

THE DEVELOPMENT, EVALUATION, AND APPLICATION OF A CONCEPTUAL
FRAMEWORK FOR K-12 RENEWABLE ENERGY EDUCATION

by

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A Thesis
submitted in partial fulfillment of the
requirements of the degree

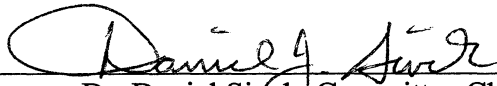
MASTER OF SCIENCE
IN
NATURAL RESOURCES
(ENVIRONMENTAL EDUCATION)

College of Natural Resources

UNIVERSITY OF WISCONSIN
Stevens Point, Wisconsin

May 2003

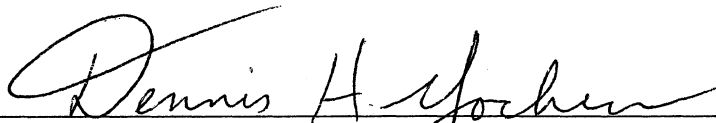
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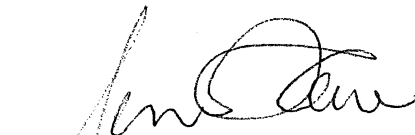
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Abstract

Our society's dependence on non-renewable energy has affected the environment, domestic policies, and international relations. One way to alleviate some of the tensions caused by non-renewable energy use is to shift to using renewable resources. Currently, only five percent of our energy needs are being met by renewable energy (Wisconsin Division of Energy, 2001). Furthermore, research has shown that the public has misconceptions regarding renewable energy use (Sheaffer, 1975; Barrow and Morrissey, 1987). Renewable energy education will provide people with facts associated with renewable energy use, thus helping them make informed energy-related decisions. The purpose of this study, sponsored by the Wisconsin K-12 Energy Education Program (KEEP), was to develop, evaluate, and apply a conceptual framework for K-12 renewable energy education. A conceptual framework is a thorough list of main ideas that provides a method through which curricula and educational programming can be developed. The renewable energy conceptual framework delineates major concepts important in understanding renewable energy, including the development, effects of development, and management of solar, wind, hydropower, biomass, and geothermal energy resources. The framework was created and validated using a modified Delphi process; that is, a method of generating ideas and facilitating consensus among experts in a selected field. The application of the framework involves using it, along with a dichotomous key and rubric that were created as part of this study, to evaluate activity guides for renewable energy content. The framework, dichotomous key, and rubric can be used together to determine the percentage of concepts in the framework covered by a given activity guide. The

results of this process can be used to shape program development. The development, evaluation, and application of a renewable energy conceptual framework gives others a comprehensive, thorough tool to guide the development of renewable energy education programming and curricula. Together, they provide a solid base for renewable energy education.

Acknowledgements

I would like to thank a whole lot of people starting with Dr. Dan Sivek and Jennie Lane. Both have provided immeasurable guidance and support over the past two years. Dan has always offered kind words, a smile, and project advice. He has helped keep this thesis manageable and unbiased. Jennie has been a great mentor over the past two years. Her leadership and organizational skills are unsurpassed. She has always been generous in offering her most precious resource: time! No matter if she was on her way to Japan or juggling PhD classes in Madison while simultaneously directing KEEP, she always found time to meet with me and read countless drafts of my thesis. To call Jennie instrumental in the conceptualization and completion of this project is a gross understatement. Endless thanks to both Jennie and Dan.

I would also like to thank Dr. Tehri Parker and Dr. Dennis Yockers. Both gave their time and energy willingly to see that this thesis was up to par! Tehri's insight into the renewable energy world strengthened this project immensely. And Dennis always went above and beyond the call of duty, offering resources that helped me form this thesis and will continue to help me in the future.

Thank you to the KEEP staff, past and present. What a great working environment you all have created up there on the fourth floor! It was always nice to see the smiling faces of such beautiful, dedicated, working women. What a competent, fun, and crazy bunch you are! I will miss you all.

My committee, the KEEP and the WCEE staff made the last two years better than I ever could have imagined. I consider it an honor to have worked with such an amazing bunch of environmental educators.

In addition, I'd like to thank my friends in New York and beyond for their love and encouraging words over the past two years. In the darkness of the Wisconsin winter, they were always there to remind me what a worthwhile thing I was doing. They helped to keep me focused and to remind me how fortunate I was to be where I was, doing what I was doing. They were also always there to remind me of the parties and Indian food that I was missing in New York, but hey, it gives me something to look forward to when I return!

I'd especially like to thank Rachid, who has encouraged me to push myself beyond my limitations and for his help in mastering Excel. Without his help, I'd still be analyzing data right now.

I wouldn't have made it through the past years of grad school without the love and laughter of my dear friend, Mike Kerkman. He is my biggest fan, always raving about my cooking and laughing the loudest at my jokes. I feel like we've known each other forever. Thanks, Mike, for sharing so many ridiculously funny moments with me.

And finally, thank you to my family. Without their unconditional love I wouldn't be where I am today. Their love helped me to cope with my father's unexpected death last spring. Crying and laughing with them gave me the strength and courage that I needed to come back to Wisconsin and finish this thesis! Thank you Mom, Dad, Mere, Jen, Matt, Will, Victoria, Jim and Edite.

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Chapter One

The Problem and Its Setting

The Importance of the Study

Energy is more than an individual economic, environmental, or sociopolitical issue or a passing concern. It is the agent of change for all processes on Earth and throughout the universe. Every interaction among living and nonliving things is accompanied by the transfer and conversion of energy. Energy is the underlying “currency” that is necessary for everything humans do with each other whether in the work place or in their personal lives. (KEEP Conceptual Framework, 1996)

We use energy every minute of every day. It is inside and all around us. Few people are aware of the role that energy plays in our lives, from providing us with hot water every morning to shaping the nation’s foreign policy. Since the Industrial Revolution, the United States has used fossil fuels as our primary energy resource. Fossil fuels have long been known to have a detrimental impact on the environment. It is widely accepted in the scientific community that the gases emitted into the atmosphere from fossil fuel burning are a cause of many of the environmental problems that our planet now faces. Furthermore, our energy consumption has increased since the Industrial Revolution as our population has grown and more energy-intensive products have been introduced into our society such as automobiles, computers, high-definition televisions, and video games. Thus, as a society we are using ever-increasing amounts of fossil fuels to feed our growing energy demand.

Moreover, fossil fuels are a nonrenewable resource; they cannot be replenished in our lifetime. They require millions of years to form deep beneath the earth and once they are removed for our consumption, they are unavailable for future use. Few people realize the implications of using such vast quantities of a nonrenewable resource. Our dependence on fossil fuels has resulted in great importance being placed on ensuring access to these resources. This, in turn, has lead to tension in regions that possess fossil fuel resources, namely oil in the Middle East. In the case of the Gulf War, the United States was willing to go to war, in part, to protect our access to oil.

In order to help people become more aware of where our energy resources originate and the important role they play in our society, national, statewide, and local energy education programs have sprouted up throughout America. One such program is the Wisconsin K-12 Energy Education Program (KEEP); it has as its mission statement to initiate and facilitate the development, dissemination, implementation, and evaluation of energy education programs within Wisconsin schools. KEEP began in 1995 to help promote energy education by creating a curriculum and offering teacher education classes that examine how we use energy and where it comes from, how we develop energy resources, the effects of energy resource development, and how to manage energy resource use.

One possible way of managing energy resource use is to educate about the possibility of a shift from using fossil fuels to renewable energy resources, such as solar, wind, hydropower, biomass, and geothermal energy. Since large amounts of energy are needed to meet the growing demand and the amount of energy needed

continues to increase as our economy expands and our standard of living improves, it is of utmost importance that we manage our existing nonrenewable resources wisely and pursue the research and development of renewable energy resources.

Solar, wind, hydropower, geothermal, and biomass energy are all present in Wisconsin. Wisconsin does not contain any fossil fuel resources; they all are imported into the state. Developing renewable energy resources could diversify and boost Wisconsin's economy and decrease our dependence on fossil fuels, reducing the environmental problems and international tensions associated with fossil fuel use.

A small percentage of people in Wisconsin are currently using renewable energy. According to the Wisconsin Division of Energy, five percent of energy demands are met with renewable energy (2001). However, certain utility companies are beginning to investigate its benefits. Some companies have already installed wind farms for electricity generation and some new buildings are using geothermal systems to meet heating and cooling needs. For the most part though, renewable energy technology is still not widely accepted by the general populous. Common complaints include its high cost compared to fossil fuel generated electricity and the potential adjustments in lifestyle that using renewable energy would require. These concerns may or may not be valid, depending on the situation.

Energy education programs help clarify ideas involving renewable energy use. They provide people with accurate information regarding the benefits and challenges of using renewable energy and how to incorporate it into their lifestyle so that it can work for them, if they so choose. Potentially, energy education can increase the number of people using and supporting the development of renewable energy

resources. KEEP has effectively been increasing and improving energy education in Wisconsin and is currently enhancing its renewable energy component with hopes of providing educators with facts regarding alternative energy.

In this study, sponsored by KEEP and Wisconsin Focus on Energy, a renewable energy conceptual framework and an instrument to measure the percentage of concepts in the framework that are covered by a given activity guide were created. The development and subsequent use of a renewable energy conceptual framework increases awareness and gives others a comprehensive, thorough tool to guide the development of teaching and implementing renewable energy education programs and curricula. Educators can use the renewable energy conceptual framework to identify concepts that can help people understand renewable energy. The framework includes major concepts important in understanding renewable energy, including the development and management of solar, wind, hydropower, biomass, and geothermal energy resources. The framework is organized in a way as to facilitate a logically sequenced, comprehensive renewable energy education. A comprehensive renewable energy education will help to produce a knowledgeable citizenry capable of making informed decisions.

The second part of this project included developing an instrument to determine the extent to which a given activity guide addressed the renewable energy concepts presented in the framework. The instrument consisted of a dichotomous key and rubric, which were used to assess the KEEP activity guide for its coverage of renewable energy concepts by measuring the percentage of concepts in the framework addressed by the guide. Although the key and rubric were tested on the

KEEP activity guide, they can be used to assess the renewable energy content of any activity guide. The instrument could also be used as a blueprint for future renewable energy education curricular materials. The applications of the framework and associated tool are many. Together, they provide a solid base for renewable energy education.

The Statement of the Problem and Sub-problems

Problem

The purpose of this study was to develop a conceptual framework for K-12 renewable energy education and to create an instrument to determine the percentage of concepts in the framework that are covered by a given activity guide.

Sub-problems

The sub-problems are as follows:

1. Develop a valid conceptual framework for K-12 renewable energy education.
2. Design an instrument to determine the percentage of concepts in the framework that are covered by a given activity guide.

Limitations

1. The study solicited input from a sample of eleven selected renewable energy experts.
2. The participants involved in the validation of the renewable energy conceptual framework were chosen using the Delphi process; they were not randomly selected.
3. The conceptual framework included only what were determined to be key representational concepts.
4. The study was limited to the development of the conceptual framework; the creation of a curriculum from the conceptual framework was not part of the study.
5. Personal judgment is necessary when using the instrument to measure the percentage of concepts in the framework covered by a given activity guide.
6. The evaluation of the KEEP activity guide for renewable energy content focused only on the 44 activities found in the KEEP activity guide, not activities found in the KEEP Elementary Supplement.
7. The design and organization of the renewable energy conceptual framework was based on existing KEEP documents.

Definition of Terms

Concept A concept is a broad statement under which there may be several topics and many facts.

Conceptual Framework A conceptual framework identifies essential ideas necessary for understanding a particular topic. It provides guidance for curriculum development and program design.

Delphi Technique A method of generating ideas and facilitating consensus among individuals who have special knowledge to share, but who are separated by geographical distance.

KEEP The Wisconsin K-12 Energy Education Program.

Nonrenewable Resource A naturally occurring raw material or form of energy that does not have the capacity to quickly replenish itself through ecological cycles and sound management practices. Nonrenewable resources cannot be replenished within a person's lifetime. Oil, coal, and gas (fossil fuels) are examples of nonrenewable resources.

Renewable Resource A naturally occurring raw material or form of energy that has the capacity to quickly replenish itself through ecological cycles and sound

management practices. Renewable resources are often replenished on a daily basis.

The sun, wind, falling water, and trees are examples of renewable resources.

Renewable Energy Expert/Professional A renewable energy expert is an experienced person in the field of renewable energy, displaying special knowledge derived from training or experience.

Tool or instrument to measure the percentage of concepts in the framework covered in a given activity guide This refers to a dichotomous key and rubric. The dichotomous key was used to determine if a given concept was addressed by an activity, while the rubric was used to record the findings and determine the percentage of concepts covered by the guide.

Assumptions

1. The renewable energy experts that offer guidance during the study are qualified and knowledgeable in their field.
2. There are certain renewable energy concepts that should be included in the conceptual framework because they are key representational concepts.
3. KEEP will use the renewable energy conceptual framework to create a comprehensive renewable energy education activity guide.

Chapter Two

The Review of the Related Literature

Introduction

This section discusses literature relevant to the development of a renewable energy conceptual framework and to the development of an instrument that can determine the percentage of renewable energy concepts covered by a given activity guide. The chapter is organized into the following sections:

1. Environmental Education
2. Energy Education
3. Renewable Energy Education
4. Need for a Conceptual Framework
5. Delphi Process as a Technique to Identify Valid Essential Concepts
6. Applications of a Conceptual Framework: To Assess Curricula
7. Summary

Environmental Education

Engleson and Yockers (1994) state that the aim of environmental education is to help students become aware, knowledgeable, skilled, dedicated citizens who are committed to work to improve and sustain the quality of the environment on behalf of present and future generations of all living things. Many topics are taught as part of environmental education such as land use, water, and energy education. Energy education, like environmental education, has as its goal to increase awareness and knowledge and give people the tools they need to make responsible energy choices. Generally, environmental education and its associated topics are not separate subjects taught in school, but are integrated into different subject areas throughout many grade levels. Environmental education has the potential then to reach students of all ages and across many different disciplines. In fact, the Wisconsin Department of Public Instruction (DPI) requires that environmental education be taught to all students at every grade level, as is has developed state academic standards for EE. Furthermore, school districts in Wisconsin are required to develop a K-12 environmental education curriculum. The majority of Americans support the inclusion of environmental education in school curricula; a Roper poll found that 95% of adult Americans supported environmental education being taught in schools (2001).

Environmental education proposes that students should understand that humans are components of the natural ecosystem. We depend on the natural

resources found in our environment to provide energy to maintain our lifestyle and feed our growing economy. We use the ecosystem to satisfy our needs and desires; humans maintain a certain level of ecological dominance (Sheaffer, 1975). This has had serious environmental consequences. Effects of human development permeate every ecosystem on the planet.

Environmental education has the potential to increase understanding of the human effects on the natural world so as to produce a knowledgeable citizenry capable of making responsible decisions. A person who has received effective environmental education will be able to, for instance, make wise energy decisions taking into account various factors including the environmental, economic, social and political effects of a particular decision. Environmental education is unique in the fact that it has an opportunity to lay out the vision of what could be, and to take steps toward achieving that vision (Sheaffer, 1975).

Energy Education

One facet of environmental education is energy education. The aim of energy education is to increase awareness and knowledge regarding energy: where it comes from, how we use it, how we develop and manage energy resources, and the effects of energy use. The DPI requires that energy be taught in Wisconsin schools, as concepts involving energy can be found in the state academic standards for environmental

education and science. The goal of energy education, as in environmental education, is to produce a citizenry capable of making informed energy-related decisions.

The concept of energy education came into the forefront during the energy crisis of the early 1970s. In October of 1973, panic gripped the United States. The oil-rich Middle-Eastern countries had cut off exports of petroleum to Western nations as punishment for their involvement in Arab-Israeli conflicts. Although the oil embargo would not ordinarily have made a tremendous impact on the US, panicking investors and oil companies caused a gigantic surge in oil prices (Kochan & Allen, 1981). The situation turned out to be one of the most memorable of the 1970s. Those who can remember the so-called "Mideast oil crisis" also remember long lines at the gas pump due to petroleum shortages and high gasoline prices.

Management and consumption of energy resources were suddenly viewed as major issues in our nation. Energy education in the classroom began to take on a new importance (Kochan & Allen, 1981). However, it was realized that teachers were not energy literate themselves and thus not properly educating their students regarding energy issues. It was during this time that many energy education programs began. However, even many years after the oil crisis, when energy education was supposed to have taken hold, adults were still found to have little hard knowledge about energy and had little sense of civic efficacy in impacting solutions to energy issues (Kochan & Allen, 1981). For example, research conducted by La'wrenz (1986) showed that forty two percent of science teachers in Arizona were reported as not teaching energy education in their classroom (La'wrenz, 1986).

The lack of energy education in the classroom has been perceived as having a detrimental effect on students' attitudes toward energy. Overall, students have been shown to have a poor attitude regarding energy (Barrow & Morrissey, 1987). That is, students did not show support for energy conservation and showed little concern for environmental problems in a survey that was distributed to ninth-graders. This is a serious concern for energy educators, as Barrow and Morrissey delineated that positive attitudes toward energy were imperative for world survival. Indeed, a major goal of energy education is to modify students' attitudes toward energy (Barrow & Morrissey, 1987). This could be accomplished through the inclusion of energy education in the grades K-12 curriculum as recommended by the National Association of School Boards (Barrow & Morrissey, 1987). In fact, there was a short-lived movement to incorporate energy education into school curricula in the late 1970s and early 1980s (Karst, 1985). Based on research conducted in the late 80s by Barrow and Morrissey (1987) of students' attitudes and knowledge regarding energy, this movement either did not take hold in public schools or did not have the desired effect of increasing knowledge regarding energy usage.

Regardless, Barrow and Morrissey (1987) still argue that energy education in schools is the best vehicle for generating public awareness of areas of energy concern, as certain school-based energy education programs have been shown to have a direct and immediate impact on energy conservation by students (Allen, LaHart, Dawson and Patterson, 1977). Classrooms across the nation offer opportunity for intensive and effective energy education programs.

In 1995 the Wisconsin K-12 Energy Education Program (KEEP) was founded with the mission of initiating and facilitating the development, dissemination, implementation, and evaluation of energy education programs within Wisconsin schools. KEEP developed a comprehensive energy conceptual framework, activity guide, and teacher education program. Almost 2,000 teachers have participated the teacher-education classes offered by KEEP. It is possible by that educating teachers, KEEP will increase the amount of energy education being taught in schools, thus ensuring that statistics such as those documented by La'wrenz (1986) in Arizona schools not be repeated Wisconsin. La'wrenz found that 42% of science teachers in Arizona were not teaching about energy. With ongoing turmoil regarding the planet's oil supply and our access to it, deregulation and high energy prices, energy education is an increasing national and a personal need in America.

As with environmental education, the majority of the public has been shown to support energy education in schools (Roper Poll, 2002). A Roper poll conducted in 2002 showed that 90% of Americans support energy education being taught in public schools. Results of the survey of 1,500 Americans suggested that Americans want energy education to begin in childhood and to extend into adulthood.

Despite the overwhelming support for energy education by the American public, and despite earlier research on the need for, importance of, and success of energy education programs (Barrow & Morrissey, 1987; Allen et al., 1977), a Roper poll (2002) found that Americans' knowledge regarding energy is still not satisfactory. Just 12% of Americans surveyed passed a basic quiz measuring energy knowledge. Thirty years after the oil crisis of the 1970s, just one in eight Americans

can correctly answer questions such as how most of our electricity is generated, whether gas mileage is rising or falling, and what the fastest growing sector of the economy is with regard to energy consumption. The lack of energy knowledge displayed by the American public is important in that the results of the Roper poll (2002) suggest that actual knowledge, i.e., the number of correct answers scored on the energy quiz, correlates with the likelihood of participating in energy-friendly activities. Such activities could include recycling and using public transportation or biking in lieu of using private vehicles. It may be inferred that higher levels of knowledge of energy production, consumption, and conservation as measured by the number of correct answers on the quiz section are associated with an increased likelihood of engaging in day-to-day activities that directly or indirectly conserve energy. Increased knowledge of energy issues alone will not improve the management and conservation of energy resources. However, in order for Americans to understand and participate in energy-conservation practices, a markedly higher level of knowledge is required (Roper Poll, 2002). It is important to create opportunities for the population to expand its energy-related knowledge, resulting in educated adults who make responsible, informed energy-use decisions.

Although research regarding energy education that took place in the late 70s through the mid 80s showed that energy education was needed in schools and that it was beneficial (Barrow & Morrissey, 1987; Allen et al., 1977), it seems to have had little effect on the knowledge and attitudes of the adults surveyed in the 2002 Roper poll. It is plausible that the energy education and its associated research that took place in the late 70s and early-to-mid 80s was a short term result of the 1970s oil

crisis and failed to extend beyond the mid 80s, as this is when the research on energy education seems to have almost completely ceased. Regardless, based on the dearth of research on energy education from the mid 80s to the present day combined with the failing marks of Americans on an energy quiz (Roper Poll, 2002), it is clear that energy education is needed.

Renewable Energy Education

Energy education was an important result of the national oil crisis. However, increased research and development of fossil fuel alternatives was also a result of the crisis (Karst, 1985). Long lines at the gas station and increased fuel prices amplified the need for renewable energy. Oil and natural gas availability were no longer viewed as being dependable in the long run (Jackson, 1985). This caused people to look for alternative energy sources.

Renewable energy sources have been used throughout human history, with our dependence on fossil fuels developing only with the onset of the industrial revolution. Thus, the major sources of energy have changed from renewable ones such as plants and animals, to depletable ones such as coal, oil, and natural gas. Following the oil crisis, there was a renewed interest once again in energy resources that can be replenished with relative ease (Allen et al., 1977).

After the oil crisis, the government began to devote increasing resources to the research and development of renewable energy sources. In the mid-1970s, the United States Department of Energy published a study on solar energy, addressing how we

might use the sun's energy more efficiently, thereby cutting heating and cooling costs and improving quality of the environment (Karst, 1985). However, there is more to be done than simply using passive solar energy to heat and cool our homes. While these actions are laudable, Sheaffer (1975) suggested that we have to consider some basic changes in the systems that serve our society. Increasing awareness and knowledge of renewable energy systems is a necessary first step in a societal shift away from fossil fuel dependence. Renewable energy education is pivotal in making the change to utilizing renewable energy resources. One of the great virtues of education is that it has the potential to help society shape imaginative solutions to its problems (Karst, 1985).

Many students of today are not aware that there was an energy crisis in the 1970s. However, it is evident that even into the late 1980s, students were skeptical regarding the use of fossil fuels. Barrow and Morrissey (1987) found that sixty five percent of ninth-grade students in New Brunswick, Canada and Maine, United States worry about the effects of petroleum products on the environment. Other important reasons have emerged that remind us of the need for renewable energy education. In the year 2000, many Californians experienced rolling power blackouts due to, in part, the high power demand and limited fossil fuel resources. Furthermore, the increased greenhouse gases in our atmosphere that are causing global warming are believed to be caused by the burning of fossil fuels. Increasing consumption of energy derived from fossil fuels leads to deleterious impacts on ecosystems such as increased carbon dioxide, a greenhouse gas, and heat in the atmosphere (Engleson & Yockers, 1994). Global warming will affect all nations and all species on the planet. It is a constant

reminder that there is a growing need for increased use of less polluting renewable energy.

Sheaffer (1975) suggested that our failure to implement many renewable energy programs is due in part to our poor attitude regarding energy. For instance, Sheaffer proposed that Americans believe waste is useless once it enters a garbage dump. Instead, waste can be used to generate biogas, a renewable energy resource. Renewable energy education has the potential to change or improve any negative attitudes that may persist today.

Research conducted in the mid 1980s by Jackson suggested that limits to an energy-intensive way of life, at least one based on the non-renewable fossil fuels resources, were fast being approached, and thus some form of energy transition was inevitable (Jackson, 1985). Jackson (1985) concluded that simultaneous signs were emerging that suggest new perceptions, attitudes, and behaviors regarding energy use were becoming more prevalent among certain proportions of the public. In Jackson's study, 490 undergraduates at the University of Alberta rated a series of energy-related statements using a five-point Likert scale; the statements were designed to measure the perceptions, attitudes, and behavior of the students regarding energy use. Jackson found that 43.3 percent of those surveyed support the implementation of energy conservation practices and renewable energy use, as opposed to a society based on the use of synthetic fuels, oil, gas, coal, and nuclear energy. The percentage of people found to support energy conservation practices and renewable energy use increased from a study conducted by Jackson and Foster in 1982. Jackson concluded that these

changes in perceptions were symptomatic of the early stages of a shift from dependence on fossil fuels to renewable energy resources.

Although Jackson's work is promising from an environmental point of view, as of 2003, there still has not been a shift from fossil fuel use to renewable energy. Renewable energy resources are currently meeting only five percent of Wisconsin's energy needs (Wisconsin Energy Division, 2001). Renewable energy education must not only continue, but also increase if changes in attitude and a resulting shift in type of energy dependence are to occur.

There are many misconceptions and misinformation regarding renewable energy use. Students demonstrated a positive attitude toward solar energy, but less positive support for modification of lifestyles in a study conducted by Barrow & Morrissey (1987), suggesting that students believe that using renewable energy will involve changes in lifestyle. This is not necessarily the case. In many areas in the world, solar energy can produce enough heat and electricity for nearly any modern home without a noticeable change in lifestyle. Furthermore, students surveyed by Jackson (1985) were found to view solar energy as a long-term solution to our energy problems, but not a short term one. This finding indicates a perception that solar energy needs major technological breakthroughs before it is competitive with other energy resources (Jackson, 1985). This is also not the case. Homes, businesses and factories in this country and abroad are currently utilizing solar energy.

More recently, a Roper poll conducted in 2001 of 1,500 Americans documented the lack of knowledge surrounding renewable energy use. When asked

which was a renewable resource, 12% of those surveyed chose oil, 4% chose iron ore, 6% chose coal and 24% didn't know (Roper Poll, 2001).

Clearly, renewable energy education needs to reach more Americans. There are many resources such as books, activity guides, videos, and websites that are helping to facilitate the incorporation of renewable energy education into classrooms. A list of selected renewable energy education resources and websites is included in Appendices A and B, respectively. Renewable energy education must be assimilated into classrooms across the nation, in all grade levels, in order to be most effective.

Need for a Conceptual Framework

If renewable energy education is to be assimilated into schools across the country, it is necessary that a framework exist to delineate for teachers those concepts necessary in understanding and teaching renewable energy. Generally speaking, a conceptual framework is a method of organizing thinking about a particular topic (Taba, 1962). It outlines the subject content for learning the knowledge representing a subject (Kemp, 1985).

Tossing together a curriculum of fragmented topics rather than a coordinated and articulated plan for learning will not work; a conceptual framework is needed (Erickson, 2001). A conceptual framework provides a thorough list of main ideas that provide a method through which inquiry and lessons can be developed. Frameworks are important in delineating curricular development (Kemp, 1985). It is

important to keep in mind the conceptual framework while developing activities, making sure that the activities address the concepts, not merely facts. It is recognized that understanding concepts and principles signifies a deeper understanding than merely memorizing and comprehending facts (Erickson, 2001).

Erickson (2001) explains that studying facts as information to be memorized fails to engage the deeper intellect of students. When students are encouraged to think beyond the facts and connect factual knowledge to ideas of conceptual significance, they find relevance and personal meaning. When students become personally and intellectually engaged, they are more motivated to learn because their emotions are involved. This type of learning, called conceptual learning, stems from a conceptual framework and is important because it allows students to retain more information. Again, it demonstrates a higher cognitive level (Erickson, 1998).

Providing a conceptual framework for curriculum developers and teachers to use can help remind them to emphasize the concepts, or facts that illustrate the concepts, not isolated facts.

Furthermore, a conceptual structure is an efficient means for handling the growing body of information available to students today. Concepts focus and streamline the breadth of content; they provide an instructional model that is “idea centered,” rigorous, and engaging for both students and teachers and ensure that teachers are clear on the concepts and “big ideas” that students must understand in regard to a particular concept. Concept-based curriculum and instruction solve the problems of how to reduce an overloaded curriculum, and how to systematically articulate the K-12 curriculum to engage higher-level, complex thinking and develop

deeper understanding. Moreover, idea-centered curricula raise academic standards by bringing relevance and rigor to learning (Erickson, 2001). Concept-based curriculum design allows the teacher to control rather than be controlled by the subject matter and provides the flexibility to allow students to search for and construct knowledge.

A conceptual framework is especially needed today, in the information age, where knowledge is expanding exponentially and the ability to process a large amount of information at abstract levels of thinking becomes more critical each year (Erickson, 1998). Global interdependence and sophisticated technologies require that we raise the intellectual standards in classrooms (Erickson, 2001). The fact-based model of curriculum design is limiting and antiquated in today's world. If we are to develop the thinking abilities of students systematically then we need to move from a solely topic-centered to an idea-centered model of curriculum design (Erickson, 1998). Topic-centered curricula focus heavily on the memorization of facts and assume the development of deeper ideas. Idea-centered curricula focus on deeper, conceptual ideas and use facts to support the understandings. A conceptual framework will facilitate the idea-centered type of curriculum design that Erickson recommends for effective learning.

The need for a conceptual framework is further suggested by the fact that teachers prefer to use educational tools that have already been created and tested for effectiveness; they do not have time to create materials themselves. Thus, it would be beneficial to have national subject area organizations develop lists of the most significant organizing concepts to serve as frames for the critical curricula content (Erickson, 2001). This would save educators valuable time. A conceptual framework

would also provide consistency in the topics to be covered in subject areas throughout the nation. In the case of energy education, it has been found that there is almost no consistency in the type of energy education materials that are used (La'wrenz, 1986). This translates to students receiving an incomplete, fragmented energy education. A conceptual framework may provide the consistency necessary for effective education. Furthermore, national standards include the statement that students will understand the concepts and principles of science. It would therefore be valuable for educators to have a conceptual framework in hand so that they would know which concepts to teach.

In summary, any enterprise as involved and complex as curriculum development necessitates a conceptual framework to guide it (Taba, 1962). Concepts are the foundational organizers for both integrated curriculum and for single-subject curriculum design (Erickson, 2001). The flexibility of a framework enables units to be produced that are appropriate for any grade level (Allen et al., 1977). And because of its multidisciplinary nature, a framework can be used in both formal and non-formal educational settings. A renewable energy conceptual framework in particular can serve as a tool for educators involved in the development of energy-related materials and teaching units; it can provide a core for the development and implementation of a viable energy education program (Allen et al., 1977).

Delphi Survey as a Technique to Identify Essential Concepts

It has been established, then, that a conceptual framework is needed for the development of any comprehensive energy education program. But which concepts are selected to appear in the framework and how are they chosen? The Delphi technique is one approach to select and validate concepts to be included in a framework.

The Delphi survey approach is a technique for gathering data that is similar to using focus groups. Unlike focus groups, however, Delphi groups do not have to physically meet. The Delphi technique is a method of generating ideas and facilitating consensus among individuals who have special knowledge to share, but who are not always in contact with each other. Unlike survey research, which insists on a random sample that represents all parts of the population, a Delphi study carefully selects individuals who have knowledge necessary to analyze a specific problem. The persons selected comprise the panel and are considered experts in their field; that is, they are persons who have sufficient knowledge and experience derived from training. An expert is a source of valuable information and has the advantage of a wider view of the topic area and its interrelationships (Wulf & Schave, 1984). Through a series of surveys, they share and generate new ideas based on an emerging consensus among panel members.

As outlined in Crance's study (1987), there are typically three rounds in a Delphi survey. The first round is a series of open-ended questions. Respondents give

their responses, from which appropriate statements or questions are drawn. The nature of the open-ended questions, responses, and statements drawn from the responses are dependent on the aim of the project. In round two, participants rate or modify questions or statements. The responses are tabulated, analyzed, and fed back to the experts. The results of round two are included in the revised questions or statements, which are then sent to the panel again. In round three, panel members re-answer the questions in light of the information generated by the aggregate responses. Panel members justify their response if it differs from the norm.

Although traditional Delphi studies begin with open-ended questions, Uhl (1975) suggested that a structured questionnaire in which panel members were asked to modify statements or add items they believed to be important provided for the consideration of a larger number of items and produced less statistical mortality in the study. Furthermore, Schuster, Frissell, Baker, and Loveless (1985) found that as the three Delphi rounds progressed, there was convergence toward consensus but overall median ratings did not change. The first round provided a near-perfect approximation of the final results. It is important, however, to conduct more than one round as consensus enhances credibility (Schuster et al., 1985). Items to be ranked in the modified Delphi survey used in this study, as in the studies of Eggers and Jones (1998), were developed from a careful review of literature and validated by a focus group of knowledgeable people in the field. This process created the initial structured questionnaire.

The number of experts chosen to participate in the Delphi process varies among studies. An optimal number of panelists has not been determined. There have

been studies that have recruited over 100 panel members. However, it has been suggested that ten to fifteen participants is enough and that few new ideas are generated once the size exceeds thirty individuals (Delbecq, Van de Ven, & Gustafson, 1975). Crance (1987) states that a panel consisting of about ten experts is ideal, but more than ten may be used if desired. Research by Schuster et al. (1985) suggests that there is no significant difference between panels of six and eleven; their median ratings were virtually identical.

Crance (1987) outlined in a study the process whereby experts are chosen. Schuster et al. (1985) followed a similar method. One or two people considered experts on the particular topic were identified in Crance's study. They were then called and interviewed. The objectives of the proposed exercise, the Delphi process in general, and the need for the study were discussed with the expert who was then asked the following questions: Do you feel comfortable being considered an expert? Would you agree to serve as a panelist of the proposed Delphi exercise? Whom do you consider to be highly knowledgeable about this topic? This procedure was repeated until a list of 15 to 20 potential panelists was obtained. Delbecq et al. (1975) agree that this nomination process is a valid method of selecting panel members.

Decisions made by groups are more likely to be correct than predictions made by the same individuals working alone (Kaplan, Skogstad, and Girschick, 1950); groups of people have been shown to converge toward the correct answer (Reeves & Jauch, 1978). Furthermore, the Delphi technique makes the collection of opinions from distant geographical areas possible since this methodology does not allow for face-to-face meetings. Therefore, using the Delphi process to reach a consensus

regarding important renewable energy concepts is a valid method for producing a conceptual framework.

Validity of the resulting judgment of the entire group is typically measured in terms of explicit degree of consensus among the experts (Linstone & Turoff, 1975). What distinguishes the Delphi from an ordinary polling procedure is the feedback of the information gathered from the group and the opportunity of the individuals to modify or refine their judgments based upon their reaction to the collective views of the group. Other characteristics of the Delphi process include various degrees of anonymity imposed on the individual and collective responses to avoid undesirable psychological effects.

Delphi can be applied to a wide range of activities (Delbecq et al., 1975; Schuster et al., 1985). However, certain properties of studies lead to greater need for employing Delphi. It has been suggested that it is particularly useful to employ Delphi when developing a conceptual framework since its development does not lend itself to analytical techniques but instead benefits from a variety of collective judgments (Brody, 1995; Reeves & Jauch, 1978). Using the Delphi technique as a means to identify those concepts essential in understanding renewable energy insures that a consensus is reached among renewable energy professionals. Using the Delphi process improves the rationality of the design process and enhances decision-making with respect to curricular development (Reeves & Jauch, 1978).

Applications of a Conceptual Framework: To Assess Curricula

Once the essential concepts are identified and placed into a framework, it is then necessary to examine its application as an educational tool so that it can be utilized in educational settings across the nation. For if the concepts are valid, but educators do not find it useful, it will not become a valuable educational resource.

A renewable energy conceptual framework can be used, among other things, to assess existing curricula and programs, as well as to plan future curricula projects. It can be used to determine to what extent existing activities or activity guides address renewable energy or it can serve as a model when developing curriculum as to which concepts are to be covered.

Assessment is the process of determining the value of something (Woody, 1997). It is a complex and detailed process that uses measurement to gauge program needs and outcomes (Cooper & Saunders, 2000). The implications of assessing current programs and curricula for renewable energy content are many. The results can be used to determine if it is necessary to create supplemental activities that better address the renewable energy concepts. Assessment can also be used to measure what has been accomplished, thus obtaining funding or justifying to stakeholders your worth. Or assessment can serve as justification for receipt or application of funding to improve the program. When in jeopardy of losing funds, results of an evaluation or assessment often play an important role (Woody, 1997). An assessment can be used to direct attention toward the goals and accomplishments of a particular program. If programs are not able to articulate their value, they probably will not survive

(Barron, 1993). Assessment can also be used to plan future programs. Prior to designing and implementing any programmatic initiative (refining, redesigning, creating new programs), the programmer should consider assessment (Cooper & Saunders, 2000).

Even if evaluation or assessment results are not positive, they are still of tremendous use for the purpose of advocacy. Results can be used to guide decision making, as well as to develop grant proposals and recommend curriculum changes (Barron, 1993). The results of an assessment can clarify what changes are needed to help the program and can lead to positive changes in the curriculum (Woody, 1997).

Assessment tools need to be developed in order to more efficiently review a program or curricula. Exline and Tonelson (1997) stress that effective assessment tools are especially needed in science education. With an assessment tool in place, a K-12 science program can be assessed, data analyzed, a report prepared, and remediation prescribed within a relatively short time period (Exline & Tonelson, 1997). Thus, data are available quickly for informed short, intermediate, and long-range planning. Having an assessment tool that can be readily adapted to evaluate various programs can effectively and efficiently provide valid and useful data for making decisions about programs.

A wide variety of materials can be used for program evaluation (Woody, 1997). One particular type of assessment tool that is being increasingly used is the rubric (Custer, 1995). Custer defines rubrics as scoring devices or tools designed to assist in the process of clarifying, communicating, and assessing expectations; they are particularly useful in assessing criteria that are complex and subjective. In this

case, an activity or an activity guide is being evaluated using the renewable energy framework. Determining if an activity addresses a particular renewable energy concept is subjective, thus Custer would argue that a rubric would be an appropriate assessment tool. A rubric helps organize the data, making it easier to assess the activity guide and see the results.

Rubrics exist in a variety of forms and vary considerably in degree of complexity. All are focused on measuring an identified performance and include some form of scale used to rate performance (Custer, 1995). Creating a template of a rubric may be helpful as templates are adaptable and can be easily used to assess performance in many different settings. Using a template improves assessment efficiency, as the necessary data can be plugged into “the shell” and results can be generated quickly. A “shell”, or template, provides a means of maintaining consistency within and among assessments (Custer, 1995).

Custer (1995) advises that when using a template, the initial step in filling it in is to select and validate the objectives (concepts, in this case) for a unit or activity. The Delphi is one means of validating the concepts (see previous section). The importance of this step cannot be overstated because objectives maintain a focus on the purpose of the activity rather than allowing the activity to become an end in itself (Custer, 1995).

Rubrics may not only be used to assess existing programs, but they may also be used when creating new programs or activities. Rubrics, with the objectives or concepts listed on the template, may be openly shared with curriculum developers and program coordinators at the outset of program development so as to clearly

communicate expectations (Custer, 1995). Curriculum developers and program coordinators can then refer back to the rubric to monitor their activity and progress throughout the creative process.

Rubrics are potentially an extremely useful tool. Custer (1995) discusses many of the advantages of using rubrics in assessment; they enable assessment to be more objective and consistent, focus the attention of the evaluator on the important outcomes, demystify the objectives or concepts to be covered, allow educators to focus on weak areas, force the evaluator to clarify his/her criteria, encourage a consciousness about the criteria and provide benchmarks against which to measure and document progress. Implementation of a rubric as an assessment tool should be seen as a beginning for potential reform and improvement, not as an end in itself. Decisions can be made on a well-informed basis once an assessment model is complete.

It is noteworthy that although rubrics clearly lay out and objectify those factors that are to be assessed, there is still a certain amount of subjectivity involved in the assessment itself. For example, if a rubric was being used to assess a project done by students, then on one axis a list of students' names would appear and on the other a list of criteria used to assess the student's work would be listed. The criteria used to grade the project might include subjective parameters such as neatness and creativity. One teacher may think that a student's work is very neat, but not very creative, while another teacher may look at the same work and think that is it messy, but very creative.

The review of related literature provided evidence that rubrics can help objectify the parameters used in assessment and even that the methods used to choose the parameters can be validated by processes such as the Delphi technique. However, no tool or method was discovered in the literature to help minimize the subjectivity involved when using a rubric for assessments that do not clearly have a right or wrong answer.

However, based on the literature involving the use of rubrics, they are useful tools. As previously mentioned, the results of using a rubric as part of an assessment that involves subjectivity, such as curricular assessment, could vary depending on who is conducting the review. No tool to minimize subjectivity involved in such a process was found in the review of related literature.

In the case of this study, the concepts in the framework provided the content against which a curriculum was evaluated, while the rubric provided the organization and consistency needed to make this an effective process. This technique of assessment can be applied to many different curricula in various education settings.

Summary

To improve the quality of life and environmental integrity in modern society, we need to make better use of our energy resources. One reason for our failure to better manage our energy resources is a lack of understanding of the choices regarding energy use that are available and the effects our choices have on the

environment. It is an information gap rather than a technological lack that prevents us from realizing the potential benefits that could result from better management of energy resources (Sheaffer, 1975). Energy education can play a central role in lessening this information gap.

In order for society to make responsible energy-use decisions, people must be educated as to the effects and benefits of each energy source. Education must begin with very young children and continue throughout their school years. It would be most beneficial to integrate renewable energy education into many different academic disciplines. In order to ensure that the information received by students is consistent, there must exist a framework of ideas around which educators could structure lessons and activities.

The renewable energy framework, in order to be most effective, must have practical uses for the educator. It can serve as the backbone for the assessment of activity guides regarding the extent to which they cover renewable energy concepts. This has many implications, such as defining the need to create more renewable energy education materials. Rubrics can help organize the information in an assessment and serve as a useful educational tool. Together, a renewable energy conceptual framework and accompanying rubric can help educators evaluate existing educational material and plan future curricula with relative efficiency and considerable effectiveness.

