Introduction

Doable Renewables, the KEEP renewable energy education supplement, provides K–12 teachers in a variety of subject areas with easy-to-use, hands-on, minds-on activities designed to promote energy literacy in Wisconsin students. The Wisconsin Department of Public Instruction's Academic Content and Performance Standards were referenced during the development of this supplement. See the Cross-Reference Charts in the Appendix to learn how activities in this guide relate to different subject areas and address different approaches to utilizing a variety of teaching methods.

Thematic Organization of the KEEP Renewable Energy Education Supplement

The activities are divided into three out of the four themes. Within the themes, the activities are subdivided by grade levels (K–4, 5–8, and 9–12). KEEP's *Conceptual Guide to K–12 Energy Education in Wisconsin* directed the development of *Doable Renewables*.

Theme I: We Need Energy

Goal: To help students appreciate the nature of energy and to provide them with an awareness of how energy is used to maintain, organize, and change systems that affect their everyday lives. Through participation in activities from this theme, students gain a fundamental knowledge about energy, including what it is, where it comes from, and what forms it takes. In addition, they become familiar with energy conversions and limitations of energy use.
NOTE: See the KEEP *Energy Education Activity Guide* for Theme I activities.

This supplement is organized by the following themes:

Theme II: Developing Energy Resources

Goal: To help students identify different energy resources and analyze the processes involved in making those resources available to meet our needs. Understanding what energy is and how it flows through systems is necessary to appreciate how humans have come to harness, value, and treat energy resources.

Theme III: Effects of Energy Resource Development

Goal: To encourage students to investigate how energy use affects their lives. Recognizing these effects increases students' awareness of why and how they use energy and promotes an understanding of why societies and individuals manage their energy resource use.

Theme IV: Managing Energy Resource Use

Goal: To provide students with knowledge and skills they can use to help ensure that energy resources are effectively used on a sustainable basis. For students to willingly and effectively take action to manage energy resource use, they must have a thorough understanding and appreciation of what energy is, how it flows through systems, its value as a resource, and the effects its use has on human societies and the environment.

Grade Levels and Theme Emphasis

Concepts within all the themes are relevant to teachers at any grade level and in a variety of subject areas (see Cross Reference Charts: Grade Levels and Subject Areas in Appendix). However, when building a K–12 renewable energy education program, certain themes can be stressed at different grade levels.

Participating in activities from **Theme I: We Need Energy** provides students with a fundamental knowledge about energy. The concepts within this theme are the foundation upon which concepts in the other three themes are built. Therefore, We Need Energy should be emphasized in grades K-4. The KEEP *Energy Education Activity Guide* as well as KEEP's Renewable Energy website offer a variety of lessons and ideas for supporting student learning of Theme I energy concepts.

Activities and teaching ideas from **Theme II: Developing Energy Resources** have students identify and look at

different sources of energy. These concepts are appropriate for the elementary grades, especially grades 3–5. However, other concepts within this theme require higher level thinking skills because students must interpret and examine the process of energy resource development. Therefore, many of the activities from this theme pertain to students in middle school.

Awareness of how renewable energy use positively and negatively affects quality of life, economic activity, and the environment can begin during the primary grades; however, because of the complexity of many issues, these concepts may be better introduced at a later stage. The majority of the activities within **Theme III: Effects of Energy Resource Development** are appropriate for the middle school years. High school students can take what they have learned earlier and use the knowledge and skills to conduct special projects (see Appendix). Educators can teach younger students the importance of renewable energy use. However, younger students may not comprehend the reasoning behind these efforts until they learn to think more abstractly.

The higher level thinking skills (such as linking economic activity and energy flows, linking environmental impacts and energy flows, and extrapolating how today's actions could affect the availability of energy resources tomorrow) are best suited for more mature students. Consequently, most of the activities from **Theme IV: Managing Energy Resource Use** are designed for middle and high school students. By the time students graduate from high school, they should have mastered the concepts and learned lessons from the world around them. These competencies will enable them to make wise decisions regarding energy choice, to understand the workplace and career opportunities and associated school-to-career elements, and to take actions that reflect their personal ethic and knowledge of energy.

Advice for Elementary Teachers

Elementary teachers will find activities in *Doable Renewables* for their students including a **K–4 Renewable Energy Sparks** section designed to "spark" ideas for increasing student awareness of renewable energy resources. The **Resources** section within the Appendix lists books, websites, and support materials for young learners interested in renewable energy. Many of the activities for middle school aged students can be adapted for lower grades. As explained within the ***Development of Doable Renewables*** section, most of the supplement's activities are geared for middle and high school students because mastering renewable energy concepts involves higher level thinking skills. There are many opportunities to engage younger students in learning about renewable energy, however. Visit the KEEP website for many links and tips for increasing renewable energy education at the elementary level.

