TESTING THE POWER OF THE SUN

Performance Standards 12E/12C/11B/13A/13B.J

Students will apply the concepts, principles and processes of technological design to investigate the technologies of the earth sciences and the interaction of energy with matter and its conservation in generation of electricity accordingly:

- *Knowledge:* understand the relationship of structural elements associated with the simple and commercial generation of electricity from solar power.
- *Application:* apply technological design processes to design and test a simple solar-powered device.
- *Communication:* present and compare qualitative and quantitative findings from tests of solar-powered prototypes.

Procedures

1. ***In order to know and apply concepts that describe the features and processes of the Earth and its resources (12E); concepts that describe properties of matter and energy and the interactions between them (12C); the concepts, principles and processes of technological design (11B); the accepted practices of science (13A); and concepts that describe the interaction between science, technology and society (13B),*** students should experience sufficient learning experiences to develop the following:
   - Generate ideas for the recent, current and prospective engineering solutions needed for solar-powered propellers for generation of electricity.
   - Research the scientific and engineering principles (electric motor/generators, circuits, propellers) associated with solar energy, circuitry, electrical generation, etc.
   - Identify the necessary materials and procedural sequence.
   - Determine success criteria, design constraints, safety considerations and testing logistics for class investigations.
   - Sketch progressive schematics of the design components.
   - Determine and collect the appropriate prototype materials/supplies and testing/safety equipment.
   - Construct solar-driven electrical prototype.
   - Test prototype components through multiple trials, according to success criteria, scale and design constraints.
   - Collect reliable and precise data with available technologies.
   - Analyze data to evaluate design by comparing and summarizing data from multiple trials for suitability, acceptability, benefits, etc.
   - Evaluate conflicting data.
   - Communicate design evaluation report.
   - Select graphs or charts that can display findings from investigation.
   - Relate historic, present and future solar-powered designs and impact from engineering solution.
   - Identify applicable local, state, national and global scientific policies associated with solar power.
   - Analyze how scientific and technological progress associated with solar power affect (past/present/future) job markets and everyday life.
   - Generate alternative design modifications which can be or could have been tested.

   Note to teacher: This activity relates to knowledge associated with Standards 12E and 12C, while addressing the Performance Descriptors for Stage J within Standard 11B. It integrates principles of safety and career applications as suggested in Standards 13A and B. The students will investigate in theory and practice the conversion of solar energy to electrical energy in the design and testing of a system of operating electrical devices such as motors and electronic circuits from solar energy. They will study the laws of conversion of energy and efficiency of all devices. Solar energy is recognized as an excellent alternative fuel to generate electricity. Scientists and engineers predict that this fuel will be used for 21st century generation of electricity. There will be extensive industrial related technical occupations associated with this source of energy. Industrial occupations programs should incorporate the concept of solar energy into their training as an example of potential future employment opportunities.
2. Have students review and discuss the assessment task and how the rubric will be used to evaluate their work.

3. Students should have a background in the basic operation of permanent magnet DC motors as generators (possibly Rowe Series 60D) and direct current circuitry. The investigation can begin with discussions about the engineering research for solar power. They should brainstorm the kinds of career and occupational settings and decisions that are associated with this engineering innovation and solution. Set the stage for the investigation with references to commercial solar energy systems and inquiry questions about how they work and how they can be made. Proceed with research on elements 1-3 on the Student Idea Page of the activity. Continue with class and group decisions about testing the different kinds of solar cells and load devices such as Rowe Series 60D permanent magnet electric motors. Students should determine the criteria that should be used to evaluate prototype designs and the procedural constraints for the investigation. Students should secure drawings of engineering designs and sketch a progressive sequence for construction and testing. Students should determine the materials and supplies needed to construct the selected design, as well as the necessary testing equipment and safety procedures and equipment. They should test their designs and collect appropriate data which can be used to evaluate the prototype's success. They should share their findings and compare design elements among classmates to evaluate the engineering progression of the design elements. Finally they should record conclusions and rationales about the best designs for solar-powered devices. Direct students to follow instructions and record qualitative and quantitative observations in each variation of the inquiry investigation. Continue activity by applying this understanding to the design of a simple system of converting solar energy to electrical energy to drive an electromechanical device or an electronic circuit. Students should evaluate "product" designs according to their established criteria and discuss the findings of the individual group efforts.
4. Evaluate each student's work using the Science Rubric as follows and add the scores to determine the performance level:
   - *Knowledge*: The relationship of structural elements and basic concepts of simple and commercial conversion of solar energy to electrical energy was complete and accurate.
   - *Application*: The strategies to test the conversion in experimental design methods and analysis records were complete and correct.
   - *Communication*: The findings of both investigations were thorough, coordinated, well detailed and well reasoned.