The renewable energy conceptual framework was created with the hope of providing the necessary information for people to make responsible energy-use decisions. It was designed for teachers to use and adapt for any subject or grade level.

Lack of energy education material has been cited as a barrier to implementing energy education in the classroom. In a study of teachers in Arizona, La'wrenz (1986) found that of the teachers who did not include energy education in their classrooms, 87% said it was because of the lack of instructional material. Thus, more valid, useful educational tools are necessary to promote effective renewable energy education. This framework will serve as a valuable educational resource for teachers interested in promoting renewable energy education. The framework delineates the essential components of renewable energy so that when all of the concepts have been covered, educators can be confident that their students have received a complete renewable energy education. Conceptual frameworks have the important job of telling the audience where their education is headed, for "if people don't know where they're going, how can they get there, and how do they know when they have arrived?" (Roeder, 1994).

It is noteworthy that in conducting a review of related literature it was found that the majority of the resources dealing with energy education were published before 1988. This further justifies the need for this project; the idea of energy education needs to be updated and brought into the 21st century. Furthermore, literature on renewable energy education was nearly nonexistent. Thus, it is with great importance that a renewable energy conceptual framework is created and that it is accessible and useful for educators. Research may then be carried out as to the effects that this educational tool has on the students of today. This will make it easier

for future educators and researchers to effectively develop more renewable energy education resources for teachers and their pupils.

Chapter Three

Methods

Introduction

The purpose of this study was to develop a renewable energy conceptual framework for K-12 renewable energy education and to create an instrument to determine the percentage of concepts in the framework that are covered by a given activity guide. The Wisconsin K-12 Energy Education Program (KEEP) funded the project. KEEP's renewable energy program is funded by Focus on Energy, a statewide public benefits program. Focus on Energy is a public-private partnership offering energy information and services to residential, business, and industrial customers throughout Wisconsin. The goals of Focus on Energy are to encourage energy efficiency and use of renewable energy, enhance the environment, and ensure the future supply of energy for Wisconsin.

The Wisconsin K-12 Energy Education Program began in 1995 with the goal of increasing teacher awareness and knowledge of energy. As of 2003, almost 2,000 teachers throughout the state have participated in KEEP energy education classes and received the accompanying conceptual framework and activity guide. When participants in the classes were asked what was lacking in KEEP, one common response was renewable energy information. Thus, KEEP desired to increase the

amount of renewable energy information in their guide. They hired a graduate student to create a renewable energy conceptual framework.

To create the framework, important renewable energy concepts were first identified. A graduate committee was selected based on the expertise that each member could offer the project; the graduate committee served as the advisory committee. A draft framework was then assembled from those important concepts and validated using the Delphi Process. The renewable energy conceptual framework was finalized using the feedback received from the Delphi process. A dichotomous key and accompanying rubric were identified and then created as a means to assess to what extent a given activity guide addressed renewable energy. A panel of non-formal energy educators used the key and rubric to assess the KEEP activity guide. This chapter outlines the steps in detail that were used to create the renewable energy conceptual framework and the tool to measure the percentage of concepts in the framework that are covered by a given activity guide. The organization of the chapter is as follows:

Sub-problem 1. Develop a valid conceptual framework for K-12 renewable energy education.

Task 1.1 Identify concepts essential in understanding renewable energy.

Task 1.2 Create a draft renewable energy conceptual framework.

Task 1.3 Validate the draft framework using the Delphi process.

Task 1.4 Finalize the renewable energy conceptual framework.

Sub-problem 2. Design an instrument to determine the percentage of concepts in the framework that are covered by a given activity guide.

Task 2.1 Identify and develop an instrument to measure the percentage of concepts in the framework that are covered by a given activity guide.

Task 2.2 Apply the instrument.

Each sub-problem and its associated tasks are listed below and the methodology that was used to accomplish each is explained.

Sub-problem 1. Develop a valid conceptual framework for K-12 renewable energy education

Task 1.1 Identify concepts essential in understanding renewable energy

An extensive search of renewable energy education material was completed over the course of three months, from June to August 2001. Materials reviewed included books on renewable energy technology, which were located in the Learning Resources Center (LRC) at the University of Wisconsin Stevens Point and in the Wisconsin Center for Environmental Education (WCEE) library within the LRC. Other materials reviewed for content included energy and/or renewable energy education activity guides and curricula in the WCEE library and on the Internet. A list of renewable energy education resources from the WCEE library and a list of websites were created. A review of both energy education and renewable energy

education resources was conducted because often energy education material has a renewable energy component. Careful attention was paid to the source of the information, especially on the Internet; websites created by government agencies such as the National Renewable Energy Lab (NREL) and the Department of Energy (DOE) were favored. It was assumed that information on these websites would be reliable and accurate. Information was photocopied or downloaded from the resources, compiled, and filed into folders based on the renewable energy resource that it addressed. Key points were extracted and synthesized into a separate document in a narrative form. The key points would form the basis of the draft framework.

Task 1.2 Create a draft renewable energy conceptual framework

The process of creating a draft renewable energy conceptual framework began by forming an advisory committee. The advisory committee and the graduate committee were one in the same, as the members of the graduate committee had extensive experience in developing environmental education curricula. Also, the methods that others have used to create frameworks were examined. The processes used to create the Project WET and KEEP conceptual frameworks were studied in detail in order to gain an understanding of the processes used.

Jennie Lane, the director of KEEP and member of the advisory committee, reviewed the renewable energy ideas and key points extracted from activity guides, books, and websites. Kane and Lane decided that the renewable energy conceptual framework should follow a similar format to the existing KEEP conceptual framework, therefore facilitating the renewable energy conceptual framework's

infusion into the existing framework. The KEEP conceptual framework is included in Appendix C. The renewable energy conceptual framework would enrich the existing KEEP framework with renewable energy facts and ideas; it would not be a stand-alone document. The advisory committee supported the idea.

Thus, the renewable energy concepts were placed into the four themes of the KEEP conceptual framework: We Need Energy, Developing Energy Resources, Effects of Energy Resource Development, and Managing Energy Resource Use. The first theme, We Need Energy, defines energy, describes how energy is transferred and converted from one form into another, and explains how energy flows through systems. The second theme, Developing Energy Resources, describes the sources of energy and how we use them to meet our needs. Effects of Energy Resource Development addresses how using energy resources affects human societies and the environment. Managing Energy Resource Use, the fourth theme, identifies ways in which we can help resolve many of the effects of energy development and use. After being placed into one of the four themes, the renewable energy concepts were further organized into subheadings mirroring those in the KEEP conceptual framework. Thus, a draft of the renewable energy conceptual framework was created.

Several meetings were held with members of the advisory committee regarding the content and organization of the renewable energy conceptual framework. Based on these discussions, revisions were made and again reviewed by members of the advisory committee. Staff from the Midwest Renewable Energy Association (MREA) provided further guidance and feedback. The MREA is a private non-profit that provides educational programming for people of all ages; they

also serve as a resource for those people seeking information regarding renewable energy. A preliminary draft of the conceptual framework was given to Clay Sterling, a renewable energy education specialist at the MREA. He was asked to identify major key points missing in the framework. Again, revisions were made based on Sterling's feedback and reviewed by the advisory committee.

For the next step in creating the draft framework, a focus group was held. The group consisted of experts in the energy and environmental curriculum development field. Participants included Jennie Lane and Bobbi Zbleski, KEEP staff; Dan Sivek, environmental education professor at UWSP and the major advisor of the project; Clay Sterling of the MREA; and Steve Hansen, a high school science teacher involved with renewable energy implementation at his school. Before the focus group met, the draft of the framework was altered to include space for comments and additional concepts. An example of a concept reformatted for the focus group follows in Figure 3.1.

Figure 3.1. A Concept Reformatted for the Focus Group

| |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>3. The five renewable sources used most often are solar, wind, hydropower (water), biomass and geothermal.</p> <p><i>Additional Concepts:</i></p> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

The focus group met for two hours. Discussion included concepts that were neglected, the importance of the existing concepts and whether or not they should be included, and the organization of the headings. The draft framework was again revised based on the feedback of the focus group.

Task 1.3 Validate the draft framework using the Delphi process

Research showed that the Delphi process was an acceptable method of validating the framework. Thus, after a draft of the framework was created, attention shifted to completing the Delphi process. Participants for the Delphi process were chosen by first selecting two renewable energy professionals, Jennie Lane and Tehri Parker, director of the Midwest Renewable Energy Association. Lane and Parker were instructed to name three other qualified renewable energy professionals each. Those three professionals were each instructed to name three more renewable energy professionals. This process continued until a total of thirteen professionals were named.

Those named were sent a letter over email inviting them to participate in assessing a renewable energy conceptual framework using the Delphi process. The project and the Delphi process were explained. A stipend of \$200 was offered to each participant.

A packet of information was mailed in February 2002 to the participants that included a thank-you letter explaining the project, a letter outlining the Delphi technique, a consent form, directions as to how to complete the Delphi process, a copy of the draft framework, a copy of the original KEEP conceptual framework, and

a scan-tron answer sheet. The procedure that the participants would follow by participating in the Delphi survey was submitted and approved by the Institutional Review Board at the University of Wisconsin-Stevens Point.

Participants were instructed to rate each concept using a Likert scale. The scale ranged from one to five, with one being “not important/do not include” and five being “very important/definitely include” Responses were recorded on scan-tron answer sheets. There was also space provided below each concept for the professionals to add additional key points. Before adding a particular concept, participants were instructed to first consult the KEEP conceptual framework in order to ensure that it was not already included in that document.

Upon completion of the exercise, the professionals mailed their survey back to KEEP where the results were analyzed. The mean, median and standard deviation for each concept were tabulated. The mean is commonly known as the average. The median is the score that divides a distribution exactly in half. And the standard deviation is a measure of variability; it uses the mean of the distribution as a reference point and measures the variability by considering the distance between each score and the mean. It determines whether the scores are generally near or far from the mean. They were then inserted into the draft framework underneath the concept that the statistics described. An example of a concept after round 1 of the Delphi survey with the mean, standard deviation, and median inserted below the concept follows in Figure 3.2.

Figure 3.2. A Concept with the Mean, Standard Deviation, and Median

5. Renewable energy is reliable for residential and commercial production.

Mean: 4.45

SD: 0.52

Median: 4.0

Additionally, any comments made by the renewable energy professionals were listed under the appropriate concept. Each concept was revised according to the comments made by the Delphi participants. In April 2002 the draft framework was sent out again as part of a packet provided to the Delphi process participants. Included in the packet were a thank-you letter, a letter introducing the Delphi technique, instructions for completing the second round, the revised draft framework with the relevant statistical information inserted beneath each concept, and a scan-tron answer sheet. In the second round, participants were asked to rate the concepts again using the same Likert scale. This time though, they were instructed to take into account the statistics (mean, median, and standard deviation) embedded beneath each concept. Using this method, participants were able to view the collective responses of their colleagues, analyze their own responses, and re-rate the concepts.

The second round responses were mailed to KEEP and analyzed. Comments made by the Delphi participants were recorded and inserted below the concept that they were addressing. After the comments were recorded, the mean, median and standard deviation were determined for the second round of the Delphi process and a chart was created to compare the results of the two rounds. Comparing the results of the two rounds required special attention, as the numbering changed from round one

to round two due to suggestions from the Delphi panel. As per their requests, some of the concepts had been combined, while others had been split. Also, new concepts were added. Thus, when comparing the results, a table was first created which listed the concept numbers from round two next to their corresponding numbers from round one.

The corresponding numbers were determined using a methodological process. First, the concepts from round one were listed in one column. Then, each concept from round two was read. The principal researcher of the project decided which concept in round two the concept from round one corresponded to, and the numbers were listed next to one another in a table. It was in this manner, using a chart, that the results from round one and round two could most easily be compared. The statistics of both rounds were analyzed and recorded by Kane.

Task 1.4 Finalize the renewable energy conceptual framework

After the second round of the Delphi process, with the individual concepts having been rated twice, the concepts to be included in the renewable energy conceptual framework were revised. Revisions were made in accordance with the comments of the panelists. Once the framework was revised for the final time based on the panelists' comments, it was given to members of the advisory committee for further review.

Advisory committee members met with Kane in June 2002 to review the post-Delphi framework. Revisions were made based on the renewable energy and curriculum development expertise of the advisory committee. Finally, the document

was presented to and reviewed by the advisory committee in its entirety. The concepts and organization were discussed and revisions were made. The framework was then proofread and edited by Dr. Dan Dieterich, Professor of English at the University of Wisconsin at Stevens Point, in August 2002. The framework was re-read in early September by the advisory committee, Dieterich's suggestions were discussed and implemented and the renewable energy conceptual framework was finalized.

Once the final draft was completed, a copy was sent to each participant in the Delphi survey along with a thank you letter.

Sub-problem 2. Design an instrument to determine the percentage of concepts in the framework that are covered by a given activity guide

Task 2.1 Identify and develop an instrument to measure the percentage of concepts in the framework that are covered by a given activity guide

After completion of the final draft of the renewable energy conceptual framework, applications of the framework were explored. From the framework, a dichotomous key and rubric were developed to serve as a tool for assessing the extent to which renewable energy concepts were covered by a given activity guide. The idea of a dichotomous key to determine the percentage of renewable energy concepts covered by a given activity guide was generated by Kane and approved by the advisory committee as a suitable strategy. A rubric, which in this case was used to

record the results evaluating an activity guide using the dichotomous key, was found to be an effective means of organizing information according to the related literature. The advisory committee approved the idea of the use of the rubric to record results of an activity guide assessment using the dichotomous key. The key was used to determine the number of renewable energy concepts covered by a given guide (the KEEP guide, in this case), which were then recorded using the rubric and converted into the percentage of concepts addressed by the guide.

The dichotomous key consisted of a series of statements, one negating the other, with one set of statements corresponding to each concept in the framework. For example, concept number 3 in the framework reads, “Humans have used renewable resources to meet their energy needs throughout history.” In order to determine if an activity addresses this concept, the key has two statements, one of which will be true. The first is, “The activity addresses the history of development of one or more sources of renewable energy” and the second is, “The activity does not address the history of development of one or more sources of renewable energy.” A series of statements such as these was created for each renewable energy concept contained in the framework. If the first statement was true, then the activity being reviewed addressed the concept in question. If the first statement was false, the user was to continue to the statement immediately below it, which should be true. In this case, the activity did not address the concept in question and the reviewer could move on to the next series of statements.

Directions were provided as to how to use the key. Kane created the directions, which were reviewed by members of the advisory committee. Revisions

were made according to their suggestions. The directions first provided a rationale explaining the purpose of the key. A general overview of dichotomous keys and a suggested strategy for evaluating an activity guide were given. Specific directions for using the dichotomous key were then provided.

The rubric was created by placing the name of the activity to be reviewed on the y-axis and the concept number on the x-axis. Directions as to how to use the rubric to record the results of an activity guide assessment and to determine the percentage of renewable energy concepts covered by an activity guide were provided. Instructions were given as to how to calculate the percentage both manually, without modern electronics, and by using an electronic version of the rubric in Excel. Reviewers of the dichotomous key were given both a paper and electronic version of the necessary materials.

The percentage of concepts covered by an activity could be determined automatically if the reviewer filled in the electronic version of the rubric using Excel. The rubric was created using Excel; the names of the activities were listed on the y-axis and the concept numbers were listed on the x-axis. The rubric was designed so that upon entering a "1.0", "0.5", or "0.0", the calculations would immediately be determined by the program. The participants were instructed to mark a 1.0 in the box if the concept was addressed directly by the activity; that is, if it was addressed in the objectives or the procedure. They were to mark a 0.5 if the concept was mentioned or referenced (in the background or extension of the activity, for example) but was not directly addressed by the activity.

A glossary of renewable energy terms was created by extracting renewable energy terms found in the KEEP glossary and placing them into a new document. Additional terms were found by visiting glossaries found on energy/renewable energy government websites. From these sources an exhaustive glossary of renewable energy terms was created. Participants using the key and rubric were instructed to use the glossary to confirm meanings of words and/or phrases regarding renewable energy that they came across while reviewing activities with which they were unfamiliar.

Task 2.2 Apply the instrument

The KEEP activity guide, dichotomous key, directions, glossary, and rubric were reviewed by the advisory committee and then given to three non-formal energy educators: Michelle Gransee, Renewable Energy Education Specialist with KEEP, Sterling, and Kane. Each used the key to evaluate the 44 activities in the KEEP guide; results were recorded using the Excel rubric and documented by Kane.

Summary

The methods involved in producing a renewable energy conceptual framework included identifying important renewable energy concepts after conducting a detailed literature/website review, forming an advisory committee, and

then creating a draft framework. The draft framework was reviewed several times by the advisory committee and revised accordingly. A focus group was also held to fine-tune the draft. It was then necessary to validate those concepts in the draft framework by using the Delphi process.

Thirteen renewable energy professionals agreed to participate in the Delphi process. A modified Delphi approach was used; the process was reduced to two rounds and began with a structured questionnaire in which the participants rated individual concepts. The structured questionnaire was a draft of the renewable energy conceptual framework. There was space for participants to rate and comment on each concept. Results were tabulated, analyzed and sent out to the experts again. In round two, the participants re-rated the concepts, taking into account the responses of their colleagues. Thus, the renewable energy concepts were validated. The document was then reviewed and revised by members of the advisory committee and Kane, the primary researcher. This draft of the renewable energy conceptual framework was presented before the entire advisory committee. The committee again reviewed and revised the framework and the final renewable energy conceptual framework was created.

Applications and potential uses of the renewable energy conceptual framework were studied. One such application was its use in developing a tool to assess the extent to which an activity guide addressed renewable energy concepts. A dichotomous key and accompanying rubric were identified as a suitable means to determine the percentage of renewable energy concepts covered by a given activity guide and thus were created. Three energy educators used the framework, together

with the key and rubric, to evaluate the KEEP activity guide for renewable energy content.

A renewable energy conceptual framework was thus created and used to evaluate an activity guide for renewable energy content. This process can be applied to various activity guides or individual activities to determine renewable energy content.

Chapter Four

Results

Introduction

In this chapter, the conceptual framework for K-12 energy education and the instrument to measure the percentage of concepts in the framework that are covered by a given activity guide, the KEEP activity guide in this case, are presented. The results of the project are organized as follows:

Sub-problem 1. Develop a valid conceptual framework for K-12 renewable energy education.

Task 1.1 Identify concepts essential in understanding renewable energy.

Task 1.2 Create a draft renewable energy conceptual framework.

Task 1.3 Validate the draft framework using the Delphi process.

Task 1.4 Finalize the renewable energy conceptual framework.

Sub-problem 2. Design an instrument to determine the percentage of concepts in the framework that are covered by a given activity guide.

Task 2.1 Identify and develop an instrument to measure the percentage of concepts in the framework that are covered by a given activity guide.

Task 2.2 Apply the instrument.

Sub-problem 1. Develop a valid conceptual framework for K-12 renewable energy education

Task 1.1 Identify concepts essential in understanding renewable energy

The identification of initial renewable energy concepts began by developing a list of books, activity guides, and websites containing information on renewable energy. Twelve books and/or activity guides can be found on the list included in Appendix A, while 16 websites can be found on the list found in Appendix B. Key conceptual ideas regarding renewable energy were extracted from these resources, synthesized, and written in a narrative form, which is included in Appendix D. Topics discussed in this document include solar, wind, hydropower, biomass, and geothermal energy. For each of these renewable energy sources, the technology of how it works and its applications were explored. Additionally, the environmental effects of the development of each renewable energy resource were included in the document.

Task 1.2 Create a draft renewable energy conceptual framework

From the renewable energy narrative found in Appendix D, 59 key concepts were extracted and placed into a format mirroring the KEEP conceptual framework. This can be found in Appendix E. The themes that the concepts were placed under fell into three of the four existing themes in the KEEP framework. Theme I, We Need Energy, contains no renewable energy concepts, as it covers basic energy ideas. The 59 concepts were placed into Themes II, III, and IV. The placement of the

concepts is as follows: 27 concepts fell under Developing Energy Resources, 23 under Effects of Energy Resource Development, and 9 concepts fell under Managing Energy Resource Use. The concepts were further organized under subheadings including solar, wind, hydropower, geothermal, biomass, and hydrogen energy, as well as quality of life, lifestyles, health and safety, economic, sociopolitical, ethical, quality of the environment, environmental effects, and future outlooks for the development and use of energy resources. The draft was fine-tuned by a five-person focus group consisting of renewable energy professionals, non-formal, or formal educators. The first draft of the renewable energy conceptual framework contained 61 concepts and included information about six types of renewable energy: solar, wind, hydropower, biomass, geothermal, and hydrogen. A draft of the renewable energy conceptual framework is included in Appendix F. The themes and subheadings under which the concepts were organized were identical to those mentioned in the discussion of Appendix E.

Task 1.3 Validate the draft framework using the Delphi process

One hundred percent, or 13 out of 13, of the experts invited to participate in the Delphi process agreed. The letter inviting the experts to participate in the Delphi process can be found in Appendix G. However, 2 renewable energy experts dropped out before the first round, thus input was received by 11 renewable energy experts. A list of the renewable energy professionals that participated in the Delphi process is included in Appendix H. The information sent to the Delphi participants in Round 1 included a thank-you letter, an introduction to the Delphi technique, an informed

consent form, instructions for completing the Delphi survey, and a draft of the renewable energy conceptual framework. This information can be found in Appendices I-L and F, respectively. Additionally, a scan-tron answer sheet and copy of the KEEP conceptual framework were mailed to the Delphi panel.

A Likert scale was used to rate each of the 61 concepts found in the first round draft, where 5 was the most favorable (should absolutely be included in the framework) and 1 the least favorable (should definitely not be included in the framework). The mean, median, and standard deviation were determined for each concept. Results can be seen in Table 4.1. The comments made by the Delphi participants were listed below the relevant concepts; the opinions expressed by the participants sometimes varied greatly and at other times they were more or less in agreement. Their comments can be found in Appendix M. The concepts were modified according to the feedback provided by the Delphi participants; the revised conceptual framework can be found in Appendix N.

In the second round of the Delphi survey, participants were asked to comment on and rate each of the 56 concepts found in the second round draft using the same Likert scale another time. The number of concepts changed due to the feedback received by the Delphi participants; certain concepts were reorganized and condensed, thus affecting the final number of concepts found in the framework. Information sent out in the second round of the Delphi survey included a thank you letter for participating in round two of the Delphi survey, an introduction to Delphi technique, instructions for completing the Delphi survey, and a draft of the revised renewable energy conceptual framework. These documents can be seen in

Appendices O, J, L, and N, respectively. Again, participants were also mailed a scan-tron answer sheet. The comments from round two of the Delphi process can be found in Appendix P. The comments of the Delphi participants were listed below the relevant concepts, which were then modified based on the feedback of the participants. The mean, median, and standard deviation were determined for each concept; the results can be seen in Table 4.1. Table 4.1 was created to compare the results of round one and round two.

Table 4.1. Comparison of Round 1 and Round 2 of the Delphi Process

| CORRESPONDING NUMBERS | | CORRESPONDING MEANS | | CORRESPONDING STANDARD DEVIATIONS | | CORRESPONDING MEDIAN | |
|--------------------------|-----------|------------------------|-----------|--------------------------------------|-----------|-------------------------|-----------|
| round one | round two | round one | round two | round one | round two | round one | round two |
| 1 | 3 | 4.8 | 4.9 | 0.4 | 0.3 | 5 | 5 |
| 2 | 1 | 4.6 | 4.8 | 0.7 | 0.4 | 5 | 5 |
| 3 | 2 | 4.4 | 4.9 | 1.2 | 0.3 | 5 | 5 |
| 4 | 4 | 4.6 | 4.6 | 0.5 | 0.5 | 5 | 5 |
| 5 | 5 | 4.5 | 4.6 | 0.5 | 0.7 | 4 | 5 |
| 6 | 6 | 4.6 | 4.7 | 0.7 | 0.5 | 5 | 5 |
| 7 | 7 | 4.6 | 4.7 | 0.5 | 0.5 | 5 | 5 |
| 8 | 8 | 4.6 | 4.7 | 0.5 | 0.5 | 5 | 5 |
| 9 | 5 | 3.4 | 4.6 | 1.4 | 0.7 | 4 | 5 |
| 10 | 10 | 4.6 | 4.9 | 0.5 | 0.3 | 5 | 5 |
| 11 | 11 | 4.8 | 4.8 | 0.4 | 0.4 | 5 | 5 |
| 12 | 5 | 3.3 | 4.6 | 1.6 | 0.7 | 4 | 5 |
| 13 | 13 | 4.7 | 4.7 | 0.5 | 0.5 | 5 | 5 |
| 14 | 5 | 4.3 | 4.6 | 1.2 | 0.7 | 5 | 5 |
| 15 | 14 | 4.6 | 4.7 | 0.5 | 0.5 | 5 | 5 |
| 16 | 13 | 4.5 | 4.7 | 1.2 | 0.5 | 5 | 5 |
| 17 | 5 | 3.7 | 4.6 | 1.5 | 0.7 | 4 | 5 |
| 18 | 16 | 4.6 | 4.9 | 0.7 | 0.3 | 5 | 5 |
| 19 | 17 | 4.6 | 4.7 | 0.7 | 0.5 | 5 | 5 |
| 20 | 18 | 4.6 | 4.7 | 0.5 | 0.5 | 5 | 5 |
| 21 | 19 | 3.8 | 4.5 | 0.9 | 0.7 | 4 | 5 |
| 22 | 19 | 4.6 | 4.5 | 0.5 | 0.7 | 5 | 5 |
| 23 | 20 | 3.9 | 4.6 | 0.9 | 0.5 | 4 | 5 |
| 24 | 21 | 3.6 | 4 | 1 | 1.1 | 4 | 4 |
| 25 | 22 | 4 | 4.1 | 1 | 1 | 4 | 4 |
| 26 | 23 | 4.2 | 4.2 | 0.6 | 1 | 4 | 4 |
| 27 | 23 | 4.3 | 4.2 | 0.7 | 1 | 4 | 4 |
| 28 | 24 | 4.6 | 4.5 | 0.5 | 0.7 | 5 | 5 |
| 29 | 25 | 4.6 | 4.7 | 0.5 | 0.5 | 5 | 5 |
| 30 | 26 | 4.8 | 3.7 | 1.3 | 1.6 | 4 | 4 |
| 31 | 27 | 4.4 | 4.1 | 0.9 | 1 | 5 | 4 |
| 32 | 28 | 3.9 | 4.6 | 1 | 0.5 | 4 | 5 |
| 33 | 28 | 3.9 | 4.6 | 1.6 | 0.5 | 5 | 5 |
| 34 | 29 | 3.6 | 3.6 | 0.9 | 1.1 | 4 | 4 |
| 35 | 30 | 3.6 | 3.6 | 1.2 | 0.7 | 4 | 3 |
| 36 | 33 | 4.4 | 4.2 | 1 | 0.8 | 5 | 4 |
| 37 | 34 | 3.7 | 3.6 | 1.6 | 1.3 | 4 | 4 |
| 38 | 35 | 3.9 | 4.9 | 1.2 | 0.3 | 4 | 5 |
| 39 | 35 | 4.4 | 4.9 | 0.9 | 0.3 | 5 | 5 |
| 40 | 36 | 3.7 | 4.3 | 1.4 | 0.8 | 4 | 4 |
| 41 | 37 | 4.6 | 4.5 | 0.5 | 0.7 | 5 | 5 |
| 42 | 38 | 4.8 | 4.7 | 0.4 | 0.5 | 5 | 5 |
| 43 | 39 | 3.1 | 4 | 1 | 0.8 | 3 | 4 |
| 44 | 40 | 4 | 4.6 | 1.4 | 0.5 | 5 | 5 |
| 45 | 41 | 4 | 4.2 | 1.1 | 1.3 | 4 | 5 |
| 46 | 42 | 4.2 | 4.5 | 1 | 0.8 | 4 | 5 |
| 47 | 43 | 4.4 | 4.4 | 0.7 | 0.7 | 4.5 | 4.5 |
| 48 | 44 | 4.2 | 4.4 | 0.6 | 0.5 | 4 | 4 |
| 49 | 45 | 4 | 4.3 | 0.9 | 0.7 | 4 | 4 |
| 50 | 50 | 3.9 | 3.6 | 0.7 | 1.1 | 4 | 4 |
| 51 | 49 | 3.6 | 3.9 | 1.4 | 1.2 | 4 | 4 |
| 52 | 51 | 3.5 | 4 | 1.4 | 1.1 | 4 | 4 |
| 53 | 26 | 3.6 | 3.7 | 1.2 | 1.6 | 4 | 4 |
| 54 | 52 | 4.1 | 4.3 | 1 | 1.2 | 4 | 5 |
| 55 | 53 | 4.2 | 4.7 | 0.8 | 0.5 | 4 | 5 |
| 56 | 53 | 4.3 | 4.7 | 0.7 | 0.5 | 4 | 5 |
| 57 | 52 | 3.7 | 4.3 | 1.4 | 1.2 | 4 | 5 |
| 58 | 53 | 3.9 | 4.7 | 1 | 0.5 | 4 | 5 |
| 59 | 53 | 4.1 | 4.7 | 0.8 | 0.5 | 4 | 5 |
| 60 | 53 | 3.6 | 4.7 | 1 | 0.5 | 4 | 5 |
| 61 | 53 | 3.5 | 4.7 | 1.3 | 0.5 | 4 | 5 |

Note that some concept numbers in round two don't have a corresponding concept in round one because they were added as a result of the first round. These numbers include 9, 12, 15, 31, 32, 46, 47, and 48. Also note that the median was rounded to the nearest whole number.

The mean increased or remained the same from round one to round two for 80% of the concepts. The exceptions include the following concepts: 22/19 (number 22 in the first round, 19 in the second), 27/23, 28/24, 30/26, 31/27, 35/30, 36/33, 37/34, 41/37, 42/38, and 50/50.

The median increased or remained the same from round one to round two for 95% of the concepts. The exceptions are as follows: 31/27 (number 31 in the first round, 27 in the second), 35/30, and 36/33.

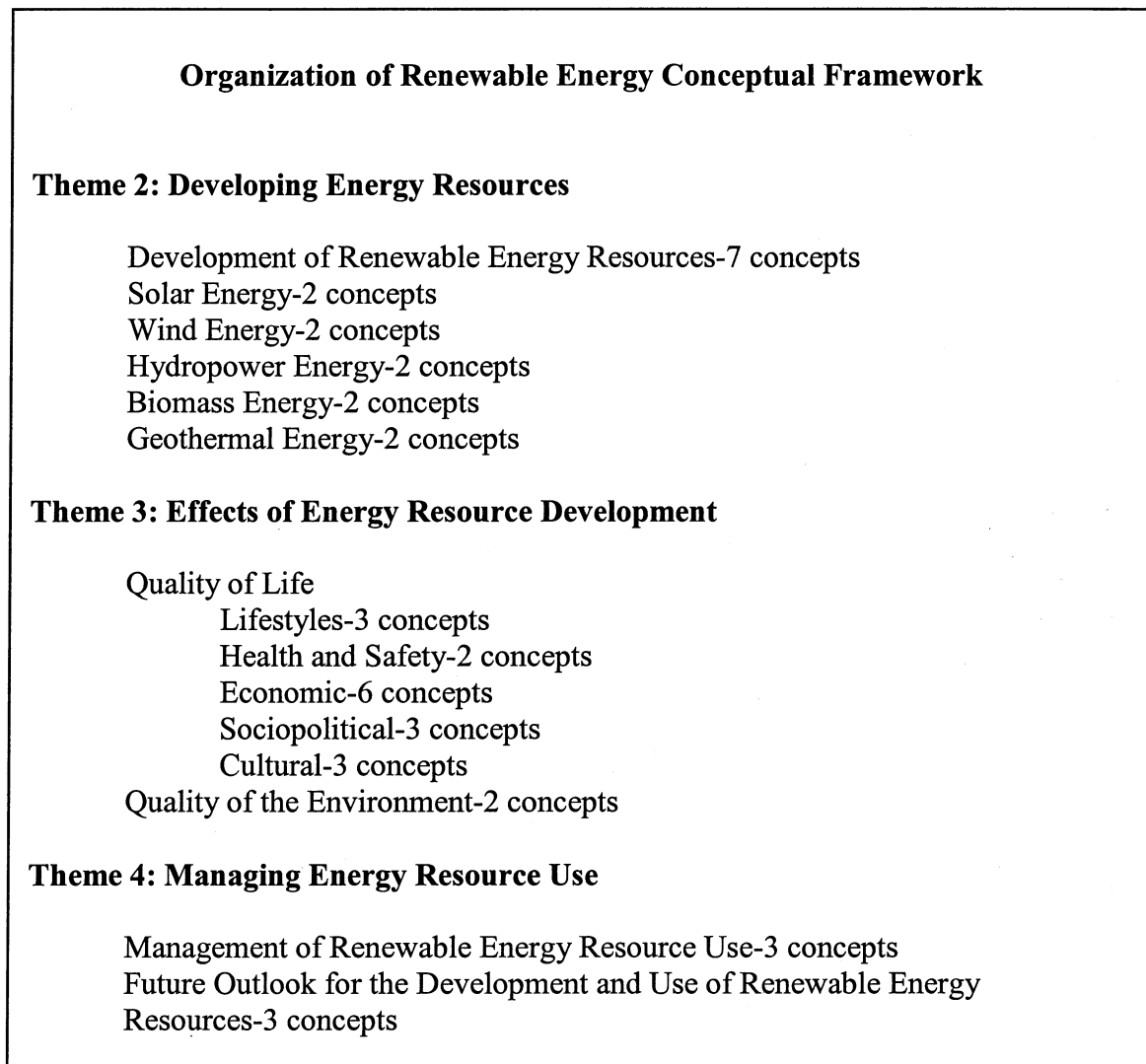
The standard deviation got smaller or remained the same from round one to round two for 71% of the concepts. The exceptions include the following concepts: 5/5 (number 5 in the first round, 5 in the second), 22/19, 24/21, 25/22, 26/23, 27/23, 28/24, 30/26, 31/27, 34/29, 41/37, 42/38, 45/41, 50/50, 53/26, and 54/52. Those concepts where the standard deviation increased were reviewed by the graduate committee and found acceptable; they were not eliminated from the framework.

Task 1.4 Finalize the renewable energy conceptual framework

The final version of the renewable energy conceptual framework includes concepts regarding five sources of renewable energy: solar, wind, biomass, hydropower, and geothermal. Hydrogen energy, which was included in the draft, was determined to be a non-renewable form of energy by the Delphi panel.

There are 42 concepts in the final draft, placed under three of KEEP's themes: Developing Energy Resources, Effects of Energy Resource Development, and Managing Energy Resource Use. After the final round of the Delphi process, the concepts were reviewed and edited by the graduate committee. In some cases, concepts were combined and/or reworded, thus the reduction of the number of concepts between round 2 of the Delphi process and the final draft. The final 42 concepts are organized in the framework in the following manner: Developing Energy Resources contains 17 concepts and is organized into 6 sub-themes. The concepts address general renewable energy information, as well as definitions and applications of different renewable energy resources. Effects of Energy Resource Development contains 19 concepts that are divided between two sub-themes. This theme contains concepts regarding quality of life and quality of the environment issues as they relate to renewable energy use. Managing Energy Resource Development contains 6 concepts that are divided evenly between two sub-themes: management of renewable energy resource use and future outlook for the development and use of renewable energy resources. The organization and number of concepts found in each sub-theme of the final renewable energy conceptual framework are included in Figure 4.1.

Figure 4.1. The Organization of the Renewable Energy Conceptual Framework



The final draft of the renewable energy conceptual framework is included in Appendix Q. A letter was sent to the renewable energy experts who participated in the Delphi process thanking them for their involvement in the process. The letter can be found in Appendix R.

Sub-problem 2: Design an instrument to determine the percentage of concepts in the framework that are covered by a given activity guide

Task 2.1 Identify and develop an instrument to measure the percentage of concepts in the framework that are covered by a given activity guide

A dichotomous key was created; directions and a glossary were written to accompany the key. The key contains paired statements, one negating the other, for each concept and each theme. See sub-problem 2, task 2.1, in chapter three for further details about the creation of these documents.

A rubric was created using Excel to document and more easily calculate the results produced by using the dichotomous key. Listed on the y-axis of the rubric are the names of activities and the x-axis are the concept numbers. The dichotomous key, directions, glossary, and rubric are included in Appendices S, T, U, and V, respectively.

Task 2.2 Apply the instrument

Three renewable energy non-formal educators used the dichotomous key, rubric, and glossary to determine the percentage of renewable energy concepts covered by the KEEP activity guide. The results of the KEEP evaluation using the dichotomous key and rubric can be found in Table 4.3. The three evaluators' findings for the overall evaluation of the KEEP activity guide were between 19 and 47.6 for

the percentage of concepts fully covered by the guide and 69 and 73.8 percent for the percentage of concepts fully covered by the guide and/or covered in the background.

The results were then analyzed by grade level. Evaluators agreed that KEEP did not fully address any renewable energy concepts in activities aimed at grades K-2 and that only 4.76 percent of the concepts were fully covered and/or covered in the background of activities for the same grade level.

Results indicated a higher percentage of concepts fully covered and/or covered in the background by activities for grades 3-5 in the KEEP activity guide than for grades K-2. Results of the three evaluators ranged from 28.6 or 35.7 percent for activities aimed at grades 3-5. Likewise, the percentage of concepts covered fully by activities aimed at grades 3-5 was also higher than those for K-2 audiences, with results ranging from 11.9 to 19 percent.

The trend of increasing percentage of concepts covered with increasing grade level continued in activities aimed at grades 6-8. Results ranged from 47.6 to 57.1 for the percentage of concepts fully covered and/or covered in the background by KEEP activities for grades 6-8. Results ranged from 9.52 to 28.6 for the percentage of concepts covered by 6-8 activities.

However, evaluators' findings indicate the percentage of concepts fully covered and/or covered in the background of activities geared for grades 9-12 decreased compared to the results for grades 6-8. Results ranged between 23.8 and 26.8 percent. The percentage of concepts covered fully by activities for grades 9-12 ranged from 9.52 to 19. Table 4.2 illustrates the evaluators' findings.

Table 4.2. Results of the KEEP Activity Guide Evaluation Using the Dichotomous Key and Matrix

| Variable | Rater | | |
|--------------------------------------------------------------------------------------------------|-------------------|----------------|--------------------|
| | Gransee's results | Kane's results | Sterling's results |
| Percentage of concepts fully covered by guide | 28.6 | 19 | 47.6 |
| Percentage of concepts fully covered by guide and/or covered in the background | 73.8 | 69 | 73.8 |
| KEEP GUIDE COVERAGE ON GRADE BASIS | | | |
| K-2 | | | |
| Percentage of concepts fully covered by guide K-2 activities | 0 | 0 | 0 |
| Percentage of concepts fully covered by guide K-2 activities and/or covered in the background | 4.76 | 4.76 | 4.76 |
| GRADE 3-->5 | | | |
| Percentage of concepts fully covered by guide 3-->5 activities | 14.3 | 11.9 | 19 |
| Percentage of concepts fully covered by guide 3-->5 activities and/or covered in the background | 35.7 | 35.7 | 28.6 |
| GRADE 6-->8 | | | |
| Percentage of concepts fully covered by guide 6-->8 activities | 21.4 | 9.52 | 28.6 |
| Percentage of concepts fully covered by guide 6-->8 activities and/or covered in the background | 52.4 | 47.6 | 57.1 |
| GRADE 9-->12 | | | |
| Percentage of concepts fully covered by guide 9-->12 activities | 11.9 | 9.52 | 19 |
| Percentage of concepts fully covered by guide 9-->12 activities and/or covered in the background | 26.2 | 23.8 | 26.2 |

The complete results of the non-formal educators' evaluations can be found in Appendix W.

Summary

The renewable energy conceptual framework was created using a process that solicited input from various stakeholders, from energy educators to renewable energy gurus to public utility employees. The 42 concepts were placed under three headings and further organized under subheadings based on the original KEEP conceptual framework. A dichotomous key and rubric were developed to measure the percentage of concepts covered by a given activity. Three energy educators used the key and rubric to assess the KEEP activity guide for renewable energy content.

Chapter Five

Conclusions, Discussion, and Recommendations

Introduction

In this study, a conceptual framework for K-12 renewable energy education and an instrument to determine the percentage of concepts in the framework covered by a given activity guide were created. The framework was developing by soliciting input from a variety of sources, including books and websites, as well as renewable energy professionals from throughout Wisconsin. This process resulted in the creation of a comprehensive renewable energy conceptual framework. Furthermore, a dichotomous key and accompanying rubric were developed in order to systematically review educational material for renewable energy content. The framework and rubric can be used to determine the percentage of renewable energy concepts covered by a given activity guide. Together, the framework, dichotomous key, and rubric provide a solid foundation for renewable energy program development and evaluation.

In this chapter, the conclusions, discussion, and recommendations will be stated. The problem statement and sub-problems are re-stated below.

Problem Statement

The purpose of this study was to develop a conceptual framework for K-12 renewable energy education and to create an instrument to determine the percentage of concepts in the framework that are covered by a given activity guide.

Sub-problems

The sub-problems are as follows:

1. Develop a valid conceptual framework for K-12 renewable energy education.
2. Design an instrument to determine the percentage of concepts in the framework that are covered by a given activity guide.

Overview of Project Results and Discussion

Based on the results of the study, it can be concluded that:

- **A valid conceptual framework for K-12 renewable energy education was created.**

The final framework for K-12 renewable energy education consists of 42 concepts dividing among three themes: Developing Renewable Energy Resources, Effects of Renewable Energy Development, and Managing Renewable Energy Resource Use. The content of the concepts ranges from technical information, such as

explaining what wind energy is and how it is used, to economic and sociopolitical information, like discussing the idea of payback as it relates to renewable energy and how support for renewable energy varies with different political administrations.

