SOLAR ENERGY EDUCATION:
NEW MATERIALS FOR TEACHERS AND STUDENTS

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Abstract -- The Florida Solar Energy Center (FSEC) has developed teacher education materials for classroom use. One set of the materials has been designed for elementary/middle-school students, and the other for upper level/high school students. The middle school level includes more than 25 hands-on exercises for classroom use, covering the basics of solar water heating, photovoltaics, solar design and various principles. The unit also has a bibliography, teacher and student internet links, and other reference materials. The complete curriculum unit is available at no charge from the FSEC web site. The high school unit contains several PowerPoint presentations on various aspects of solar energy, ready for classroom presentation or hand out to students. Materials currently available include nearly 100 slides showing applications of solar energy systems around the world and explaining the principles and concepts of the technologies; case studies on successful solar applications; a presentation on solar energy uses in agriculture, and a philosophical case study on the uses of solar energy to replace fossil fuels. This complete set of materials is also available at no charge on the Internet web site. This presentation will discuss these materials, offer ideas on using them in the classroom, and how to work with teachers to get the materials in use. Sample presentation materials will be shown. This will be the first presentation of the new upper level/high school materials

1. INTRODUCTION

From many conversations with teachers and on-going requests for information, it is clear that there is a lack of solar energy materials available for use in schools. This is a critical problem at the upper elementary/intermediate and high school levels where energy and related subjects are required and information and experience is limited. During teacher workshops, conference exhibits, and other meetings, the Florida Solar Energy Center has received hundreds of requests for materials teachers can use in their classes. We receive daily requests for teacher information via the internet as well. Educators need materials to teach the basics of solar energy as an alternative to the use of conventional fossil fuels. Many have received little or no education on solar energy in their own background and thus do not have the knowledge to discuss the material. Other teachers who know about solar do not have or cannot afford to buy the materials that can be used in their classes. Education materials for solar energy were totally lacking, incomplete, too elementary, or too technical. Because of the shortage of fossil fuels, the problems of global warming and the greenhouse effect, the need for education materials that would address these areas was both critical and timely.

2. DEVELOPMENT OF SOLAR ENERGY CURRICULUM UNITS

Quality, current, comprehensive materials were developed at the intermediate and high school levels. The materials were written for teachers to be able to understand and present to students in an educationally-sound format. Both units can be used as individual lessons or as entire units of study. The two units can also be taught in complement. The intermediate unit, Solar Matters, contains information and activities not contained in the high school unit, Solar Wonders.
Some of the information includes an extensive timeline, facts about the sun and solar energy, and activities addressing global problems such as global warming, ultra violet rays as they affect our lives, and the effects of growing global population. Solar Wonders has slides that extend and enrich Solar Matters by showing international examples of solar energy applications. By using the two units together, information and activities supplement and enhance one another.

Both units encourage further study, critical thinking strategies, extended research, and the opportunity for user feedback and suggestions. Because both units are available at no cost to teachers on the internet, they are updated, extended, and modified in an ongoing effort to continue to provide the most current and comprehensive solar energy education materials available to educators.

### 3. THE INTERMEDIATE LEVEL UNIT

**Solar Matters** is an interdisciplinary unit designed for intermediate students, those in grades four through eight. It can however be easily adapted for students in higher and lower grades. **Solar Matters** was developed as a result of searching every available source of materials and compiling information into the most comprehensive and current unit available. It was written following specific criteria, guidelines, and format, while including comprehensive content material. Using the 28 included hands-on activities, students extend their understanding of science by experiencing the power of solar energy first-hand and investigating the variables that affect solar energy transfer.

Background information, history, teacher directions, vocabulary, and extension activities provide opportunities for students to explore new concepts and further their understanding by asking questions and designing their own investigations. The activities in **Solar Matters** incorporate science process skills, which encourage higher order thinking skills through observing, predicting, hypothesizing, gathering information, recording, analyzing, and communicating data, and drawing conclusions.