Examples of Student Work
- Meets
- Exceeds

Time Requirements
- 1 - 2 class periods for explanation of expectations for investigation and design options; 1 - 2 weeks for construction and testing of design; 2 - 3 days for presentations and design comparisons

Resources
- Motors, generators, circuitry equipment
- Testing equipment
- Solar cells and prototype construction materials
- Access to research resources
- Testing the Power of the Sun Student Idea Page
- Internet references: http://shop.emotorstore.com/estore/product_dcm.asp?pf%5Fid=6979&dept%5Fid=6042& http://www.siliconsolar.com http://www.electroscience.com http://www.howstuffworks.com/solar-cell.htm
- Science Rubric

TESTING THE POWER OF THE SUN
Student Idea Page

Solar energy is recognized as an excellent alternative 'fuel' to generate electricity. Scientists and engineers predict that this fuel will be used for 21st century generation of electricity.

CONVERTING SOLAR ENERGY TO ELECTRICAL ENERGY

1. Research information on the basic operation of solar cells and their capabilities.
2. Research information to determine the different types of solar cells in use today in the world.
3. Research specifications on the Rowe Series 60D permanent magnet electric motor.
4. Discuss criteria to determine the most efficient method of converting the energy from the solar cell to the electric motor.
5. Divide into groups to design prototypes to build and test the ideal solar cell to operate the Rowe Series 60D permanent magnet electric motor. Collect specifications on the electronic circuit provided.
6. Decide the best available solar cells to drive this motor according to class criteria.

YOU NEED TO DECIDE:

What will be the success factors for the class' investigation? For example: How will you judge what works best?

What kinds of materials will be allowed?

How much time is to be allowed?

How will the prototypes be tested?

What factors will you test?

What safety factors need to be considered for the classroom testing?

Where can you find information?

What steps will you follow?

Sketch your initial and final design.

What career or occupational settings could need or use these kinds of concepts, principles or processes?

How will you record your data? What kind of chart or table do you need?

Which design works the best? How do you know?

SCIENCE RUBRIC

Exceeds - must receive no more than one 3 and the rest 4s in the other areas of the rubric.
Meets - may receive no more than one 2 and a combination of 3s and 4s in the other areas of the rubric.
Approaches - may receive no more than one 1 and a combination of 2s, 3s or 4s, in the other areas of the rubric.
Begins - must receive at least a 1 in all 3 areas of the rubric.

	KNOWLEDGE Knows and understands scientific terms, facts, concepts, principles, theories and methods.	**APPLICATION** Applies scientific knowledge, skills and methods to manipulate, analyze, synthesize, create and evaluate.	**COMMUNICATION** Communicates scientific knowledge and applications through writing, speech and visual displays.
4	• Descriptions of scientific terms, facts, concepts, principles, theories and methods are complete and correct.	• Applications are thorough, appropriate and accurate.	• Written, oral and/or visual communication is well organized and effective.
3	• Descriptions of scientific terms, facts, concepts, principles, theories and methods are mostly complete and correct.	• Applications are mostly thorough, appropriate and accurate.	• Most of the written, oral and/or visual communication is well organized and effective.
2	• Descriptions of scientific terms, facts, concepts, principles, theories and methods are somewhat complete and correct.	• Applications are somewhat appropriate and accurate.	• Some of the written, oral and/or visual communication is organized and effective.
1	• Descriptions of scientific terms, facts, concepts, principles, theories and methods are minimally present or correct.	• Applications are minimally appropriate and accurate.	• Little of the written, oral and/or visual communication is organized and effective.
0	• All descriptions of scientific terms, facts, concepts, principles, theories and methods are missing and/or incorrect.	• All applications are missing and/or incorrect.	• All of the written, oral or visual communication is missing and/or lacks organization.
Score			