The framework provides a comprehensive overview of renewable energy. Using the Delphi process ensured that the framework was both a comprehensive and valid document, as it allowed and encouraged input from a variety of stakeholders.

Successes and Challenges of the Delphi Process

The use of a modified Delphi process was valuable in that it provided a systematic way of producing a draft framework; it was a worthwhile means of soliciting and receiving input on the conceptual framework from renewable energy professionals across Wisconsin. It allowed for feedback from various stakeholders including public utilities, non-profits, and independent renewable energy professionals. It gave a voice to a wide variety of people in diverse geographical areas.

The renewable energy experts gave feedback via the mail, thus they were free to express their initial opinions without the influence of others. However, the process did allow for ideas to be exchanged among professionals, as their comments were recorded and sent out to the entire panel with the second Delphi round. Having reviewers rate and alter each concept twice ensured that everyone was able to give

their input, read the feedback from others, and then re-rate the concept taking into account the ideas and opinions of the other Delphi participants.

In theory, the standard deviation was supposed to get smaller for each concept from round one to round two. This was to demonstrate the convergence of the renewable energy professionals toward the correct answer. In practice, there were 16 concepts where this was not the case. There are many possible explanations for this inconsistency.

The results from the Delphi process could have been affected by the time period between the two rounds. The time period between the two rounds was longer than anticipated. Approximately two months passed between rounds, during which time the opinions of Delphi participants could have changed regarding a certain concept. Many factors can influence a person's opinion over a two-month time period. Variation in human opinion was demonstrated in those concepts where the mean decreased from round one to round two although the concept itself was barely changed. Furthermore, some concepts were greatly revised between the two rounds, possibly making them unrecognizable as the same concept to the reviewer. There was much lumping and splitting of concepts based on the comments of the participants.

Members of the advisory committee met after the conclusion of the Delphi process to conduct a final edit of the framework. Although the renewable energy experts who participated in the Delphi survey provided valuable information for the framework, their feedback was often too detail-oriented for a conceptual framework. The Delphi panel was useful in confirming that the content was technically correct

and valid, but a team of educational experts was necessary to ensure that the concepts were exactly that: concepts and not facts. Also, the advisory committee members reworded the concepts as to make them more reader-friendly; that is, writing them in a consistent manner, eliminating extra verbiage, etc.

Applications of the Framework

Applications of the renewable energy conceptual framework are many. The framework can be used to guide the development of a comprehensive curriculum. One method of accomplishing this is to use the framework as part of a gap analysis; that is, as a means of organizing existing renewable energy activities. For example, one could review current environmental and energy education activities for renewable energy content (using the dichotomous key and rubric) and then organize them according to which concept and grade level they addressed. In this way, a curriculum developer could determine if an activity already exists that addresses the concept or if one needs to be created. A methodic way of organizing this would be to have three folders for each concept based on age appropriateness of the activity. For example, for concept number one in the framework, a folder would be created for Kindergarten through 4th grade, 5th through 8th grade, and 9th through 12th grade. This method could be used also if an educator wanted to teach a particular concept. If there was no activity, he/she could either continue to search for one or create his/her own activity.

In developing any piece of curriculum, it is helpful to know what materials already exist. The framework, dichotomous key, and rubric are useful tools in organizing this information. Using the materials to perform a gap analysis could

increase the efficiency and productivity of curriculum developers, as they can devote their time to creating activities that address concepts that are not yet addressed by existing activities.

Furthermore, the framework's use is not limited to curriculum development; other uses include but are not limited to serving as a guide for the development of informational brochures, websites, and renewable energy courses. It is recommended that the framework be sent out to organizations that may have an interest in developing any of the aforementioned items or who are involved with educating the public regarding renewable energy.

The conceptual framework for K-12 renewable energy education can also be used to develop the scope and sequence of a curriculum. KEEP, for instance, presented the 42 concepts found in the framework to a group of teachers who then examined and discussed each concept and placed it in a grade-appropriate category. The concepts were deemed appropriate for grades K-4, 5-8, or 9-12. In some cases, a concept was found to be appropriate for more than one category. Providing teachers with a scope and sequence can help provide an effective renewable energy education, as it guides educators in their introduction of the material to the students.

- **An instrument, which consisted of a dichotomous key and accompanying rubric, to measure the percentage of concepts in the framework that are covered by a given activity guide was created.**

The dichotomous key consists of an affirmative and negative statement for each concept found in the framework. If the affirmative statement is true, then the concept is addressed by the activity being reviewed. Alternatively, if the negative statement is true, then the concept is not addressed by the activity in question.

The rubric was created to record the results of the process of using the dichotomous key. If the electronic version of the rubric was used, calculations were automatically determined. If, on the other hand, a hard copy was used, calculations had to be completed by hand. Three non-formal energy educators used the key and rubric to evaluate the KEEP activity guide.

Successes and Challenges of the Dichotomous Key and Rubric

The dichotomous key and rubric served as a valuable means of measuring the percentage of concepts covered by a given activity guide. The key and rubric were chosen as the means to evaluate activity guides because their systematical, organized nature was hypothesized to provide evaluators with a straightforward approach to reviewing activity guides for renewable energy content. This was indeed the case, as the three non-formal science educators who tested the tool reported no difficulties in using the instruments. The tool can be used to assess an activity guide for renewable energy content, as was demonstrated. However, there is some degree of personal

interpretation when using the key, reading the activities, and judging whether the activity is to receive a 0.0, 0.5, or 1.0. A 1.0 was marked in the matrix if the concept was addressed directly by the activity; that is, if it was addressed in the objectives or the procedure. A 0.5 was recorded if the concept was mentioned or referenced (in the background or extension of the activity, for example) but was not directly addressed by the activity. Thus, there was variation when reviewing an activity due to the differing interpretations of the reviewers. This was expected and does not undermine the tool's usefulness, as it still provides valuable results. However, it does lead to insights into the usefulness of dichotomous keys.

Traditionally, dichotomous keys are used in the scientific world to identify a plant, animal, mineral, or fungus, among other things, to as specific a taxonomic level as possible. Most often, the paired statements in a dichotomous key are objective. For instance, in a manual to identify vascular plants, a statement may read, "Flowers solitary." The alternate response would read, "Flowers in dense spikes." If the flowers are solitary, it is a member of the Santalaceae family. If the flowers are in dense spikes, it is in the Amaranthaceae family. Dichotomous keys in the scientific world are most often used in objective situations where there is a clear and correct response.

The review of related literature turned up no examples of dichotomous keys being used in situations that were subjective, such as the evaluation of curricula. To my knowledge, dichotomous keys have not been used in situations such as these. And there may be a good reason for this! The results of this portion of the study, that is, non-formal energy educators using the dichotomous key and rubric to evaluate the

KEEP activity guide for renewable energy content, varied greatly depending on who was using the tool (see chapter 4, task 2.2). As was stated, it does not mean that the tool is not valid, as it did produce results. However, anyone using a dichotomous key in this way should be aware of the extreme variability that may result in individuals using the key and rubric. It may be valuable to explore alternative ways of using the key and rubric in order to produce results that are less variable. For instance, instead of individuals using the key and rubric to evaluate an activity guide, a group may use them together, coming to consensus before filling in the rubric. As was mentioned in the literature review, groups of people have been shown to converge toward the correct answer. Thus, working in a group would minimize some of the variability found in the results of the individual evaluations of the KEEP activity guide. Thus, it is not that a dichotomous key is not useful in settings that require subjectivity, only that the user of the instrument should be aware of the potential variability when individuals use it. It is advised that appropriate measures be taken to minimize the variability.

It is important to note that differences in opinion will surface in nearly any process that involves subjectivity, such as curricular assessment. It is important, then, to receive input from more than one person and if possible, to reach a consensus.

Applications of the Dichotomous Key and Rubric

As illustrated in this study, the dichotomous key and rubric can serve as a gauge or indicator for people to assess how well a particular guide covers renewable energy concepts as delineated by the framework. The evaluation of the KEEP

activity guide in this study can serve as an example for other organizations or individuals as to how to evaluate their own activity guide to assess renewable energy coverage. Other applications include using the dichotomous key and rubric to assess a single activity for renewable energy content. One could modify the rubric to determine the extent to which a single activity covers renewable energy concepts. Using the electronic version of the rubric in Excel, it is simple to change the program to calculate a wide range of information that may be helpful to an individual or the organization that is performing the analysis. A partial list of functions that the Excel rubric could perform is included in Appendix X.

In the case of KEEP, the dichotomous key and rubric were used to evaluate the activity guide. Results indicated that KEEP addressed less than half of the renewable energy concepts found in the framework. This information can be used to justify the need for a supplemental renewable energy activity guide. It can also justify the need to hire new staff. Likewise, the information could be used to re-evaluate the role and mission of KEEP and perhaps re-allocate time and money. Maybe staff time would be better spent writing grants to secure funding to develop a renewable energy supplement, for instance. If it had been found that KEEP addressed a large percentage of renewable energy concepts, it could be highlighted as a success for KEEP. Although KEEP is the organization that directly benefited from this study, the information presented can be applied to any program that wishes to evaluate their instructional materials for renewable energy content.

Recommendations

For developers and researchers of conceptual frameworks

Use of the Delphi process

- If this study is to be replicated, a definition of “concept” should be included with the material sent to the Delphi participants. As was stated earlier, much of the information the Delphi participants offered was not broad concepts but instead were specific facts regarding renewable energy. Clarification of what a concept is may have eliminated some of the fine tuning of the framework that occurred after the final round of the Delphi process.
- It is recommended that there be at least three rounds of the Delphi process, as participants would then have the opportunity to rate each concept at least three times. In this study, two rounds of the Delphi process were carried out; thus, the concepts were rated twice. There were 16 concepts where the standard deviation increased, as opposed to decreasing, which was the desired outcome. Allowing Delphi participants to rate and comment on each concept for a third time may have decreased the number of concepts in which the standard deviation increased.
- Also, it is recommended that Delphi participants submit their comments and revisions electronically. This would have made the process of recording and implementing their suggestions less time consuming.

- It is recommended that the Delphi process be used to identify and validate concepts when creating a conceptual framework. It was a valuable means of soliciting input from a variety of experts.

Use of a dichotomous key and rubric

- The results of using the dichotomous key and rubric as a tool to evaluate an activity guide for its renewable energy content were variable depending on who used it. If this study is to be replicated, it is recommended that in order to provide results that display a definitive answer as to whether or not a certain concept is addressed by a given activity guide, individuals who used the key and rubric be brought together after they use the tool in order to discuss the differences of opinion and come to a consensus.
- For future users of the dichotomous key and rubric as a means to evaluate curricula, it is recommended that the objectives of the assessment process first be identified. If he or she wants clear and definite results as to whether or not a concept is addressed by an activity, then those using the key and rubric should be brought together to work as a group, reaching a consensus before filling out the rubric. Or, those using the key should be brought together after using the key and filling out the rubric, as stated in the previous bullet.
- A topic for further research would be to have formal educators review an activity guide using the dichotomous key and rubric and to compare the results with non-formal educators. During this study, two formal educators were asked to review three KEEP activities and their results were compared

with those of the non-formal educators. This was not included as a formal part of the study due to its irrelevance with regard to the problem statement. However, the results can be found in Appendix Y.

For KEEP staff and others using the renewable energy conceptual framework

- Only the KEEP activity guide was reviewed using the dichotomous key and matrix. It is recommended that the elementary supplement also be reviewed for renewable energy content. This would have influenced the results, as the supplement contains renewable energy activities.
- It is recommended that the renewable energy concepts be linked to the state and national educational standards in as many subjects as possible, thus increasing its usefulness for educators. Educational standards are playing an increasingly important and influential role in the classroom. New curricular material is deemed more useful by educators if it is linked to the education standards, as educators are under pressure to address the standards in their classroom. With the increasing emphasis put on educational standards, it seems logical that the standards should be addressed by curricular material.
- It is recommended that a new concept be added in theme II, Developing Renewable Energy Resources under the sub-theme Development of Renewable Energy Resources. The new concept was suggested by a renewable energy education specialist and approved by members of the advisory committee. The new concept should read, “The efficiency of

converting renewable energy sources to useable energy varies according to the source and/or technology used.”

- It is recommended that the framework be sent out to organizations that may have an interest in developing any of the aforementioned items or who are involved with educating the public regarding renewable energy.
- And finally, it is recommended that KEEP create a renewable energy supplement. Non-formal energy educators agreed that the KEEP activity guide fully addressed less than half of the renewable energy concepts found in the framework. Furthermore, no comprehensive renewable energy curriculum was found while researching the subject. A renewable energy curriculum will benefit many sectors of the community.

Summary

This study was successful in that it resulted in the production of a valid conceptual framework for K-12 renewable energy education and an instrument to determine the percentage of concepts in the framework that are covered by a given activity guide. The Delphi process as a means to validate the framework was effective. It allowed input from a variety of stakeholders from throughout Wisconsin. Likewise, the instrument to measure the percentage of concepts a particular activity guide covered was effective, as those who used it came up with a percentage and reported no difficulties using it.

A renewable energy conceptual framework was greatly needed in the field, as no comprehensive framework was found during the two-year research period. The development of a renewable energy conceptual framework increases awareness and gives others a comprehensive, thorough tool to guide the development of teaching and implementing renewable energy education programs and curricula. The framework is organized in a way as to facilitate a logically sequenced, comprehensive renewable energy education. A comprehensive renewable energy education will help to produce a knowledgeable citizenry capable of making informed decisions. Furthermore, the instrument to measure the percentage of concepts in the framework is useful in evaluating activity guides for their renewable energy content. Together, they provide a solid base for renewable energy education.

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Appendix A

Renewable Energy Education Resources

Renewable Energy Education Bibliography

Wisconsin Center For Environmental Education

Reference Materials

Activity Guides for K-12

KEEP Activity Guide, Wisconsin K-12 Energy Education Program, Wisconsin Center for Environmental Education, Stevens Point, WI and Energy Center of Wisconsin, Madison, WI. (1995).

The KEEP activity guide makes the sometimes intimidating topic of energy understandable to students of all ages. The guide is organized by themes and grade levels to help teachers easily find activities appropriate for their students.

Science Projects in Renewable Energy and Energy Efficiency, American Solar Energy Society. (1991).

This book includes enjoyable projects that demonstrate the scientific method and covers most of the important concepts related to each renewable energy technology.

Activity Guides for 4-9

Hot Water and Warm Homes from Sunlight, Alan Gould. LHS Gems, Berkley, CA. (1986).

A curriculum for teaching concepts about solar energy, the greenhouse effect and general home energy use. Uses science experiments that incorporate math. This is part of a curriculum series that has been well reviewed and tested by educators.

Sunlight Works: A Student Centered Activity Guide in Solar Science, Heather Gurley and Bob Larson. Sunlight Works, Sedona, AZ. (1993).

A workbook that focuses on the sun as Earth's main source of energy. Also appropriate for grades K-4.

Activity Guides for 9-12

Science Projects in Renewable Energy and Energy Efficiency, American Solar Society. The National Energy Foundation, Salt Lake City, UT. (1991).

Contains a variety of projects that can be used to study alternative energy uses and sources. Also provides guidelines for conducting a project.

Renewables Are Ready, Union of Concerned Scientists. Cambridge, MA. (1991).

A guide to teaching renewable energy in junior and senior high school classrooms.

Renewable Energy Education Books for Children

Can You See the Wind?, Allan Fowler. Grolier Publishing, New York. (1999).

A simple discussion of the wind, the causes of air movements. and the uses of wind power.

Renewable Energy Education Books for Adults

Renewable Energy: Sources for Fuels and Electricity, Thomas B. Johansson. Island Press, Washington DC. (1993).

A comprehensive reference guide to alternative energy sources, spotlighting all aspects of each energy source. This guide is for the serious energy researcher.

Renewable Energy Education Videos

The Power of Wind, American Wind Energy Association. (1992).

This video shows how wind is a clean, free alternative to other energy sources. It suggests using wind as an energy source instead of fossil fuels because it is cleaner, more efficient, and free.

Powering Wisconsin: Renewable Energy for Jobs and the Environment, (1994).

Shows how renewable energy technology creates jobs for people in Wisconsin and is better for the environment.

Renewable Energies, The Media Guild. (1997).

Presents profitable working operations generating electricity in California and Europe. Specific examples of geothermal energy, solar energy, biomass energy, and wind power are presented. .

Tomorrow's Energy Today: The Energy Efficiency Option, U.S. Dept. of Energy and the Office of Energy Efficiency and Renewable Energy. (1993).

Two programs recorded together to examine the benefits of renewable energy technologies. The first half discusses the different renewable energy methods. The second half highlights ways to reduce energy use in individual lives.

Appendix B

Renewable Energy Websites

General Renewable Energy Education

<http://www.ase.org/educators/>

<http://www.eia.doe.gov/>

<http://www.energy.gov/>

<http://www.ucsusa.org/energy/brief.renimpacts.html>

<http://www.nrel.gov/>

<http://www.the-mrea.org/>

<http://www.wifocusonenergy.com/>

Biomass Energy

<http://www.biomass.org/>

<http://www.cglg.org/projects/biomass/>

Geothermal Energy

<http://geothermal.id.doe.gov/>

<http://geothermal.marin.org/>

Hydropower Energy

<http://www.hydro.org/default.asp>

<http://www.fwee.org/>

Solar Energy

<http://www.solarenergy.net/>

<http://www.ases.org/>

Wind Energy

<http://www.awea.org/>

ENERGY EDUCATION CONCEPTUAL FRAMEWORK



Conceptual Framework

Introduction

This energy education conceptual framework is not a curriculum in itself, rather, it is a skeleton that provides the foundation for a curriculum. Just as the bones of a skeleton provide strength and structure to a body, the concepts that make up the framework provide the basis for a strong, organized, and comprehensive curriculum. We have endeavored to provide concepts that address a variety of different issues and viewpoints.

These concepts were derived from energy-related frameworks designed by other educational organizations (National Energy Foundation, 1988; North American Association for Environmental Education, 1990) and from physical and environmental science texts. We developed additional concepts to reflect issues specific to Wisconsin. Throughout this process, the KEEP Steering Committee and two focus groups—consisting of energy resource management specialists, curriculum planners, and educators—reviewed and evaluated the framework. Their assistance helps ensure that the concepts in this framework form the basis of a logically sequenced, comprehensive energy education.

This framework is designed to evolve as energy education evolves. We encourage teachers and curriculum developers to assist with this evolution by modifying and adding to this framework as they build a curriculum that best fits the needs of their educational programs.

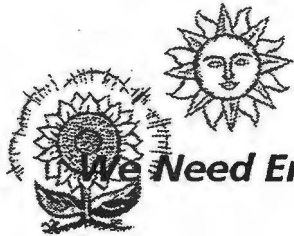
Framework Organization

The concepts within the framework are organized under four themes. Each theme consists of concepts which are further organized into subthemes.

The themes are arranged so that they build upon each other. The information in the first theme lends understanding to concepts in the second theme, and so forth. The first theme, *We Need Energy* defines energy, describes how energy is transferred and converted from one form to another according to the laws of thermodynamics, and explains how energy flows through living and nonliving systems. *Developing Energy Resources* addresses the sources of energy and how humans, through technology, use energy to meet societal wants and needs. It also shows how humans have come to treat energy as a resource. *Effects of Energy Resource Development* covers how using energy resources affects human societies and the environment. Finally, *Managing Energy Resource Use* identifies strategies we can use to help resolve many of the issues presented in the third theme. In addition, this theme discusses how today's energy-related decisions and actions influence the future availability of energy resources.

Themes

Page



We Need Energy6



Developing Energy Resources10

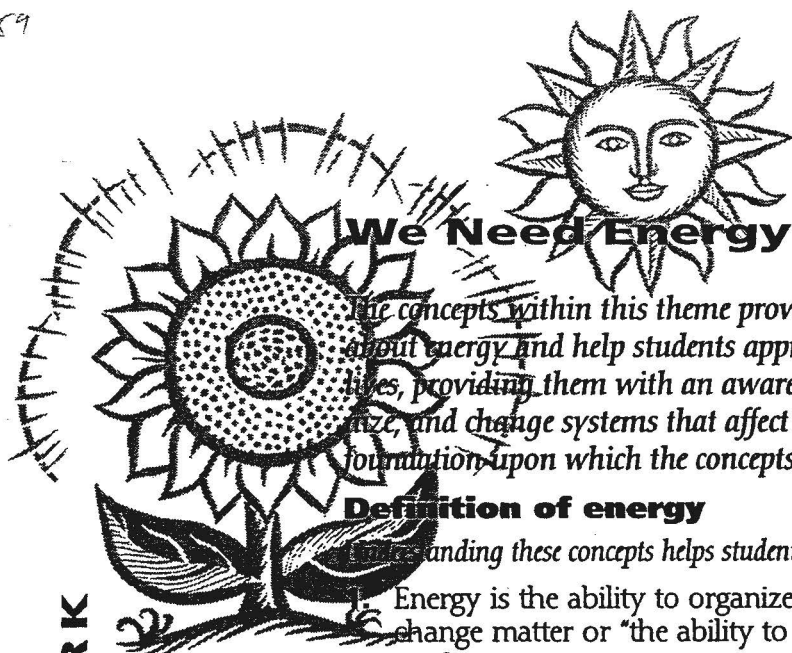


Effects Of Energy Resource Development12



Managing Energy Resource Use14

KEEP
5



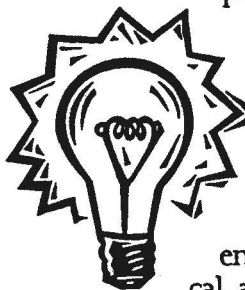
The concepts within this theme provide students with a fundamental knowledge about energy and help students appreciate the nature of energy in their everyday lives, providing them with an awareness of how energy is used to maintain, organize, and change systems that affect their lives. These concepts also provide the foundation upon which the concepts in the following themes are built.

Definition of energy

Understanding these concepts helps students to identify forms of energy.

1. Energy is the ability to organize or change matter or "the ability to do work."

2. Energy exists in two main forms: potential energy (energy stored in matter) and kinetic energy (energy of motion). More specific forms of energy include thermal, elastic, electromagnetic (such as light, electrical, and magnetic energy), gravitational, chemical, and nuclear energy.



3. Energy can be measured and quantified. Different units of

measure can be used to quantify energy. One unit can be converted to another. Units of measure for energy include calories and kilowatt-hours.

4. Power is the rate at which energy is used. Units of measure for power include horsepower and watts.



Natural laws that govern energy

Mastering these concepts helps students interpret how energy is transferred and converted. It also helps them recognize that there are natural limitations to the amount of energy that anyone or anything can use.

5. Energy can be transferred from one location to another, as in when the sun's energy travels through space to Earth. The two ways that energy can be transferred are by doing work (such as pushing an object) and by transferring heat (conduction, convection, and radiation).

6. Energy can neither be created nor destroyed, it can only be converted from one form to another. This is the first law of thermodynamics. For example, the chemical energy stored in coal can be converted into thermal energy.

7. With each energy conversion from one form to another, some of the energy becomes unavailable for further use. This is the second law of thermodynamics. For example, the thermal energy released by burning coal is eventually dispersed into the environment and cannot be used again. The measure of this dispersal of energy is called "entropy." For example, the entropy of an unburned piece of coal and its surroundings is lower than the entropy of the ashes, cinders, and the warmed surroundings due to burning that piece of coal.

Energy flow in systems

Comprehending these concepts helps students interpret the natural laws that govern energy flow through living and nonliving systems.

8. All systems obey the natural laws that govern energy.
9. Some of the energy converted by systems flows through them. The

rest is stored within them for seconds or even millions of years. Some systems convert energy more efficiently than others.

Energy flow in nonliving systems

Understanding these concepts helps students explain how energy creates weather patterns and shapes the Earth's surface.

10. Energy flows through and is stored within a variety of nonliving systems.

- Solar energy absorbed and distributed on Earth's surface gives rise to weather systems and ocean currents.

- The thermal energy stored in Earth's interior shapes and

moves Earth's crust as in earthquakes, mountain building, and volcanic activity.



Energy flow in living systems

By mastering these concepts, students should be able to illustrate how humans and other organisms get the energy they need to survive.

11. Living systems use energy to grow, change, maintain health, move, and reproduce. Some of the energy acquired by living systems is stored for later use.

- Plants and other autotrophs convert solar energy to chemical energy via photosynthesis.

- Animals and other heterotrophs convert chemical energy in plants or in other animals to chemical energy they can use via cellular respiration.

- Energy is needed for maintaining the health-nutrition and the quality and quantity of food-of all organisms, including humans.

12. Living systems differ in how fast they use energy. Some living systems—such as birds—use energy quickly for growth and metabolism, and therefore must replace it quickly. Others—such as turtles—use energy more slowly and, therefore, need to replace it less frequently.

We Need Energy *Continued*

Energy flow in ecosystems, including human societies

Fully comprehending these concepts helps students recognize how energy flows through and characterizes ecosystems. It also helps students appreciate that the world around them—including human societies—depends on a continuous supply of energy.

- 13.** Ecosystems use energy to maintain biogeochemical cycles—such as the sedimentary, gaseous, and hydrologic cycles—between living and nonliving systems.

- 14.** Ecosystems are characterized by:

- Types and quantities of available energy sources, such as the chemical energy stored in plants.
- Types and characteristics of energy flows, such as food webs.
- Energy budgets, which are the amount of energy available with respect to the amount of energy used by an ecosystem. The total energy budget of an ecosystem determines its carrying capacity.
- An ability to use energy to maintain a balanced or steady state.

- 15.** Wisconsin has five main biological communities: northern forests, southern forests, prairies, oak savanne and aquatic.

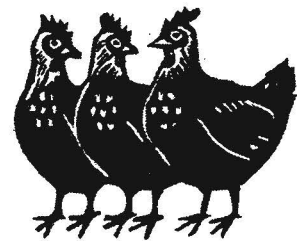
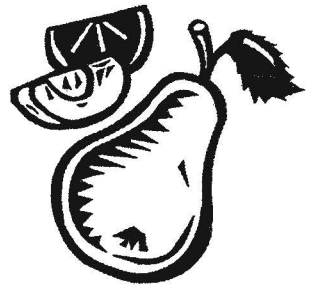
- 16.** Human societies, like natural ecosystems, need energy to organize and maintain themselves. The human use of energy follows the natural laws that govern energy flow in all systems.

- 17.** Human societies range from hunter-gatherer to industrial and can be classified by the amount of energy they use and the rate at which they use it (Miller, 1988).

- Hunter-gatherer societies are adapted to their natural envi-

ron-
ments.
They
depend
on ener-
gy and
materials
available
directly

from nature, and their rates of consumption of the energy and materials they use are often in balance with nature.



- Nonindustrial agricultural societies modify their natural environments primarily to domesticate food sources. They depend on modest technologies to provide energy and materials.



- Industrial societies attempt to remake and control their natural environment. They have high rates of energy consumption,

depend on sophisticated technologies, and require a substantial energy subsidy to provide energy and materials for residential, commercial, industrial, agricultural, and transportation needs.

18. In general, Wisconsin and the rest of the United States is an industrial, technologically advanced, high-energy-use society.



Developing Energy Resources

This theme helps students realize how they and other humans have become more and more dependent on the development and use of energy resources to satisfy their standard of living. Understanding what energy is and how it flows through systems is necessary to appreciate how humans have come to value and treat energy as a resource.

Development of energy resources

Understanding these concepts helps students explain how humans have used technology to further their ability to use energy. It also helps students identify and compare different energy resources—such as renewable and nonrenewable—and appreciate the importance of energy-related technologies.

- 19.** Primary energy sources are those that are either found or stored in nature.

- ➔ See concept 20 for secondary energy resources.
- ➔ See concept 25 for renewable and nonrenewable energy resources.

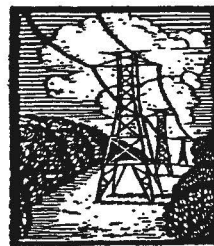


•The sun is a primary energy source and the principal source of Earth's energy. Energy from the sun is

stored in other primary energy sources such as coal, oil, natural gas, and biomass (such as wood). Solar energy is also responsible for the energy in the wind and in the water cycle (the hydrologic cycle).

- ➔ See concept 13 for the hydrologic and other biogeochemical cycles.
- Other primary energy sources found on Earth include nuclear energy from radioactive substances, thermal energy stored in Earth's interior, and potential energy due to Earth's gravity.

- 20.** Secondary energy resources are produced from primary energy resources using technology. For example, we produce electricity—a secondary resource—by burning coal in a power plant or by using photovoltaic cells to harness solar energy. We can also produce alcohol fuel from crops.



- 21.** Energy sources are considered to be energy resources by individuals and society when they serve societal needs and wants. Examples of using resources are burning wood for warmth, and extracting and refining oil to produce fuel for transportation or materials such as plastic.



- 22.** Human societies have obtained energy resources in the following ways:
- Hunter-gatherer societies get their energy from decentralized

energy systems—as in gathering wood from a forest and burning it to cook food.

- Nonindustrial agricultural societies also get their energy from decentralized energy systems—such as using wind-mills to grind grain—although these systems are more centralized than those of hunter-gatherer societies.
- Industrial societies get their energy from a mix of centralized energy systems (power plants) and decentralized energy systems (solar panels on rooftops), with centralized energy systems being the dominant energy system. Most of these energy systems were developed by understanding the natural laws that govern energy and applying this knowledge to create sophisticated energy technologies.

23. Some energy sources are concentrated, such as the nuclear energy stored in enriched uranium used in a nuclear power plant, and others are diffuse, such as thermal energy stored in the oceans.

24. Geographically, Earth's energy sources are unevenly distributed.
25. Certain energy resources are renewable because they can be replaced by natural processes quickly. Renewable resources include solar energy, wind, hydropower, and biomass. Even some of these resources can be depleted when their rate of use exceeds their rate of replacement. Other energy resources are nonrenewable because they are either replaced very slowly or are not replaced at all by natural processes. Nonrenewable resources include fossil fuels—coal, oil, and natural gas—and nuclear fuels such as uranium.
26. Wisconsin has primary energy sources.
27. Most of the energy resources currently used in Wisconsin are fossil and nuclear fuels, all of which are imported into the state. Other resources used in Wisconsin include biomass, hydropower, solar energy, and wind, all of which are renewable and can be found within the state.

Consumption of energy resources

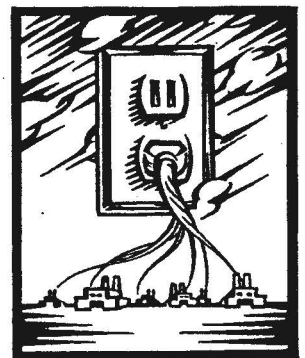
Mastering these concepts helps students assess modern human societies' dependence on energy and analyze how we have come to value energy as a resource.

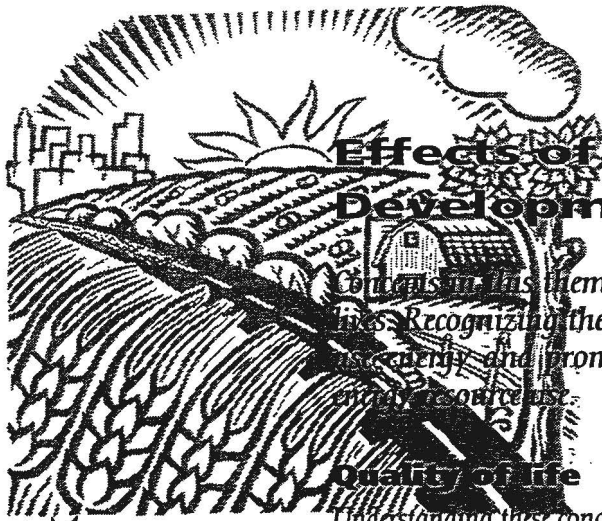
28. Supply and demand influence energy resource discovery, development, and use. The supply and demand for an energy resource is determined by resource availability, level of technological development, and societal factors such as lifestyle, health and safety, economics, politics, and culture.

➡ See the next theme, *What Are The Effects Of Energy Resource Use?* for concepts that address the economic and sociopolitical effects of energy consumption.

29. Global demands for energy resources are increasing. This is

due to human population growth and increasing worldwide consumption. As certain energy resources are depleted and demand increases, competition for these resources also increases. This is especially true of non-renewable resources, such as fossil fuels.





Effects of Energy Resource Development

Concepts in this theme help students investigate how energy use has affected their lives. Recognizing these effects increases students' awareness of why and how they use energy and promotes an understanding of why it's important to manage energy resource use.

Quality of life

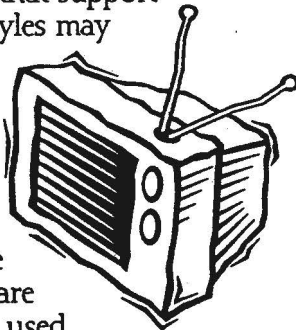
Understanding these concepts helps students analyze current energy-use practices and evaluate how they affect quality of life.

Lifestyles

- 30.** A driving factor in the development of energy-related technology has been people's desire for comfort, convenience, and entertainment.

➔ See concepts 44 - 47 for how comfort, convenience, and entertainment relate to cultural aspects of energy development and use.

- 31.** Technologies that support people's lifestyles may lead to the inefficient use of energy resources, depending on how these technologies are designed and used.



Health and safety

- 32.** There are personal and community health and safety factors associated with the development and use of energy resources. Energy resource development and use may pose direct risks to personal and community health and safety. By affecting the quality of the environment, energy use may pose indirect risks to personal and community health and safety.

➔ See concept 48 for environmental risks to the health and well-being of human and nonhuman life.

- 33.** The health and safety of Wisconsin citizens is related to the development and use of energy resources.

Economic

- 34.** The availability and use of energy resources influence the economic growth and well-being of society.
- 35.** Many occupations, businesses, and public services—such as utilities—result from the development and use of energy resources.
- 36.** The market price of energy includes the cost of energy resource exploration, recovery, refining, pollution control, distribution, and transportation, as well as taxes and other fees.
- 37.** Other costs that are not part of the market price of energy (called externality costs) are due to factors such as environmental damage, property damage, civil unrest, war, and health care.



- 38.** The rate of energy consumption is influenced by energy prices and externality costs.
- 39.** The cost of energy is a factor in Wisconsin's economic development and affects the household budget of Wisconsin citizens.

Sociopolitical

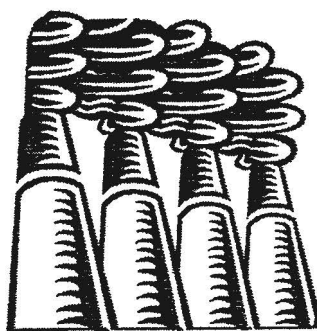
40. Sociopolitical processes result in laws and regulations that govern energy development, availability, and use. Sociopolitical processes have usually governed centralized energy systems such as public utilities.
41. The demand for energy resources influences relationships—alliances and conflicts—among states, regions, and nations.
42. The positive and negative effects of energy resource development and use are not shared equally among states, regions, nations, and individuals, although sociopolitical processes have made some effort to address this.
43. Wisconsin's sociopolitical processes result in laws and regulations that govern energy development, availability, and use.

Cultural

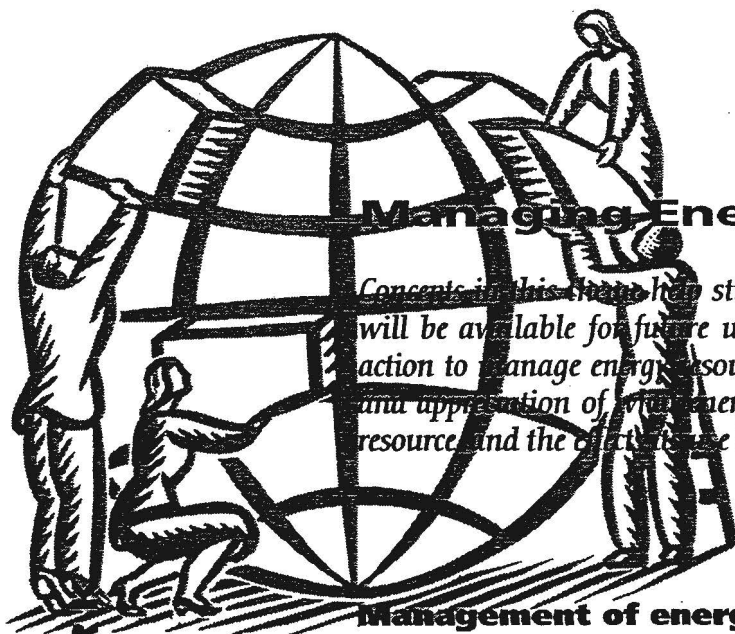
44. The availability of energy resources has shaped cultures, and each culture has value systems that influence how energy resources are used.
45. Energy use by cultures is expressed through art, architecture, urban planning, music, language and literature, theater, dance, other forms of media, sports, and religion.
46. Because society's understanding of and relationship with energy changes over time, cultural expressions of energy use change over time as well. For example, ancient Egyptians worshiped the sun, while modern societies associate the sun with a positive mood, recreation, and nature.
47. Wisconsin's culture has been, and will continue to be, shaped in part by available energy resources.

Quality of the environment

By comprehending these concepts, students will be able to explain how current energy use practices affect the quality of the environment and the health of organisms living in the environment.



48. Energy resource development and use can alter environmental conditions leading to, for example, reduced air and water quality, deforestation, and changes in land use due to road building. These altered environmental conditions may pose risks to the health and well-being of human and other life-forms.
49. The faster and more extensively energy resources are developed and used, the more likely that environmental conditions will be altered to a greater degree.
50. It takes less energy and less money to preserve the environment than it does to restore the environment after it has been altered.
51. Wisconsin's environment has been, and continues to be, altered by energy resource development and use.



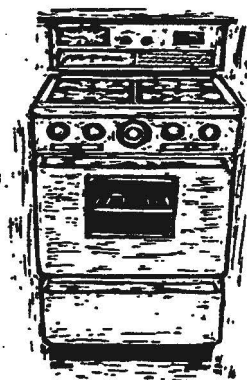
Managing Energy Resource Use

Concepts in this theme help students identify ways to ensure that energy resources will be available for future users. 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 effect its use has on human societies and the environment.

Management of energy resource use

By mastering these concepts, students will recognize their ability to make decisions regarding which resources to use and how those decisions influence the future availability of resources. Students will also identify actions they can take based on these decisions.

52. The choice of energy resource and how it is used influences how energy resources are managed.
53. Energy resources may be managed through conservation, which includes reducing wasteful energy use, using energy for a given purpose more efficiently, or reducing energy use altogether. Energy conservation prolongs the availability of energy resources and contributes to the development of a sustainable society.
54. A citizen, acting individually or as part of a group or organization, may make decisions (such as deciding to ride a bicycle instead of driving a car) and take actions (riding the bicycle) that determine how the energy they use will be managed. Citizens may also affect the actions of other individuals, groups, or organizations to determine how the energy they use will be managed. This can be accomplished by ecomanagement (physical action), education, persuasion, consumer action, political action, or legal action.
55. The decisions and actions taken by societies and their citizens depend on the barriers and incentives associated with energy management choices. Examples of barriers include high energy costs, lack of access to new technologies, and laws that discourage the development or use of certain energy resources. Examples of incentives include rebates, building codes that promote energy conservation, and appliance efficiency standards.
56. Energy management products and programs are available to help Wisconsin citizens use energy resources more efficiently, such as through conservation programs, home heating fuel options, and programs that promote certain lifestyles. These products and programs also help maintain the quality of the environment within and beyond Wisconsin.



Future outlooks for the development and use of energy resources

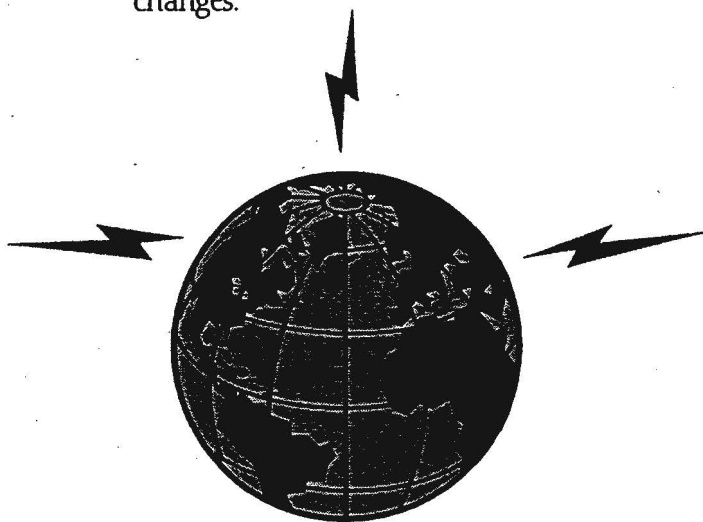
By understanding these concepts, students can evaluate how their actions affect the quality of life and the environment of their community, nation, and world. Students will also predict how scientific, technological, and social changes will influence future energy resource availability.

- 57.** New energy resources, new ways of managing energy resources, and new energy technologies will be developed in the future.



- 58.** Choices made today about energy resource management will affect the future quality of life and the environment.

- 59.** New types of societies—such as a sustainable society or a postindustrial society whose economy is based on information and service—may emerge as energy resource development and use changes.



Appendix D

Renewable Energy Education Framework in a Narrative Form

Renewable Energy

Renewable energy sources can be replenished in a short period of time. The five renewable sources used most often are solar, wind, hydropower (water), biomass and geothermal.

Solar Energy

The sun has produced energy for billions of years. Solar energy is the solar radiation that reaches the earth. It can be converted directly or indirectly into other forms of energy, such as heat and electricity. Solar energy is used for heating water for domestic use, space heating of buildings, drying agricultural products, and generating electrical energy. The simplest systems power many of the small calculators and wrist watches we use every day.