Renewable Energy Education Online

Visit the KEEP website for many more renewable energy education learning opportunities (www.uwsp.edu/keep). Click on the *Renewable Energy Education* link to find extensions and other support materials that complement activities within *Doable Renewables*. Elementary teachers will find a plethora of resources and teaching ideas to promote awareness and understanding of renewable energy. In the Curriculum & Resources section of the KEEP website you will find the activity guide *BioFutures* which is a compilation of biomass energy activities. Also available is a renewable energy online course, which is offered for credit annually. The course content is available year-round. Visit the *Professional Development* section of the KEEP website to learn more.

Types of Activities

Activities in *Doable Renewables* are fully developed activities that provide educators with background information, explicit objectives, a detailed procedure, and assessment strategies. They are designed to be self-contained lessons. Background information is usually found within the activity; occasionally other sections of the guide may be referenced. Most activities require some preparation time to locate and set up materials. However, this time should decrease with successive uses. For the most part, the materials should be available in local stores or within the school. Some activities have student pages or will reference other background materials that can be found on the KEEP website.

"Green Home Design" and "Sustainable Communities" are activities which can be used as a single lesson or they may be used as the culminating activity for a unit on renewable energy. This unit may take several weeks to complete. Many activities in *Doable Renewables* have a **Final Connection** section which will indicate how the activity may be tied into "Green Home Design" or "Sustainable Communities."

Integrating Energy Concepts

Concepts in the Supplement are applicable to teachers of Science, Mathematics, Social Studies, Language Arts, Technology Education, Family and Consumer Science, or to anyone who wants to promote energy as part of their environmental education curriculum. Educators can use KEEP's Cross-Reference Charts to identify activities relevant to a variety of their teaching needs, such as *Subject Areas* and *Grade Level*. KEEP activities can be used to address the Academic Content and Performance Standards developed by the Wisconsin Department of Public Instruction. These standards identify what students should understand and how they should demonstrate achieved learning. For more information about state standards, contact the Wisconsin Department of Public Instruction, P.O. Box 7841, Madison, WI 53707-7841.

In addition to the various Cross-Reference Charts, educators and curriculum developers can refer to the **Suggested Scope and Sequence** in the Appendix that provides guidelines showing when and to what extent energy concepts could be integrated into school curricula. For example, teachers can use the scope and sequence to identify the concepts appropriate for their subject and grade level. The next step for educators is to determine which of these concepts are already included in and which are lacking from their curricula. Activities found within *Doable Renewables* provide teachers with opportunities to bring these energy concepts into curricula.

Assessing Student Learning

Doable Renewables provides several approaches for assessing student learning. It is helpful to assess students' current understandings and misconceptions about energy. Use the lesson "Energy Ideas" on the following pages to gain insight into what students currently think and feel about energy. Furthermore, the **Orientation** of each activity procedure provides suggestions for ascertaining what students know about the upcoming lesson. **Formative** and **Summative Assessment** ideas are located within each theme activity. The **Formative Assessment** points out events during the activity when educators can check their students' achievement of the objectives. **Summative Assessment** takes place near the end of the activity or after the activity's completion. The aim of Summative Assessment is to determine if students can take what they have learned and apply it to a different experience.

Special Projects

Students' comprehension of concepts within an entire theme can be assessed through units or special projects. These units or projects provide teachers with the means to make objective evaluations of which concepts students have mastered and which areas students need further instruction. See the **Special Projects in Renewable Energy** section in the Appendix.

Activity Format

Summary: Briefly describes student learning and activity procedure

Objectives
Knowledge and skills students will acquire as a result of doing the activity.

Rationale
Importance of students learning the concepts or skills in this activity.

Materials
Items needed for the activity. Any necessary preparation of materials is described in **Getting Ready**.

Student Activity Sheets are noted in bold green italics.

Getting Ready
Directions for preparing materials or setting up demonstrations prior to conducting the activity with students.

Background
Description of energy topics and concepts addressed in the **Procedure**.

Procedure
Orientation
Discussion topics that can be used to relate forthcoming concepts to students' lives and to assess what students currently know about the concepts in the activity.

