles and jars</td>
<td>12,070</td>
<td>3,110</td>
</tr>
<tr>
<td>Disposable diapers</td>
<td>2,980</td>
<td>negligible</td>
</tr>
<tr>
<td>Tires</td>
<td>3,690</td>
<td>560</td>
</tr>
</tbody>
</table>

Illustrating the Waste Alternative
Provide students with a copy of Recycling Paper. Help students understand that recycling paper avoids many of the energy-consuming steps needed to make paper from wood (cutting down trees, transporting to the mill, debarking the tree, turning the wood into pulp). Recycling paper also has energy costs because the paper needs to be separated and turned into pulp. Removing ink and other foreign materials and disposing of these materials requires energy as well and also affects the environment. Involve students in a debate in which they discuss the pros and cons of recycling paper. Invite speakers from a lumber company, a paper manufacturer, and a paper recycling plant to speak to the class or take students on a tour of such facilities. Have students look for the recycling symbol on recycled paper products and packaging. What could the prevalence of this symbol mean for energy and natural resource savings?

An alternative is to show students overhead transparencies of Steps in Making Aluminum Products from Raw Materials and Steps in Making Recycled Aluminum Products and to compare energy uses between aluminum manufacturing and recycling.
Background

Transportation plays an important part in our everyday lives. We rely on cars, buses, trains, bicycles, and even our own feet to take us where we need to go. All of these methods are powered by some source of energy. For example, most cars today run on gasoline.

Gasoline is a refined product of crude oil, or petroleum. The word *petroleum* comes from the Latin words “petra” meaning rock and “oleum” meaning oil. Petroleum is a fossil fuel formed millions of years ago from the remains of microscopic organisms. As these tiny plants and animals died they sank to the sea floor, and over many centuries they were buried with sand and mud. With increased pressure and heat from the layers above, the tiny organisms were transformed, ever so slowly, into *hydrocarbons*, the building blocks for petroleum and natural gas.

Most of the petroleum consumed in the United States is used for transportation. The process to convert petroleum into gasoline and other products begins at the refinery. The United States has more than 170 active refineries.

Follow the refinery process on the teacher page. From a well to a pipeline, the incoming petroleum is treated to remove sulfur, nitrogen, and trace metals. The next step takes advantage of the fact that different hydrocarbons boil at different temperatures. In a fractionating tower the petroleum is heated until it boils. Horizontal trays divide the column at different levels. As the petroleum boils, it vaporizes. Each hydrocarbon rises to a tray at a temperature just below its own boiling point. There, it cools and turns back into a liquid. This process separates the petroleum into different products. These products go through additional processing (cracking/coking, alkylation, blending and removal of impurities) to become the products we use each day.

Improved refining technologies have made it possible to produce more than 19 gallons of gasoline from a barrel (42 gallons) of petroleum. This is a remarkable advance over the industry's early days, when a barrel of petroleum yielded just 11 gallons of gasoline. Diagram 1 shows the percentage of different products that are refined from a typical barrel of crude oil.

The final step of the refining of gasoline is purifying and fine-tuning the fuels to meet today's performance and environmental standards. Additives that keep engines clean and increase oxygen help today's gasolines burn cleaner.

While gasoline is a versatile fuel, yields a relatively high amount of energy, and is easy to transport, when combusted (burned) it releases carbon dioxide and other pollutants into our atmosphere. Over the years, technological advancements have led to many improvements in automobile emissions and fuel economy. Those improvements have included the introduction of catalytic converters, the construction of lighter and more energy efficient cars, and the development of cleaner fuels (by eliminating lead in gasoline and reducing the amount of sulfur in diesel fuel).

Much can be done on the part of consumers to ensure this progress continues. One example is to use gasoline more efficiently by...
carpooling, planning trips more efficiently, and getting regular tune-ups for your car. Another example is to find alternatives to driving such as walking, bicycling, and using public transportation.

One of the most important environmental decisions a consumer can make is choosing a car with good fuel mileage. In general, small cars have better fuel economy than larger cars, and cars have better fuel economy than vans, sport utility vehicles, and trucks. Fuel economy is measured in terms of miles per gallon, that is, the number of miles you can drive in that vehicle on a gallon of gas.

Electric vehicles are gaining attention as an option for reducing air emissions. However, their use is limited because the batteries are expensive, heavy, and store little power, allowing a car to travel only 60-70 miles on a charge.