Generating Electricity

Photovoltaic energy is the conversion of sunlight into electricity through a photovoltaic (PV) cell, commonly called a solar cell. A photovoltaic cell is a nonmechanical device usually made by silicon alloys.

How It Works

Sunlight is composed of photons, or particles of solar energy. When photons strike a PV cell, they may be reflected, pass right through, or be absorbed. Only the absorbed photons provide energy to generate electricity. When enough sunlight (energy) is absorbed by the material (a semiconductor), electrons are dislodged from the material's atoms. Special treatment of the material surface during manufacturing makes the front surface of the cell more receptive to free electrons, so the electrons naturally migrate to the surface.

When the electrons leave their position, holes are formed. When many electrons, each carrying a negative charge, travel toward the front surface of the cell, the resulting imbalance of charge between the cell's front and back surfaces creates a voltage potential like the negative and positive terminals of a battery. When the two surfaces are connected through an external load, electricity flows. You can put together many solar cells to form an array, which can provide electricity for an entire building.

Using Photovoltaic Cells

PV cells were originally developed for use in space. PV still powers nearly every satellite circling the earth because it operates reliably for long periods of time with virtually no maintenance.

PV cells use the energy from sunlight to produce electricity-the fuel is free. With no moving parts, the cells require little upkeep. These low-maintenance, cost-effective PV systems are ideal for supplying power to communication stations of mountain tops, navigational buoys at sea, or homes far from utility power lines. Even in urban areas, PV systems can be cost effective. PV systems are usually placed close to where the electricity is being used, requiring much shorter power lines than if power is brought in from the utility grid. In addition, using PV eliminates the need for a step-down transformer from the utility line. Less wiring means lower costs, shorter construction time, and reduced permitting paperwork.

Generating Heat

We also use solar energy to heat swimming pools, heat water for domestic use, and space heating of buildings. For these purposes, the general practice is to use flat-plate solar energy collectors with a fixed orientation, along with a storage tank.

Generally, all flat-plate collectors consist of (1) a flat-plate absorber, which intercepts and absorbs the solar energy, (2) a transparent cover that allows solar energy to pass through but reduces heat loss from the absorber, (3) a heat-transport fluid (air or water) flowing through tubes to remove heat from the absorber, and (4) a heat insulating backing.

The sun heats the absorber plate in the collector, which, in turn, heats the fluid running through tubes within the collector. To move the heated fluid between the collector and the storage tank, a system either uses a pump or gravity, as water has a tendency to naturally circulate as it is heated.

Applications

We use solar energy to heat hot water heaters and to heat pools. Solar energy can also heat homes, with the addition of a mechanism to circulate the warm air. Also, passive solar heating is present in an increasing number of homes and businesses. This is when sunlight is incorporated into the architecture of the house, to naturally warm or cool the house. This is accomplished by the orientation of the house and window placement.

Wind

How It Works

The uneven heating of the Earth's surface causes wind. We can harness this wind to generate electricity. Wind turbines are mounted on a tower to capture the most energy. At 100 feet (30 meters) or more aboveground, they can take advantage of the faster and less turbulent wind. Turbines catch the wind's energy with their propeller-like blades. Usually, two or three blades are mounted on a shaft to form a rotor.

A blade acts much like an airplane wing. When the wind blows, a pocket of low-pressure air forms on the downwind side of the blade. The low-pressure pocket then

pulls the blade toward it, causing the rotor to turn. This is called lift. The force of the lift is actually much stronger than the wind's force against the front side of the blade, which is called drag. The combination of lift and drag causes the rotor to spin like a propeller, and the turning shaft spins a generator to make electricity.

Applications

Wind turbines can be used as stand-alone applications, or they can be connected to a utility power grid or even combined with a photovoltaic system. Stand-alone wind turbines are typically used for water pumping or communications. However, homeowners or farmers in windy areas can also use wind turbines as a way to cut their electric bills. For utility-scale sources of wind energy, a large number of wind turbines are usually built close together to form a wind plant. Several electricity providers today use wind plants to supply power to their customers.

Hydropower

Of the renewable energy sources that generate electricity, hydropower is the most often used.

How It Works

Hydropower plants capture the kinetic energy of falling water to generate electricity. The water's flow or fall determines the amount of available energy in moving water. The faster the flow or the greater its fall (as in a waterfall), the more energy is available. The water pushes against and turns blades in a turbine to spin a generator to produce electricity. The turbine and a generator first convert the energy from the water to mechanical and then electrical energy. The turbines and generators are installed either in or adjacent to dams, or use pipelines (penstocks) to carry the pressured water below the dam. Hydropower projects are generally operated in a run-of-river peaking or storage mode.

Run-of-river projects use the natural flow of the river and produce relatively little change in the stream and stream flow. A peaking project impounds and releases water when the energy is needed. A storage project extensively impounds and stores water during high-flow periods to augment the water available during available during low-flow periods, allowing the flow releases and power production to be more constant. The power capacity of a hydropower plant is primarily the function of two variables: (1) flow rate expressed in cubic feet per second, and (2) the hydraulic head, which is the elevation difference the water falls in passing through the plant.

Most conventional hydropower plants include six major components:

1. Dam. Controls the flow of water and increases the elevation to create the head. The reservoir that is formed is, in effect, stored energy.
2. Penstock. Carries water from the reservoir to the turbine in a power plant.
3. Turbine. Turned by the force of water pushing against its blades.
4. Generator. Connects to the turbine and rotates to produce the electrical energy.

5. Transformer. Converts electricity from the generator to usable voltage levels.
6. Transmission lines. Conduct electricity from the hydropower plant to the electric distribution system.

The principal advantages of using hydropower are its large renewable domestic resource base, the absence of polluting emissions during operation, its capability in some cases to respond quickly to utility load demands, and its very low operating costs. Also, there are beneficial effects such as recreation in reservoirs or in tailwaters below the dam. Disadvantages can include high initial capital cost and potential site-specific and cumulative environmental impacts.

Types of Hydroplants

Hydropower technology can be categorized into two types: conventional and pumped storage. Conventional hydropower plants use the available water energy from a river, stream, canal system, or reservoir to produce electrical energy. In conventional multipurpose reservoirs and run-of-river systems, hydropower production is just one of many competing purposes for which the water resources may be used. Competing water uses include irrigation, flood control, navigation, and municipal and industrial water supply. Pumped storage plants pump the water resource, usually through a reversible turbine, from a lower reservoir to an upper reservoir. While pumped storage facilities are net energy consumers, they are valued by a utility because they can be rapidly brought on-line to operate in a peak power production mode. The pumping to replenish the upper reservoir is performed during off-peak hours when electricity costs are lowest. This process benefits the utility by increasing the load factor and reducing the cycling of its base load units. In most cases, pumped storage plants run a full cycle every 24 hours.

Applications

The major application for hydropower energy is in the bulk power market, where it accounts for about 77,000 MW conventional capacity and 18,000 MW of pumped storage capacity, or about 10% of the electric generating capacity in the United States. Hydropower is an essential contributor in the national power grid because of its ability to respond in seconds to large and rapidly varying loads, which other base load plants with steam systems powered by combustion or nuclear processes cannot accommodate.

Biomass

How It Works

The term Biomass refers to all the Earth's vegetation and many products and coproducts that come from it. Biomass contains energy that has been stored through photosynthesis. That energy content remains when plants are processed into other materials such as paper and animal wastes, and even into forms of energy we use every day, such as electricity and transportation fuel. The key to accessing the energy content in biomass is converting the raw material (feedstock) into a usable form, which is accomplished most often through combustion. The nation's potential

biomass resource is great enough to meet a large part of our energy needs. Domestic biomass resources include agricultural and forestry wastes, municipal solid wastes, industrial wastes, and terrestrial and aquatic crops grown solely for energy purposes, known as energy crops.

Applications

Agricultural Waste

More than 86 million metric tons (95 million tons) of agricultural waste are generated in the U.S. each year. This includes agricultural residues such as wheat straw, corn stover and orchard trimmings. Corn alone provides more waste than all other sources of biomass in this country. United States farmers plant about 80 million acres of corn each year, with a potential stover (leaves, stalks, and cobs) harvest of some 120 million dry tons. This is nearly four times greater than the biomass available from wood waste and paper.

Forestry Waste

From 90 to 254 million metric tons (100 million to 280 million tons) of forestry wastes could be collected in the United States each year. Forestry waste includes underutilized wood and logging residues, imperfect commercial trees, and non-commercial trees that need to be thinned from crowded, unhealthy, fire-prone forests. Forest thinning is not only necessary to help western softwood forests regain their natural health, but it will also provide a large supply of waste wood that can be converted to biomass power or biofuels.

Biofuels

Biofuels are made from cellulosic biomass such as herbaceous and woody plants, which are often byproducts of agricultural and forestry processes. The term biofuels can refer to fuels for electricity and fuels for transportation. Ethanol, a fuel for transportation, is being widely developed and used today. More than 1.5 billion gallons are added to gasoline in the US each year to improve vehicle performance and reduce air pollution. Ethanol is an alcohol, and most is made using a process similar to brewing beer.

Ethanol Production

1. Milling: The feedstock passes through hammer mills, which grind it into a fine meal.
2. Liquefaction: The meal is mixed with water and alpha-amylase, and passes through cookers with a high temperature stage and a lower temperature holding period, where the starch is liquefied. Heat is applied to enable liquefaction. The high temperatures reduce bacteria levels in the mash.
3. Saccharification: The mash from the cookers is cooled and the secondary enzyme (gluco-amylase) is added to convert the liquefied starch to fermentable sugars (dextrose).
4. Fermentation: Yeast is added to the mash to ferment the sugars to ethanol and carbon dioxide. Using a continuous process, the fermenting mash is allowed to

flow through several fermenters until the mash is fully fermented and then leaves the final tank.

5. Distillation: The fermented mash contains about 10% alcohol, as well as all the nonfermentable solids from the corn and yeast cells. The mash is pumped to the continuous flow, multicolumn distillation system where the alcohol is removed from the solids and the water. The residue mash, called stillage, is transferred from the base of the column to the coproduct processing area.
6. Dehydration: The alcohol from the top of the column passes through a dehydration system where the remaining water is removed. The alcohol product at this stage is called anhydrous (pure, without water) ethanol.
7. Denaturing: Fuel ethanol is denatured with a small amount of some product such as gasoline, to make it unfit for human consumption.
8. Coproducts: Two main coproducts, carbon dioxide and distillers grain, are created during ethanol production. Carbon dioxide is given off during fermentation. Many ethanol plants collect it, compress it and sell it for use in carbonate beverages or to flash freeze meat. Wet and dried distillers grains are high in protein and are valued as a livestock feed ingredients.

Ethanol production is a no-waste process that adds value to the feedstock by converting it into more valuable products. In some areas of the US today, ethanol is blended with gasoline to form a blend. This increases octane and improves the emissions quality of gasoline.

Municipal Solid Waste

By the year 2000, approximately 196 million metric tons (216 million tons) of municipal solid waste will be generated in the United States. Each year, American industry generates about 11 billion metric tons (12 billion tons) of wastes requiring treatment and disposal. Due to the large volume of waste generated by industry and private homes, landfills are becoming increasingly expensive and closely regulated. Many landfills are being forced to close because of more stringent regulations required for their operation. Instead of burying this waste in landfills, much of it could be used to make biofuels or generate biopower.

Biomass is an attractive energy source for a number of reasons. First, it is a renewable energy source as long as we manage vegetation appropriately. Biomass is also more evenly distributed over the earth's surface than finite energy sources, and may be exploited using less capital-intensive technologies. It provides the opportunity for local, regional and national energy self-sufficiency across the globe. And energy derived from biomass does not have the negative environmental impact associated with non-renewable energy sources.

In the United States, it is estimated that about 77 million hectares (190 million acres) of land could be used to produce energy crops. Energy crops are crops developed and grown specifically for fuel. These include fast-growing trees, shrubs, and grasses, such as hybrid poplars, willows, and switchgrass. Energy crops can be grown on agricultural lands not needed for food, feed, and fiber. In addition, farmers can plant

energy crops along riverbanks, around lakeshores or between farms and natural forests or wetlands to create habitat for wildlife and renew the soils. Trees can be grown for as long as a decade, then be harvested for energy. The U.S. Department of Agriculture estimates that there will be about 100 million acres available for growing energy crops in the 21st century.

Another advantage of energy crops is that they provide diversity of production to farmers, reducing risks from fluctuating markets and stabilizing farm income. The typical modern farm usually only produces one or two major commercial products such as corn, soybeans, milk or beef. The net income of the entire operation is often vulnerable to fluctuations in market demand, unexpected production costs, and the weather, among other factors. Energy crops are also more resistant to disease and pests and relatively inexpensive to grow.

Geothermal

How It Works

Heat from the earth, called geothermal energy, can be collected. Usually, engineers try to collect this heat in places where the Earth's crust is thin by drilling into the crust and allowing the heat to escape, either as steam or very hot water. Pipes carry the hot water to a plant, where some of the steam is allowed to "flash", or separate from the water. The steam then turns a turbine-a generator to make electricity.

Applications

The electricity generated from geothermal energy is used to power homes, businesses and industry.

Environmental Effects of Renewable Energy

Solar

The environmental impact of a photovoltaic system is minimal, requiring no water for system cooling and generating no by-products. Because it burns no fuel and have no moving parts, PV systems are clean and silent.

Wind

The environmental impact of a wind system is minimal, requiring no water for system cooling and generating no by-products. Some find the turbines to be unattractive, detracting from the scenery. Also, the spinning of the turbines produces noise.

Hydropower

Hydropower produces no waste products and does not pollute the air or water. However, the environmental effects of using hydropower are many. Most often, to harness the energy in water a dam is constructed, disrupting the aquatic ecosystem. It floods a large area behind the dam, destroying the existing habitat. It also regulates the flow of the river as to eliminate the river's flooding cycle. This affects the many

plants and animals that are dependent on the periodic inundation of the floodplain. Perhaps the most prominent environmental impact is imposed on the salmon population. They are born in fresh water streams and rivers, travel downstream and live their adult lives in the ocean, and then migrate upstream to their birthplace in order to spawn. The presence of dams makes it extremely difficult for salmon to make the trip back upstream. The existence of many salmon species is threatened or endangered due to the difficulties imposed on them by dams. Many birds and bears are directly dependent on salmon for survival.

Biomass

Producing and using biomass is much better for the environment than burning fossil fuels. Biomass produces fewer harmful emissions (ozone and sulfur dioxide) during production and combustion and they contribute less carbon dioxide to the atmosphere. The amount of carbon dioxide released is offset by the amount of carbon dioxide that is consumed through photosynthesis during the crop's growth.

Ethanol can replace the most toxic parts of gasoline with a fuel that quickly biodegrades in water, reducing the threat that gasoline poses to waterways and groundwater. Ethanol spills or leaks are not an environmental hazard.

Geothermal

Geothermal energy has a major environmental benefit because it offsets air pollution that would have been produced if fossil fuels were the energy source. Geothermal energy has a very minor impact on the soil. Since the slightly cooler water is reinjected into the ground, there is only a minor impact, except is there is a natural geyser field close by.

Appendix E
Draft of Renewable Energy Conceptual Framework That Mirrors KEEP's
Organization

Conceptual Framework for Renewable Energy Education

A work in progress...

Developing Renewable Energy Resources

This theme helps students to realize how they and other humans have become more and more dependent on the development and use of energy resources to satisfy their standard of living.

The following concepts under the theme of Developing Renewable Energy Resources would expand on concept #25 in the KEEP conceptual framework.

Renewable Energy

Mastering these concepts will help students to comprehend renewable energy.

1. Renewable energy sources can be used to generate electricity and heat and provide fuel for vehicles.
2. Renewable energy sources can be replenished in a short period of time.
3. Six renewable sources commonly used are solar, wind, hydropower, biomass, geothermal and hydrogen.
4. Renewable energy has been used for many generations.
 - Solar (passive solar heating) and biomass energy have been used by humans for thousands of years.
 - Wind has been used by humans for many generations.
 - Hydropower has been used for thousands of years to provide mechanical energy to grind grain, drive sawmills, and pump water.
 - Harnessing geothermal and hydrogen energy has more recent origins.
5. Renewable energy is reliable for residential and commercial production.

Solar Energy

Comprehending these concepts will help students to understand solar energy.

1. Solar energy is the solar radiation that reaches the earth.
2. Solar energy is used for space and water heating.
 - Passive heating is when air or water is warmed and is allowed to naturally circulate.
 - Active heating involves the use of pumps or other devices to disseminate the warmed air or water.

3. Solar energy is used to generate electricity. Photovoltaic energy is the conversion of sunlight into electricity through a photovoltaic (PV) cell, commonly called a solar cell.
 - PV cells were originally developed for use in space. PV still powers nearly every satellite circling the earth because it operates reliably for long periods of time with virtually no maintenance.
4. Solar technology can be installed in residential and commercial settings.

Wind Energy

Mastering these concepts will help students to comprehend the wind energy.

1. Wind is air in motion and is produced by the unequal heating of the earth's surface by the sun.
2. Wind turbines capture wind energy to generate electricity.
 - The rotor spins like a propeller and turns a shaft that is connected to a generator.
3. Wind systems can be installed in residential and commercial settings.

Hydropower

Understanding hydropower will help students comprehend using water to generate electricity. Of the renewable energy sources that generate electricity, hydropower is the most often used.

1. Hydropower refers to the energy of flowing water.
2. Hydropower plants can capture the energy in flowing water by damming a river, or channeling a portion of a river through a generating facility.
3. Hydropower plants capture the kinetic energy of falling water to generate electricity.
 - The water pushes against and turns blades in a turbine to spin a generator to produce electricity.
4. The water's flow or fall determines the amount of available energy in moving water.
5. Hydropower is most often used to generate electricity on a commercial scale.

Biomass Energy

Understanding biomass will help students comprehend the uses of vegetation as an energy source.

1. Biomass refers to all Earth's vegetation and many products and coproducts that come from it.
2. Biomass can be used for a variety of purposes.
 - Combustion of biomass can be used to generate electricity.
 - Combustion of biomass can be used to produce heat for climate control and manufacturing.
 - Ethanol, a fuel, is produced from the fermentation of grains.

- Gasification converts decaying biomass in landfills and biogas digesters into a gas called methane, the main ingredient in natural gas.

Geothermal Energy

Mastering these concepts will help students realize how the Earth's internal energy can be used as an energy source.

1. Geothermal energy originates in the interior of the earth.
2. The most active, high temperature geothermal resources are usually found along major tectonic plate boundaries where earthquakes and volcanoes are concentrated.
3. High temperature geothermal resources can be used to generate electricity.
 - Geothermal plants drill wells to capture underground steam, which spins a turbine to produce electricity.
4. Low temperature geothermal resources are used for residential and commercial heating and for other heating tasks.
 - Low temperature geothermal exchange systems, or ground source heat pumps, can be used almost everywhere in the U.S. These systems use fluids circulating through underground pipes to transfer the heat from the ground into buildings in winter and out of buildings in summer.
 - In the United States, the earth's temperature a few feet below the surface is remarkably constant year round, ranging from 50-65 degrees Fahrenheit.

Hydrogen Energy

Comprehending how we may obtain energy from hydrogen will help students appreciate the diversity of uses of one of Earth's most abundant elements.

1. Hydrogen is the third most abundant on the earth's surface.
 - Hydrogen is found primarily in water and organic compounds.
 - Hydrogen as a gas (H^2) does not exist on Earth; it is always combined with other elements.
2. Hydrogen can be obtained from a variety of sources.
 - Hydrogen can be produced from renewable (methanol and biomass) and nonrenewable (natural gas, coal, and gasoline) energy sources through the application of heat.
 - Hydrogen can be produced from bacteria or algae through photosynthesis.
 - Hydrogen can be produced using electricity or sunlight to split water into hydrogen and oxygen.
3. Hydrogen's potential use in fuel and energy is diverse.
 - Applications include powering vehicles, running turbines or fuel cells to produce electricity, and generating heat and electricity for buildings.
4. The current focus is on hydrogen's use in fuel cells.
 - A fuel cell works like a battery but does not run down or need recharging. It will produce electricity and heat as long as fuel (hydrogen) is supplied.

- Hydrogen fuel cells produce clean, potable water as a byproduct.

Effects of Renewable Energy Resource Development

This theme will help students investigate how renewable energy use affects the environment. Recognizing these effects increases students' awareness of why and how they use energy.

Quality of life

Understanding these concepts helps students analyze current energy-use practices and evaluate how they affect quality of life.

Lifestyles

1. Depending on renewable energy for all energy needs may require a less energy-intensive lifestyle.
- Energy efficiency is especially important when using renewable energy.

Health and safety

1. Using renewable energy may help to maintain the health of the surrounding ecosystem and thus minimize personal and community health risks.
- The number of respiratory illnesses has increased as smog produced by fossil fuels has increased.

Economic

1. The market price of energy includes the cost of energy resource exploration, recovery, refining, pollution control, distribution, and transportation, as well as taxes and other fees. (# 36 in KEEP conceptual framework)
 - The nonrenewable energy industry is subsidized by taxpayer money, thereby lowering the cost of energy to consumers.
2. Converting to a renewable energy-based economy would create many jobs. (Similar to #35)
 - Most renewable energy investments are spent on materials and workmanship to build and maintain facilities, rather than on costly energy imports.
 - Renewable energy investments are usually spent within the United States, frequently in the same state, and often in the same town. This means that your energy dollars stay at home to create jobs and fuel local economies, rather than going overseas.
3. Using renewable energy means that the U.S. could become energy independent.
 - Currently, the U.S. relies on foreign imports to fuel the economy.
4. The U.S. spends large amounts of money on oil imports.
 - U.S. trade balance sheets show that oil imports drain great amounts of money from the U.S. economy every week.
 - The government spends taxpayer dollars to subsidize oil exploration and to militarily defend access to oil in the Middle East.

Sociopolitical

(Bullet point for #43)

- Wisconsin has certain zoning laws that prevent wind turbines from being constructed in residential areas.
- 1. When using renewable energy, electrical production is put in the hands of the consumer, who then is no longer dependent on an external entity.
 - The sun and wind are not regulated and free to whomever chooses to take advantage of them. For the most part, people have equal access to the power source.

Ethical

1. Some people feel a moral obligation to minimize human impact on the planet and thus choose to use renewable energy.
2. Our current practices of extracting fossil fuels from other countries to support our energy intensive lifestyle may comprise the cultures of other countries.

Quality of the environment

By comprehending these concepts, students will be able to explain how current energy use practices affect the quality of the environment.

(Bullet point under #48)

- Mass consumption of oil requires continual drilling into pristine wilderness areas, influencing ecosystems.
- 1. Renewable energy technologies are clean sources of energy that have a lower environmental impact than conventional energy technologies.
- 2. There are costs involved in the manufacturing and distribution of renewable energy technologies.

Effects of solar energy technology

1. The environmental impact of a photovoltaic system is minimal, requiring no water for system cooling and generating no by-products. Because it burns no fuel and have no moving parts, PV systems are clean and silent.
2. Using passive solar designs in building construction could reduce electricity demand (and the bills) without the customer ever knowing.
3. The use of solar panels may require large tracks of land.

Effects of wind energy technology

1. The environmental impact of a wind system is minimal, requiring no water for system cooling and generating no by-products.
2. There are concerns regarding the impacts of wind farms.
 - Some find the turbines to be unattractive, detracting from the scenery.
 - Some are concerned with the numbers of migratory birds that are killed by wind turbines.
 - The spinning of turbines on wind farms produces noise.

Effects of hydropower technology

1. Hydropower produces no waste products and does not pollute the air.
2. The environmental effects of using hydropower are many.
 - Most often, to harness the energy in water a dam is constructed, disrupting the aquatic ecosystem. It floods a large area behind the dam, destroying the existing habitat; it may also disrupt human settlements.
 - It regulates the flow of the river as to eliminate the river's flooding cycle. This affects the many plants and animals that are dependent on the periodic inundation of the floodplain.
 - There is siltation behind the dam, thermal pollution in impoundments, and a disruption of migratory fish.

Effects of biomass energy technology

1. The amount of carbon dioxide released is offset by the amount of carbon dioxide that is consumed through photosynthesis during the crop's growth.
2. Ethanol can replace the most toxic parts of gasoline with a fuel that quickly biodegrades in water, reducing the threat that gasoline poses to waterways and groundwater.

Effects of geothermal energy technology

1. Geothermal energy has a very minor impact on the soil since the slightly cooler water is reinjected into the ground.
2. Pumps used in geothermal energy may be powered by fossil fuels, increasing greenhouse gases in the atmosphere.

Effects of hydrogen energy technology

1. The harnessing of hydrogen gas can originate from either renewable or nonrenewable sources. Using nonrenewable sources may increase greenhouse gases.

Managing Renewable Energy Resource Use

By mastering these concepts students will gain an understanding of renewable energy use today and in the future.

Future outlooks for the development and use of energy resources

By understanding these concepts, students can evaluate how their actions affect the quality of life and the environment of their community, nation, and world. Students will also predict how scientific, technological, and social changes will influence future energy resource availability.

Current and future uses of renewable energy

1. Currently, alternative energy technologies are not subsidized and are thus, in general, are more expensive than conventional power sources.
 - Wind energy costs approximately the same per kilowatt hour as using nonrenewable energy sources.

2. Alternative energy use is growing.

Current and future uses of solar energy

1. Solar energy is used worldwide.
 - In rural settings with no power sources, solar energy is used to cook, heat water, and power schools, among other uses.
 - Solar energy is primarily being used in residential settings.

Current and future uses of wind energy

1. Wind Energy is used throughout the world.
 - Denmark is a leader in the industry.
 - The Midwest, especially North and South Dakota, have tremendous potential for wind energy.
2. Many states are beginning to install wind farms.
 - Wind farms are supplying a substantial proportion of California's power.

Current and future uses of hydropower

1. Hydropower is used worldwide.
 - The Hoover Dam on the Colorado River and the dam on the Niagra Falls provide many people with electricity.
 - The Three Gorges Dam in China will be the largest dam in the world when construction is finished.
 - The Itaipu Dam on the border of Brazil and Paraguay is currently the largest dam in the world and provides southern Brazil and nearly all of Paraguay with their electricity.

Current and future uses of biomass energy

1. Biomass is used worldwide.
 - Biomass, especially wood, is a major fuel source to heat homes.

Current and future uses of geothermal energy

1. Geothermal energy is used worldwide.
 - California is a leader in geothermal technology.
 - Iceland is a leader in geothermal technology with nearly all of their energy needs being met by geothermal energy.

Current and future uses of hydrogen energy

1. Hydrogen energy is used worldwide.
 - Fuel cells are a promising technology for use as a source of heat and electricity for buildings and as an electrical power source for electric vehicles.

Appendix F
Draft Framework for Round One of the Delphi Survey

**(Draft) Conceptual Framework for Renewable Energy
Education**

A work in progress...

Developing Renewable Energy Resources

This theme helps students to realize how they and other humans have become more and more dependent on the development and use of energy resources to satisfy their standard of living.

Renewable Energy

Mastering these concepts will help students to comprehend renewable energy.

1. Renewable energy sources can be used to generate electricity and heat and provide
fuel for vehicles.

Comments:

2. Renewable energy sources can be replenished in a short period of time.

Comments:

3. Six renewable sources commonly used are solar, wind, hydropower, biomass, geothermal and hydrogen.

Comments:

4. Renewable energy has been used for many generations.

- Solar (passive solar heating) and biomass energy have been used by humans for thousands of years.
- Wind has been used by humans for many generations.
- Hydropower has been used for thousands of years to provide mechanical energy to grind grain, drive sawmills, and pump water.
- Harnessing geothermal and hydrogen energy has more recent origins.

Comments:

6. Renewable energy is reliable for residential and commercial production.

Comments:

Solar Energy

Comprehending these concepts will help students to understand solar energy.

6. Solar energy is the solar radiation that reaches the earth.

Comments:

7. Solar energy is used for space and water heating.
- Passive heating is when air or water is warmed and is allowed to naturally circulate.
 - Active heating involves the use of pumps or other devices to disseminate the warmed air or water.

Comments:

8. Solar energy is used to generate electricity. Photovoltaic energy is the conversion of sunlight into electricity through a photovoltaic (PV) cell, commonly called a solar cell.
- PV cells were originally developed for use in space. PV still powers nearly every satellite circling the earth because it operates reliably for long periods of time with virtually no maintenance.

Comments:

9. Solar technology can be installed in residential and commercial settings.

Comments:

Wind Energy

Mastering these concepts will help students to comprehend the wind energy.

10. Wind is air in motion and is produced by the unequal heating of the earth's surface
by the sun.

Comments:

11. Wind turbines capture wind energy to generate electricity.

- The rotor spins like a propeller and turns a shaft that is connected to a generator.

Comments:

12. Wind systems can be installed in residential and commercial settings.

Comments:

Hydropower

*Understanding hydropower will help students comprehend using water to generate electricity. **Of the renewable energy sources that generate electricity, hydropower is the most often used.** –don't include this (BH) consistency*

13. Hydropower refers to the energy of flowing water.

Comments:

14. Hydropower plants can capture the energy in flowing water by damming a river, or channeling a portion of a river through a generating facility.

Comments:

15. Hydropower plants capture the kinetic energy of falling water to generate electricity.

- The water pushes against and turns blades in a turbine to spin a generator to produce electricity.

Comments:

16. The water's flow or fall determines the amount of available energy in moving water.

Comments:

17. Hydropower is most often used to generate electricity on a commercial scale.

Comments:

Biomass Energy

Understanding biomass will help students comprehend the uses of vegetation as an energy source.

18. Biomass refers to all Earth's vegetation and many products and coproducts that come from it.

Comments:

19. Biomass can be used for a variety of purposes.

- Combustion of biomass can be used to generate electricity.
- Combustion of biomass can be used to produce heat for climate control and manufacturing.
- Ethanol, a fuel, is produced from the fermentation of grains.
- Gasification converts decaying biomass in landfills and biogas digesters into a gas called methane, the main ingredient in natural gas.

Comments:

Geothermal Energy

Mastering these concepts will help students realize how the Earth's internal energy can be used as an energy source.

20. Geothermal energy originates in the interior of the earth.

Comments:

21. The most active, high temperature geothermal resources are usually found along major tectonic plate boundaries where earthquakes and volcanoes are concentrated.

Comments:

- 22.** High temperature geothermal resources can be used to generate electricity.
- Geothermal plants drill wells to capture underground steam, which spins a turbine to produce electricity.

Comments:

- 23.** Low temperature geothermal resources are used for residential and commercial heating and for other heating tasks.
- Low temperature geothermal exchange systems, or ground source heat pumps, can be used almost everywhere in the U.S. These systems use

fluids circulating through underground pipes to transfer the heat from the ground into buildings in winter and out of buildings in summer.

- In the United States, the earth's temperature a few feet below the surface is remarkably constant year round, ranging from 50-65 degrees Fahrenheit.

Comments:

Hydrogen Energy

Comprehending how we may obtain energy from hydrogen will help students appreciate the diversity of uses of one of Earth's most abundant elements.

24. Hydrogen is the third most abundant on the earth's surface.
- Hydrogen is found primarily in water and organic compounds.
 - Hydrogen as a gas (H^2) does not exist on Earth; it is always combined with other elements.

Comments:

25. Hydrogen can be obtained from a variety of sources.
- Hydrogen can be produced from renewable (methanol and biomass) and nonrenewable (natural gas, coal, and gasoline) energy sources through the application of heat.
 - Hydrogen can be produced from bacteria or algae through photosynthesis.
 - Hydrogen can be produced using electricity or sunlight to split water into hydrogen and oxygen.

Comments:

26. Hydrogen's potential use in fuel and energy is diverse.
- Applications include powering vehicles, running turbines or fuel cells to produce electricity, and generating heat and electricity for buildings.

Comments:

27. The current focus is on hydrogen's use in fuel cells.
- A fuel cell works like a battery but does not run down or need recharging. It will produce electricity and heat as long as fuel (hydrogen) is supplied.
 - Hydrogen fuel cells produce clean, potable water as a byproduct.

Comments:

Effects of Renewable Energy Resource Development

This theme will help students investigate how renewable energy use affects the environment. Recognizing these effects increases students' awareness of why and how they use energy.

Quality of life

Understanding these concepts helps students analyze current energy-use practices and evaluate how they affect quality of life.

Lifestyles

28. Depending on renewable energy for all energy needs may require a less energy-intensive lifestyle.
- Energy efficiency is especially important when using renewable energy.

Comments:

Health and safety

29. Using renewable energy may help to maintain the health of the surrounding ecosystem and thus minimize personal and community health risks.
- The number of respiratory illnesses has increased as smog produced by fossil fuels has increased.

Comments:

Economic

30. The nonrenewable energy industry is subsidized by taxpayer money, thereby lowering the cost of energy to consumers.

Comments:

31. Converting to a renewable energy-based economy would create many jobs.
- Most renewable energy investments are spent on materials and workmanship to build and maintain facilities, rather than on costly energy imports.
 - Renewable energy investments are usually spent within the United States, frequently in the same state, and often in the same town. This means that your energy dollars stay at home to create jobs and fuel local economies, rather than going overseas.

Comments:

32. Using renewable energy means that the U.S. could become energy independent.
- Currently, the U.S. relies on foreign imports to fuel the economy.

Comments:

33. The U.S. spends large amounts of money on oil imports.
- U.S. trade balance sheets show that oil imports drain great amounts of money from the U.S. economy every week.
 - The government spends taxpayer dollars to subsidize oil exploration and to militarily defend access to oil in the Middle East.

Comments:

Sociopolitical

34. Wisconsin has certain zoning laws that prevent wind turbines from being constructed in residential areas.

Comments:

35. When using renewable energy, electrical production is put in the hands of the consumer, who then is no longer dependent on an external entity.
- The sun and wind are not regulated and free to whomever chooses to take advantage of them. For the most part, people have equal access to the power source.

Comments:

Ethical

36. Some people feel a moral obligation to minimize human impact on the planet and thus choose to use renewable energy.

Comments:

37. Our current practices of extracting fossil fuels from other countries to support our energy intensive lifestyle may comprise the cultures of other countries.

Comments:

Quality of the environment

By comprehending these concepts, students will be able to explain how current energy use practices affect the quality of the environment.

38. Mass consumption of oil requires continual drilling into pristine wilderness areas, influencing ecosystems.

Comments:

39. Renewable energy technologies are clean sources of energy that have a lower environmental impact than conventional energy technologies.

Comments:

40. There are costs involved in the manufacturing and distribution of renewable energy technologies.

Comments:

Effects of solar energy technology

41. The environmental impact of a photovoltaic system is minimal, requiring no water for system cooling and generating no by-products. Because it burns no fuel and have no moving parts, PV systems are clean and silent.

Comments:

42. Using passive solar designs in building construction could reduce electricity demand (and the bills) without the customer ever knowing.

Comments:

43. The use of solar panels may require large tracks of land.

Comments:

Effects of wind energy technology

44. The environmental impact of a wind system is minimal, requiring no water for system cooling and generating no by-products.

Comments:

45. There are concerns regarding the impacts of wind farms.
- Some find the turbines to be unattractive, detracting from the scenery.
 - Some are concerned with the numbers of migratory birds that are killed by wind turbines.
 - The spinning of some turbines on wind farms produces noise.

Comments:

Effects of hydropower technology

46. Hydropower produces no waste products and does not pollute the air.

Comments:

47. The environmental effects of using hydropower are many.

- Most often, to harness the energy in water a dam is constructed, disrupting the aquatic ecosystem. It floods a large area behind the dam, destroying the existing habitat; it may also disrupt human settlements.
- It regulates the flow of the river as to eliminate the river's flooding cycle. This affects the many plants and animals that are dependent on the periodic inundation of the floodplain.
- There is siltation behind the dam, thermal pollution in impoundments, and a disruption of migratory fish.

Comments:

Effects of biomass energy technology

48. The amount of carbon dioxide released is offset by the amount of carbon dioxide that is consumed through photosynthesis during the crop's growth.

Comments:

49. Ethanol can replace the most toxic parts of gasoline with a fuel that quickly biodegrades in water, reducing the threat that gasoline poses to waterways and groundwater.

Comments:

Effects of geothermal energy technology

50. Geothermal energy has a very minor impact on the soil since the slightly cooler water is reinjected into the ground.

Comments:

51. Pumps used in geothermal energy may be powered by fossil fuels, increasing greenhouse gases in the atmosphere.

Comments:

Effects of hydrogen energy technology

52. The harnessing of hydrogen gas can originate from either renewable or nonrenewable sources. Using nonrenewable sources may increase greenhouse gases.

Comments:

Managing Renewable Energy Resource Use

By mastering these concepts students will gain an understanding of renewable energy use today and in the future.

Future outlooks for the development and use of energy resources

By understanding these concepts, students can evaluate how their actions affect the quality of life and the environment of their community, nation, and world. Students will also predict how scientific, technological, and social changes will influence future energy resource availability.

Current and future uses of renewable energy

53. Currently, alternative energy technologies are not subsidized and are thus, in general, are more expensive than conventional power sources.
- Wind energy costs approximately the same per kilowatt hour as using nonrenewable energy sources.

Comments:

54. Alternative energy use is growing.

Comments:

Current and future uses of solar energy

55. Solar energy is used worldwide.
- In rural settings with no power sources, solar energy is used to cook, heat water, and power schools, among other uses.
 - Solar energy is primarily being used in residential settings.

Comments:

Current and future uses of wind energy

56. Wind Energy is used throughout the world.
- Denmark is a leader in the industry.

- The Midwest, especially North and South Dakota, have tremendous potential for wind energy.

Comments:

57. Many states are beginning to install wind farms.
- Wind farms are supplying a substantial proportion of California's power.

Comments:

Current and future uses of hydropower

58. Hydropower is used worldwide.
- The Hoover Dam on the Colorado River and the dam on the Niagra Falls provide many people with electricity.
 - The Three Gorges Dam in China will be the largest dam in the world when construction is finished.
 - The Itaipu Dam on the border of Brazil and Paraguay is currently the largest dam in the world and provides southern Brazil and nearly all of Paraguay with their electricity.

Comments:

Current and future uses of biomass energy

59. Biomass is used worldwide.
- Biomass, especially wood, is a major fuel source to heat homes.

Comments:

Current and future uses of geothermal energy

60. Geothermal energy is used worldwide.
- California is a leader in geothermal technology.
 - Iceland is a leader in geothermal technology with nearly all of their energy needs being met by geothermal energy.

Comments:

Current and future uses of hydrogen energy

61. Hydrogen energy is used worldwide.
- Fuel cells are a promising technology for use as a source of heat and electricity for buildings and as an electrical power source for electric vehicles.

Comments:

Appendix G
Letter Inviting Renewable Energy Professionals to Participate in the Delphi Survey

Hello.

My name is Stephanie Kane and I am a graduate student at the University of Wisconsin Stevens Point. I am working with the Wisconsin K-12 Energy Education Program (KEEP) to create a renewable energy conceptual framework that will complement KEEP's existing framework. Potential uses of the additional renewable energy concepts include the creation of more renewable energy activities in the KEEP activity guide, as well as the creation of a renewable energy curriculum or class. These are only a few of the potential uses.

However, before these concepts can be integrated into KEEP's conceptual framework, I would like to ask for your help in validating them. I am going to use an abbreviated version of the Delphi process. The Delphi process uses experts in the appropriate field (renewable energy, in this case) to read and comment on the concepts included in the renewable energy conceptual framework in order to determine which of the concepts should be included in the final draft.

Jennie Lane, director of KEEP, and Tehri Parker, director of the Midwest Renewable Energy Association (MREA), have suggested that your expert renewable energy knowledge would be of great help in developing the renewable energy conceptual framework for KEEP. All materials, including the draft framework, a short introduction to the Delphi process, and return postage will be mailed to you. The Delphi process requires no face-to-face meetings and only a couple of hours of your time. The success of the project depends on the participation of qualified experts such as yourself to ensure its validity.

Please respond ASAP. I also ask that you email me with the names of three additional people who you consider to be knowledgeable renewable energy professionals. The renewable energy fields included in the framework include solar, wind, hydropower, biomass, geothermal and hydrogen.

Your participation would be greatly appreciated. Thank you for your time and I look forward to hearing from you.

Sincerely,
Stephanie Kane

Energy Education Specialist
K-12 Energy Education Program

Appendix H
List of Delphi Participants

| Delphi Participant | Associated Organization |
|---------------------------|------------------------------------------------|
| Larry Krom | L&S Associates |
| Kurt Nelson | SOLutions |
| Mick Sagrillo | Sagrillo Power & Light |
| Leo Udee | Alliant Energy |
| Kelly Zagrzebski | Wisconsin Public Service |
| Jennie Lane | Wisconsin K-12 Energy Education Program |
| Tehri Parker | Midwest Renewable Energy Association |
| Jeff Delaune | Wisconsin Public Service |
| Chip Bircher | Wisconsin Public Service |
| Bill Hereen | DC Everest School District |
| Steve Carlson | CDH Energy Corporation |

Appendix I
Thank you letter

February 4, 2002

Dear «first_name» «last_name»:

Thank you for agreeing to serve as a panelist for the development of a renewable energy conceptual framework.

The purpose of this exercise is to develop a valid renewable energy conceptual framework that will complement and be integrated into the existing Wisconsin K-12 Energy Education Program's Conceptual Framework. The framework will serve as a guide for creating future renewable energy education projects, such as an activity guide and inservice course for teachers. The Delphi technique is being used as a method to edit and validate those concepts currently included in the draft renewable energy conceptual framework. The opinions of the panelists will be the primary basis for determining which concepts are to be included in the framework. By participating in this Delphi panel, you are helping to create a framework that will in turn support comprehensive and accurate renewable energy education.