Steps
Suggested strategy for completing the activity. Written instructions and materials for students are found on separate ***Student Activity Sheets*** directly following the activity.

Closure
Discussion topics that can be used to conclude the activity and to assess what students have gained from participating in the activity.

Assessment
Formative
Questions about student actions that occurred during the activity.

Summative
Suggested activities that have students applying learned information or skills to new situations.

Extensions
Variations and additions to the activity.

Grade Level:
Suggested grade levels: K–4, 5-8, 9–12 (those found in parentheses indicate the possibility of adapting the activity for those grade levels).

Subject Areas:
Relevant subject areas.

Setting:
Recommended location.

Time:
Preparation time: Approximate time needed to review background information and set up materials. Initial set up time may take longer than indicated.
Activity time: Average class time needed to conduct the activity.

Vocabulary:
Key terms introduced or used in the activity.

Major Concept Areas:
Lists the major concepts covered in this activity.

Standards Addressed:
Lists some of the standards that are addressed by the activity including Wisconsin Model Academic Standards, Common Core State Standards, and Next Generation Science Standards.

Related KEEP Activities:
Theme activities and teaching ideas from Energy Sparks that can precede, supplement, or follow this activity.

Summary: Gaining understanding of students' thoughts about energy and renewable energy.

Energy Ideas

Grade Level:
K–12

Subject Areas:
All

Time:
One 50-minute period

Objectives
Students will be able to

- express and analyze ideas about energy;
- discriminate among scientific and common definitions of energy

Rationale

Renewable energy education is often equated with activities that involve young students in using renewable energy technologies. While students may enjoy building a solar cooker, it is important that students understand the reasons for these activities. Without proper understanding of energy resources, energy degradations, and energy conservation, students might consider the activity simply a game and not see the reason to continue these actions after the lesson is completed. It is also important that students understand the "basics" of energy and energy efficiency before they learn about renewable energy.

What should teachers do when trying to teach students about energy? Although it is unrealistic to expect young children to grasp complex and abstract conceptions of energy, they can begin to investigate various definitions of energy and analyze what energy means to them. If they share these thoughts and ideas with their teachers, lessons can be designed to strengthen correct understandings of energy and to help children recognize limitations in incorrect definitions. The following strategy is one approach to help elicit students' thoughts about energy and give them the opportunity to analyze their ideas.

Materials
Bulletin board or newsprint

Background
You sure have a lot of energy!

Energy is getting expensive!

I think my battery has run out of energy.

It will take a lot of energy to move that rock.

These are all common uses of the term energy, but in strict scientific terms they are not exactly correct (see **True or False?** for explanations of why some common uses of the term energy are scientifically incorrect). Given that the word is used so often and in so many different ways, it is no wonder that students may have misconceptions about what energy is. Secondary science teachers sometimes struggle with trying to get students to overcome misunderstandings of energy.

Teachers can help prepare students to appreciate what energy is by encouraging them to become aware of the presence of energy in their lives. By participating in activities in the KEEP *Energy Education Activity Guide* and *Doable Renewables*, students receive an introduction to basic energy and renewable energy concepts and begin to appreciate the energy in their lives.

To better prepare students for their renewable energy education, it would be helpful for teachers to know students' current thoughts and ideas about energy. This activity suggests a procedure for providing students with the opportunity to share their ideas about energy and explore how they apply energy to various aspects of their lives and within science class. While listening to students explain phenomena they observe, teachers can assess if and how students use energy and energy-related terms.

For example, it will be helpful to teachers to know if students equate energy with terms such as effort, force, motion, or fuel. Subsequent lessons could further help students distinguish between these terms and understand how they are used in

science. These lessons would help students construct foundational knowledge about energy that would support more scientific energy conceptions later in their learning career. **Energy Basics** provides a brief overview of some basic energy concepts. See **True or False?** for common energy misconceptions.

Procedure

Designate a bulletin board or a section of your classroom wall to post "Renewable Energy Ideas." Have students write sentences that depict what they think energy is. Students can generate ideas in one classroom lesson or you might want to give them a week to post ideas as they think of them. Make sure students know that any idea is a good one; for now they are to generate as many ideas as possible. NOTE: Have preliterate students draw pictures and dictate their thoughts to be transcribed.

After students have posted a number of ideas, give students a chance to read through or look at all the ideas. See if students think any ideas are similar and should be grouped together. Try to narrow the number of ideas to five or less.

Have students generate a one-sentence description for each idea. Ask students to examine each idea to be sure it makes sense to them.