Each activity in **Solar Matters** is written following the same consistent format as can be exemplified in the following page:

#### Scientific Process/Procedure for Activities

**Problem:** The question to be answered by doing the activity

**Hypothesis:** An educated guess based on background knowledge

I think ______ (will happen) because

(possibly there is a reason)

**Materials:** Listed for each activity

**Procedure:**

1. Discussion of safety issues and procedures prior to each activity. Several activities involve equipment and/or heat.
2. Step by step instructions

**Data/Results:** Directed questions to be answered; data may be reported using various methods such as pictures, words, charts, graphs. Note: When possible, each activity should be done 3 times with the results averaged for greater validity.

**Conclusion:** Refers back to Hypothesis

My hypothesis was correct (  ) or incorrect (  ) because

Analysis: Student reaction to the activity and its validity to the solution of the problem

Was this a FAIR TEST? ____ Why or why not?

(What, if anything, would you change to make your results more valid?)

**Teacher Analysis:**

In order to promote further student analyzing, questioning, and investigating, the following teacher questions and comments may be useful at the conclusion of any activities/investigations. These questions can be used for small/large group discussions, science log/journal entries, or as writing prompts.

- How do you feel about your results? Are they valid?
- Did you conduct a “FAIR TEST”?
- What, if anything, would you change to make your results more valid?
- Did you control your variables?
- Did your results cause you to think of more questions to explore?

Each activity in **Solar Matters** follows the above format and includes student worksheets, student data sheets, and student experiment sheets when appropriate. Each activity is designed using cooperative learning (groups of students working
together to solve problems). The teacher delivers information, but acts primarily as a facilitator. Students learn by being actively involved in their learning. The activities are inquiry-based and incorporate a wide variety of materials and strategies. Curriculum integration for each activity is suggested where appropriate. (If an activity meets objectives in another academic area it is stated, such as art, mathematics, social studies, etc.) Also included in the activities are objectives, vocabulary, background information, a list of suggested materials, step-by-step procedure, assessments, and teacher analysis.

The activities are written to align with U.S. National Science Standards and can easily be adapted to meet the mandated standards of local school districts and municipalities.

*Solar Matters* includes a comprehensive timeline of the history of solar energy, a scoring rubric for assessing student performance, and a list of performance assessments, tools which measure learning by demonstrating knowledge of content through observable outcomes and products. An example is to conduct and analyze results of an energy audit of home or school and write an appropriate family or school budget or make recommendations to improve energy efficiency. Solar Matters also includes a section on photovoltaics with activities to demonstrate the concept and effectiveness.

The sections and activities are included in *Solar Matters* are:

**GENERAL INFORMATION**
- A Note to Teachers
- Process and Procedure
- Scoring Rubric
- Performance Assessments
- What is Solar Energy? (facts about the sun and solar energy)
- Solar Energy Timeline

**SUN AND ENERGY INFORMATION**
- World Population (as it relates to energy consumption)
- Bead Magic (ultraviolet beads)
- UV Tracking
- Energy Wheel (renewable and nonrenewable energy sources)
- Battle of the Bands (energy resources)

**K(now)-W(ant to know)-L(earned) (general information about solar energy)**
- Poster Contest (history)

**SUN TRACKING AND SHADOWS**
- Sun Misconceptions
- Gnomons

**SOLAR THERMAL**
- Thermometers
- Sun and Shade (as they relate to temperature)
- Sand or Soil (solar energy creates heat)
- Hot and Cold Colors (heat absorption)
- Ice Baggies (energy transfer)
- Ice Cube Race (insulation)
- Melting Ice Contest (absorption)
- Rain Machine (evaporation)
- What’s Cooking (solar cooking)

**PHOTOVOLTAICS**
- Solar Cell Simulation (photovoltaic effect)
- “Solar System” (PV cells, motors, propellers)
- Angles and Meters (PV energy output)

**SOLAR ENERGY AND ME**
- UV and Sunscreen
- Save or Waste (energy wasting and conserving)
- Remember When (comparing energy usage)
- Apple of Our Eye (energy usage and natural resources)
- Population Riddles (population ad energy consumption)
- Food for Thought (resource distribution)
- Greenhouse Effect and Global Warming

**RESOURCES**
Glossary
Reading and References List
Internet Links – Teachers
Internet Links - Students

An extensive listing of resources to extend and enrich the activities and information is included. Specific internet links are provided with each activity and a list of general, non-specific links are found in the resources section at the end of Solar Matters.