General information about the Delphi technique, instructions and materials for completing the first round of the exercise are enclosed. A couple of hours of your time will be required to complete the first round and subsequent round of the Delphi. You, no doubt, have many demands on your time but please respond to each round promptly. **Please return the draft framework, scan-tron answer sheet and consent form by February 28, 2002.**

I will serve as monitor of the exercise. This means that I will prepare the material for each round, summarize responses, and prepare a final report, including rationale for the final renewable energy conceptual framework. Anonymity among panelists will be maintained throughout the exercise.

If you have any questions, do not hesitate to contact me. Thank you again for consenting to be a panelist. I look forward to receipt of your input.

Stephanie Kane
Renewable Energy Education Specialist
K-12 Energy Education Program
715-346-4320
Stephanie.H.Kane@uwsp.edu

Appendix J

Introduction to the Delphi Technique

An Introduction to the Delphi Technique

The Delphi technique is a method of generating ideas and facilitating consensus among individuals who have special knowledge to share, but who are not always in contact with each other. The Delphi survey approach is a technique for gathering data that are similar to focus groups, however Delphi groups do not have to physically meet. Also, unlike survey research, which insists on a random sample that represents all parts of the population, a Delphi study carefully selects individuals who have knowledge necessary to analyze a specific problem. The persons selected comprise the panel and are considered experts in their field. Through a series of surveys, they share and generate new ideas based on an emerging consensus among panel members.

In the development of the renewable energy conceptual framework, a modified Delphi approach will be used. The Delphi process will consist of two rounds and will begin with a structured questionnaire in which the participants will rate the importance of the individual concepts. The structured questionnaire is a draft of the renewable energy conceptual framework. There is space for participants to rate and comment on each concept. Results (the mean, median, mode) will be tabulated for each concept, analyzed and a revised draft framework will be sent out to the experts. In round two, they will re-rate the concepts taking into account the responses of their colleagues.

Studies have shown that decisions made by groups are more likely to be correct than predictions made by the same individuals working alone. Validity of the resulting judgment of the entire group is typically measured in terms of explicit degree of consensus among the experts. What distinguishes the Delphi from an ordinary polling procedure is the feedback of the information gathered from the group and the opportunity of the individuals to modify or refine their judgments based upon their reaction to the collective views of the group. Other characteristics of the Delphi process include various degrees of anonymity imposed on the individual and collective responses to avoid undesirable psychological effects.

Delphi can be applied to a wide range of activities. Using the Delphi technique as a means to identify those concepts essential in understanding renewable energy insures that a consensus is reached among renewable energy professionals.

Appendix K

Informed Consent to Participate in Human Subject Research

Stephanie Kane, University of Wisconsin Stevens Point graduate student working with the Wisconsin K-12 Energy Education Program (KEEP), is conducting a study to identify important renewable energy concepts as suggested by renewable energy professionals. These will be used to create a renewable energy conceptual framework. We would appreciate your participation in this study, as it will assist us in furthering renewable energy education.

As part of the study, Kane would like to mail a survey to renewable energy professionals. The survey will ask the subjects to rate a series of renewable energy concepts. There will be no face-to-face meetings between the subjects themselves or between the subjects and Kane. Participants will be paid for this service.

We do not anticipate the study will present any social risk to you other than the inconvenience of the time required for filling out the survey. We hope, however, that the opportunity to share your ideas regarding renewable energy education will lead to greater awareness regarding the development of educational materials. Your insights will help to produce a sound renewable energy education product that may be used to create activities or serve as a guide to develop a course.

The information Kane gathers through the survey process will be kept in the strictest confidence. Kane will use pseudonyms in all documentations. You will be allowed to review any reports that she generates. We will not release information on you to anyone that could identify you.

If you want to withdraw from the study at any time you may do so without penalty. The information she collects from you up to that point would be destroyed.

Once the study is completed, we would be glad to give you the results. In the meantime, if you have any questions, please ask or contact:

Stephanie Kane
Wisconsin K-12 Energy Education Program
WCEE, 403 LRC
University of Wisconsin-Stevens Point
Stevens Point, WI 54481 715-346-4320

If you have any complaints about your treatment as participant in this study, please call or write:

Dr. Sandra Holmes, Chair
Institutional Review Board for the Protection of Human Subjects
Department of Psychology
University of Wisconsin-Stevens Point
Stevens Point, WI 54481 715-346-3952

Although Dr. Holmes will ask your name, all complaints are kept in confidence.

I have received a complete explanation of the study and agree to participate.

Name _____ Date _____
(Signature of subject)

This research project has been approved by the UWSP Institutional Review Board for the Protection of Human Subjects.

Appendix L

Instructions for Completing the Delphi Survey

1. Read the information included in the packet before beginning the Delphi process. This includes:
 - The cover letter
 - The introduction to the Delphi Technique
 - Instructions for completing the Delphi Survey
 - Consent form
2. Write your name on the scan-tron. Although the Delphi Technique is anonymous, I would like to be able to contact you should I have any specific questions.
3. Please read through each concept in the draft renewable energy conceptual framework carefully. **Rate the importance of each concept using the scan-tron answer sheet. A #2 pencil is necessary to fill out the scan-tron sheet.** The rating scale is as follows:
 - A = not important/do not include
 - B = not very important
 - C = neutral
 - D = important
 - E = very important/definitely include

[Note: Some concepts include bulleted lists. Please consider these lists in your review; you do not need to evaluate each bullet point separately.]
4. Use the space below each concept for comments, such as suggesting alternative wording, lending more information, adding relevant concepts or correcting misinformation.
5. There is additional space at the end of the draft framework to suggest any additional concepts. You might want to review the existing Wisconsin K-12 Energy Education Program conceptual framework to be sure that the concept is not already present in the existing framework.
6. When you have rated each concept **return the consent form, the draft framework and the scan-tron answer sheet** using the enclosed envelope.
7. **Please return the draft framework and scan-tron by February 28, 2002.**

Thank you!

Appendix M
Draft of the Renewable Energy Conceptual Framework with Comments from
Delphi Participants after Round One

(Draft) Conceptual Framework for Renewable Energy
Education

A work in progress...

Developing Renewable Energy Resources

This theme helps students to realize how they and other humans have become more and more dependent on the development and use of energy resources to satisfy their standard of living.

Renewable Energy

Mastering these concepts will help students to comprehend renewable energy.

1. Renewable energy sources can be used to generate electricity and heat and provide
fuel for vehicles.

Comments:

- (BH) This concept should be part of p 10's statement for the overall concept of what an energy source is. Before distinguishing between RE and nonRE, students should know what an energy source is. Modified, this objective is important.
- (TP) "resources" not "sources"
- (KN) might want to re-phrase "electricity and heat, as well as to provide fuel for vehicles".

2. Renewable energy sources can be replenished in a short period of time.

Comments:

- (BH) This is included within item 25 on p 11. However, students need to be able to understand why renewable is advantageous This is one reason.
- (SC) "they don't run out" or "are continuously replenished"
- (CB) reword: replenished "relatively" short ..."compared to fossil fuels"
- (LU) "most" renewable energy sources...
- (TP) "sources" seems misleading to me-sun, wind are not replenished, they are always available

- (LK) This concept is too general and neglects the point that renewable resources are dissimilar. Some sources are always available, although the supply may be variable. See his written concepts for elaboration.
- (KN) might be more useful to say that renewable energy sources are constantly renewed or replenished. It is a little confusing to say that (for instance) the sun can be replenished in a short period of time or that sunshine can be replenished. Perhaps, “compared to fossil fuels, renewable energy can be replenished in a short period of time”.

3. Six renewable sources commonly used are solar, wind, hydropower, biomass, geothermal and hydrogen.

Comments:

- Hydrogen is not a renewable resource but derived from RE. (Mick)
- Is geothermal really RE? (Mick)
- (BH) Is it necessary to say six?
- (BH) 3 and 4 can be combined.
- (SC) hydrogen is really secondary form. It has to be produced using another form of energy. The hydrogen cycle, water-hydrogen-water. “renewable” with the addition of energy.
- (CB) some would include nuclear, but your list is consistent with the definition in wi legislation. Also, some may argue that only low-head hydro would qualify.
- (TP) “sources”. Hydrogen isn’t usually listed as a renewable energy resource. It is a fuel that can be made from renewable resource-like ethanol and biodiesel.
- (LK) hydrogen is not a renewable “source”. As an energy carrier, it is derived or produced from various sources, some renewable
- (JD) Don’t include hydrogen as a renewable resource. The other five are available in the natural environment. Hydrogen must be manufactured from a feedstock fuel. Eventually photo/biological creation of large amounts of hydrogen may become available. No guarantees that it will be affordable or plentiful.
- (KN) I think it is important to recognize common renewable energy sources. However, understanding hydrogen is a little more complex as hydrogen is not a renewable energy source but rather it is useful as a clean and efficient way to store and convert renewable energy. Essentially, the same amount of energy used to produce the hydrogen is available for use when the hydrogen is burned or used in a fuel cell. So hydrogen is not a source of renewable energy, but rather a storage medium.

4. Renewable energy has been used for many generations.

- Solar (passive solar heating) and biomass energy have been used by humans for thousands of years.
- Wind has been used by humans for many generations.
- Hydropower has been used for thousands of years to provide mechanical energy to grind grain, drive sawmills, and pump water.
- Harnessing geothermal and hydrogen energy has more recent origins.

Comments:

- (BH) cross out “by humans”
- (BH) I would prefer there being listed different types of renewable sources AND then there being a separate concept look at the history of energy sources. Students will discover until recently most energy sources used have been renewable.
- (LU) first bullet should read Solar..., biomass and geothermal energy have been used...
- (LU) note: humans sheltered themselves in caves and used hot springs in ancient times due to earth’s temperatures.
- (TP) first bullet: ...years “for heating and cooling”
- (TP) second bullet: ...many generations “for?”
- (TP) what about pv? How about this for concept wording: “Humans have always used renewable resources to meet their energy needs.”
- (LK) you are not generous enough. Wind goes back to 6000 BC for sailing ships ; windmills 12th century. Geothermal (passive) use in shelters way back
- (JL) either explain how each has been used or none. Right now only hydro looks odd.

7. Renewable energy is reliable for residential and commercial production.

Comments:

- (BH) “reliable” and cost effective
- (BH) need to have comparison between RE and non RE.
- (SC) it’s applicable for use in residential and commercial applications, it’s less reliable since it is generally intermittent or non dispatchable, it’s harvested as its available
- (TP) Production of what?
- (TP) Renewable energy is a reliable energy source for many residential and commercial applications.
- (LK) RE is reliable for all sectors including agricultural and industrial. Paper companies; use of wood in cogeneration is a typical industrial use of RE in WI.

Historical, before rural electrification, most water pumping and electricity on rural homesteads and farms was generated by wind power.

- (JD) what does reliable mean? Constant? No. It works? Yes. Dependable? Maybe-day/night for solar, windy, calm for wind, plentiful rain/drought for hydro.
- (JL) Put other sources here like you did for generations in bullet form, explaining that some are more appropriate for some than others.
- (KN) might expand to say, "Renewable energy can provide reliable energy for our homes and industries".

Solar Energy

Comprehending these concepts will help students to understand solar energy.

6. Solar energy is the solar radiation that reaches the earth.

Comments:

- (BH) The problem with this concept is that solar energy is defined with words that are more complex (radiation vs. energy) than the words themselves.
- (LK) poorly stated and not precise. A major commercial use of solar energy is in space. As such, solar energy is usable, predicated on distance and access to our sun, whether on the moon, on mars, or on the earth is irrelevant. There is in fact more solar energy available in space because it is not attenuated by atmospheric effects and it's available 24 hours/day.
- (JD) more accurately, as an energy source, it's the solar radiation that reaches the earth's surface. Solar power stations in earth orbit are interesting, but may never happen.
- (JL) cross out "the" and just say "Earth."
- (KN) might be better to have it be the sun, such as "Solar energy is the radiant energy from the sun that falls on the earth. This radiant energy can be utilized in many ways."

7. Solar energy is used for space and water heating.

- Passive heating is when air or water is warmed and is allowed to naturally circulate.
- Active heating involves the use of pumps or other devices to disseminate the warmed air or water.

Comments:

- (BH) the bullet points: I'm torn about whether to include this wording or even getting that specific here. Since it is really a listing of two different types of space heating, I vote leave it as is.

- (SC) ex-standing in the sun is an example of passive heating
- (CB) correct first bullet point (cross out “is allowed to”) and add “s” to circulate. For example, sunlight coming through a south-facing window warms the floor and the air in the house.
- (CB) second bullet point: for example, a pump circulates a fluid through a solar collector. Add examples to clarify.
- (LU) second bullet: replace “disseminate” with “move”
- (TP) first bullet: replace “water” with “liquid”; ...warmed “by the sun” and is...
- (TP) second bullet: replace “water” with “liquid”
- (TP) Many systems circulate antifreeze rather than water
- (JL) might need more of an explanation for passive?
- (KN) could be splitting hairs, but I’m not fond of “disseminate” here. I wonder if “transfer” would make point more clearly. Also, there is some confusion over passive and active systems. Another way of looking at it is that passive solar is usually part of a building’s architecture. A greenhouse on the side of a building is passive solar, even if it may happen to have a fan incorporated into it that helps move the heated air.

8. Solar energy is used to generate electricity. Photovoltaic energy is the conversion of sunlight into electricity through a photovoltaic (PV) cell, commonly called a solar cell.

- PV cells were originally developed for use in space. PV still powers nearly every satellite circling the earth because it operates reliably for long periods of time with virtually no maintenance.

Comments:

- While PV cells are maintenance free the batteries and balance of system components require regular attentions (Mick).
- (BH) should be mention of how solar cells actually work
- (BH) bullet should not be included here.
- (CB) re word. The definition of pv includes the term itself in the definition.
- (TP) the concept is much more important than the bullet
- (JD) ...sunlight “directly” into...
- (KN) as electricity can be generated by solar energy in processes other than photovoltaics, I’d consider re-phrasing this. Perhaps, “Solar energy can be utilized to generate electricity. In one such process solar cells, also known as photovoltaic cells, are used to convert the radiant energy in sunlight directly into electricity”.

9. Solar technology can be installed in residential and commercial settings.

Comments:

- (BH) Goes without saying-don't say
- (SC) PV is often used in remote locations where electric power from a utility is not available or too costly to deliver
- (SC) solar requires surface area to capture the sun-more energy, more surface area
- (TP) replace "installed" with "used"
- (TP) not a concept-just application
- (LK) solar technology can be installed in agricultural and industrial settings, along highways, in parking lots, etc. Emphasize its versatility and modularity, along with all the product forms it might take, i.e. mobile radio charging roll-out mats (military) to building roofs.
- (JD) in fact this will likely be its primary application. And, it can be included in building design very simply by adding south facing windows and a good overhang/summer shading device.
- (JL) put under #5
- (KN) or "Energy from the sun can be used to efficiently heat and power our homes and industries".

Wind Energy

Mastering these concepts will help students to comprehend the wind energy.

10. Wind is air in motion and is produced by the unequal heating of the earth's surface
by the sun.

Comments:

- (BH) depending on the student application, I might reword unequal heating of the earth's surface by the sun. The teacher can do that. This is fun.
- (JL) might need to check this out further; make sure accurate. Add wind speed determines energy quantity?
- (KN) "Wind energy is actually a form of solar energy. The uneven heating of the earth's surface by the sun causes the air currents we refer to as wind."

11. Wind turbines capture wind energy to generate electricity.

- The rotor spins like a propeller and turns a shaft that is connected to a generator.

Comments:

- (BH) “transform” not “capture” into electrical energy.
- (TP) add to concept: The generator creates electricity
- (LK) it might be clearer to state that rotating aerodynamic blades (rotor) turns a shaft...

12. Wind systems can be installed in residential and commercial settings.

Comments:

- Don't forget farms (Mick).
- (BH) don't include
- (TP) replace “installed” with “used”
- (TP) not a concept, just an application
- (LK) the siting of wind depends on a good wind resource, terrain roughness, and other factors. A residential setting (suburban or urban) is usually not conducive (lack of space for fall zone, many trees, no wind) and a commercial setting may have the same limitations. Agricultural or rural settings are probably the best settings, although very small wind machines are used to power pond aeration, recreational vehicles, and vacation homes.
- (JL) combine with #5. Add info about utility production for all?
- (KN) If you want to break up the verbage from the different categories, maybe “Wind systems can range in size from small residential systems to very large, utility scale ‘wind farms’”.

Hydropower

*Understanding hydropower will help students comprehend using water to generate electricity. **Of the renewable energy sources that generate electricity, hydropower is the most often used.** –don't include this (BH) consistency*

13. Hydropower refers to the energy of flowing water.

Comments:

- (BH) reword. Energy “generated by using flowing water”
- (SC) typically represented by the change in the height of the water level that is possible.
- (CB) reword: energy “contained in” cross out “of” flowing water.
- (KN) or “falling” water (it's the fall that makes the flow).

14. Hydropower plants can capture the energy in flowing water by damming a river, or channeling a portion of a river through a generating facility.

Comments:

- (BH) water “in many ways” bullet point –damming rivers, channeling rivers, creating artificial reservoirs
- (BH) combine 14 and 15 and 16
- (JL) no comma after river. Combine with #15.
- (KN) right, the damming of the river is what creates the height or ‘head’ for the water to fall.

15. Hydropower plants capture the kinetic energy of falling water to generate electricity.

- The water pushes against and turns blades in a turbine to spin a generator to produce electricity.

Comments:

- (CB) cross out “to spin” and replace with “connected to” and cross out “to” and replace with “that”. The generator itself doesn’t spin.
- (CB) 13 and 15 can be combined.
- (LU) “Most commonly” hydropower plants...

16. The water’s flow or fall determines the amount of available energy in moving water.

Comments:

- “and” not “or” (Mick).
- (JD) flow? Volume, density, speed (head height)
- (JL) bullet under #13.
- (KN) yup, actually the fall (height) times the volume would be a somewhat more complete formula to determine the amount of energy in a given hydro resource.

17. Hydropower is most often used to generate electricity on a commercial scale.

Comments:

- (BH) how else is it used?
- (SC) it was once used to turn machinery directly
- (TP) not a concept, just an application
- (JL) add to #5
- (KN) yup, commercial or industrial scale. Lots of hydro plants are privately owned by paper companies or corporations that produce aluminum.

Biomass Energy

Understanding biomass will help students comprehend the uses of vegetation as an energy source.

18. Biomass refers to all Earth's vegetation and many products and coproducts that come from it.

Comments:

- (BH) reword. Biomass energy is energy created from the earth's...
- (BH) distinction needs to be made between biomass and fossil fuels –don't they fit under this category?
- (SC) vegetation and animal manure
- (CB) include example to clarify.
- (CB) cross out "all Earth's" and replace with "the production of energy from"
- (JD) does this include cow manure?
- (KN) I'm wondering if referring to biomass as the "Earth's vegetation" doesn't send a confusing message, as the energy in biomass doesn't come from the earth but rather from the sun. Perhaps, "Biomass energy refers to the energy stored in all plant material."
 - new bullet. This energy originates in the sun and is turned into stored chemical energy through the plant's photosynthesis process.
 - new bullet. All fossil fuels came from similar origins and were once the biomass energy of earth's prehistoric past.

19. Biomass can be used for a variety of purposes.

- Combustion of biomass can be used to generate electricity.
- Combustion of biomass can be used to produce heat for climate control and manufacturing.
- Ethanol, a fuel, is produced from the fermentation of grains.

- Gasification converts decaying biomass in landfills and biogas digesters into a gas called methane, the main ingredient in natural gas.

Comments:

- Of grains or plant stalks (Mick)
- (BH) reword. Biomass energy sources.
- (BH) combustion , not combustication.
- (BH) cross out 2nd two bullets
- (SC) combustion
- (CB) combustion
- (CB) new bullet point: garbage and farm waste can be used to produce methane
- (LU) combustion
- (TP) combustion; pretty vague concept
- (TP) would this include food energy? There seems to be some missing concepts with biomass-considered renewable because it can be quickly replenished, etc.
- (LK) combustion. In regard to ethanol, it can be produced from many organic materials and combinations including cheese whey, potato sludge, and beet pulp.
- (JL) combustion
- (KN) ethanol doesn't just come from the fermentation of grains, but includes other plants and plant materials.

Geothermal Energy

Mastering these concepts will help students realize how the Earth's internal energy can be used as an energy source.

20. Geothermal energy originates in the interior of the earth.

Comments:

- (BH) reword. GE is energy that comes from the earth's interior. Thermal energy.
- (CB) correction: for many low temp geothermal devices, like geothermal heat pumps, the heat is drawn from the surface layers of the soil. This heat is not from the earth's interior. It is from stored solar energy that has a seasonal fluctuation.
- (TP) no, not really. Much of it is stored energy from the heat of the sun. geothermal systems get heat out of the top 8 feet of soil or water resources, not the earth's core.
- (JL) should read, "...originates in Earth's interior."

- (KN) yup, but a lot of the space heating systems that utilize ground water heat pumps isn't what I'd call true geothermal. Up near the surface, some of the heat in the soil and sand is from the sun. The active, high temp stuff you talk about in #21 is what I would consider as truly geothermal but I think #20 is OK.

21. The most active, high temperature geothermal resources are usually found along major tectonic plate boundaries where earthquakes and volcanoes are concentrated.

Comments:

- (BH) cross out. At best, should be a bulleted subset of the previous concept. (otherwise with the wind resources and water resources. Mention should be made as to where those resources are most available).
- (SC) where the earth's crust is thin
- (CB) continued at end of concept, "or where hot springs exist"
- (JL) could bullet under #20. Add lower temperature definition.

22. High temperature geothermal resources can be used to generate electricity.

- Geothermal plants drill wells to capture underground steam, which spins a turbine to produce electricity.

Comments:

- (KN) I think there are also systems where the heat from the earth's interior is used to generate steam, but steam isn't actually what they are tapping into.

23. Low temperature geothermal resources are used for residential and commercial heating and for other heating tasks.

- Low temperature geothermal exchange systems, or ground source heat pumps, can be used almost everywhere in the U.S. These systems use fluids circulating through underground pipes to transfer the heat from the ground into buildings in winter and out of buildings in summer.
- In the United States, the earth's temperature a few feet below the surface is remarkably constant year round, ranging from 50-65 degrees Fahrenheit.

Comments:

- (BH) lose the bullets

- (SC) ground source heat pumps are coupled more closely to solar resources than to heat from deep inside the earth. The temperature of the ground to several hundred feet equals the average annual air temperature. The ground temp remains so steady because the ground is so massive.
- (CB) I suggest a slightly larger range for the ground temps: 45-70 degrees.
- (LU) Low temperature geothermal “or geoexchange” resources...for other heating “and cooling” tasks.
- (LU) new bullet: Earth is the largest solar collector known to man. The sun’s energy renews and replenishes the ground temperature.
- (JL) This one needs work. Pull out some and put under #21(second bullet), put some under #5.
- (JL) second bullet: cross out “the” and just have Earth.
- (KN) might change the tail end of the first bullet. Transfer the heat from the ground to the building during the winter, and during the summer the system can run in reverse to provide cooling (it’s not transferring heat from the ground out of the building in the summer).

Hydrogen Energy

Comprehending how we may obtain energy from hydrogen will help students appreciate the diversity of uses of one of Earth’s most abundant elements.

- 24.** Hydrogen is the third most abundant on the earth’s surface.
- Hydrogen is found primarily in water and organic compounds.
 - Hydrogen as a gas (H^2) does not exist on Earth; it is always combined with other elements.

Comments:

- Third most abundant ELEMENT (Mick)
- (BH) combine with 25
- (BH) 2nd bullet don’t include
- (SC) element
- (SC) its not useful in its natural form. It must be processed
- (CB) ELEMENT; second bullet point: subscript H2 and exist “naturally” on Earth.
- (TP) hydrogen is an element rather than renewable resource
- (JL) could combine somehow with #25.
- (JL) should read: “...abundant element on Earth’s surface.”
- (KN) ELEMENT. Also, in the second bullet maybe it should read “Hydrogen (H) as a gas does not exist on Earth, it is always combined with other elements or, as it exists in our atmosphere, combines with itself (H2)”

25. Hydrogen can be obtained from a variety of sources.

- Hydrogen can be produced from renewable (methanol and biomass) and nonrenewable (natural gas, coal, and gasoline) energy sources through the application of heat.
- Hydrogen can be produced from bacteria or algae through photosynthesis.
- Hydrogen can be produced using electricity or sunlight to split water into hydrogen and oxygen.

Comments:

- (SC) hydrogen must be produced, its not found or harvested like the other resources
- (TP) hydrogen is a fuel, belongs in a different category

26. Hydrogen's potential use in fuel and energy is diverse.

- Applications include powering vehicles, running turbines or fuel cells to produce electricity, and generating heat and electricity for buildings.

Comments:

- (BH) heat and electricity? If so, should be combined with 27
- (SC) use "as" a fuel
- (CB) use "as a" not "in" and cross out "and energy"
- (TP) important, but not part of this group of concepts
- (JL) could bullet under #27

27. The current focus is on hydrogen's use in fuel cells.

- A fuel cell works like a battery but does not run down or need recharging. It will produce electricity and heat as long as fuel (hydrogen) is supplied.
- Hydrogen fuel cells produce clean, potable water as a byproduct.

Comments:

- (BH) another bullet: highly efficient
- (BH) you might want to include some discussion of fuel cells using hydrogen generated from fossil fuels. Because of efficiencies, less CO₂ is generated .
- (SC) a fuel cell runs down and needs recharging or its fuel source, a fuel cell is a reactor that combines a fuel and oxygen without combustion to produce heat and electricity.
- (TP) important, but not part of this group of concepts

Effects of Renewable Energy Resource Development

This theme will help students investigate how renewable energy use affects the environment. Recognizing these effects increases students' awareness of why and how they use energy.

- (BH) there should be a RE/nonRE comparison in this section

Quality of life

Understanding these concepts helps students analyze current energy-use practices and evaluate how they affect quality of life.

Lifestyles

28. Depending on renewable energy for all energy needs may require a less energy-intensive lifestyle.
- Energy efficiency is especially important when using renewable energy.

Comments:

- (BH) change "may"
- (BH) if long term costs are included with short term costs, non renewable energy sources probably would require a less energy-intensive lifestyle. We need to change the way people think about RE.
- (SC) efficiency is often achieved at less cost than adding the capability to capture more RE. Increased efficiency usually leads to more use. Look at the increase in driving as the cost of owning car has decreased.
- (CB) new bullet: for residences, it's a good idea to apply energy conservation and energy efficiency strategies before considering renewable energy.
- (TP) seems like a couple of concepts. 1. renewable energy can be used to meet most of our energy needs
 - electricity, heat, transportation, etc2. relying on RE to provide energy for home uses will require an energy efficient home and lifestyle.
- (LK) It may require a lifestyle change, but not necessarily. I would make a differentiation between energy conservation and energy efficiency. It is currently possible with a different design ethic to create super-efficient homes and buildings that use passive solar design to heat, cool, light, use efficient appliances and drive cars that use two-thirds less fuel. Do we want to encourage decisions that promote "wise-use" of energy, or conjure up images or martyrdom, self-sacrifice and discomfort?
- (JL) somewhat ambiguous, might need to clarify.

Health and safety

29. Using renewable energy may help to maintain the health of the surrounding ecosystem and thus minimize personal and community health risks.
- The number of respiratory illnesses has increased as smog produced by fossil fuels has increased.

Comments:

- “will” help (Mick)
- (BH) what about CO2 levels? Especially if wind/geothermal/hydrogen/and solar renewable sources have.
- (TP) this is two concepts: human health and environment and mental health
- (LK) I would include mercury contamination and other issues related to aquatic habitat.
- (JL) wind installation risk?

Economic

30. The nonrenewable energy industry is subsidized by taxpayer money, thereby lowering the cost of energy to consumers.

Comments:

- (BH) people need to know the real cost, not the subsidized cost. Do you know what the real cost is?
- (SC) seems more political than economic. Not to any extent that makes conventional sources more cost-effective. Public funds are geared toward advancing the state of the art or current resources and protecting those resources. We don't necessarily internalize all the “costs” of current resources-environmental impact, especially long-term impacts, since our society is geared toward immediate gratification.
- (CB) “both the nonrenewable and renewable industries are”. It is important to be objective. I think it could be stated that the nonrenewable industry has more government subsidies than renewable.
- (LU) add: It would be fair to provide similar subsidies for renewables.
- (TP) should read, ...thereby “providing a false sense of inexpensive fossil fuel.”
- (TP) another concept: the cost of the environment impacts of fossil fuel use are not included in the cost to consumers.
- (JL) I say re-write to say renewables currently expensive but with more production, technological advances, and subsidies prices could be reduced.
- (KN) maybe it should read as “thereby lowering the **apparent** cost of energy to the consumers”.

31. Converting to a renewable energy-based economy would create many jobs.
- Most renewable energy investments are spent on materials and workmanship to build and maintain facilities, rather than on costly energy imports.
 - Renewable energy investments are usually spent within the United States, frequently in the same state, and often in the same town. This means that your energy dollars stay at home to create jobs and fuel local economies, rather than going overseas.

Comments:

- (BH) To be fair, both perspectives should be represented. While it is true that many jobs would be created, there would be a huge cost involved in the conversion to the renewable energy based companies.
- (SC) another political statement. The “costly energy import” are far more cost effective than the alternatives.
- (SC) banning farm machinery would create jobs too, there is something disturbing about this statement. Seems to promote dangerous isolationism. A free market with low cost energy would create more jobs.
- (CB) Wisc. Stats supporting this concept could be added. Steve Klemer, former wisc. Energy bureau staff member wrote a paper on this topic in 1995.
- (LU) add: Most renewable investments are a one time investment in reducing the need and expenses of fossil fuels.
- (JL) first bullet: cross out “costly”.
- (JL) second bullet: eliminate last sentence.

32. Using renewable energy means that the U.S. could become energy independent.
- Currently, the U.S. relies on foreign imports to fuel the economy.

Comments:

- (SC) nuclear energy has a better chance of leading to independence.
- (CB) add stats-% of foreign imports is over 50% and has grown in last 10 years.
- (LU) ...could before “more” energy independent. Bullet: US relies “much” on foreign...
- (JD) 1. this may not be possible. 2. “fuel the economy”? Imports are primarily oil used for vehicle fuel, space heating and chemical production. Natural gas will become a greater import in the future.
- (JL) maybe too extreme?
- (KN) just a matter of verbage here. I don’t think this is where you are talking about fueling the economy (that was a previous statement). “The U.S. relies on foreign imports to meet its energy needs”.

33. The U.S. spends large amounts of money on oil imports.
- U.S. trade balance sheets show that oil imports drain great amounts of money from the U.S. economy every week.
 - The government spends taxpayer dollars to subsidize oil exploration and to militarily defend access to oil in the Middle East.

Comments:

- (SC) I disagree, the value the US economy creates far outweighs the relatively small amount spent on energy. And “subsidy” is small relative to the value of the economy.
- (JL) this is covered by #30 and not really a “renewable” concept

Sociopolitical

34. Wisconsin has certain zoning laws that prevent wind turbines from being constructed in residential areas.

Comments:

- That “sometimes” prevent...(Mick)
- Not true in all zoned residential areas (Mick)
- (BH) what about the ethanol additives to gasoline in Milwaukee area?
- (BH) it seems to me that we could come up with other sociopolitical events for more of the RE and nonRE energies.
- (SC) The previous section was the political section. Some people find the structures ugly, the noise annoying, the use of land wasteful and the potential impact on birds disturbing. Etc all form have negatives.
- (LU) “Some” WI “communities have” certain zoning...wind turbines “and other renewable energy equipment” from being...
- (LU) more of a local issue than state issue
- (TP) need more general concept. Zoning laws and housing covenants may restrict the installation of RE systems. These restrictions tend to be based on misconceptions, aesthetics, and concerns about resale values of homes.
- (LK) Zoning laws usually emanate from local jurisdictions, which may be a municipality, county or township. In regard to wind turbines and similar tall structures, such as cell towers, zoning should be based on issues of public health and safety. For example, residential areas may not have lots large enough to accommodate a projects “fall zone”. Zoning restrictions based on other issues such as esthetics or neighborhood disapproval would probably not be supported by case law.
- (JD) many local subdivisions also have covenants that prevent the installation of residential solar energy systems.
- (JL) maybe start with a more generic concept?

35. When using renewable energy, electrical production is put in the hands of the consumer, who then is no longer dependent on an external entity.
- The sun and wind are not regulated and free to whomever chooses to take advantage of them. For the most part, people have equal access to the power source.

Comments:

- (BH) fuel cells also hold much promise in allowing electrical generation from taking place at the residential level there by reducing resistance losses.
- (SC) independence is one value that attracts people to these technologies before they are cost effective to the masses
- (CB) cross out “no longer” and replace with “less”. Very few.
- (LU) replace “an external entity” with “other providers”
- (LK) It is an attractive idea to be totally energy independent, but usually not affordable or necessary. Most renewable systems are sized to generate a portion of energy requirements. At times the systems generate more than required, other times less. On small renewable systems, less than 20kW, the utility company can “fun the customers meter backwards” when more RE is generated than used. This arrangement is called “net metering”. It’s like having an energy bank account.
- (JD) not true, large scale bulk production of electricity even with renewables, will be conducted by large energy producers. Only residential use of solar and wind justify this statement.
- (JL) there are many utility based renewable generation plants therefore this isn’t always true.
- (KN) I like the bullet but think the first sentence could use a little work. Utilities can generate electricity with renewables such as wind farms, and the power is not in the hands of the consumer. You may be speaking of distributed production or decentralized power production.

Ethical

36. Some people feel a moral obligation to minimize human impact on the planet and
thus choose to use renewable energy.

Comments:

- (BH) This one needs to be reworded. Renewable and nonrenewable energies can be evaluated for the long-term impact on planet earth.
- (SC) the challenge is to define the impact properly.

- (JL) perhaps re-write to say reasons why people choose to use renewable include- and cite examples.
- (KN) might be a good place to plug energy efficiency into the formula again. "and thus choose to use renewable energy and energy efficiency to supply their energy needs".

37. Our current practices of extracting fossil fuels from other countries to support our energy intensive lifestyle may comprise the cultures of other countries.

Comments:

- (SC) it might also enrich their lifestyles, and improve their economy. Exporting our culture and energy intensive lifestyle is probably more damaging than buying natural resources from them.
- (SC) sp. COMPROMISE
- (CB) replace "our" with "the US". This statement is somewhat biased, I suggest rewording it in a more neutral tone.
- (LU) COMPROMISE
- (TP) ...cultures of "and environments and the health of individuals" other countries.
- (JD) the other side of the coin is that it improves the local economy, jobs, taxes, development of infrastructure, health care, education. Bottom line-it must be done carefully.
- (JL) not a renewable energy concept. Perhaps need a "sustainable" statement though.

Quality of the environment

By comprehending these concepts, students will be able to explain how current energy use practices affect the quality of the environment.

38. Mass consumption of oil requires continual drilling into pristine wilderness areas, influencing ecosystems.

Comments:

- (BH) but it is not just drilling into the pristine areas that influence ecosystems.
- (SC) counter point: drilling might be less destructive than covering wilderness areas with wind turbines and solar collectors to produce an equivalent energy output. I suspect farming has had the largest impact on wilderness areas. Some perspective would be good in these types of statements to illustrate the choices that have been made and are yet to come.

- (CB) oil “may require” cross out “continual”...areas, “which can influence” ecosystems.
- (LU) replace “pristine wilderness areas” with “the earth”.
- (LU) new bullet: It is important to protect wilderness areas and pristine ecosystems.
- (LK) This is not precisely true. Technologies are continually improved to exploit existing oil and gas resources in areas with existing extraction activities. Oil is a precious resource, and it is used in many products. It should not be wantonly wasted, especially to the detriment of future generations. Drilling in pristine areas is a choice, not a requirement. There are transitional options. For example, our oil supply can be wisely extended with bio-fuels, such as biodiesel and ethanol/gas mixtures.
- (JD) define “pristine wilderness”
- (JL) not a renewable concept

39. Renewable energy technologies are clean sources of energy that have a lower environmental impact than conventional energy technologies.

Comments:

- (BH) make certain that we know what conventional means. Also, are all renewable energy sources clean? Biomass for instance?
- (SC) not hydro-doubtful statement if the impact here normalized for and equivalent energy output.
- (LK) generally true, but I wouldn't sugar coat renewables. Large hydropower can have damaging effects. Wind turbines with lattice towers or guyed support have more impacts than turbines on tubular towers. Burning wood in inefficient stoves or furnaces can create air particulates.
- (JD) needs more definition. Air emissions yes. Coal mine, gas and oil field, eys. Geographic foot print no.

40. There are costs involved in the manufacturing and distribution of renewable energy technologies.

Comments:

- (BH) this should be part of 31
- (SC) these technologies are costly because they collect a diffuse energy source whereas conventional sources have offered tremendous amounts of energy from concentrated sources.

- (CB) this seems too obvious. Perhaps rewording it to make the point that the fuel is free (or lower cost than fossil) but the equipment has costs for manufacturing and distribution.
- (LU) There are costs “and energy consumption” involved...
- (TP) costs or environmental impacts?
- (LK) everything has a cost, what are you trying to say here?
- (JD) monetary costs or all costs?
- (KN) might add “development” to manufacturing and distribution

Effects of solar energy technology

41. The environmental impact of a photovoltaic system is minimal, requiring no water

for system cooling and generating no by-products. Because it burns no fuel and have no moving parts, PV systems are clean and silent.

Comments:

- (BH) what is the life expectancy of current PV systems? Are they recycleable?
- (SC) the only impact is the embodied energy, chemicals used in production, and potential land use. Hopefully they are applied to wasteland first eg rooftops, etc.
- (CB) cross out “no water for system cooling” and “generating” and replace with “only sunlight to produce electricity” and “producing”, respectively.
- (TP) what about the manufacturing and materials?
- (JD) true except for the manufacturing, delivery and installation of the equipment.
- (KN) There are embedded energy costs in the manufacturing of PV panels. The amount of energy that it takes to produce a PV panel is typically generated by the panel (replaced) in the first 2 to 4 years of its operation.

42. Using passive solar designs in building construction could reduce electricity demand

(and the bills) without the customer ever knowing.

Comments:

- (CB) make is solar design (singular). Replace “could” with “can”, “electricity” with “heating” and “without the customer ever knowing” with “with little impact on customer lifestyle”
- (LK) wrong. If done properly, the customer will know, because the building will be more comfortable, enjoyable. It will be orientated toward basic human needs. Among those needs achieved though passive solar design are a view to

the outdoors, proper air exchange rate, even distribution of heating, natural non-glare lighting, comfortable levels of cooling, etc.

- (JL) end statement after the word “demand”

43. The use of solar panels may require large tracts of land.

Comments:

- (BH) The use of solar panels may not require large tracts of land. I don't like the use of “may”.
- (SC) Only if misapplied. Hopefully it will be applied to waste areas first. Our agricultural land is already a huge solar collector creating biomass.
- (CB) “Large, centralized solar energy systems” instead of “the use of solar panels”. Small systems (residential) usually don't require any additional land because they are mounted on the roof.
- (LK) wrong. Real estate is expensive and not necessarily required to generate solar power. Roof areas, parking lots, roadway barriers, awnings, and window view glass can all be used to place solar electric products. Solar panels are also found on powering applications on water, such as monitoring stations, lighting harbor buoys, and pond aeration. Some of the most popular solar innovations are those integrated into building components such as roofing material and window glass.
- (JD) ...solar “electric” panels “for large scale production of electricity” may....
- (JL) should read: “...panels ‘on a utility scale’ may...”

Effects of wind energy technology

44. The environmental impact of a wind system is minimal, requiring no water for system cooling and generating no by-products.

Comments:

- (BH) combine 44, 45
- (SC) it is minimal normalized for its output. Compared to what? What is the framework for this statement?
- (CB) replace “no water for system cooling” with “only wind to generate electricity” and “generating” with “producing”
- (TP) what about the manufacturing and materials?
- (LK) true, there are no by-products, but the wind tower location and height, whether guy wires are used to support the tower, whether nonreflective coatings used on the blades-all may have some environmental impact. If birds can see or hear the blades, it has been shown that they will avoid them but guy wires are more problematic.

45. There are concerns regarding the impacts of wind farms.

- Some find the turbines to be unattractive, detracting from the scenery.
- Some are concerned with the numbers of migratory birds that are killed by wind turbines.
- The spinning of some turbines on wind farms produces noise.

Comments:

See Mick's comments regarding evidence disputing these claims.

- (SC) they also use some land.
- (SC) the technology comes with choices and tradeoffs.
- (CB) regarding the "community" impacts...
- (CB) first bullet: the "wind" turbines...
- (CB) second bullet: replace "with the numbers" with "that, in some locations". Cross out "that are" and replace with "may be"
- (CB) third bullet: replace "turbines" with "blades". There are noise limits that must be met.
- (TP) too vague to be a concept.
- (LK) Some people find turbines attractive and mesmerizing. Some are more attractive than others. Studies show that turbines in WI won't have impact on birds-guy wires will be more of a problem for birds and bats. Supported by work done in MN. Larger, aerodynamically designed and slow-moving blades generate little sound. Part of what isn't discussed is the positive economic effect that sitting wind turbines can have for farms and the benefits of the tourist appeal.

Effects of hydropower technology

46. Hydropower produces no waste products and does not pollute the air.

Comments:

- (BH) how much energy is lost in transmission of electricity from water source?
- (TP) what about the manufacturing and materials?
- (KN) although maybe not considered "pollution", hydropower does produce large amounts of greenhouse gases. By damming a river to produce a reservoir, large tracts of land and vegetation are flooded which creates a situation resulting in the production of large quantities of methane.