Option: You might want to narrow the ideas down even further. Have students decide whether they agree or disagree that each idea defines energy. Encourage students to express the reasoning behind their opinion.

This discussion could continue over several days or weeks, supplemented by activities to explore each idea. Over time, students might change their opinions or generate new ideas. Some of the ideas will be more scientifically accurate than others. Challenge students to categorize their thoughts about energy into "scientific" explanations compared to common everyday expressions.

Option: Invite a physical science teacher in to examine the ideas. She or he might identify true meanings behind some of the ideas. For example, the sentence: "It takes a lot of energy to move a boulder" would be more correctly stated, "It takes a lot of work to move a boulder." The teacher might also be able to identify supplementary activities to help students examine their ideas more extensively.

Option: Divide the class into groups of three or four. Have each group design a poster or a skit to portray their understanding of energy. You might want to work with the art teacher to identify creative ways for students to illustrate their posters.

Assessment

- During the activity, observe student contribution and analysis of ideas.
- Examine students' posters to see if they reflect the ideas generated during class.
- Ask students to provide a definition of energy.

Energy Basics

A common definition of energy is the ability to do work (or to organize or change matter). Work involves force and motion. You can see evidence of energy when something moves or changes (when work is done). Light, thermal energy, and sound are other ways we can detect energy. People might think of energy as a substance such as fuel or a force or power, but in scientific terms energy is a state or condition that can be quantified and measured.

Scientists use energy to describe certain properties of an object or a series of objects. It is similar to how you can describe an object's weight or size, and you can assign a value to quantify an object's energy.

Energy is transferred from one object to another during work (when there is movement or change). The amount of energy that is present before and after work is the same (scientists say energy is conserved). For example, let's say you drop a ball. Scientists can measure the energy before, during, and after the fall. The amount of energy remains constant throughout the process—it is just in different states. Likewise, when an object is thrown, a spring released, or something burned, the energy can be measured and will remain constant. This is the reason behind the statement, "Energy can neither be created nor destroyed, it can only be converted from one form to another." Scientists have found that the amount of energy in a closed system remains constant.

Wherever you look, you can see examples of energy transfers. When you turn on a light, you see the result of energy being transferred from the sun to the plants to the coal to electricity and finally to the light you see. During each of these transfers, energy changes form. There are two main forms of energy—kinetic energy (motion) and potential energy (position). To further classify energy, these forms are sometimes described as thermal (heat), elastic, electromagnetic (light, electrical, magnetic), gravitational, chemical (food), and nuclear energy. See the KEEP *Energy Education Activity Guide* for more information on kinetic and potential energy.

During energy transfers, it might seem that energy does go away or become reduced. For example, a bouncing ball stops bouncing, a battery dies, or a car runs out of fuel. The energy still exists but it has become so spread out that it is essentially unavailable. Burning a piece of wood releases light and thermal energy (commonly called heat). The light and heat become dispersed and less useful. Another way to describe this process is to say the energy is concentrated in the wood (chemical energy) and becomes less concentrated in the forms of thermal and light energy.

Energy has often been called the currency of life. It flows through Earth's processes, creating wind, providing light, and enabling plants to create food from water and air (carbon dioxide). Humans have tapped into this flow to generate electricity, fuel our cars, and heat our homes. The sun provides Earth with most of its energy. It is important for students to recognize and appreciate this source of energy and to explore the transformations that bring the sun's light into their home in the form of light, heat, food, and fuel. We are fortunate to have many "concentrated" sources of energy. Besides the sun, there is chemical energy found in fossil fuels such as coal and oil and in nuclear resources.

While the amount of energy in our world remains constant, as we use it (transfer it from one form to another), it becomes spread out and less useful. Energy also gives us the ability to work. Through education and becoming aware of what energy is and how we use it, we can learn (i.e., work) to use our concentrated resources more wisely and ensure that they will be available for future generations.

Renewable Energy Basics

Renewable energy resources have been used throughout history. They come from sources that can be continuously replenished such as solar, wind, hydropower, biomass, and geothermal. Renewable energy can be a reliable energy source for many residential and commercial applications, including heat generation, electricity generation, and vehicle fuel. The availability of renewable energy varies; some renewable resources are in constant supply, while others are intermittent. Intermittent energy can be stored for future use. Many homeowners who utilize renewable energy sources will use more than one source in order to compensate for times when energy may not be available (a wind turbine does not produce energy unless there is wind to spin the turbine).