4. THE HIGH SCHOOL LEVEL UNIT

The goal for the high school unit, Solar Wonders, was to compile information at the appropriate level using downloadable PowerPoint presentations for teachers. The presentations combined background information with slides of applications from around the world to extend their students’ understanding of solar energy, an awareness of the power of solar energy, and its impact on their lives. The presentations can be used as stand-alone lessons or as a total unit. The unit features overviews of the technologies, an understanding of their principles, and detailed case studies and examples of their uses and applications. Each presentation concludes with discussion questions.

The Solar Works educational unit has been developed to meet the developmental needs of high school students. The purpose of this unit is to help you give students. The programs presented in the unit provide an overview of the technologies, an understanding of their principles, and detailed case studies of their uses. Pictures of their applications around the world show actual examples to students.

By using the slide presentations and case studies, students will extend their understanding of solar technologies by reading about and seeing examples of their principles and applications around the world. Not only will students view examples of the power of solar energy firsthand, but they will also investigate the variables that affect solar energy transfer. Solar Works has been designed as an interactive unit for use in high school classes. Each presentation is in PowerPoint slides for direct use in class, and can either be used as background material to extend and enrich curriculum, or can be copied for students to use. The materials will provide opportunities for your students to explore new concepts and extend their understanding by asking questions and designing their own investigations.

The presentations may be viewed and downloaded in both HTML format and in PowerPoint.

Also included in Solar Works are a glossary and an extensive listing of Internet links to promote further research.

The eight presentations in Solar Works encourage students to observe, hypothesize, gather information, gather and record data, analyze and communicate information, and draw conclusions. Each presentation begins with an overview and definition of the technology, shows examples of the application using photos from around the globe, and concludes with discussion questions. The questions are designed to encourage higher order thinking skills.

The Presentations are:

- Introduction to Solar Energy
- Solar Thermal Energy
- Photovoltaics
- High Temperature Solar Thermal Systems
- Passive Solar Design
- Solar Energy Uses in Agriculture
- A Renewable Energy House in Australia
- Why Use Solar Energy?

Examples of some of the 35 slides in Presentation 3 (Photovoltaics) are:

Slide 1: Photovoltaics Using the sun to generate electricity. (2 PV panels)

Slide 2: An increasingly popular use of solar energy involves solar electric systems, called photovoltaics. Photovoltaic (PV) systems convert sunlight directly into electricity, and are potentially one of the most useful of the renewable energy technologies. (text only)

Slide 4: The heart of a photovoltaic system is a solid-state device called a solar cell. (hand holding a round PV cell)

Slide 27: Maybe no uses are as dramatic and important as the portable PV panels and small refrigerators carried around Africa on the backs of camels. (camel carrying PV cells on his back being led by a man)

Slide 34: In many parts of the world, getting water is as important as getting energy. This experimental system in Israel uses PV and wind energy in a desalination project. (the project)

Slide 35: Discussion Questions: Are PV systems as efficient or economic as fossil-fueled systems? Is PV a viable alternative for all of our power needs? For homes? For vehicles? For other needs? Is PV the answer to all of the world’s power needs? (text only).
This presentation shows applications in the U.S., Switzerland, France, Eritrea, Spain, Mexico, Philippines, Kenya, Ivory Coast, Australia, Israel, and offshore in the ocean.

*Solar Wonders* will be expanded over time. Presentations will be modified and added.

5. **CONCLUSION: IMPACT IN THE CLASSROOM**

Response to both units has been overwhelming. Teachers and other education and environmental professionals from around the world have contacted us to express their positive reactions to our materials. Because of the state of the earth’s environment and its impact on the world’s population, “Solar Matters” and “Solar Wonders” are proving to be vehicles making a difference in the lives of the next generation of world leaders.

Both units have been posted on FSEC’s web page and are available at no cost at [http://www.fsec.ucf.edu/Ed/Teachers](http://www.fsec.ucf.edu/Ed/Teachers).