47. The environmental effects of using hydropower are many.

- Most often, to harness the energy in water a dam is constructed, disrupting the aquatic ecosystem. It floods a large area behind the dam, destroying the existing habitat; it may also disrupt human settlements.
- It regulates the flow of the river as to eliminate the river's flooding cycle. This affects the many plants and animals that are dependent on the periodic inundation of the floodplain.
- There is siltation behind the dam, thermal pollution in impoundments, and a disruption of migratory fish.

Comments:

- (SC) again choices and tradeoffs
- (CB) Cross out "It floods" and add "is flooded" at the end of that sentence (first bullet).
- (CB) second bullet: replace "it" with "the dam". Cross out "as"
- (CB) third bullet: add "patterns" at the end of the sentence.
- (LU) third bullet: replace "as to" with "and may"
- (KZ) this is not confirmed in our research
- (LK) I would make a distinction in size here. Small hydropower operations can be much different from larger. Highly engineered small dams can be planned to have less environmental impact. The small projects may create pond and lake habitats, recreational opportunities, and have minimal impact on fish populations and flooding. Trade offs.
- (KN) also mercury release from the soil (the flooding of the land also results in organic mercury being released into the ecosystem). Methane also as mentioned above.

Effects of biomass energy technology

48. The amount of carbon dioxide released is offset by the amount of carbon dioxide that is consumed through photosynthesis during the crop's growth.

Comments:

- Released "in a short period of time"...crop's growth "over many years" (Mick).
- (BH) are the amounts equal? How much energy goes into harvesting?
- (CB) "In some types of biomass, the amount..." is released "during combustion" is offset... Not all types of biomass are closed loop.
- (LU) new bullet: Carbon dioxide is a "green house" gas, which contributes to raising the earth's overall temperature.
- (TP) ...released "during what?" if offset by...
- (JL) check to see if this is true
- (KN) in many biomass processes using combustion, other harmful emissions are released including mercury.

49. Ethanol can replace the most toxic parts of gasoline with a fuel that quickly biodegrades in water, reducing the threat that gasoline poses to waterways and groundwater.

Comments:

- (SC) growing crops specifically to produce ethanol would be a poor choice of land use. Hopefully it is made from waste stock.
- (CB) cross out "most toxic" and add "that pose the greatest environmental hazards." after "gasoline". Cross out "with a fuel that" and replace with "Ethanol", cross out "that gasoline posed to" and replace with "of contamination from spillage into" the ground water. Should read: "Ethanol can replace the parts of gasoline that pose the greatest environmental hazards. Ethanol quickly biodegrades in water, reducing the threat of contamination from spillage into waterways and ground water."
- (TP) there are all kinds of biomass types that reduce impacts-why choose ethanol?
- (LK) clarify this. Do you mean ethanol replacing the fuel additive and oxygenate "MBTE" or do you mean using pure ethanol as a fuel? Both implementations are attractive. Replacing "MBTE" is a more near term reality.

Effects of geothermal energy technology

50. Geothermal energy has a very minor impact on the soil since the slightly cooler water is reinjected into the ground.

Comments:

- (SC) some drilling at(?) plant is constructed, so some impact on the local environment occurs.
- (CB) this only applies to systems using water
- (LU) slightly "warmer or" cooler...and replace "is reinjected into" with "transfers temperature to and from" the ground.
- (TP) "very minor impact" is too vague
- (TP) geothermal may change ground temperature by reinjecting...
- (LK) this is not precise enough. There are closed loop geothermal systems that recirculate fluid that never leaves the system. In summer, the water discharge from an open-loop systems would probably be slightly warmer.
- (JL) issues around high temperature? Installation?
- (KN) some systems in WI do receive a permit to actually tap into ground or well water and then discharge to surface waters or re-inject into the ground.

In most systems I've heard about the water is closed-looped and is just circulated through an extensive pipe system buried in the ground.

51. Pumps used in geothermal energy may be powered by fossil fuels, increasing greenhouse gases in the atmosphere.

Comments:

- (SC) Hopefully you are making more power from your geothermal system than your pumps are using.
- (CB) energy "systems". The same is true for any pump. This isn't a major point regarding geothermal systems.
- (LU) Pumps used in geothermal"/geoexchange systems"...powered by "electricity using" fossil fuels...
- (LU) add bullet: Because of their extremely high efficiencies and renewable component, geothermal/geoexchange heat pump systems used in many building can substantially reduce greenhouse gases as compared to more conventional natural gas and electricity powered systems.
- (LK) If the energy from the pumps is offsetting heating from electric resistance heating elements, it is probably decreasing the greenhouse gas. If the pumps are circulating fluid in a well insulated in-floor radiant system with thermal mass, they are probably decreasing the greenhouse gas. It is also possible to have a solar hot water assist to help the fluid for even more greenhouse gas reduction. We always get back to how well the system is designed and sized for its task.
- (JD) is this true on an overall net basis?
- (KN) the primary mover here is the heat pump, which is essentially a compressor like one would find in a refrigerator. There are also regular pumps in such a system and both run on electricity which raises questions about their true efficiency.

Effects of hydrogen energy technology

52. The harnessing of hydrogen gas can originate from either renewable or nonrenewable sources. Using nonrenewable sources may increase greenhouse gases.

Comments:

- (BH) use the same format of ads/disads for each energy type.
- (SC) statement doesn't have much to do with hydrogen. The hope of hydrogen is to reduce the pollution from the transportation system by reducing hydrocarbon combustion.

- (LK) it depends on whether the hydrogen is displacing other fuels. One aspect to consider is that harnessing hydrogen may alter the location where the pollution is produced. For instance, using a hydrogen-powered fuel cell for backup power in an urban setting will be far less polluting at that location than using a diesel generator. Gasification of oil and natural gas into hydrogen usually is done in a central refinery complex. Having hydrogen used in transportation applications, rather than other refinery products such as gasoline, diesel fuel or natural gas, is probably less polluting

Managing Renewable Energy Resource Use

By mastering these concepts students will gain an understanding of renewable energy use today and in the future.

Future outlooks for the development and use of energy resources

By understanding these concepts, students can evaluate how their actions affect the quality of life and the environment of their community, nation, and world. Students will also predict how scientific, technological, and social changes will influence future energy resource availability.

Current and future uses of renewable energy

53. Currently, alternative energy technologies are not subsidized and are thus, in general, are more expensive than conventional power sources.
- Wind energy costs approximately the same per kilowatt hour as using nonrenewable energy sources.

Comments:

- Bullet point true for wind farms
- (BH) if use bullet listed, include bullets for other renewable energy sources
- (SC) enough with the subsidy conspiracy theory. The technologies are more expensive because they collect a diffuse resource.
- (CB) replace “are not subsidized” with “receive relatively little government subsidies”.
- (CB) bullet point: “In very large projects,” wind energy...
- (CB) this statement is inaccurate on two points. First, renewables do receive govt funding and some subsidies. Second, renewables are not more expensive due to lack of subsidies. They are more expensive due to lower volume, higher technical sophistication and other factors.
- (TP) bullet: this doesn’t make sense to me-how did you come up with this?
- (JD) 1. not completely true. Federal tax credit for wind, commercial tax credit for installation of solar equipment. 2. wind energy cost. Only true in high wind areas (class 4 and 5).
- (JL) already addressed under economic

- (KN) you sorta have conflicting statements here. “Currently, alternative energy technologies are not subsidized and therefore more expensive”, and then the bullet “Wind energy costs the same as non-renewable energy sources”. Also, renewable energy technologies do receive some subsidies, just not anywhere near the huge amounts fossil fuels and nukes receive.

The cost deal is even more complex. It is not just a matter of renewables receiving way, way less in government subsidies, but also that they aren’t paying the true costs associated with their production and consumption. This should be included as a concept.

54. Alternative energy use is growing.

Comments:

- (BH) reword or cut. Current and historical use of RE.
- (SC) how can you quantify this statement? Or is the perception growing? I doubt it’s growing relative to the overall growth rate. Along with our realization that our current practices might be causing great long-term harm to our environment, and be unsustainable.
- (CB) reword to read “A large majority of Americans support increased research and development of renewable energy”
- (LU) RENEWABLE not alternative
- (JL) somewhat weak-could make more explicit (give general current and then examples). Bullet #55 (the bullets from 55?), the others under #54.
- (KN) but in this instance, and the above, I would replace “alternative energy” with “renewable energy”. The nuke industry put out a big campaign some years ago placing itself in the same category as “alternative energy”. It was then the RE advocates wanted to use the Renewable Energy title.

Current and future uses of solar energy

55. Solar energy is used worldwide.

- In rural settings with no power sources, solar energy is used to cook, heat water, and power schools, among other uses.
- Solar energy is primarily being used in residential settings.

Comments:

- (BH) list other solar applications
- (CB) first bullet: replace “setting” with “regions”; “power sources” with “electrical grid” and “is” with “can be”

- (TP) #55-61: these concepts are really too vague. You could lump them all together into RE is used worldwide, or find something specific to say about each.
- (LK) in WI, at least 30 schools (includes tech and university) settings have solar systems, some of them quite large. There are countless small systems used in the telecommunications field, road-building industry, and all those uses are growing because they are cost-effective. It may be, in WI, that nonresidential use outnumbers residential use.
- (JL) under #54
- (KN) I like the solar worldwide statement and it is very true. I wonder if it wouldn't be better to find another way of saying "in rural settings with no power sources, solar energy is used". It is not just the fact that solar energy is in itself a power source, but it also seems like it is saying that solar gets used in places where regular energy can't be found. Sorta true but misleading. Also, in the second bullet maybe could read "Unlike centralized power production, solar energy is primarily being used in residential settings also known as 'distributed generation'".

Another bullet could say "Distributed generation reduces the expenses and inefficiencies associated with the power lines and pipelines necessary to distribute energy production in centralized systems."

Current and future uses of wind energy

56. Wind Energy is used throughout the world.

- Denmark is a leader in the industry.
- The Midwest, especially North and South Dakota, have tremendous potential for wind energy.

Comments:

- N and S Dakota "and Texas" (Mick).
- (BH) mention how new technologies allow for wind to be used for energy generation in areas previously thought unavailable for wind energy generation
- (SC) what does tremendous mean? Vague.
- (CB) replace "tremendous" with "strong"
- (JL) under #54

57. Many states are beginning to install wind farms.

- Wind farms are supplying a substantial proportion of California's power.

Comments:

- (BH) include in 56
- (SC) this statement seems doubtful-how big is substantial? In 1999 12% was from "other" non-fossil, non-hydro. In 1998 wind produced 2,745 out of 188,759. 1.5% source DOE, EIA
- (CB) I believe this is false. California get about 1/3 of its energy from all renewables. Check with American wind energy assoc for data (www.awea.org).
- (LU) bullet: are "beginning to" supply a "growing" proportion of "the US" power.
- (TP) new bullet: Wisconsin specific stats?
- (LK) I don't think the statement regarding CA is accurate. In any case, it's also a statement that is so general as to be useless. You should state a percentage at a particular point in time.
- (JL) under #54
- (JL) maybe under this section add a concept about technology and renewable energy.

Current and future uses of hydropower

58. Hydropower is used worldwide.

- The Hoover Dam on the Colorado River and the dam on the Niagra Falls provide many people with electricity.
- The Three Gorges Dam in China will be the largest dam in the world when construction is finished.
- The Itaipu Dam on the border of Brazil and Paraguay is currently the largest dam in the world and provides southern Brazil and nearly all of Paraguay with their electricity.

Comments:

- (BH) if the concepts are going to be used, information should be included that describes to what extent the various sources are used. This could be posted on internet or updated yearly.
- (CB) second bullet: end statement with "in [year]".
- (LK) I would get some local perspective on this one. What about the dams on the WI river? What proportion of WI's power is generated from hydropower? What role did it play in WI's history?
- (JL) under #54

Current and future uses of biomass energy

59. Biomass is used worldwide.

- Biomass, especially wood, is a major fuel source to heat homes.

Comments:

- (BH) another bullet: ethanol. And waste/garbage/refuse energy generation.
- (CB) bullet: add “and cook food” at end. Deforestation is resulting in some areas.
- (LK) I would address how biomass can be used in a sustainable manner. Also discuss all the other products now derived from biomass, such as plastics, inks, a plethora of chemicals, not to mention fuels—that can replace those previously derived from fossil hydrocarbon sources.
- (JL) under #54
- (KN) bullet might read better as “in many parts of the world biomass energy, especially wood, is a major source of heating and cooking fuel”.

Current and future uses of geothermal energy

60. Geothermal energy is used worldwide.

- California is a leader in geothermal technology.
- Iceland is a leader in geothermal technology with nearly all of their energy needs being met by geothermal energy.

Comments:

- (BH) heat pumps should be mentioned here
- (SC) used in a few places –worldwide sounds like widespread
- (CB) first bullet: “In the US,” California...technology, “partly because it has many potential sites with good resources.”
- (CB) second bullet: replace “their” with “its”
- (LU) current and future uses of “deepwell” geothermal energy
- (JL) under #54
- (KN) I’m not sure geothermal is used worldwide, at least not in the context we have been discussing. Also, are the bullets sorta conflicting or perhaps could be combined?

Current and future uses of hydrogen energy

61. Hydrogen energy is used worldwide.

- Fuel cells are a promising technology for use as a source of heat and electricity for buildings and as an electrical power source for electric vehicles.

Comments:

- (SC) where is it used?
- (CB) This needs clarification. There is currently very limited use of hydrogen anywhere in the world.

- (LK) current use of hydrogen includes its use both as a fuel and as a chemical. It is indispensable for the H₂/O₂ fueled space shuttle, space station, manufacturing uses (high quality steel), refining, foods (hydrogenating), etc.
- (JL) under #54
- (JL) add un-discovered technologies to access resources?
- (KN) Not sure hydrogen has real worldwide use yet. I wonder if it wouldn't be better to have the bullet read something like "Fuel cells are a promising technology for producing electricity and their use in powering electric vehicles holds a particularly high potential". I think the heat thing got addressed in the fuel cell section proper.

General Comments:

- For general organization see Bill Hareen's comments
- All these concepts should be included under respective sections on pages # 9?, 12 and 14. (Bill Hareen)
- P 10 needs better distinction between RE and nonRE (BH)
- See SC's general comments
- See CB's general comments. Lots of additions and general organizational stuff.
- (LU) add concept #62: Insulating buildings to keep hot or cold temperatures out is an important part of minimizing our energy and fossil fuel use.
 - insulation can easily be made from trees and vegetation (biomass)
 - pound for pound and dollar for dollar insulation is one of our least expensive energy reducing technologies.
 - cellulose and strawbales are two renewable insulations.
- (LK) see his general comments.
- (KN) see his general comments.

Mick=Mick Sagrillo

BH=Bill Hareen

SC=Steve Carlson

CB=Chip Bircher

LU=Leo Udee

TP=Tehri Parker

KZ=Kelly Zagrzebski

LK=Larry Krom

JL=Jennie Lane

KN=Kurt Nelson

JD=Jeff Dulaune

Appendix N
**Draft Renewable Energy Conceptual Framework Sent Out for Round Two of
the Delphi Survey**

**(Draft) Conceptual Framework for Renewable Energy
Education**

A work in progress...

Developing Renewable Energy Resources

This theme helps students to realize how they and other humans have become more and more dependent on the development and use of energy resources to satisfy their standard of living.

Renewable Energy

Mastering these concepts will help students to comprehend renewable energy.

1. Renewable energy sources are continuously replenished.

Mean: 4.55

SD: 0.69

Median: 5.0

Comments:

2. Renewable resources commonly used are solar, wind, hydropower, biomass and geothermal.

- Hydrogen energy, while not a renewable resource, has potential for providing non-polluting fuel and will be discussed in this section.

Mean: 4.36

SD: 1.21

Median: 5.0

Comments:

3. Renewable energy resources can be used to generate electricity and heat, as well as to provide fuel for vehicles.

Mean: 4.82

Standard deviation (SD): 0.40

Median: 5.0

Comments:

4. Humans have used renewable resources to meet their energy needs throughout history.

- Solar (passive solar heating), biomass and geothermal energy have been used for heating and cooling for thousands of years.
- Wind has been used for many generations to power windmills used to grind grain.
- Hydropower has been used for thousands of years to provide mechanical energy to grind grain, drive sawmills, and pump water.

Mean: 4.55

SD: 0.52

Median: 5.0

Comments:

8. Renewable energy is a reliable energy source for many residential and commercial applications.

- Each renewable energy resource has characteristics that make it suitable for some uses more than others; e.g., solar power is particularly useful in isolated locations where it would be too expensive to bring in power lines.

Mean: 4.45

SD: 0.52

Median: 4.0

Comments:

Solar Energy

Comprehending these concepts will help students to understand solar energy.

6. Solar energy is the solar radiation that reaches Earth's surface.

Mean: 4.55

SD: 0.69

Median: 5.0

Comments:

7. Solar energy is used for space and water heating.

- Passive solar heating is when air or liquid is warmed by the sun and naturally circulates. Passive solar is usually incorporated into a building's architecture. For example, sunlight entering a room through a south-facing window warms the floor and air in the house.

- Active solar heating involves the use of pumps or other devices to move the warmed air or liquid. For example, a pump may move liquid through a solar plate collector which will then warm the house.

Mean: 4.60

SD: 0.52

Median: 5.0

Comments:

8. Solar energy can be used to generate electricity. In one such process solar cells, also known as photovoltaic cells, are used to convert the radiant energy in sunlight directly into electricity.

- A solar or PV cell consists of semiconducting material that absorbs sunlight. The solar energy knocks electrons loose from their atoms, allowing the electrons to flow through the material to produce electricity.

Mean: 4.64

SD: 0.50

Median: 5.0

Comments:

9. Solar energy is an intermittent resource. It can be stored for future use when the sun is not shining.

New Concept

Comments:

Wind Energy

Comprehending these concepts will help students to understand wind energy.

10. Wind is air in motion and is produced by the unequal heating of Earth's surface by the sun.

- Wind speed increases with increased height above Earth's surface, so wind turbines are mounted on tall towers.

Mean: 4.64

SD: 0.50

Median: 5.0

Comments:

11. Wind turbines transform wind energy to generate electricity.

- The blades spin like a propeller and turn a shaft that is connected to a generator. The generator creates electricity.

Mean: 4.82

SD: 0.40

Median: 5.0

Comments:

12. Wind energy is an intermittent resource. It can be stored for future use when the wind is not blowing.

New Concept

Comments:

Hydropower

Understanding these concepts will help students to comprehend hydropower energy.

13. Hydropower refers to the kinetic energy generated by falling water.

- The water's flow (volume) and fall (height) determine the amount of available energy in moving water.

Mean: 4.73

SD: 0.47

Median: 5.0

Comments:

14. Hydropower plants capture the kinetic energy of falling water to generate electricity.

- The energy may be captured by damming a river, creating an artificial reservoir, or channeling a portion of a river through a generating facility.
- The captured turns the blades in a turbine that are connected to a generator which produces electricity.

Mean: 4.27

SD: 1.19

Median: 5.0

Comments:

15. Dams can regulate the quantity and timing of electricity generated with hydropower to meet the varying demands of a community.

New Concept

Comments:

Biomass Energy

Understanding biomass will help students comprehend the uses of vegetation as an energy source.

16. Biomass energy refers to the energy stored in plant material.

- Biomass energy is the sun's energy turned into stored chemical energy through the plant's photosynthesis process.
- Coal, a fossil fuel, was once the biomass energy of Earth's prehistoric past.

Mean: 4.64

SD: 0.67

Median: 5.0

Comments:

17. Biomass can be used for a variety of purposes.

- Combustion of biomass can be used to generate electricity.
- Combustion of biomass can be used to produce heat for climate control and manufacturing.
- Ethanol is produced from the fermentation of grains and other plant materials and is used as a fuel.
- Gasification converts decaying biomass in landfills and biogas digesters into a gas called methane, the main ingredient in natural gas.

Mean: 4.55

SD: 0.69

Median: 5.0

Comments:

Geothermal Energy

Mastering these concepts will help students realize how the Earth's internal energy can be used as an energy source.

18. Geothermal energy is heat energy that originates within Earth.

- Geothermal resources range from shallow ground to hot water, steam and rock several miles below Earth's surface.

Mean: 4.55

SD: 0.52

Median: 5.0

Comments:

19. High temperature geothermal resources are underground reservoirs of hot water or steam and can be tapped for electrical power production.

- Geothermal plants drill wells to capture underground steam, which spins a turbine to produce electricity.
- The most active, high temperature geothermal resources are usually found along major tectonic plate boundaries where earthquakes and volcanoes are concentrated.

Mean: 4.55

SD: 0.52

Median: 5.0

Comments:

20. Low temperature geothermal resources, or geothermal or ground-source heat pumps, use the relatively constant temperature of the soil or surface water as a heat source and sink for a heat pump, which provides heating and cooling for buildings.

- Heat for many low-temperature geothermal systems is based on stored solar energy in the soil rather than heat from inside Earth.

Mean: 3.91

SD: 0.94

Median: 4.0

Comments:

Hydrogen Energy

Comprehending how we may obtain energy from hydrogen will help students appreciate the diversity of uses of one of Earth's most abundant elements.

21. Hydrogen is the third most abundant element on Earth.

- Hydrogen gas (H) does not exist naturally on Earth; it is always combined with other elements or, as it exists in our atmosphere, combines with itself (H₂).

Mean: 3.64

SD: 1.03
Median: 4.0

Comments:

22. Hydrogen (H) must be produced since it does not occur naturally on Earth.
- Hydrogen can be produced from renewable (methanol and biomass) and nonrenewable (natural gas, coal, and gasoline) energy sources through the application of heat.
 - Hydrogen can be produced using electricity or sunlight to split water into hydrogen and oxygen.

Mean: 4.00
SD: 1.00
Median: 4.0

Comments:

23. Hydrogen's potential use as a fuel is diverse.
- Applications include powering vehicles, running turbines or fuel cells to produce electricity, and generating heat and electricity for buildings.

Mean: 4.18
SD: 0.60
Median: 4.0

Comments:

Effects of Renewable Energy Resource Development

This theme will help students investigate how renewable energy use affects the environment. Recognizing these effects increases students' awareness of why and how they use energy.

Quality of life

Understanding these concepts helps students analyze current energy-use practices and evaluate how they affect quality of life.

Lifestyles

24. Relying on renewable energy to provide energy for home use will require energy conservation and an energy efficient home and lifestyle.

Mean: 4.64
SD: 0.50
Median: 5.0

Comments:

Health and safety

25. Using renewable energy will minimize personal and community health risks since it generally releases fewer pollutants into the environment.

Mean: 4.64

SD: 0.50

Median: 5.0

Comments:

Economic

26. Renewable energy is currently expensive but with more production, technological advances, and subsidies prices could be reduced.

- Renewable energy systems could save money over time because they require less (or no) fuel.

New Concept

Comments:

27. Although there is a cost involved, converting to a renewable energy-based economy

would create many jobs.

- Most renewable energy investments are spent on materials and labor to build and maintain facilities, rather than on energy imports.

Mean: 4.36

SD: 0.92

Median: 5.0

Comments:

28. Using renewable energy would allow the U.S. to become more energy independent.

- US investments in renewable energy are usually spent within the United States, frequently in the same state, and often in the same town.

Mean: 3.91

SD: 1.04

Median: 4.0

Comments:

Sociopolitical

29. Zoning laws and housing covenants may restrict the installation of renewable energy systems.

- These restrictions tend to be based on misconceptions, aesthetics, and concerns about resale value of homes.

Mean: 3.55

SD: 0.93

Median: 4.0

Comments:

30. Residential use of renewable energy puts electrical production in the hands of consumers, who then are less dependent on other providers

- “Independent living” is a term which refers to living off the grid, not relying on commercial utility companies for electricity.

Mean: 3.64

SD: 1.21

Median: 4.0

Comments:

31. A centralized energy system is when large amounts of an energy resource are converted from one form into another form in a central location. The energy is then distributed to and used by a large number of consumers.

New Concept

Comments:

32. A decentralized energy system is when small amounts of an energy resource are converted from one form into another form for use by an individual or small number of consumers. The conversion and consumption of the energy resource usually occurs in the same location.

New Concept

Comments:

Ethical

33. Reasons people choose to use renewable energy include the differing environmental, economic and aesthetic impacts of renewable energy compared to nonrenewable energy.

Mean: 4.36

SD: 1.03
Median: 5.0

Comments:

34. The current practices of extracting fossil fuels from other countries to support the energy intensive lifestyle of the U.S. affects the cultures, environments and health of individuals of other countries.

Mean: 3.73
SD: 1.56
Median: 4.0

Comments:

Quality of the environment

By comprehending these concepts, students will be able to explain how current energy use practices affect the quality of the environment.

35. Many renewable energy technologies are clean sources of energy that have a lower environmental impact than energy technologies that use fossil fuels.

Mean: 4.36
SD: 0.92
Median: 5.0

Comments:

36. There are environmental costs involved in the development, manufacture and distribution of renewable energy technologies.

Mean: 3.73
SD: 1.42
Median: 4.0

Comments:

Effects of solar energy technology

Benefits of using solar energy

37. The environmental impact of a photovoltaic system is minimal, requiring only sunlight to produce electricity and producing no by-products. PV systems are clean and silent.

Mean: 4.55
SD: 0.52
Median: 5.0

Comments:

38. Using passive solar design in building construction can reduce heating demand (and the bills) with little impact on customer lifestyle.

Mean: 4.82
SD: 0.40
Median: 5.0

Comments:

Costs of using solar energy

39. Large, centralized solar energy systems require large tracks of land.

Mean: 3.09
SD: 1.04
Median: 3.0

Comments:

Effects of wind energy technology

Benefits of using wind energy

40. The environmental impact of a wind system is minimal, requiring only wind to generate electricity and producing no by-products.

Mean: 4.00
SD: 1.41
Median: 5.0

Comments:

Costs of using wind energy

41. There are concerns regarding the impacts of wind farms.

- Some find the wind turbines to be unattractive, detracting from the scenery.
- Some are concerned that, in some locations, migratory birds are killed by wind turbines.
- The spinning of some blades on wind farms produces noise.

Mean: 4.00
SD: 1.05
Median: 4.0

Comments:

Effects of hydropower technology

Benefits of using hydropower

42. Hydropower produces no waste products and does not pollute the air.

Mean: 4.18

SD: 0.98

Median: 4.0

Comments:

Costs of using hydropower

43. The environmental effects of using large hydropower plants are numerous.

- Most often, to harness the energy in water a dam is constructed, disrupting the aquatic ecosystem. A large area behind the dam is flooded, destroying the existing habitat; it may also disrupt human settlements.
- The dam regulates the flow of the river to eliminate the river's flooding cycle. This affects the many plants and animals that are dependent on the periodic inundation of the floodplain.
- There is siltation behind the dam, thermal pollution in impoundments, and a disruption of migratory fish patterns.

Mean: 4.40

SD: 0.70

Median: 4.5

Comments:

Effects of biomass energy technology

Benefits of using biomass energy

44. In some types of biomass, the amount of carbon dioxide released during combustion

is offset by the amount of carbon dioxide that is consumed through photosynthesis during the crop's growth.

Mean: 4.18

SD: 0.60

Median: 4.0

Comments:

45. Ethanol, one type of biofuel, can replace the parts of gasoline that pose the greatest

environmental hazard. Ethanol quickly biodegrades in water, reducing the threat of contamination from spillage into waterways and ground water.

Mean: 4.00

SD: 0.89

Median: 4.0

Comments:

Costs of using biomass energy

46. Large areas of land are needed to grow biomass crops.

New Concept

Comments:

47. Careful management of crops and land are needed for biomass to be a sustainable resource.

New Concept

Comments:

Effects of geothermal energy technology

Benefits of using geothermal energy

48. Because geothermal heat pump systems are efficient and have a renewable component, they can substantially reduce greenhouse gases as compared to more conventional natural gas and electricity powered systems.

New Concept

Comments:

Costs of using geothermal energy

49. Pumps used in low-temperature geothermal energy systems may be powered by electricity generated by fossil fuels, contributing to the environmental problems associated with nonrenewable energy use.

Mean: 3.55

SD: 1.37

Median: 4.0

Comments:

50. Geothermal systems may change ground temperature since the energy from slightly warmer or cooler water (a bi-product of harvesting geothermal energy) is re-injected into the soil.

Mean: 3.90

SD: 0.74

Median: 4.0

Comments:

Effects of hydrogen energy technology

Benefits/costs of using hydrogen energy

51. The harnessing of hydrogen gas can originate from either renewable or nonrenewable sources. Using nonrenewable sources may increase greenhouse gases.

Mean: 3.45

SD: 1.37

Median: 4.0

Comments:

Managing Renewable Energy Resource Use

By mastering these concepts students will gain an understanding of renewable energy use today and in the future.

Future outlooks for the development and use of energy resources

By understanding these concepts, students can evaluate how their actions affect the quality of life and the environment of their community, nation, and world. Students will also predict how scientific, technological, and social changes will influence future energy resource availability.

Current and future uses of renewable energy

52. Renewable energy use is increasing in the United States.

Mean: 4.09

SD: 1.04

Median: 4.0

Comments:

53. Renewable energy is used worldwide.

- Solar energy is used worldwide. It is particularly useful in remote rural settings where it is used to cook, heat water and power schools.

- Wind energy is used worldwide. Denmark is a leader in the industry. North and South Dakota and Texas have strong potential for generating electricity from wind.
- Hydropower is used worldwide. Electricity generated from hydropower is used on every continent except Antarctica.
- Biomass is used worldwide. In many parts of the world biomass, especially wood, is a major source of heating and cooking fuel.
- Geothermal is used worldwide. Iceland is a leader in geothermal technology with nearly all of their energy needs being met by geothermal energy. Throughout the U.S., geosystems are used to heat/cool homes.
- Hydrogen as a fuel is being promoted worldwide. Fuel cells are a promising technology for use as a source of heat and electricity for buildings and as an electrical power source for electric vehicles
 - A fuel cell works like a battery but does not run down or need recharging. It will produce electricity and heat as long as fuel (hydrogen) is supplied.
 - Hydrogen fuel cells produce clean, potable water as a byproduct.

New Concept

Comments:

54. Transitional technologies may play a role in future RE development: (i.e. fuel blends, portable power applications, partial power from renewables, more creative use of passive solar design, etc.)

New Concept

Comments:

55. Intelligent and creative engineering can play an important role in reducing environmental impacts from technologies such as hydropower, wind turbines, and biomass fuels.

New Concept

Comments:

56. There is tremendous opportunity to reinvent how we use power and how we can creatively alter the characteristics of equipment to use less power.

New Concept

Comments:

Appendix O
Thank You Letter for Round Two of the Delphi Survey

May 7, 2002

Dear «first_name» «last_name»:

Thank you for your extensive comments on the draft renewable energy conceptual framework. They were extremely helpful in making revisions. I appreciate the time and energy already invested in this project. This, the second round of the Delphi process, will also be the last. The framework has been revised based on your comments, so hopefully the reviewing process will be much quicker this time around!

The purpose of this exercise is to develop a valid renewable energy conceptual framework that will complement and be integrated into the existing Wisconsin K-12 Energy Education Program's Conceptual Framework. The framework will serve as a guide for creating future renewable energy education projects, such as an activity guide and inservice course for teachers. The Delphi technique is being used as a method to edit and validate those concepts currently included in the draft renewable energy conceptual framework. The opinions of the panelists will be the primary basis for determining which concepts are to be included in the framework. By participating in this Delphi panel, you are helping to create a framework that will in turn support comprehensive and accurate renewable energy education.

General information about the Delphi technique, instructions and materials for completing the second round of the exercise are enclosed. A hour or two of your time will be required to complete the second round of the Delphi. You, no doubt, have many demands on your time but please respond to each round promptly. **Please return the draft framework, scan-tron answer sheet and consent form by May 31, 2002.**

I will serve as monitor of the exercise. This means that I will prepare the material for each round, summarize responses, and prepare a final report, including rationale for the final renewable energy conceptual framework. Anonymity among panelists will be maintained throughout the exercise.

Upon receipt of your ratings and comments on this last round of the Delphi survey, you are entitled to \$200.00 to compensate for the time and energy you have put into this project. In order to receive your check, I will need your social security number. You may contact me by email, phone or mail with this information.

If you have any questions, do not hesitate to contact me. Thank you again for consenting to be a panelist. I look forward to receipt of your input.

Stephanie Kane
Renewable Energy Education Specialist
K-12 Energy Education Program
715-346-4320
Stephanie.H.Kane@uwsp.edu

Appendix P
Draft of the Renewable Energy Conceptual Framework with Comments for
Round Two of the Delphi Survey

(Draft) Conceptual Framework for Renewable Energy
Education

A work in progress...

Developing Renewable Energy Resources

This theme helps students to realize how they and other humans have become more and more dependent on the development and use of energy resources to satisfy their standard of living.

Renewable Energy

Mastering these concepts will help students to comprehend renewable energy.

1. Renewable energy sources are continuously replenished.
2. Renewable resources commonly used are solar, wind, hydropower, biomass and geothermal.
 - Hydrogen energy, while not a renewable resource, has potential for providing non-polluting fuel and will be discussed in this section.
3. Renewable energy resources can be used to generate electricity and heat, as well as to provide fuel for vehicles.
4. Humans have used renewable resources to meet their energy needs throughout history.
 - Solar (passive solar heating), biomass and geothermal energy have been used for heating and cooling for thousands of years.
 - Wind has been used for many generations to power windmills used to grind grain.
 - Hydropower has been used for thousands of years to provide mechanical energy to grind grain, drive sawmills, and pump water.

(LK) On the statement, “Wind has been used for many generations to power windmills”-- Windmills in Europe are noted in the 12th Century. That’s centuries. Of more note and importance in world history, is the use of wind to power sailing ships

as far back as 6000 B.C. If one contemplates the role of wind-powered transportation, commerce, and world exploration, it is a contribution that can't be overlooked.

Thousands of years.

(CB) bullet should read, "used for hundreds of years"

9. Renewable energy is a reliable energy source for many residential and commercial applications.

- Each renewable energy resource has characteristics that make it suitable for some uses more than others; e.g., solar power is particularly useful in isolated locations where it would be too expensive to bring in power lines.

Solar Energy

Comprehending these concepts will help students to understand solar energy.

6. Solar energy is the solar radiation that reaches Earth's surface.

(JL) Perhaps change the second "solar" to "sun" to avoid redundancy?

Perhaps create a new concept about availability (indicating that some renewable resources are in constant supply and some are intermittent) and place after concept #5 (make a new #6). Fold concepts 9, 12, and 15 under this.

(CB) "surface from the sun."

7. Solar energy is used for space and water heating.

- Passive solar heating is when air or liquid is warmed by the sun and naturally circulates. Passive solar is usually incorporated into a building's architecture. For example, sunlight entering a room through a south-facing window warms the floor and air in the house.
- Active solar heating involves the use of pumps or other devices to move the warmed air or liquid. For example, a pump may move liquid through a solar plate collector which will then warm the house.

(LU) Pumps require electricity, which may be generated by fossil fuels to move the liquids through solar collectors.

(CB) "fluid" not water. Bullet should read, "devices to move a heated fluid."..."then be used to warm the house"

(KN) change "a solar plate collector" to simply read "solar collector". It could also read "solar flat-plate collector" but I think it is easier to understand as it reads above.

(JL) Consistency #7 and #8 compared to #17 and compared to #19 and #20. It bothered me a little that that solar has two separate concepts about each of its uses (as does geothermal) and all of biomass is all lumped under one. I am leaning toward lumping (making them all more like #17, but am not adamant about the change.

8. Solar energy can be used to generate electricity. In one such process solar cells, also

known as photovoltaic cells, are used to convert the radiant energy in sunlight directly into electricity.

- A solar or PV cell consists of semiconducting material that absorbs sunlight. The solar energy knocks electrons loose from their atoms, allowing the electrons to flow through the material to produce electricity.

(CB) eliminate "are used to"

9. Solar energy is an intermittent resource. It can be stored for future use when the sun is not shining.

(SC) Replace "it" with "The heat or electricity it produces" to be more precise. The solar energy itself cannot be stored.

Wind Energy

Comprehending these concepts will help students to understand wind energy.

10. Wind is air in motion and is produced by the unequal heating of Earth's surface by the sun.

- Wind speed increases with increased height above Earth's surface, so wind turbines are mounted on tall towers.

(JL) consider moving the bullet to under number 11.

(KN) The bullet is sorta okay but maybe you could add (or another bullet) "Winds close to the ground are more varied and turbulent"

11. Wind turbines transform wind energy to generate electricity.

- The blades spin like a propeller and turn a shaft that is connected to a generator. The generator creates electricity.

(CB) bullet "blades on a turbine...propeller on an airplane"

12. Wind energy is an intermittent resource. It can be stored for future use when the wind is not blowing.

(SC) Replace "it" with "The electricity it produces" to be more precise. The wind energy itself cannot be stored.

Hydropower

Understanding these concepts will help students to comprehend hydropower energy.

13. Hydropower refers to the kinetic energy generated by falling water.

- The water's flow (volume) and fall (height) determine the amount of available energy in moving water.

14. Hydropower plants capture the kinetic energy of falling water to generate electricity.

- The energy may be captured by damming a river, creating an artificial reservoir, or channeling a portion of a river through a generating facility.
- The captured turns the blades in a turbine that are connected to a generator which produces electricity.

(CB) bullet "the flowing water turns..."

15. Dams can regulate the quantity and timing of electricity generated with hydropower to meet the varying demands of a community.

(SC) Might explicitly state that storage is inherent in hydropower to maintain parallel with storage comments on other sources.
KN Don't really like the way this one is stated. On wind and solar, you stated that they were intermittent sources. Maybe this one could follow that trend and read "although the rainfalls that supply water to a hydropower system are intermittent, the system's dam creates a vast reservoir of stored water to make the hydro system's output more constant".

Biomass Energy

Understanding biomass will help students comprehend the uses of vegetation as an energy source.

16. Biomass energy refers to the energy stored in plant material.

- Biomass energy is the sun's energy turned into stored chemical energy through the plant's photosynthesis process.
- Coal, a fossil fuel, was once the biomass energy of Earth's prehistoric past.

(CB) bullet "sun's energy converted to..." It's important that the definition of biomass include waste recycling systems like landfills and manure digestions on farms. I suggest: "Biomass energy refers to energy from biological systems or processes."

17. Biomass can be used for a variety of purposes.

- Combustion of biomass can be used to generate electricity.
- Combustion of biomass can be used to produce heat for climate control and manufacturing.
- Ethanol is produced from the fermentation of grains and other plant materials and is used as a fuel.
- Gasification converts decaying biomass in landfills and biogas digesters into a gas called methane, the main ingredient in natural gas.

Geothermal Energy

Mastering these concepts will help students realize how the Earth's internal energy can be used as an energy source.

18. Geothermal energy is heat energy that originates within Earth.

- Geothermal resources range from shallow ground to hot water, steam and rock several miles below Earth's surface.

19. High temperature geothermal resources are underground reservoirs of hot water or steam and can be tapped for electrical power production.

- Geothermal plants drill wells to capture underground steam, which spins a turbine to produce electricity.
- The most active, high temperature geothermal resources are usually found along major tectonic plate boundaries where earthquakes and volcanoes are concentrated.

20. Low temperature geothermal resources, or geothermal or ground-source heat pumps, use the relatively constant temperature of the soil or surface water as a heat source and sink for a heat pump, which provides heating and cooling for buildings.

- Heat for many low-temperature geothermal systems is based on stored solar energy in the soil rather than heat from inside Earth.

(SC) The use of heat pumps is more of an application than an energy source. Heat pumps can extract heat out of the air. Does this mean air-source heat pumps are renewable too? The outdoor air temperature is maintained by solar energy...

(CB) "resources, used for ground..."

Hydrogen Energy

Comprehending how we may obtain energy from hydrogen will help students appreciate the diversity of uses of one of Earth's most abundant elements.

21. Hydrogen is the third most abundant element on Earth.

- Hydrogen gas (H) does not exist naturally on Earth; it is always combined with other elements or, as it exists in our atmosphere, combines with itself (H₂).

(SC) The bullet item is confusing. Hydrogen gas (H₂) is its natural state. You wouldn't find or be able to maintain elemental hydrogen outside a plasma. The point is that HYDROGEN GAS cannot be harvested, but must be produced.

(CB) Bullet: Hydrogen gas is H₂. To make this point accurate, state "hydrogen does not exist in a monoatomic state. It is always combined...atmosphere, as diatomic gas."

22. Hydrogen (H) must be produced since it does not occur naturally on Earth.

- Hydrogen can be produced from renewable (methanol and biomass) and nonrenewable (natural gas, coal, and gasoline) energy sources through the application of heat.
- Hydrogen can be produced using electricity or sunlight to split water into hydrogen and oxygen.

(SC) This is the same point as 21

(KN) On the final bullet, are you saying that hydrogen can be produced from water by direct sunlight, or with the electricity produced by solar PV panels? I really don't know, but how about "To produce hydrogen, water can be split into its constituent parts of hydrogen and oxygen using electricity produced by wind generators or photovoltaic panels."

(JL) could be folded under #21.

(CB) H₂ (not Hydrogen) gas is produced. This statement is better if the "H" is omitted or the word gas is added and the formula H₂ is included. Second bullet: This process is called electrolysis.

23. Hydrogen's potential use as a fuel is diverse.

- Applications include powering vehicles, running turbines or fuel cells to produce electricity, and generating heat and electricity for buildings.

Effects of Renewable Energy Resource Development

This theme will help students investigate how renewable energy use affects the environment. Recognizing these effects increases students' awareness of why and how they use energy.

Quality of life

Understanding these concepts helps students analyze current energy-use practices and evaluate how they affect quality of life.

Lifestyles

24. Relying on renewable energy to provide energy for home use will require energy conservation and an energy efficient home and lifestyle.

(JD) Define "relying" and "require". Conservation and efficiency are desirable but not required.

(CB) "home use goes hand-in-hand with energy..." Energy efficiency is not required, it just makes good sense.