Renewable energy systems can be centralized or decentralized. A centralized energy system is one in which large amounts of an energy resource are converted from one form into another form in one location. A decentralized energy system is one in which small amounts of an energy resource are converted from one form into another form in many locations by individuals or small groups of consumers. With the current prices of energy, some decentralized renewable energy systems will accomplish a full payback within their lifespan. Factors that influence payback include the type of technology, resource used, and location. If demand, production, and technological advances in renewable energy increase, equipment and installation prices will be reduced and the likelihood of payback will increase.

Solar energy is used to generate electricity or to heat air or water. Solar heating can be passive or active. A passive solar heating system captures the sun's energy within a structure and converts it into low temperature heat, which then naturally circulates. In an active solar heating system, collectors absorb solar energy, and pumps or other devices are used to circulate the heated fluid.

Wind is air in motion and is produced by the unequal heating of Earth's surface by the sun. Wind energy is used to generate electricity, grind grain, and pump water. Wind speed increases above Earth's surface, so wind turbines are mounted on tall towers.

Hydropower is the kinetic energy generated by falling water. The water's flow (volume) and fall (height) determine the amount of available energy in moving water. Hydropower plants capture the kinetic energy of falling water to generate electricity. People capture the energy by damming a river, creating an artificial reservoir, or channeling a portion of a river through a generating facility.

Biomass energy is the energy released from living or recently living organic matter (as opposed to fossil fuels). People release the energy in organic matter through processes such as burning and fermentation. Biomass can be used for a variety of purposes. It can be burned to generate electricity and heat and can be processed to produce fuel.

Geothermal energy is heat energy that originates within Earth. Geothermal resources range from shallow ground sources (low temperature) to hot water, steam and rock miles below Earth's surface (high temperature). Geothermal resources can be used for a variety of purposes. Low temperature geothermal resources use the relatively constant temperature of the soil or surface water as a heat source and sink for a heat pump, which heats and cools buildings. High temperature geothermal resources are underground reservoirs of hot water or steam that can be tapped for electrical power production.

True or False?

Energy is found only in living objects.

Energy is a force.

Energy is associated only with movement.

Energy causes things to happen.

Energy is a fuel.

Energy is a substance or fluid.

Energy is a product of an activity.

Renewable energy resources are the answer to future energy problems.

Renewable energy is an environmentally friendly alternative to fossil fuels.

In strict scientific views, all these statements are false. Following are explanations of why these energy descriptions are "wrong":

- ***Energy is found only in living objects.***
  This statement is not correct because everything has energy. The composition of an object or its placement determines what kind of energy it has (e.g., chemical, thermal, gravitational). Living things are unique in that they have the natural capacity to convert energy to another form from the food they consume.
- ***Energy is a force.***
  A force is a push or a pull. Energy is needed to create the force, but it is not the force. A force, through movement, changes the state of energy in an object (e.g., from potential to kinetic energy).
- Energy is associated only with movement.
  Nonmoving objects have potential energy (sometimes called stored energy).
- ***Energy causes things to happen.***
  It is acceptable to say energy is needed to lift an object or move things, but other conditions (such as force) are needed as well.
- ***Energy is a fuel.***
  Fuel is a source of energy, but the fuel itself is not energy. Fuel is a resource, such as oil, coal, or foods that we eat. Fuel sources have potential energy in the chemical bonds that make up the substance.
- ***Energy is a substance or fluid.***
  Energy is a state; it is not matter (i.e., it does not contain molecules). For example, steam, liquid water, and ice are all the same substance (contain the same molecular structure), but because of their different states of energy, they appear different.
- ***Energy is a product of an activity.***
  Energy is transferred as the result of an activity such as electricity generation or eating food. Energy is not created.
- ***Renewable energy resources are the answer to future energy problems.***
  Renewable energy technologies are available today on a large and small scale. They can be used to supplement a home's energy needs or to power up an entire system. Some principles of design incorporate renewable energy into the development of a structure such as: day lighting, landscape considerations, and orientation of the structure. Future and current energy problems require a mixture of efficient use of traditional fuel sources as well as increased use of renewable energy.
- ***Renewable energy is an environmentally friendly alternative to fossil fuels.***
  Electricity generation from wind, solar, and water does not involve fuel combustion; so therefore they are cleaner sources of energy. However, there are environmental costs to renewable energy production and generation. Burning wood, cutting trees, and damming rivers can have detrimental effects on natural resources. The construction and installation of wind turbines uses resources and they are viewed by some community members as visually unattractive.

To find more misconceptions about renewable energy visit the KEEP website.