Electric vehicles are sometimes referred to as "zero-emission" vehicles because they produce virtually no pollution through fuel evaporation or burning. However, while electric cars themselves are clean, generating the electricity to charge the vehicle batteries produces air pollution and solid waste.

**Hybrid vehicles**, which combine two power sources, are another option to reduce gasoline use. These vehicles have a small, clean, internal combustion engine combined with an electric motor powered by batteries. They recover energy when braking, will shut off the gasoline engine when stopped, use advanced aerodynamics to reduce drag, use low-rolling resistance tires, and use lightweight materials to reduce the weight of the vehicle. This combination of features allows these hybrid cars to achieve better gas mileage and still have a similar range, performance, and convenience of conventional gasoline cars.

Fuel cells are yet another viable alternative fuel source for vehicles. Like batteries, fuel cells rely on chemical reactions rather than combustion. Many fuel cell prototypes have been developed but cost continues to be a challenge.

**Getting Ready**

Review sample travel log on the Teacher Page, 49. View the EPA website www.fueleconomy.gov. Become familiar with the process of looking up different vehicles and determining the miles per gallon (mpg) the vehicles achieve. On a playing field or in a multi-purpose room, mark two lines that are about 10 steps apart (20 feet). Label one line “home” and the other “school.” Divide the width of the area into 5 days—Monday through Friday. See Diagram 2.

**Doing the Activity**

**Part A**

1. Begin a discussion with your students about how they get around in their community. What methods of travel do they use? What sources of energy do they use? How far do they travel? Keep a list of their answers to compare after they complete the Travel Log.

2. Instruct students to calculate the amount of miles their family vehicle travels during a week. Students without vehicles should estimate the number of miles they travel (walk, bus, etc.). Have students create a travel log. Students should work with a parent or guardian and record the mileage of the vehicle(s) on Sunday evening. Throughout the
week, they will log the use of the vehicle, the purpose of the trip, the type of travel, and mileage. They will record the mileage again the following Sunday evening.

3. Discuss the findings with the students. What was the average mileage per vehicle? Average mileage per student? Compare the findings with the list developed at the beginning of the activity.

4. Ask students what they think gasoline is made from? How is it made? Where do we get petroleum from? What are some different products that are made from petroleum? What different types of gasoline are they familiar with? Discuss how a refinery operates. Make a list of how students use gasoline. What are some impacts of using gasoline?

**Part B**

1. Ask students what type of vehicle they would like to drive. Why did they choose this vehicle?

2. Have students select and research a vehicle make and model of their choice. They should get a picture (newspaper, brochures, magazines) or create a drawing of their vehicle. The students should determine the number of people the vehicle holds and check the EPA Fuel Economy website for the mpg rating. Other information could include: type and size of engine, cost, and options that are available.

Students will do a simulation in which they will use their vehicles to "drive" to school and then home again for 5 days. Give the students 3 poker chips to represent 3 gallons of gasoline. For the purpose of the simulation their vehicle will go...
“steps per gallon” instead of miles per gallon. For example, if the vehicle is rated 24 mpg, every 24 steps they will drop a chip to indicate they have used a gallon of gasoline.

Have the students begin at the line marked home in the Monday area (See diagram). They will count the number of steps they take to travel to school (10) and then return home for Monday. They will drop a chip each time they use one gallon of gasoline. Do the same with Tuesday. Continue for one week. Have the students stop in place when they “run out” of gasoline. Which vehicles ran out first? Do any still have gasoline?

3. For Round 2, give each student 3 chips again. Challenge the students to think of a way to get the greatest amount of trips using the same amount of gasoline. How can they increase it? (They might suggest carpooling but the limit is the number of people the vehicle holds).

4. For Round 3, give each student 3 chips again. A bus arrives that can carry 45 people and gets 5 mpg (EPA Estimate). Pooling the gasoline, how far can the bus go?

**Enrichment**

- Students conduct a survey to determine the average vehicle occupancy in your community. First, choose an observation point that is safe and yet allows students a vantage point for seeing the number of people in vehicles passing by. Have students tally the number of passing vehicles and the number of people in each vehicle. Tallying works best with partners, with one person being the counter and the other being the recorder. Have students keep count for 10 minutes or until they record 100 vehicles. Compare the results for different times and, if possible, different sites in the community. Discuss how occupancy affects the amount of gasoline being used. What ways could your community try to increase the average vehicle occupancy?

- Using Mapquest (www.mapquest.com) have students take a trip with a car. How many miles will they go? How many mpg will the car get? How many gallons will they need for the round trip? How much will it cost in fuel?