Health and safety

25. Using renewable energy will minimize personal and community health risks since it generally releases fewer pollutants into the environment.

(JL) Add new concept under lifestyles (a new #25) saying that individuals with decentralized systems must be interested and willing to monitor and maintain their own systems.

(CB) "will reduce some health risks...environment compared to fossil fuels" Renewable don't minimize all personal and community health risks, so this broad statement can't be justified. Also, since you use the word "fewer" the sentence should include the comparison... 'fewer than what?'

Economic

26. Renewable energy is currently expensive but with more production, technological advances, and subsidies prices could be reduced.
- Renewable energy systems could save money over time because they require less (or no) fuel.

(JL) the bullet confuses me.

(MS) Comment: The "cost" of conventional fossil and nuclear fuels does not take into consideration imbedded subsidies or the socialized costs of the "tail pipe" emissions of these technologies. Therefore, the higher cost of renewable energy is being taken out of context. do you want to purvey this message?

(SC) Subsidies DO NOT reduce cost. Someone must pay the subsidy and subsidies reduce the market forces to innovate and reduce costs. Why not simply state the wishful thinking that this item is trying to communicate? Namely, that with technological advances and economies of scale, costs of renewables could fall in the future. The bullet item is trying to note life cycle costs, where a large investment is returned slowly over time because of the reduced or eliminated fuel cost. Most renewables are currently uneconomical in comparison in mainstream applications - They will wear out before they have saved their initial cost. (eg. Residential solar PV has a payback of 100 years, but the systems will only last 20 to 30 years). I think there are two points here (1) the potential for lower cost with

innovation and economies of scale and (2) the recovery of the initial cost over time from lower operating costs.

(CB) sp. Subsidies. Comma after expensive. "more demand and production" bullet "fuel compared to conventional energy systems.

(KN) You are saying RE is pricey stuff, but with cash from the Gov and such, prices may come down. The fossil and nuclear energy industry is heavily subsidized by the Government and this creates a situation where-in you cannot compare fossils and solar like apples to apples. Just the environmental "costs" brought about by our dependence on these energy sources alone will make RE look much more promising from an economic perspective. These "true costs" are not factored into the price we pay at the meter or pump.

I think you guys are being careful to not put statements in the framework that may offend certain individuals but these are facts not opinions. When you discuss the cost of RE you are by the very nature of the discussion making the cost of fossil fuels and nuclear energy the base-one of "what regular energy costs". At that point you are buying into a formula that has to consider factors regarding the use/cost of renewables that diverge from that baseline comparison. The real costs of acid rain, smog, mercury and other environmental expenses, as well as current government subsidies to these industries, have to be factored in.

And again the fact (again, it's a fact) that our heavy dependence on fossil fuels creates a situation that requires a huge investment (militarily) in defending "our" fossil fuel resources in those regions of the globe that are politically unstable or...

- Our dependence on energy imports contributes to an unstable economy (ok, leave that part out, but...) and attempts to stabilize (protect) our over-seas resources results in large

expenditures of US military dollars which are not included in the price of energy.

This is really not an opinion. Almost any Senator or Representative, even the Prez, will admit that we spend huge amounts of dollars "protecting our overseas resources". When we look at a PV panel as still being "way too expensive to compete with fossil fuels", we need to factor in all the costs associated with the energy source.

I might also add that solar thermal (like SDHW) is price competitive with electric and natural gas right now.

27. Although there is a cost involved, converting to a renewable energy-based economy

would create many jobs.

- Most renewable energy investments are spent on materials and labor to build and maintain facilities, rather than on energy imports.

(JL) the wording for this one still bothers me. I feel like there needs to be an adjective, such as "start up" or "transfer" before the word "cost"

(CB) bullet "on fuel, which is often imported"

28. Using renewable energy would allow the U.S. to become more energy independent.

- US investments in renewable energy are usually spent within the United States, frequently in the same state, and often in the same town.

(CB) "town as where the resource is located"

Sociopolitical

29. Zoning laws and housing covenants may restrict the installation of renewable energy systems.

- These restrictions tend to be based on misconceptions, aesthetics, and concerns about resale value of homes.

(LK) **Solar and Wind Access Laws.** The statement that zoning laws and housing covenants may restrict the installation of renewable energy systems is misleading and not accurately stated. Specifically, no unit of government in Wisconsin can legally restrict a solar or wind installation based on concerns such as aesthetics and resale value. Wisconsin State Statutes, tested by case law in 1983 and 2001, would take precedence over those types of zoning or covenant restrictions. In Wisconsin, we have extensive statutory legal protection for solar and wind access:

- zoning protection (zoning laws can only restrict solar or wind systems if the restriction is based on public health and safety),
- voiding of all undo restrictions on construction and operation regarding solar and wind systems on platted land (subdivisions),
- renewable energy easement protection that states renewable easements are like all other easements -- that they run with the land benefited and the land burdened unless stated otherwise by the easement,

- property owners with wind or solar energy systems can apply for permits which will guarantee unobstructed access to solar and wind resources, and
- the statutes apply to counties, towns, and municipalities for residential, commercial, and industrial sectors.

If you are interested in the actual Chapter and section text from the Wisconsin Statutes, it can be provided.

30. Residential use of renewable energy puts electrical production in the hands of consumers, who then are less dependent on other providers

- “Independent living” is a term which refers to living off the grid, not relying on commercial utility companies for electricity.

(CB) bullet: off the “electrical” grid. Add bullet: Living off the grid usually required that the building owners take responsibility for operating and maintaining their own energy system. It’s critical to convey the responsibilities that people must assume if they choose to live “independently”.

(KN) change off the grid to read “off-grid”.

(JL) is only true for decentralized systems.

(JD) renewable energy is not the only way to provide electrical production on site.

(LU) for those who do not/can not live off of the grid commercial utility companies provide a choice of renewable energy sources to the consumer. More consumers choosing renewable sources will require utilities to invest in more renewable sources.

31. A centralized energy system is when large amounts of an energy resource are converted from one form into another form in a central location. The energy is then distributed to and used by a large number of consumers.

(JL) #31 and #32: I think I confused things by adding my request to include 'centralized' vs. 'decentralized.' Maybe you could have a new general concept (e.g., a new #7) and say renewable energy systems can be centralized or decentralized and then have bullets defining each.

(LU) known as a distributed resource

(CB) “is one is which large...”

(KN) forma is misspelled

32. A decentralizes energy system is when small amounts of an energy resource are converted from one form into another form for use by an individual or small number of consumers. The conversion and consumption of the energy resource usually occurs in the same location.

(CB) “A distributed energy system is one is which small...” The term in the industry is “distributed generation”.

(KN) how bout a bullet or rephrase to include “ Most renewable energy systems are decentralized, with the power being consumed at the same location it is produced.

Ethical

33. Reasons people choose to use renewable energy include the differing environmental, economic and aesthetic impacts of renewable energy compared to nonrenewable energy.

34. The current practices of extracting fossil fuels from other countries to support the energy intensive lifestyle of the U.S. affects the cultures, environments and health of individuals of other countries.

(JL) delete or fold under #28.

(SC) This statement is neutral in tone now. Most will think it to be negative, although I see all those point as positive improvements.

(JD) the effects can be both positive and negative

(CB) "individuals in other..." new bullet: Many third world countries are benefiting from the development and deployment of renewable energy equipment from industrialized nations.

As I indicated in my original comments, this statement is biased.

Mostly we benefit other countries by giving away our own wealth.

Let's make it more balanced or eliminate it.

Quality of the environment

By comprehending these concepts, students will be able to explain how current energy use practices affect the quality of the environment.

35. Many renewable energy technologies are clean sources of energy that have a lower environmental impact than energy technologies that use fossil fuels.

36. There are environmental costs involved in the development, manufacture and distribution of renewable energy technologies.

(JL) could be folded into #35.

(CB) These costs vary with different types of renewable energy.

(KN) The environmental cost of RE are mostly in the manufacturing.

Effects of solar energy technology

Benefits of using solar energy

37. The environmental impact of a photovoltaic system is minimal, requiring only sunlight to produce electricity and producing no by-products. PV systems are clean and silent.

(CB) new bullet: The manufacturing process for PV systems does involve significant amounts of time and labor.

(KN) This statement conflicts somewhat with #36. Maybe you need to separate these two a little better. I think you are making two different points. Another concept is that there are embedded energy costs associated with the production of a PV panel. The embedded energy in a PV panel is returned (?) in the first couple years that the panel is generating electricity in the sun.

38. Using passive solar design in building construction can reduce heating demand (and the bills) with little impact on customer lifestyle.

(KN) Not sure "customer" is the right choice but it works. Summertime cooling can be an even bigger concern, how bout another bullet that reads something like "A properly designed passive solar home is not only warmer and less expensive to heat in the winter, it is also cooler during the summer months, reducing or eliminating air conditioning loads."

Costs of using solar energy

39. Large, centralized solar energy systems require large tracks of land.

(KN) Bullet? Decentralized solar energy systems can utilize existing roof space.

Effects of wind energy technology

Benefits of using wind energy

40. The environmental impact of a wind system is minimal, requiring only wind to generate electricity and producing no by-products.

Costs of using wind energy

41. There are concerns regarding the impacts of wind farms.
- Some find the wind turbines to be unattractive, detracting from the scenery.
 - Some are concerned that, in some locations, migratory birds are killed by wind turbines.
 - The spinning of some blades on wind farms produces noise.

(MS) Comment: I e-mail you last time on wind gennys and birds. Was that not taken into consideration? If you do not accept what I have sent you in the past, perhaps you will accept what is written by the National Wind Coordinating Committee, a consortium of wind technology experts, industry reps, AND representatives of environmental groups, including the Audubon Society and the independent consultants who have done the bird studies. Their conclusion is that bird kills, even on the two problematic wind farms (Altamont Pass in California and one in Spain), are statistically insignificant. If you are interested, I can send the URL of their latest study, wherein they compare bird kills from wind farms versus those of other man made structures, including power lines, buildings, guyed communication towers, plus vehicle collisions and cats. By continuing to repeat such statements as "Some are concerned that, at some locations, migratory birds are killed by wind turbines" you are institutionalizing what is acknowledged as a misconception, simply because it is out of context with other bird kills. The result is that children think that wind generators kill birds. End of story! While this is true, it is also true that "some are concerned that people fall off of swings and are killed when the swing hits them on the head." A true statement. However, this accounts for less than 10 deaths per year. But taken out of context, it can do great damage. Please reconsider spreading this misconception. You have the ability to do great damage by ingraining this "concept" in children.

(CB) "birds may be killed..." However, all turbines must meet noise standards. As in my original comments, I suggest adding the point about compliance with noise standards.

(KN) not all wind machines and systems create noticeable noise.

Effects of hydropower technology

Benefits of using hydropower

42. Hydropower produces no waste products and does not pollute the air.

(KN) new hydro installations create large quantities of methane, a major green house gas. This is due to the flooding of the land behind the dam and decay of all the submerged plant material and organic matter in the soil. Also, or perhaps as it related to number 43, mercury is often released into the waters associated with the hydro systems again due to the flooding of the land mass.

Costs of using hydropower

43. The environmental effects of using large hydropower plants are numerous.

- Most often, to harness the energy in water a dam is constructed, disrupting the aquatic ecosystem. A large area behind the dam is flooded, destroying the existing habitat; it may also disrupt human settlements.
- The dam regulates the flow of the river to eliminate the river's flooding cycle. This affects the many plants and animals that are dependent on the periodic inundation of the floodplain.
- There is siltation behind the dam, thermal pollution in impoundments, and a disruption of migratory fish patterns.

(JL) Perhaps delete "numerous" and reword to simply say "environmental effects of using large power plants include the following:"

(CB) "effects of developing large..."

Effects of biomass energy technology

Benefits of using biomass energy

44. In some types of biomass, the amount of carbon dioxide released during combustion

is offset by the amount of carbon dioxide that is consumed through photosynthesis during the crop's growth.

(CB) This is called closed-loop biomass.

45. Ethanol, one type of biofuel, can replace the parts of gasoline that pose the greatest environmental hazard. Ethanol quickly biodegrades in water, reducing the threat of contamination from spillage into waterways and ground water.

(JL) Can this be generalized more rather than specifically saying ethanol?

Costs of using biomass energy

46. Large areas of land are needed to grow biomass crops.

(JL) #46 and #47 combine?

(LK) 46. 47. "Large areas of land are needed to grow biomass crops." Any production agriculture requires large areas of land. Many types of biomass

crops have dual or triple use. For example, corn stover (the dried stalks and leaves of corn), wood waste from milling operations, switchgrass grown on CRP land, barley residue (grown for malting) are all examples of multi-use biomass crops. I know it might be difficult to explain to kids, but we want to see many uses for any particular crop, not just energy production. There is a saying that "nearly everything that can be made from a barrel of oil can be made from biomass". So take an example like soybeans. Soybeans can produce food for people and animals, inks for printing, plastics, cooking oils, lubricants and also a oil that can take the place of diesel fuel or be used as an additive to reduce the emissions of diesel fuel. We want to see this multi-use approach because we are interested in the sustainability of how we use land, it's smarter -- the economic benefits are greater in making many products out of a crop instead of just one, it allows farmers to have more than one market for their crop, and the community benefits because more jobs are generated from processing of crops. A substantial amount of materials and energy production research is coming to fruition that will change how we look at crops and how we can become more sustainable in farming operations. We will grow food, drugs, fiber, fuel, plastics, chemicals, and energy, while employing better practices for sustainability. This is certainly achievable and also attractive because better practices have the bonus of being better for the bottom line.

47. Careful management of crops and land are needed for biomass to be a sustainable resource.

(LU) the fibers of bio-mass crops are used not only for fuel but also for insulation materials.

Effects of geothermal energy technology

Benefits of using geothermal energy

48. Because geothermal heat pump systems are efficient and have a renewable component, they can substantially reduce greenhouse gases as compared to more conventional natural gas and electricity powered systems.

(LK) Heat pumps are basically a refrigeration technology. They are only considered to be efficient if they can be used to heat in the winter **and** cool in the summer. It's important that they are used for situations where both heating and cooling are needed. Otherwise, in Wisconsin's climate, they would not be considered as an efficient choice if only used for heating.

(SC) The term "substantially" is too vague. Why not just say, "they can reduce..."? I think the "efficient" term should be prefixed with "more efficient". Actually the environmental impact depends on the source of the electricity - how the utilities make electricity (the more nuclear, the better geothermal looks). In residential applications geothermal systems can increase environmental impact. In commercial systems geothermal systems can have lower emissions because they displace systems with less efficient distribution systems in the building. Geothermal heat pumps are an application

choice, not an energy source, so making broad statements about its benefits can be difficult.

(CB) "gases compared...conventional systems that use natural gas and electricity."

Costs of using geothermal energy

49. Pumps used in low-temperature geothermal energy systems may be powered by electricity generated by fossil fuels, contributing to the environmental problems associated with nonrenewable energy use.

(SC) "Pumps" should say "Heat pumps". This is the place to state that the environmental impact of the system depends on how the electricity is produced.

CB This is a minor point, and it applies to any renewable energy system that uses a pump.

50. Geothermal systems may change ground temperature since the energy from slightly warmer or cooler water (a bi-product of harvesting geothermal energy) is re-injected into the soil.

(SC) "re-injected" should be "re-circulated through the soil". Re-injected makes it sounds like water is placed into the soil. Most systems are closed or sealed. Wisconsin doesn't allow water to be returned into the ground.

(LU) may temporarily change ground temperature

(KN) it is actually usually a closed-loop system and the fluid is simply circulated through buried piping.

Effects of hydrogen energy technology

Benefits/costs of using hydrogen energy

51. The harnessing of hydrogen gas can originate from either renewable or nonrenewable sources. Using nonrenewable sources may increase greenhouse gases.

(SC) I don't think so. According to the Energy Information Agency, renewable energy use declined 4% from 1997 to 1998.

www.eia.doe.gov/kids/renewable/renewable.htm

Managing Renewable Energy Resource Use

By mastering these concepts students will gain an understanding of renewable energy use today and in the future.

Future outlooks for the development and use of energy resources

By understanding these concepts, students can evaluate how their actions affect the quality of life and the environment of their community, nation, and world. Students will also predict how scientific, technological, and social changes will influence future energy resource availability.

Current and future uses of renewable energy

52. Renewable energy use is increasing in the United States.

53. Renewable energy is used worldwide.

- Solar energy is used worldwide. It is particularly useful in remote rural settings where it is used to cook, heat water and power schools.
- Wind energy is used worldwide. Denmark is a leader in the industry. North and South Dakota and Texas have strong potential for generating electricity from wind.
- Hydropower is used worldwide. Electricity generated from hydropower is used on every continent except Antarctica.
- Biomass is used worldwide. In many parts of the world biomass, especially wood, is a major source of heating and cooking fuel.
- Geothermal is used worldwide. Iceland is a leader in geothermal technology with nearly all of their energy needs being met by geothermal energy. Throughout the U.S., geexchange systems are used to heat/cool homes.
- Hydrogen as a fuel is being promoted worldwide. Fuel cells are a promising technology for use as a source of heat and electricity for buildings and as an electrical power source for electric vehicles
 - A fuel cell works like a battery but does not run down or need recharging. It will produce electricity and heat as long as fuel (hydrogen) is supplied.
 - Hydrogen fuel cells produce clean, potable water as a byproduct.

(JL) delete "is used worldwide" after each source. Use a colon instead.

54. Transitional technologies may play a role in future RE development: (i.e. fuel blends, portable power applications, partial power from renewables, more creative use of passive solar design, etc.)

(JL) #54-56: fold under #52.

(CB) "technologies will play"

55. Intelligent and creative engineering can play an important role in reducing environmental impacts from technologies such as hydropower, wind turbines, and biomass fuels.

(SC) This statement is vague. Any examples? Or just say, "Innovation is good" seems too obvious or vague.

56. There is tremendous opportunity to reinvent how we use power and how we can creatively alter the characteristics of equipment to use less power.

(LU) if one reduces the electricity they use and chooses a 100% mix of renewable energy from their electric provider they can make a positive impact on the environment and live in a fossil fuel free electric home.

CB New concept: I think that it would be good to have information about the current costs of generating electricity from renewable energy and conventional sources. Something like this: "The cost of generating electricity varies significantly with the resource used. The following are estimates:

| Energy system | generating cost per kilowatt hour |
|-----------------|-----------------------------------|
| Coal | \$.03-.04 |
| Wind | \$.04-.08 |
| Biomass | |
| Solar (PV) | \$.20-.30 |
| Solar (thermal) | \$.15-.20 |

Appendix Q
Final Draft of Renewable Energy Conceptual Framework

Conceptual Framework for Renewable Energy Education

Developing Renewable Energy Resources

This theme helps students realize how they and other humans have developed and used renewable energy resources to satisfy their standard of living. Understanding what renewable energy is and how it flows through systems is necessary to appreciate how humans have come to value and treat renewable energy as a resource.

Development of renewable energy resources

Mastering these concepts helps students comprehend renewable energy.

1. Renewable energy resources come from sources that can be continuously replenished.
2. Renewable resources people commonly use are solar, wind, hydropower, biomass, and geothermal.
3. Human societies have used renewable resources to meet their energy needs throughout history.
4. Renewable energy is a reliable energy source for many residential and commercial applications, including heat generation, electricity generation, and vehicle fuel.
4. Each renewable energy resource has inherent qualities that make it suitable for some applications more than others.
5. 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.
7. 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.

Solar Energy

Comprehending these concepts helps students understand solar energy.

8. Solar energy is the radiation from the sun that reaches Earth's surface.
9. 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 Energy

Comprehending these concepts helps students understand wind energy.

10. Wind is air in motion and is produced by the unequal heating of Earth's surface by the sun.
11. 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

Comprehending these concepts helps students understand hydropower energy.

12. 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.
13. 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

Comprehending these concepts helps students understand biomass energy.

14. 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.

15. 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

Comprehending these concepts helps students understand geothermal energy.

16. 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).
17. 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.

Effects of Renewable Energy Resource Development

This theme will help students investigate how renewable energy use can affect their lives. Recognizing these effects increases students' awareness of why and how they may use renewable energy and promotes an understanding of why it's important to manage renewable energy resource use.

Quality of life

Understanding these concepts helps students analyze current renewable energy-use practices and evaluate how they affect quality of life.

Lifestyles

18. Individuals can purchase renewable energy from centralized sources such as power utilities. Using renewable energy from these sources requires no modification of lifestyle.
19. Individuals and businesses can create their own renewable energy from decentralized systems such as a wind system. Using renewable energy from a decentralized system may require the following lifestyle modifications:
- Monitoring and maintaining the system
 - Employing energy efficient building construction techniques
 - Using energy efficient appliances and lights
 - Monitoring and managing their energy use

20. The reasons people choose to use renewable energy include the following: environmental concerns, economic concerns, ethical concerns, interest in technology, desire to be self-sufficient, and concerns about electrical reliability.

Health and safety

21. Using renewable energy will reduce some personal and community health risks since it generally releases fewer pollutants into the environment than fossil fuels.
22. Decentralized renewable energy systems require proper maintenance to be safe.

Economic

23. When consumers consider purchasing renewable energy systems, they are often concerned about payback. Payback refers to recovering the initial cost of purchasing and installing a renewable energy system through its production of energy.
24. 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.
25. When comparing the cost of renewable energy to non-renewable energy, externality costs associated with non-renewable energy should be considered. These include environmental damage, property damage, civil unrest, war, and health care. These externality costs are not part of the market price of non-renewable energy.
26. Many occupations, businesses, and public services (such as utilities) result from the development and use of renewable energy resources.
27. Most renewable energy sources are free. Therefore, development and production investments go toward materials and labor rather than purchasing fuel. This money is often spent within the United States and is frequently spent within the same state or town where the resource is located.

28. Using renewable energy allows the United States to become more energy independent.

Sociopolitical

29. Support for renewable energy development is influenced by society and politics. In the United States, renewable energy resource development has been governed by the energy policies of political administrations.
30. Sociopolitical processes result in laws and regulations that govern renewable energy development, availability, and use. Access and zoning laws have been developed to guide renewable energy system placement and installation.
31. Renewable energy systems can be owned by individuals, communities, and governments.

Cultural

32. Support for renewable energy varies within and among countries, cultures, and governments.
33. Using renewable energy can help mitigate the effects of extracting fossil fuels. Extracting fossil fuels affects the cultures, environments, and health of individuals.
34. Many third world countries are benefiting from the development and deployment of renewable energy equipment from industrialized nations.

Quality of the environment

By comprehending these concepts, students will be able to explain how current renewable energy use practices affect the quality of the environment and the health of organisms living in the environment.

35. Renewable energy technologies use clean sources of energy that have a lower environmental impact than nonrenewable energy sources.
36. There are environmental costs and benefits involved in the development, manufacture, distribution, and installation of renewable energy technologies. Each renewable energy technology and its application (e.g. centralized or decentralized) has unique environmental costs and benefits.

Managing Renewable Energy Resource Use

Concepts in this theme will help students identify ways to ensure that renewable energy resources will be properly managed. For students to willingly and effectively take action to manage renewable energy resource use, they must have a thorough understanding and appreciation of what renewable energy is, how it flows through systems, its value as a resource, and the effects its use has on human societies and the environment.

Management of renewable energy resource use

By mastering these concepts students will gain an understanding of why and how people use renewable energy.

37. Using renewable energy resources helps prolong the availability of nonrenewable energy resources.
38. Actions supporting renewable energy use can range from simple and inexpensive (e.g., purchasing solar powered calculators) to more advanced and expensive (e.g., installing a home wind system).
39. The use of decentralized renewable energy systems is usually a personal choice rather than a government mandate, although there are government programs that provide incentives for using renewable energy.

Future outlook for the development and use of renewable energy resources

By understanding these concepts, students can evaluate how their actions affect the quality of life and the environment of their community, nation, and world. Students will also predict how scientific, technological, and social changes will influence future energy resource availability.

Future uses of renewable energy

40. Renewable energy use is growing worldwide.
41. Renewable energy technologies continue to improve and become more efficient.
42. New energy resources, new ways of managing energy resources, and new renewable technologies will be developed in the future.

Appendix R
Thank You Letter to Delphi Participants

July 8, 2002

To Whom It May Concern:

Thank you for your participation in the Delphi process. Your guidance and expert advice was essential in creating the renewable energy conceptual framework. I hope you found the Delphi process to be beneficial and easy to follow. I chose this approach because it provided flexibility, as participants were able to fill out the survey at a time and location that was convenient for them. I found that the Delphi process proved to be an efficient means of collecting information from various renewable energy professionals throughout the state.

You will notice that there were many changes in the final draft of the renewable energy conceptual framework. In the end, a path of simplification was chosen. A conceptual framework serves as the backbone of an activity guide; it outlines only the basic ideas that should be covered. Thus, many of the more specific facts were eliminated. However, they were not deleted from the records. I am passing that valuable information onto the renewable energy curriculum specialist who is continuing the project. She will be developing a renewable energy activity guide and will incorporate many of the more specific ideas.

Thank you again for the time and effort that you have devoted towards this project. I think we are on the road to developing a very valuable renewable energy education resource. You will be receiving your \$200 stipend shortly, if you haven't already.

Sincerely,

Stephanie Kane

Appendix S
Dichotomous Key

**DICHOTOMOUS KEY FOR A RENEWABLE ENERGY CONCEPTUAL
FRAMEWORK**

- A.** The activity addresses one or more aspects of renewable energy.....KEY 1
- B.** The activity does not address one or more aspects of renewable energy.....
The activity does not address any renewable concept in this framework. END HERE.

DEVELOPING RENEWABLE ENERGY RESOURCES

KEY 1

- 1.1A.** The activity addresses *developing* one or more renewable energy resources and/or defines renewable energy, discusses the history of its use, its general characteristics, its availability/dependability, renewable energy systems, defines/discusses specific renewable energy resources and/or their applications.....1.2A
- 1.1B.** The activity does not address *developing* one or more renewable energy resources or does not define renewable energy, the history of its use, its general characteristics, its availability/dependability, renewable energy systems, or does not define/discuss specific renewable energy resources or their applications..... KEY 2
- 1.2A.** Renewable energy is defined in the activity.....concept #1, 1.3A
- 1.2B.** Renewable energy is not defined in the activity.....1.3A
- 1.3A.** The activity addresses one or more renewable energy resources....concept #2, 1.4A
- 1.3B.** The activity does not address one or more renewable energy resources.....
1.4A
- 1.4A.** The activity addresses the history of renewable energy development.....concept #3, 1.5A
- 1.4B.** The activity does not address the history of renewable energy development....1.5A
- 1.5A.** The activity addresses the reliability and/or applications of one or more renewable energy resources.....concept #4, 1.6A

- 1.5B.** The activity does not address the reliability or applications of one or more renewable energy resources.....1.6A
- 1.6A.** The activity addresses the inherent qualities of one or more renewable energy resources that make it suitable for some applications more than others.....concept #5, 1.7A
- 1.6B.** The activity does not address the inherent qualities of one or more renewable energy resources that make it suitable for some applications more than others.....1.7A
- 1.7A.** The activity addresses the availability (intermittent vs. constant) of one or more renewable energy resources and/or discusses how intermittent sources can be stored for future use.....concept #6, 1.8A
- 1.7B.** The activity does not address the availability of one or more renewable energy resources or does not discuss how intermittent sources can be stored for future use.....1.8A
- 1.8A.** The activity defines centralized and decentralized renewable energy systems.....concept #7, 1.9A
- 1.8B.** The activity does not define centralized and decentralized renewable energy systems.....1.9A
- 1.9A.** The activity defines solar energy.....concept #8, 1.10A
- 1.9B.** The activity does not define solar energy.....1.10A
- 1.10A.** The activity addresses one or more applications of solar energy and/or discusses active/passive solar heating.....concept #9, 1.11A
- 1.10B.** The activity does not address one or more applications of solar energy or does not discuss active/passive solar heating.....1.11A
- 1.11A.** The activity defines wind energy.....concept #10, 1.12A
- 1.11B.** The activity does not define wind energy.....1.12A

- 1.12A.** The activity addresses one or more applications of wind energy and/or the relationship between wind speed and height above Earth's surface.....concept #11,
1.13A
- 1.12B.** The activity does not address one or more applications of wind energy or the relationship between wind speed and height above Earth's earth surface.....1.1
3A
- 1.13A.** The activity defines hydropower and/or addresses how the amount of energy in moving water is determined.....concept #12,
1.14A
- 1.13B.** The activity does not define hydropower or does not address how the amount of energy in moving water is determined.....1.14A
- 1.14A.** The activity addresses one or more applications of hydropower and/or one or more methods by which hydropower energy is captured.....concept #13,
1.15A
- 1.14B.** The activity does not address one or more applications of hydropower or one or more methods by which hydropower energy is captured.....1.15
A
- 1.15A.** The activity defines biomass energy and/or addresses one or more processes by which the energy is released.....concept #14,
1.16A
- 1.15B.** The activity does not define biomass energy or does not address one or more processes by which the energy is released.....1.1
6A
- 1.16A.** The activity addresses one or more applications of biomass energy.....concept #15,
1.17A
- 1.16B.** The activity does not address one or more applications of biomass energy.....1.1
7A
- 1.17A.** The activity defines geothermal energy and/or discusses one or more different types of geothermal resources.....concept #16,
1.18A
- 1.17B.** The activity does not define geothermal energy or does not discuss one or more different types of geothermal resources.....1.18A

1.18A. The activity addresses one or more applications of geothermal energy and/or addresses one or more of the uses of different types of geothermal resources.....concept #17,

KEY 2

1.18B. The activity does not address one or more applications of geothermal energy or does not address one or more of the uses of different types of geothermal resources.....KE

Y 2

EFFECTS OF RENEWABLE ENERGY RESOURCE DEVELOPMENT

KEY 2

2.1A. The activity addresses one or more *effects* of renewable energy resource development and/or includes one or more ideas related to renewable energy and lifestyle, health, safety, economics, society, politics, culture, and/or quality of the environment.....2.

2A

2.1B. The activity does not address one or more *effects* of renewable energy resource development or does not include one or more ideas related to renewable energy and lifestyle, health, safety, economics, society, politics, culture, or quality of the environment.....KE

Y 3

2.2A. The activity addresses from where individuals can purchase renewable energy and/or discusses whether purchasing renewable energy from centralized sources would require modification of

lifestyle.....concept 18, 2.3A

2.2B. The activity does not address from where individuals can purchase renewable energy or does not discuss whether purchasing renewable energy from centralized sources would require modification of

lifestyle.....2.3A

2.3A. The activity addresses how individuals and/or businesses can create their own decentralized renewable energy systems and/or discusses whether purchasing energy from a decentralized system would require a modification of lifestyle and/or discusses the modifications. The modifications may include one or more of the following:

monitoring and maintaining the system, employing energy efficient building construction techniques, using energy efficient appliances and lights, and monitoring and managing energy

use.....concept #19,

2.4A

2.3B. The activity does not address how individuals or businesses can create their own decentralized renewable energy systems or does not discuss whether purchasing energy from a decentralized system would require a modification of lifestyle or does not discuss the modifications. The modifications do not include one or more of the following: monitoring and maintaining the system, employing energy efficient

| | |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|
| building construction techniques, using energy efficient appliances and lights, and monitoring and managing energy use..... | 2.4A |
| 2.4A. The activity addresses one or more reasons that people choose to use renewable energy..... | concept #20, 2.5A |
| 2.4B. The activity does not address one or more reasons that people choose to use renewable energy..... | 2.5A |
| 2.5A. The activity addresses how renewable energy reduces personal and/or community health risks because it releases fewer pollutants into the environment as compared to fossil fuels..... | concept #21, 2.6A |
| 2.5B. The activity does not address how renewable energy reduces personal or community health risks because it releases fewer pollutants into the environment as compared to fossil fuels..... | 2.6A |
| 2.6A. The activity addresses how proper maintenance of decentralized renewable energy systems is required to be safe..... | concept #22, 2.7A |
| 2.6B. The activity does not address how proper maintenance of decentralized renewable energy systems is required to be safe..... | 2.7A |
| 2.7A. The activity defines payback..... | concept #23, 2.8A |
| 2.7B. The activity does not define payback..... | 2.8A |
| 2.8A. The activity addresses one or more factors that influence payback..... | concept #24, 2.9A |
| 2.8B. The activity does not address one or more factors that influence payback..... | 2.9A |
| 2.9A. The activity addresses one or more externality costs associated with non-renewable energy and/or discusses how externality costs relate to renewable energy..... | concept #25, 2.10A |
| 2.9B. The activity does not address one or more externality costs associated with non-renewable energy or does not discuss how externality costs relate to renewable | |

| | |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|
| energy..... | 2.1 |
| 0A | |
| 2.10A. The activity discusses one or more occupations, businesses, and/or public services that are created from the development and/or use of renewable energy..... | concept #26, |
| 2.11A | |
| 2.10B. The activity does not discuss one or more occupations, businesses, or public services that are created from the development or use of renewable energy..... | 2.1 |
| 1A | |
| 2.11A. The activity addresses one or more ways in which renewable energy investments are spent..... | concept #27, 2.12A |
| 2.11B. The activity does not address one or more ways in which renewable energy investments are spent..... | 2. |
| 12A | |
| 2.12A. The activity addresses the idea of the United States becoming more energy independent by using renewable energy..... | concept #28, |
| 2.13A | |
| 2.12B. The activity does not address the idea of the United States becoming more energy independent by using renewable energy..... | 2.13A |
| 2.13A. The activity addresses one or more ways in which society and/or politics influences renewable energy development..... | concept #29, |
| 2.14A | |
| 2.13B. The activity does not address one or more ways in which society and/or politics influences renewable energy development..... | 2.14A |
| 2.14A. The activity addresses one or more laws and regulations that govern renewable energy development, availability, and/or use..... | concept #30, 2.15A |
| 2.14B. The activity does not address one or more laws and regulations that govern renewable energy development, availability, or use..... | 2.15A |
| 2.15A. The activity addresses the ownership of renewable energy systems..... | concept #31, |
| 2.16A | |
| 2.15B. The activity does not address the ownership of renewable energy systems... | 2.16A |

- 2.16A.** The activity addresses the varying support for renewable energy within and among countries, cultures, and/or governments.....concept #32,
2.17A
- 2.16B.** The activity does not address the varying support for renewable energy within and among countries, cultures, or
governments.....2.17A
- 2.17A.** The activity addresses how using renewable energy can help mitigate the effects of extracting fossil fuels and may discuss how extracting fossil fuels affects the cultures, environments, and/or health of
individuals.....concept #33, 2.18A
- 2.17B.** The activity does not address how using renewable energy can help mitigate the effects of extracting fossil fuels and does not discuss how extracting fossil fuels affects the cultures, environments, or health of
individuals.....2.18A
- 2.18A.** The activity addresses how many third world countries benefit from the development and/or deployment of renewable energy equipment from industrialized nations.....concept #34,
2.19A
- 2.18B.** The activity does not address how many third world countries benefit from the development or deployment of renewable energy equipment from industrialized nations.....2.19
A
- 2.19A.** The activity addresses the idea that renewable energy technologies use clean sources of energy that have a lower environmental impact than nonrenewable energy sources.....concept #35,
2.20A
- 2.19B.** The activity does not address the idea that renewable energy technologies use clean sources of energy that have a lower environmental impact than nonrenewable energy
sources.....2.20A
- 2.20A.** The activity addresses one or more of the environmental costs and/or benefits involved in the development, manufacture, distribution, and/or installation of renewable energy technologies and/or discusses how renewable energy technology and its application has unique environmental costs and benefits.....concept #36, KEY 3
- 2.20B.** The activity does not address one or more of the environmental costs or benefits involved in the development, manufacture, distribution or installation of renewable energy technologies or does not discuss how renewable energy technology and its application has unique environmental costs and
benefits.....KEY 3

MANAGING RENEWABLE ENERGY RESOURCE USE

KEY 3

3.1A. The activity addresses the *management* of renewable energy resources and/or includes ideas relating to how using renewable energy influences nonrenewable resources, how to support renewable energy use, how using renewable energy is often a personal decision, and/or future uses of renewable energy.....3.2A

3.1B. The activity does not address the *management* of renewable energy resources or does not include ideas relating to how using renewable energy influences nonrenewable resources, how to support renewable energy use, how using renewable energy is often a personal decision, or future uses of renewable energy.....The activity does not address any renewable concept in KEY 3

3.2A. The activity addresses how the management of renewable energy resources can help prolong the availability of nonrenewable energy resources.....concept #37, 3.3A

3.2B. The activity does not address how the management of renewable energy resources can help prolong the availability of nonrenewable energy resources.....3.3A

3.3A. The activity addresses how an individual can support renewable energy useconcept #38, 3.4A

3.3B. The activity does not address how an individual can support renewable energy use.....3.4A

3.4A. The activity addresses how choosing renewable energy is usually a personal decision rather than a government mandate and/or discusses how government programs exist that provide incentives for using renewable energy.....concept #39, 3.5A

3.4B. The activity does not address how choosing renewable energy is usually a personal decision rather than a government mandate or does not discuss how government programs exist that provide incentives for using renewable energy.....3.5A

3.5A. The activity addresses the fact that renewable energy use is growing worldwide.....concept #40, 3.6A

3.5B. The activity does not address the fact that renewable energy use is growing worldwide.....3.6A

3.6A. The activity addresses the future improvement and/or efficiency of renewable energy technologies.....concept #41, 3.7A

3.6B. The activity does not address the future improvement or efficiency of renewable energy technologies.....3.7A

3.7A. The activity addresses the idea that new energy resources, new ways of managing energy resources, and/or new renewable technologies will be developed in the future.....concept #42

3.7B. The activity does not address the idea that new energy resources, new ways of managing energy resources, or new renewable technologies will be developed in the future.....The activity does not address this renewable concept in this framework

Appendix T

Directions for Dichotomous Key

Directions for Evaluation of an Activity Guide for Renewable Energy Content

Rational

The accompanying dichotomous key and matrix can be used to determine the percentage of renewable energy concepts covered by a given activity guide. Alternatively, you can use the key and matrix to find out what percentage of the guide covers renewable energy concepts. The information will help the energy educator:

- Evaluate a resource for its renewable energy content
- Write lesson plans and develop curriculum
- Decide which resources to order
- Secure/justify funding

Overview of Dichotomous Key

A dichotomous key consists of a series of couplets, where one is affirmative and the other is negative. In this case, there is a couplet that corresponds to each of the 42 renewable energy concepts. Whether the affirmative or negative couplet is true determines which concepts are covered by the activity.

Suggested Strategy for Evaluating an Activity Guide

1. Review the renewable energy conceptual framework and glossary.
2. Review the activity guide you are evaluating. Look at activity titles, summary, objectives, etc., for renewable energy terms.
3. Set up the matrix using the template provided. List the activities on the y-axis. The 42 concepts are listed on the x-axis.
4. Thoroughly read each activity to be reviewed and then use the dichotomous key. (See "Using the Dichotomous Key")
5. Run the key for every activity in the guide, starting with the first activity.
6. Record results using the matrix.

Using the Dichotomous Key

Begin with "A" at the top of the key. If the affirmative statement (the first statement in the couplet) is true with regard to the activity in question, look to the right hand side of the page for directions as to what to do next (go to KEY 1, in this case). If the affirmative statement is false, continue on to the statement below it.

If you answer "true" to an affirmative statement and there is a concept number to the right (as in the example), mark the matrix with a 1.0 or a 0.5. The box to be marked is located where the name of the activity and the concept number intersect. Mark a 1.0 in the box if the concept is addressed directly by the activity; that is, if it is addressed in the objectives or the procedure. Mark a 0.5 if the concept is mentioned or referenced (in the background or extension of the activity, for example) but is not directly addressed by the activity.

Using the Dichotomous Key, cont.

For Example:

1.8A. The activity defines centralized and decentralized renewable energy systems.....concept #7, 1.9A

1.8B. The activity does not define centralized and decentralized renewable energy systems.....1.9A

If 1.8A is true, mark the box where the name of the activity and concept #2 intersect with either a 1.0 or a 0.5. Then continue to 1.9A. If 1.8A is false, continue on to 1.8B.

If 1.8B is true, continue on to 1.9A.

Determining the Percentage of Renewable Energy Concepts Covered by an Activity Guide

1. Use the matrix provided.
2. If you are using the electronic template on Excel, everything will be calculated for you once you fill in a 1.0, 0.5, or a 0.0. The percentage of concepts covered by the guide will automatically be determined for you at the bottom of the document. **It is recommended that you use the electronic version.**
3. If you have printed out the Excel template and are working with a hard copy, examine each column (extending underneath each concept number). If there is at least one rating of either 1.0 or 0.5, place a 1.0 in the lower box (in the row labeled, "Addresses the concept").
4. Tally the number of 1.0's in the row labeled, "Addresses the concept" and write the number in the total box at the end of the row.
5. Divide the total by 42 (the number of concepts) and multiply the result by 100.
6. The result is the percentage of concepts addressed either fully or partially by the activity guide.

Determining the Percentage of an Activity Guide that Covers Renewable Energy Concepts

1. Use the matrix provided.
2. If you are using the electronic template on Excel, everything will be calculated for you once you fill in a 1.0, 0.5, or a 0.0. The percentage of activities in the guide that cover at least one renewable energy concept will automatically be determined for you at the bottom of the document. **It is recommended that you use the electronic version.**
3. If you have printed out the Excel template and are working with a hard copy, examine each row (extending to the right of the activity name). If there is at least one rating of either a 1.0 or a 0.5, place a 1.0 in the right most box (in the column labeled, "Activity addresses a concept").
4. Tally the number of 1.0's in the column labeled, "Activity address a concept" and write the number in the total box at the end of the column.
5. Divide the total by the number of activities and multiply the result by 100.
6. The result is the percentage of the activity guide that covers renewable energy concepts.

Appendix U
Renewable Energy Glossary

Renewable Energy Glossary

Acid rain -Term used to describe precipitation- snow, rain, or fog with a high level of acids. Acids include nitric acid formed from nitrogen oxides and sulfuric acid formed from sulfur dioxide, both originating from human-made sources such as fossil fuel burning power plants, industries, vehicles, and from natural sources such as volcanoes.

Acid rain can adversely affect aquatic and forest ecosystems.

Active Solar Heating- A solar heating system that uses a mechanical system to transfer the sun's heat from a solar collector to various parts of a home or building for space heating and water heating purposes.

Air-Source Heat Pump - A type of heat pump that transfers heat from outdoor air to indoor air during the heating season, and works in reverse during the cooling season.

Air-to-Water Heat Pump - A type of heat pump that transfers heat in outdoor air to water for space or water heating.

Alternative Fuels - A popular term for "non-conventional" transportation fuels derived from natural gas (propane, compressed natural gas, methanol, etc.) or biomass materials (ethanol, methanol).

Ampere (abbrev. Amp; pl. Amperes [Amps])-A unit of electrical current. One ampere of current is equal to one coulomb ($6.25 \times 1,018$) of electrons passing a point in an electric circuit in one second.

Anaerobic Bacteria - Microorganisms that live in oxygen deprived environments.

Anaerobic Digestion - The complex process by which organic matter is decomposed by anaerobic bacteria. The decomposition process produces a gaseous byproduct often called "biogas" primarily composed of methane, carbon dioxide, and hydrogen sulfide.

Anaerobic Digester - A device for optimizing the anaerobic digestion of biomass and/or animal manure, and possibly to recover biogas for energy production. Digester types include batch, complete mix, continuous flow (horizontal or plug-flow, multiple-tank, and vertical tank), and covered lagoon.

Anemometer - An instrument for measuring the force or velocity of wind; a wind gauge.

Angle of Inclination - In reference to solar energy systems, the angle that a solar collector is positioned above horizontal.

Anhydrous Ethanol - One hundred percent alcohol; neat ethanol.

Annual Solar Savings - The annual solar savings of a solar building is the energy savings attributable to a solar feature relative to the energy requirements of a non-solar building.

Antireflection Coating - A thin coating of a material applied to a photovoltaic cell surface that reduces the light reflection and increases light transmission.

Aperture - An opening; in solar collectors, the area through which solar radiation is admitted and directed to the absorber.

Apparent Day - A solar day; an interval between successive transits of the sun's center across an observer's meridian; the time thus measured is not equal to clock time.

Array (Solar) - Any number of solar photovoltaic modules or solar thermal collectors or reflectors connected together to provide electrical or thermal energy.

Azimuth (Solar) - The angle between true south and the point on the horizon directly below the sun.

Bagasse - The fibrous material remaining after the extraction of juice from sugarcane; often burned by sugar mills as a source of energy.

Baling - A means of reducing the volume of a material by compaction into a bale.

Bioconversion - The conversion of one form of energy into another by the action of plants or microorganisms. The conversion of biomass to ethanol, methanol, or methane.

Bioenergy - The conversion of the complex carbohydrates in organic material into energy.

Biofuels - Biofuels are fuels that are made from cellulosic biomass such as herbaceous and woody plants. The term biofuels can refer to fuels for electricity and fuels for transportation.

Biogas - A combustible gas created by anaerobic decomposition of organic material, composed primarily of methane, carbon dioxide, and hydrogen sulfide.

Biogasification or biomethanization - The process of decomposing biomass with anaerobic bacteria to produce biogas.

Biomass - As defined by the Energy Security Act (PL 96-294) of 1980, "any organic matter which is available on a renewable basis, including agricultural crops and

agricultural wastes and residues, wood and wood wastes and residues, animal wastes, municipal wastes, and aquatic plants."

Biomass Energy - Energy produced by the conversion of biomass directly to heat or to a liquid or gas that can be converted to energy.

Biomass Fuel - Biomass converted directly to energy or converted to liquid or gaseous fuels such as ethanol, methanol, methane, and hydrogen.

Biomass Gasification - The conversion of biomass into a gas, by biogasification (see above) or thermal gasification, in which hydrogen is produced from high-temperature gasifying and low-temperature pyrolysis of biomass.

British Thermal Unit (abbr. **BTU**)- 1. A unit of energy equal to 1,055 joules or 252 calories. 2. The amount of energy needed to raise the temperature of one pound of water one degree Fahrenheit.

Carbon dioxide- A colorless, odorless gas formed during respiration, organic decomposition, and combustion of fossil and other carbon-based fuels. Carbon dioxide is taken up by green plants during photosynthesis, dissolved in bodies of water, and circulated in Earth's atmosphere.

Centralized (Energy) System - Generates power for distribution to multiple customers.

Closed-Loop - A type of heating system in which the heat transfer fluid circulates from the heating component to a heat exchanger that is immersed in a heat storage media, passing its heat to the storage media without physically contacting it.

Closed Loop Biomass - As defined by the Comprehensive National Energy Act of 1992 (or the Energy Policy Act; EPAct): any organic matter from a plant which is planted for the exclusive purpose of being used to produce energy." This does not include wood or agricultural wastes or standing timber.

Collector Fluid - The fluid, liquid (water or water/antifreeze solution) or air, used to absorb solar energy and transfer it for direct use, indirect heating of interior air or domestic water, and/or to a heat storage medium.

Collector Tilt - The angle that a solar collector is positioned from horizontal.

Combustion- 1. The process of burning. 2. A rapid chemical change in which a substance reacts with oxygen and generates heat and light.

Compact fluorescent bulb- A small fluorescent lamp designed to fit in light fixtures that use standard incandescent lamps.

Composting - The process of degrading organic material (biomass) by microorganisms in aerobic conditions.

Compound Paraboloid Collector - A form of solar concentrating collector that does not track the sun.

Concentrator (Solar) Collector - A solar collector that uses reflective surfaces to concentrate sunlight onto a small area, where it is absorbed and converted to heat or, in the case of solar photovoltaic (PV) devices, into electricity. Concentrators can increase the power flux of sunlight hundreds of times. The principal types of concentrating collectors include: compound parabolic, parabolic trough, fixed reflector moving receiver, fixed receiver moving reflector, Fresnel lense, and central receiver. A PV concentrating module uses optical elements (Fresnel lense) to increase the amount of sunlight incident onto a PV cell. Concentrating PV modules/arrays must track the sun and use only the direct sunlight because the diffuse portion cannot be focused onto the PV cells.

Coproducts-Secondary products created during the formation of another product. For example, carbon dioxide and distillers grain are created during ethanol production.

Corn Stover- That part of the corn plant that is not used commercially (e.g., the leaves, stalks, and cobs).

Dam- A structure built across a river or stream either for storing water for producing hydropower, or for controlling water flow, or both.

Darrius (Wind) Machine - A type of vertical-axis wind machine that has long, thin blades in the shape of loops connected to the top and bottom of the axle; often called an "eggbeater windmill."

Daylighting - The use of direct, diffuse, or reflected sunlight to provide supplemental lighting for building interiors.

Decentralized (Energy) System - Energy systems supply individual, or small-groups, of energy loads.

Declination - The angular position of the sun at solar noon with respect to the plane of the equator.

Digester (Anaerobic) - A device in which organic material is biochemically decomposed (digested) by anaerobic bacteria to treat the material and/or to produce biogas.

Downwind Wind Turbine - A horizontal axis wind turbine in which the rotor is downwind of the tower.

Drag- 1. a drawing along or over a surface with effort or pressure. 2. motion effected with slowness or difficulty. 3. the retarding force acting on a body (as an airplane) moving through a fluid (as air) parallel. 4. opposite to the direction of motion.

Ecosystem- Self-regulating natural community of organisms (e.g., plants, animals, bacteria) interacting with one another and with their nonliving environment. Wetlands, forests, and lakes are examples of ecosystems.

Efficiency- The ratio or percentage of useful output to the total input in any system.

Efficient- Accomplishing a task with a minimum of effort and waste.

Electricity- The behavior of negative and positive charges (electrons and protons) due to their attraction and repulsion.

Electron- 1. A subatomic particle with a negative electric charge that orbits the nucleus of an atom. 2. The basic particle that makes up an electric current.

Energy- The ability to organize or change matter; the ability to do work.

Energy conversion- The process of changing one form of energy into another. For example, the chemical energy stored in gasoline can be converted into kinetic energy (energy of motion) by an automobile engine.

Energy Crops- Developed and grown specifically for fuel.

Energy Efficiency- The ratio or percentage of useful work or energy output to total work or energy input in any energy system. For example, the efficiency of a home heating system is equal to the percentage of energy in the fuel or other source that is converted into useful heat.

Energy Efficiency Ratio (EER) - The measure of the instantaneous energy efficiency of room air conditioners; the cooling capacity in Btu/hr divided by the watts of power consumed at a specific outdoor temperature (usually 95 degrees Fahrenheit).

Energy forms- Basic kinds of energy that are different and distinct from each other.

Two main forms of energy are potential energy (the energy stored in matter) and kinetic energy (the energy of motion). More specific forms of energy include thermal, elastic, electromagnetic (e.g., light, electrical, magnetic), gravitational, chemical, and nuclear energy.

Energy resource- Energy source that is used to meet the needs of a human society.

For example, oil is an energy resource because it is used to produce fuel for transportation and heating needs. Energy resources are subsets of energy sources.

Energy source- Matter or system from which one or more forms of energy can be obtained. For instance, natural gas is a source of thermal energy, and sugarcane is a source of chemical energy.

Energy star labels- A label put on products/appliances indicating that it will save energy.

Energy Storage - The process of storing or converting energy from one form to another for later use; storage devices and systems including batteries, conventional and pumped storage hydroelectric, flywheels, compressed gas, and thermal mass.

Ethanol- A liquid fuel used to produce energy from biomass resources. It is made from corn and other grains.

Ethanol - Ethyl alcohol (C₂H₅OH) - A colorless liquid that is the product of fermentation used in alcoholic beverages, industrial processes, and as a fuel additive. Also known as grain alcohol.

Ethyl Tertiary Butyl Ether (ETBE) - A chemical compound produced in a reaction between ethanol and isobutylene (a petroleum-derived by-product of the refining process). ETBE has characteristics superior to other ethers: low volatility, low water solubility, high-octane value, and a large reduction in carbon monoxide and hydrocarbon emissions.

Fossil fuels- Carbon-rich fuel formed from the remains of ancient animals and plants. Coal, oil, and natural gas are all fossil fuels.

Fuel- Substances that are burned or consumed by some means to produce energy. Examples of fuels include coal, food, natural gas, oil, and fissionable uranium.

Fuel Cell - An electrochemical device that converts chemical energy directly into electricity.

Fuel Efficiency - The ratio of heat produced by a fuel for doing work to the available heat in the fuel.

Full Sun - The amount of power density in sunlight received at the earth's surface at noon on a clear day (about 1,000 Watts/square meter).

Generator- A device or machine that converts mechanical energy into electrical energy.

Geothermal Energy - Energy produced by the internal heat of the earth; geothermal heat sources include: hydrothermal convective systems; pressurized water reservoirs; hot dry rocks; manual gradients; and magma. Geothermal energy can be used directly for heating or to produce electric power.

Geothermal Heat Pump - A type of heat pump that uses the ground, ground water, or ponds as a heat source and heat sink, rather than outside air. Ground or water temperatures are more constant and are warmer in winter and cooler in summer than air temperatures. Geothermal heat pumps operate more efficiently than "conventional" or "air source" heat pumps.

Geothermal reservoirs- The heat from the magma that rises through the layers of the Earth's crust and heats underground pools of water.

Global climate Change- An interconnected chain of climate events brought about by an increase in trapped heat in the atmosphere. The trapped heat alters atmospheric processes and their interaction with the oceans and the land. The climate-the product of that interaction-changes as well, causing altered weather patterns that bring unexpected rain or dry spells, sudden severe storms and temperature changes.

Global warming- An enhanced greenhouse effect caused by an increase of human-generated greenhouse gases resulting in more heat rapped by the atmosphere.

Green Power - A popular term for energy produced from renewable energy resources.

Green pricing- A method used by customers so that they can choose electricity produced from renewable resources and pay for the amount they buy.

"Greenhouse effect"- The process by which the Earth's atmosphere allows solar radiation to reach Earth's surface and prevents heat radiated back from the surface from escaping into space.

Ground Reflection - Solar radiation reflected from the ground onto a solar collector.

Geothermal (ground source) heat pump: a space heating/cooling system which moves heat from and to the earth, as opposed to making heat using a fuel source. Geothermal heat pumps take advantage of the almost constant temperature just a few feet underground -- usually warmer than the air in winter and cooler than the air in summer.

Head - A unit of pressure for a fluid, commonly used in water pumping and hydropower to express height a pump must lift water, or the distance water falls. Total head accounts for friction head losses, etc.

Heat Storage - A device or media that absorbs heat for storage for later use.

Heliodon - A device used to simulate the angle of the sun for assessing shading potentials of building structures or landscape features.

Heliostat - A device that tracks the movement of the sun; used to orient solar concentrating systems.

Heliothermal - Any process that uses solar radiation to produce useful heat.

Hot Dry Rock - A geothermal energy resource that consists of high temperature rocks above 300 F (150 C) that may be fractured and have little or no water. To extract the heat, the rock must first be fractured, then water is injected into the rock and pumped out to extract the heat. In the western United States, as much as 95,000 square miles (246,050 square km) have hot dry rock potential.

Hybrid Renewable Energy System - A renewable energy system that includes two different types of renewable energy technologies that produce the same type of energy; for e.g., a wind turbine and a solar photovoltaic array combined to meet a power demand.

Hydroelectric Power Plant - A power plant that produces electricity by the force of water falling through a hydro turbine that spins a generator.

Hydrogen - A chemical element that can be used as a fuel since it has a very high energy content.

Hydropower- Electricity or mechanical energy produced by the conversion of energy from falling water. Sometimes used to refer only to the production of electricity from falling water.

Incident Solar Radiation - The amount of solar radiation striking a surface per unit of time and area.

Independent Power Producer - A company or individual that is not directly regulated as a utility. These entities produce power for their own use and/or sell it to regulated utilities.

Indirect Solar Gain System - A passive solar heating system in which the sun warms a heat storage element, and the heat is distributed to the interior space by convection, conduction, and radiation.

Inefficient- 1. Producing only a small useful output from a large total input. 2. Wasteful of time, energy, or materials; not efficient; ineffective.

Insulation - Materials that prevent or slow down the movement of heat.

Insulation Blanket - A pre-cut layer of insulation applied around a water heater storage tank to reduce standby heat loss from the tank.

Insulator - A device or material with a high resistance to electricity flow.

Infrared radiation- Solar energy coming to Earth as invisible light.

Joule- A unit of energy. One joule equals 0.2388 calories or 0.0009481 Btu.

Kilowatt hours- A unit of energy equal to 3,413 Btu or 3,600,000 joules. An amount of energy that results from the steady production or consumption of one kilowatt of power for a period of one hour.

Kinetic Energy- The energy possessed by a moving object. The formula for kinetic energy is $\frac{1}{2} (\text{mass}) \times (\text{velocity})^2$.

Load - The demand on an energy producing system; the energy consumption or requirement of a piece or group of equipment.

Log Law - In reference to a wind energy conversion system, the wind speed profile in which wind speeds increase with the logarithmic of the height of the wind turbine above the ground.

Low-E Coatings & (Window) Films - A coating applied to the surface of the glazing of a window to reduce heat transfer through the window.

Masonry Stove - A type of heating appliance similar to a fireplace, but much more efficient and clean burning. They are made of masonry and have long channels through which combustion gases give up their heat to the heavy mass of the stove, which releases the heat slowly into a room. Often called Russian or Finnish fireplaces.

Mean Power Output (of a Wind Turbine) - The average power output of a wind energy conversion system at a given mean wind speed based on a Raleigh frequency distribution.

Methane- A colorless, odorless, flammable gas; the main constitute of marsh gas and the firedamp of coalmines, obtained commercially from natural gas.

Methanol (CH_3OH ; Methyl alcohol or wood alcohol) - A clear, colorless, very mobile liquid that is flammable and poisonous; used as a fuel and fuel additive, and to produce chemicals.

Module - The smallest self-contained, environmentally protected structure housing interconnected photovoltaic cells; also called a panel.

Movable Insulation - A device that reduces heat loss at night and during cloudy periods and heat gain during the day in warm weather. A movable insulator could be an insulative shade, shutter panel, or curtain.

MTBE - Methyl Tertiary Butyl Ether (MTBE) is an ether compound used as a gasoline-blending component to raise the oxygen content of gasoline. MTBE is made by combining isobutylene (from various refining and chemical processes) and methanol (usually made from natural gas).

Municipal Waste to Energy Project (or Plant) - A facility that produces fuel or energy from municipal solid waste.

Nacelle- Is the box that sits on top of the tower (the tower blades are 60, 70 and 80 feet long and are made of steel and are hollow). The nacelle contains the generator and the mechanical system that turns wind into electricity.

Natural Cooling - Space cooling achieved by shading, natural (unassisted, as opposed to forced) ventilation, conduction control, radiation, and evaporation; also called passive cooling.

Natural Ventilation - Ventilation that is created by the differences in the distribution of air pressures around a building. Air moves from areas of high pressure to areas of low pressure with gravity and wind pressure affecting the airflow. The placement and control of doors and windows alters natural ventilation patterns.

Nonrenewable energy- Energy resource that is either replenished very slowly or is not replenished at all by natural processes. A nonrenewable resource can ultimately be totally depleted or depleted to the point where it is too expensive to extract and process for human use. Fossil fuels are examples of nonrenewable energy resources.

N-Type Semiconductor - A semiconductor produced by doping an intrinsic semiconductor with an electron-donor impurity (e.g., phosphorous in silicon).

Ocean Energy Systems - Energy conversion technologies that harness the energy in tides, waves, and thermal gradients in the oceans.

Off-Peak - The period of low energy demand, as opposed to maximum, or peak, demand.

On-Peak Energy - Energy supplied during periods of relatively high system demands as specified by the supplier.

On-Site Generation - Generation of energy at the location where all or most of it will be used.

Open-Loop System - A heating system, such as a solar water heater or geothermal heat pump, in which the working fluid is heated and used directly; in an open-loop solar system, the domestic water is circulated in the collector loop.

Orientation - The alignment of a building along a given axis to face a specific geographical direction. The alignment of a solar collector, in number of degrees east or west of true south.

Overhang - A building element that shades windows, walls, and doors from direct solar radiation and protects these elements from precipitation.

Oxygenates - Gasoline fuel additives such as ethanol, ETBE, or MTBE that add extra oxygen to gasoline to reduce carbon monoxide pollution produced by vehicles.

Ozone- A colorless, odorless, reactive gas composed of three oxygen atoms. Ozone located in the stratosphere (the ozone layer) absorbs ultraviolet radiation that would otherwise be harmful to organisms on Earth's surface. However, ozone located near Earth's surface is listed as a criteria pollutant because it adversely affects human health, damages plants, and weakens materials such as rubber and fabrics.

Panel (Solar) - A term generally applied to individual solar collectors, and typically to solar photovoltaic collectors or modules.

Panemone - A drag-type wind machine that can react to wind from any direction.

Parabolic Dish - A solar energy conversion device that has a bowl shaped dish covered with a highly reflective surface that tracks the sun and concentrates sunlight on a fixed absorber, thereby achieving high temperatures, for process heating or to operate a heat (Stirling) engine to produce power or electricity.

Parallel Connection - A way of joining photovoltaic cells or modules by connecting positive leads together and negative leads together; such a configuration increases the current, but not the voltage.

Passive/Natural Cooling - To allow or augment the natural movement of cooler air from exterior, shaded areas of a building through or around a building.

Passive Solar (Building) Design - A building design that uses structural elements of a building to heat and cool a building, without the use of mechanical equipment, which requires careful consideration of the local climate and solar energy resource, building orientation, and landscape features, to name a few. The principal elements include proper building orientation, proper window sizing and placement and design of window overhangs to reduce summer heat gain and ensure winter heat gain, and proper sizing of thermal energy storage mass (for example a Trombe wall or masonry tiles). The heat is distributed primarily by natural convection and radiation, though fans can also be used to circulate room air or ensure proper ventilation.

Passive Solar Heater - A solar water or space-heating system in which solar energy is collected, and/or moved by natural convection without using pumps or fans. Passive systems are typically integral collector/storage (ICS; or batch collectors) or thermosyphon systems. The major advantage of these systems is that they do not use controls, pumps, sensors, or other mechanical parts, so little or no maintenance is required over the lifetime of the system.

Passive Solar Home - A house built using passive solar design techniques.

Payback - The amount of time required for positive cash flows to equal the total investment costs.

Peaking Hydropower - A hydropower plant that is operated at maximum allowable capacity for part of the day and is either shut down for the remainder of the time or operated at minimal capacity level.

Peak Wind Speed - The maximum instantaneous wind speed (or velocity) that occurs within a specific period of time or interval.

Pellets - Solid fuels made from primarily wood sawdust that is compacted under high pressure to form small (about the size of rabbit feed) pellets for use in a pellet stove.

Peat- A dried mixture of partially rotted plants and grass-and the remains of harvested plants.

Penstocks- A sluice or gate for regulating a flow (as of water) or a conduit or pipe for conducting water.

Photoelectric Cell - A device for measuring light intensity that works by converting light falling on, or reach it, to electricity, and then measuring the current; used in photometers.

Photogalvanic Processes - The production of electrical current from light.

Photon- 1. A unit of intensity of light at the retina equal to the illumination received per square millimeter of a pupillary area from a surface having a brightness of one candle per square meter. 2. A quantum of electromagnetic radiation.

Photovoltaic cell (abbrs. **Pv, PV, pv cell**)- A device that converts solar energy directly into electricity. For example, photovoltaic cells provide electricity for handheld calculators, watches, battery chargers, homes, and satellites.

Photovoltaic (Conversion) Efficiency - The ratio of the electric power produced by a photovoltaic device to the power of the sunlight incident on the device.

Photovoltaic (PV; Solar) Array - A group of solar photovoltaic modules connected together.

Photovoltaic (Solar) Module or Panel - A solar photovoltaic product that generally consists of groups of PV cells electrically connected together to produce a specified power output under standard test conditions, mounted on a substrate, sealed with an encapsulant, and covered with a protective glazing. It may be further mounted on an aluminum frame. A junction box, on the back or underside of the module is used to allow for connecting the module circuit conductors to external conductors.

Photovoltaic (Solar) System - A complete PV power system composed of the module (or array), and balance-of-system (BOS) components including the array supports, electrical conductors/wiring, fuses, safety disconnects, and grounds, charge controllers, inverters, battery storage, etc.

Photovoltaic-Thermal (PV/T) Systems - A solar energy system that produces electricity with a PV module, and collects thermal energy from the module for heating. There are no commercially available systems available (as of 11/97).

Pitch Control - A method of controlling a wind turbine's speed by varying the orientation, or pitch, of the blades, and thereby altering its aerodynamics and efficiency.

Potential energy- The energy stored in an object because of its position or the arrangement of its parts. Forms of potential energy include chemical, elastic, electrical (electromagnetic), gravitational, nuclear, and thermal energy.

Power (Solar) Tower - A term used to describe solar thermal, central receiver, power systems, where an array of reflectors focus sunlight onto a central receiver and absorber mounted on a tower.

Preheater (Solar) - A solar heating system that preheats water or air that is then heated more by another heating appliance.

Projected Area - The net south-facing glazing area projected on a vertical plane. Also, the solid area covered at any instant by a wind turbine's blades from the perspective of the direction of the windstream (as opposed to the swept area).

Propeller (Hydro) Turbine - A turbine that has a runner with attached blades similar to a propeller used to drive a ship. As water passes over the curved propeller blades, it causes rotation of the shaft.

Radiant Energy - Energy that transmits away from its source in all directions.

Radiation - The transfer of heat through matter or space by means of electromagnetic waves.

Reflectance - The amount (percent) of light that is reflected by a surface relative to the amount that strikes it.

Reflective Coatings - Materials with various qualities that are applied to glass windows before installation. These coatings reduce radiant heat transfer through the window and also reflects outside heat and a portion of the incoming solar energy, thus reducing heat gain. The most common type has a sputtered coating on the inside of a window unit. The other type is a durable "hard-coat" glass with a coating, baked into the glass surface.

Refuse-Derived Fuel (RDF) - A solid fuel produced by shredding municipal solid waste (MSW). Noncombustible materials such as glass and metals are generally removed prior to making RDF. The residual material is sold as-is or compressed into pellets, bricks, or logs. RDF processing facilities are typically located near a source of MSW, while the RDF combustion facility can be located elsewhere. Existing RDF facilities process between 100 and 3,000 tons per day.

Renewable Energy - Energy derived from resources that are regenerative or for all practical purposes cannot be depleted. Types of renewable energy resources include moving water (hydro, tidal and wave power), thermal gradients in ocean water, biomass, geothermal energy, solar energy, and wind energy. Municipal solid waste (MSW) is also considered to be a renewable energy resource.

Renewable energy resource- Energy resource that can be quickly replenished. Certain renewable resources will always be available no matter how they are used, while other renewable resources can be depleted when their rate of use exceeds their rate of replacement.

Reservoir- A place where something is kept in store: as 1. an artificial lake where water is collected and kept in quantity for use 2. a part of an apparatus in which a liquid is held.

Rotor- The three blades on the turbine.

R-Value - A measure of the capacity of a material to resist heat transfer. The R-Value is the reciprocal of the conductivity of a material (U-Value). The larger the R-Value of a material, the greater its insulating properties.

Semiconductor - Any material that has a limited capacity for conducting an electric current. Certain semiconductors, including silicon, gallium arsenide, copper indium diselenide, and cadmium telluride, are uniquely suited to the photovoltaic conversion process.

Solar Access or Rights - The legal issues related to protecting or ensuring access to sunlight to operate a solar energy system, or use solar energy for heating and cooling.

Solar Air Heater - A type of solar thermal system where air is heated in a collector and either transferred directly to the interior space or to a storage medium, such as a rock bin.

Solar Altitude Angle - The angle between a line from a point on the earth's surface to the center of the solar disc, and a line extending horizontally from the point.

Solar Array - A group of solar collectors or solar modules connected together.

Solar Azimuth - The angle between the sun's apparent position in the sky and true south, as measured on a horizontal plane.

Solar Cell - A solar photovoltaic device with a specified area.

Solar Collector - A device used to collect, absorb, and transfer solar energy to a working fluid.

Solar Constant - The average amount of solar radiation that reaches the earth's upper atmosphere on a surface perpendicular to the sun's rays; equal to 1353 Watts per square meter or 492 Btu per square foot.

Solar Energy - Electromagnetic energy transmitted from the sun (solar radiation). The amount that reaches the earth is equal to one billionth of total solar energy generated, or the equivalent of about 420 trillion kilowatt-hours.

Solar Gain - The amount of energy that a building absorbs due to solar energy striking its exterior and conducting to the interior or passing through windows and being absorbed by materials in the building.

Solar Irradiation - The amount of solar radiation, both direct and diffuse, received at any location.

Solar Module (Panel) - A solar photovoltaic device that produces a specified power output under defined test conditions, usually composed of groups of solar cells connected in series, in parallel, or in series-parallel combinations.

Solar Noon - The time of the day, at a specific location, when the sun reaches its highest, apparent point in the sky; equal to true or due, geographic south.

Solar Panel - See Solar Module.

Stall - In reference to a wind turbine, a condition when the rotor stops turning.

Sun- A yellow star around which the Earth and the other planets of the solar system orbit. The sun provides nearly all the energy needed to sustain life on Earth.

Sun Path Diagram - A circular projection of the sky vault onto a flat diagram used to determine solar positions and shading effects of landscape features on a solar energy system.

Sun Tempered Building - A building that is elongated in the east-west direction, with the majority of the windows on the south side. The area of the windows is generally limited to about 7% of the total floor area. A sun-tempered design has no added thermal mass beyond what is already in the framing, wall board, and so on. Insulation levels are generally high.

Super Insulated Houses - A type of house that has massive amounts of insulation, airtight construction, and controlled ventilation without sacrificing comfort, health, or aesthetics.

Switchgrass- A dried mixture of partially rotted plants and grass-and the remains of harvested plants.

Thermal Envelope Houses - An architectural design (also known as the double envelope house), sometimes called a "house-within-a-house," that employs a double envelope with a continuous airspace of at least 6 to 12 inches on the north wall, south wall, roof, and floor, achieved by building inner and outer walls, a crawl space or sub-basement below the floor, and a shallow attic space below the weather roof. The east and west walls are single, conventional walls. A buffer zone of solar-heated, circulating air warms the inner envelope of the house. The south-facing airspace may double as a sunspace or greenhouse.

Tidal Power - The power available from the rise and fall of ocean tides. A tidal power plant works on the principal of a dam or barrage that captures water in a basin

at the peak of a tidal flow, then directs the water through a hydroelectric turbine as the tide ebbs.

Tilt Angle (of a Solar Collector or Module) - The angle at which a solar collector or module is set to face the sun relative to a horizontal position. The tilt angle can be set or adjusted to maximize seasonal or annual energy collection.

Tip Speed Ratio - In reference to a wind energy conversion device's blades, the difference between the rotational speed of the tip of the blade and the actual velocity of the wind.

Tracking Solar Array - A solar energy array that follows the path of the sun to maximize the solar radiation incident on the PV surface. The two most common orientations are (1) one axis where the array tracks the sun east to west and (2) two-axis tracking where the array can track the sun east to west and can move up and down to account for the low winter sun and the high summer sun. Tracking arrays use both the direct and diffuse sunlight. Two-axis tracking arrays capture the maximum possible daily energy.

Trailing Edge - The part of a wind energy conversion device blade, or airfoil, that is the last to contact the wind.

Transformer- Increases the voltage of electricity so that it can go into the electrical transmission and distribution system. This system takes the electricity long distances.

Turbine- A machine that converts the kinetic energy of a moving fluid (e.g., pressurized steam) into mechanical energy (the rotating motion of a shaft).

Two-Axis Tracking - A solar array tracking system capable of rotating independently about two axes (e.g., vertical and horizontal).

Voltage- A measure of the force or "push" given the electrons in an electrical circuit; a measure of electrical potential. One volt produces one amp of current when acting against a resistance of one ohm.

Watt- A unit of power. One watt equals the production or use of one joule of energy per second.

Water Source Heat Pump - A type of (geothermal) heat pump that uses well (ground) or surface water as a heat source. Water has a more stable seasonal temperature than air thus making for a more efficient heat source.

Water Turbine - A turbine that uses water pressure to rotate its blades; the primary types are the Pelton wheel, for high heads (pressure); the Francis turbine, for low to medium heads; and the Kaplan for a wide range of heads. Primarily used to power an electric generator.

Water Wheel - A wheel that is designed to use the weight and/or force of moving water to turn it, primarily to operate machinery or grind grain.

Wave Power - The concept of capturing and converting the energy available in the motion of ocean waves to energy.

Wind- The movement and circulation of Earth's atmosphere near its surface; moving air.

Wind Energy - Energy available from the movement of the wind across a landscape caused by the heating of the atmosphere, earth, and oceans by the sun.

Wind Energy Conversion System (WECS) or Device - An apparatus for converting the energy available in the wind to mechanical energy that can be used to power machinery (grain mills, water pumps) and to operate an electrical generator.

Wind Generator - A WECS designed to produce electricity.

Wind Power Plant - A group of wind turbines interconnected to a common utility system through a system of transformers, distribution lines, and (usually) one substation. Operation, control, and maintenance functions are often centralized through a network of computerized monitoring systems, supplemented by visual inspection. This is a term commonly used in the United States. In Europe, it is called a generating station.

Wind Resource Assessment - The process of characterizing the wind resource, and its energy potential, for a specific site or geographical area.

Wind Speed - The rate of flow of the wind undisturbed by obstacles.

Wind Speed Profile - A profile of how the wind speed changes with height above the surface of the ground or water.

Wind Turbine - A term used for a wind energy conversion device that produces electricity; typically having one, two, or three blades.

Windmill - A WECS that is used to grind grain, and that typically has a high-solidity rotor; commonly used to refer to all types of WECS.

Appendix V
Sample Simplified Excel Rubric for Reviewers

| ACTIVITY | | | | | | | | | | Activity addresses a concept |
|---------------------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------------------------|
| | Concept 1 | Concept 2 | Concept 3 | Concept 4 | Concept 5 | Concept 6 | Concept 7 | Concept 8 | Concept 9 | |
| Energy from Food | | | | | | | | | | |
| Evidence of Energy | | | | | | | | | | |
| Exploring Heat | | | | | | | | | | |
| Taking Temperatures | | | | | | | | | | |
| Energy Use in an Ecosystem | | | | | | | | | | |
| Food Chain Game | | | | | | | | | | |
| Potentially Kinetic | | | | | | | | | | |
| Station Break | | | | | | | | | | |
| Sun, Wind, Water | | | | | | | | | | |
| At Watt Rate? | | | | | | | | | | |
| Community Energy Use | | | | | | | | | | |
| Diminishing Returns | | | | | | | | | | |
| People Power | | | | | | | | | | |
| Roasted Peanuts | | | | | | | | | | |
| Solar Energy and the Carbon Cycle | | | | | | | | | | |
| Puzzling Wisconsin's Biological Communities | | | | | | | | | | |
| Where Does It Get Its Energy? | | | | | | | | | | |
| Circuit Circus | | | | | | | | | | |
| Digging for Coal | | | | | | | | | | |
| Fueling Around | | | | | | | | | | |
| Shoebox Solar Cooker | | | | | | | | | | |
| Addresses the concept | | | | | | | | | | |

| | |
|-------------------------------------------------------------------------------------------|---|
| Percentage of concepts covered by guide (either fully or partially; rating of 1.0 or 0.5) | 0 |
|-------------------------------------------------------------------------------------------|---|

| | |
|-----------------------------------------------------------------------------------------------------------------|---|
| Percentage of the guide that covers renewable energy concepts (either fully or partially; rating of 1.0 or 0.5) | 0 |
|-----------------------------------------------------------------------------------------------------------------|---|

Appendix W
Complete Non-formal Educators Results of Instrument Validation

| RESULTS OF NONFORMAL EDUCATORS | | | |
|--------------------------------------------------------------------------------------------------------|-------------------------------|--------------------------------|---------------------------|
| | Michelle's results | Stephanie's results | Clay's results |
| Percentage of concepts fully covered by guide | 28.6 | 19 | 47.6 |
| Percentage of concepts fully covered by guide and/or covered in the background | 73.8 | 69 | 73.8 |
| Percentage of activities that have at least one concept fully covered | 27.3 | 20.5 | 25 |
| Percentage of activities that have at least one concept fully covered and/or covered in its background | 38.6 | 43.2 | 38.6 |

| KEEP GUIDE COVERAGE ON GRADE BASIS | | | |
|--------------------------------------------------------------------------------------------------------------|------|------|------|
| K-2 | | | |
| Percentage of concepts fully covered by guide K-2 activities | 0 | 0 | 0 |
| Percentage of concepts fully covered by guide K-2 activities and/or covered in the background | 4.76 | 4.76 | 4.76 |
| Percentage of K-2 activities that have at least one concept fully covered | 0 | 0 | 0 |
| Percentage of K-2 activities that have at least one concept fully covered and/or covered in its background | 20 | 40 | 40 |
| GRADE 3-->5 | | | |
| Percentage of concepts fully covered by guide 3-->5 activities | 14.3 | 11.9 | 19 |
| Percentage of concepts fully covered by guide 3-->5 activities and/or covered in the background | 35.7 | 35.7 | 28.6 |
| Percentage of 3-->5 activities that have at least one concept fully covered | 30 | 30 | 20 |
| Percentage of 3-->5 activities that have at least one concept fully covered and/or covered in its background | 30 | 60 | 40 |

| | | | |
|---------------------------------------------------------------------------------------------------------------|------|------|------|
| GRADE 6-->8 | | | |
| Percentage of concepts fully covered by guide 6-->8 activities | 21.4 | 9.52 | 28.6 |
| Percentage of concepts fully covered by guide 6-->8 activities and/or covered in the background | 52.4 | 47.6 | 57.1 |
| | | | |
| Percentage of 6-->8 activities that have at least one concept fully covered | 26.3 | 10.5 | 21.1 |
| Percentage of 6-->8 activities that have at least one concept fully covered and/or covered in its background | 42.1 | 36.8 | 31.6 |
| | | | |
| GRADE 9-->12 | | | |
| Percentage of concepts fully covered by guide 9-->12 activities | 11.9 | 9.52 | 19 |
| Percentage of concepts fully covered by guide 9-->12 activities and/or covered in the background | 26.2 | 23.8 | 26.2 |
| | | | |
| Percentage of 9-->12 activities that have at least one concept fully covered | 40 | 40 | 50 |
| Percentage of 9-->12 activities that have at least one concept fully covered and/or covered in its background | 50 | 40 | 50 |

Appendix X

Partial List of Functions the Excel Matrix Could Perform

A more detailed rubric using Excel was created that could calculate the following:

- The percentage of concepts covered by each individual activity (those with a rating of 1.0)
- The percentage of concepts covered by each individual activity (those with a rating of 1.0 or 0.5)
- The percentage of concepts covered by the activity guide (those with a rating of 1.0)
- The percentage of concepts covered by the activity guide (those with a rating of 1.0 or 0.5)
- The percentage of activities that cover each individual concept (those with a rating of 1.0)
- The percentage of activities that cover each individual concept (those with a rating of 1.0 or 0.5)
- The percentage of activities that cover at least one renewable concept (those with a rating of 1.0)
- The percentage of activities that cover at least one renewable concept (those with a rating of 1.0 or 0.5)
- The percentage of concepts covered by K-2 activities (those with a rating of 1.0)
- The percentage of concepts covered by K-2 activities (those with a rating of 1.0 or 0.5)
- The percentage of concepts covered by 3-5 activities (those with a rating of 1.0)
- The percentage of concepts covered by 3-5 activities (those with a rating of 1.0 or 0.5)
- The percentage of concepts covered by 6-8 activities (those with a rating of 1.0)
- The percentage of concepts covered by 6-8 activities (those with a rating of 1.0 or 0.5)
- The percentage of concepts covered by 9-12 activities (those with a rating of 1.0)
- The percentage of concepts covered by 9-12 activities (those with a rating of 1.0 or 0.5)
- The percentage of K-2 activities that cover at least one renewable energy concept (those with a rating of 1.0)
- The percentage of K-2 activities that cover at least one renewable energy concept (those with a rating of 1.0 or 0.5)
- The percentage of 3-5 activities that cover at least one renewable energy concept (those with a rating of 1.0)

- The percentage of 3-5 activities that cover at least one renewable energy concept (those with a rating of 1.0 or 0.5)
- The percentage of 6-8 activities that cover at least one renewable energy concept (those with a rating of 1.0)
- The percentage of 6-8 activities that cover at least one renewable energy concept (those with a rating of 1.0 or 0.5)
- The percentage of 9-12 activities that cover at least one renewable energy concept (those with a rating of 1.0)
- The percentage of 9-12 activities that cover at least one renewable energy concept (those with a rating of 1.0 or 0.5)
- The percentage of concepts covered by each individual K-2 activity (those with a rating of 1.0)
- The percentage of concepts covered by each individual K-2 activity (those with a rating of 1.0 or 0.5)
- The percentage of K-2 activities that cover each individual concept (those with a rating of 1.0 or 0.5)
- The percentage of K-2 activities that cover at least one renewable concept (those with a rating of 1.0)
- The percentage of concepts covered by each individual 3-5 activity (those with a rating of 1.0)
- The percentage of concepts covered by each individual 3-5 activity (those with a rating of 1.0 or 0.5)
- The percentage of 3-5 activities that cover each individual concept (those with a rating of 1.0 or 0.5)
- The percentage of 3-5 activities that cover at least one renewable concept (those with a rating of 1.0)
- The percentage of concepts covered by each individual 6-8 activity (those with a rating of 1.0)
- The percentage of concepts covered by each individual 6-8 activity (those with a rating of 1.0 or 0.5)
- The percentage of 6-8 activities that cover each individual concept (those with a rating of 1.0 or 0.5)
- The percentage of 6-8 activities that cover at least one renewable concept (those with a rating of 1.0)
- The percentage of concepts covered by each individual 9-12 activity (those with a rating of 1.0)
- The percentage of concepts covered by each individual 9-12 activity (those with a rating of 1.0 or 0.5)
- The percentage of 9-12 activities that cover each individual concept (those with a rating of 1.0 or 0.5)
- The percentage of 9-12 activities that cover at least one renewable concept (those with a rating of 1.0)

Appendix Y
Comparison of Formal and Non-formal Educators' Evaluation

| Results from formal educators | | | nonformal educators | | |
|------------------------------------------------------------------------------------------|-----------|--------------|----------------------------|----------------|---------------|
| | Bob Welch | Vicky Vaughn | Michelle Gransee | Stephanie Kane | Clay Sterling |
| Percentage of concepts fully covered by Waterwheel, Windmills, and Turbines | 42.86 | 42.86 | 7.14 | 9.52 | 19.05 |
| Percentage of concepts covered fully or partially by Waterwheel, Windmills, and Turbines | 42.86 | 92.86 | 28.57 | 26.19 | 23.81 |
| | | | | | |
| Percentage of concepts fully covered by Advertising Energy | 30.95 | 92.86 | 0.00 | 0.00 | 0.00 |
| Percentage of concepts covered fully or partially by Advertising Energy | 30.95 | 100.00 | 0.00 | 0.00 | 0.00 |
| | | | | | |
| Percentage of concepts covered fully by Siting for Solar and Wind | 57.14 | 69.05 | 4.76 | 2.38 | 9.52 |
| Percentage of concepts covered fully or partially by Siting for Solar and Wind | 57.14 | 95.24 | 11.90 | 21.43 | 11.90 |