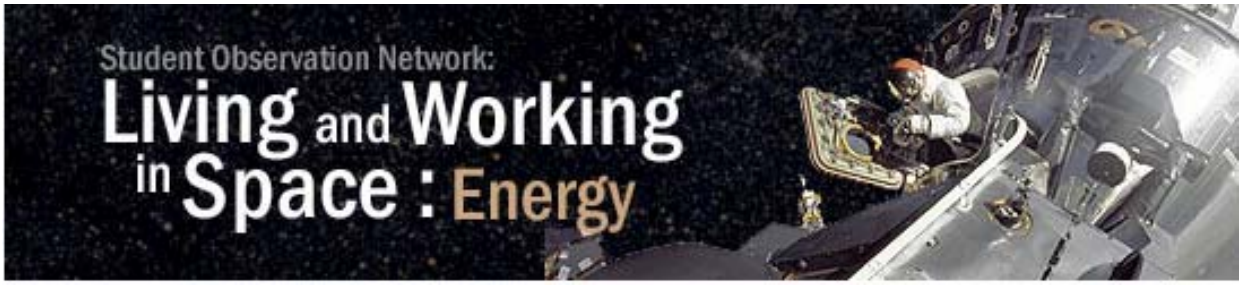
National Aeronautics and Space Administration

Solar Energy for Space Exploration
Student Assignments



ISS, Moon, Mars, and Beyond

Scenario

Humans like to explore. NASA's mission over the next few decades is to explore the Moon and Mars. Living and working on the ISS (International Space Station) is a vital steppingstone to future exploration of space. By going to the Moon for extended periods of time, astronauts will search for resources and learn how to work safely in a harsh environment. The Moon also offers many clues about the time when the planets were formed. Robotic missions to Mars have found evidence of a watery past. This suggests that simple life forms may have developed long ago and may persist beneath the surface today. Human exploration of Mars could provide answers to some important questions. Humans and robots will work together exploring the Moon and Mars. Meanwhile, NASA spacecraft will continue to send scientific data from throughout the solar system. This will lay the groundwork for potential human journeys. But how will NASA provide energy for extended research on the Moon or on Mars? Solar panels with batteries seem to be the best option.

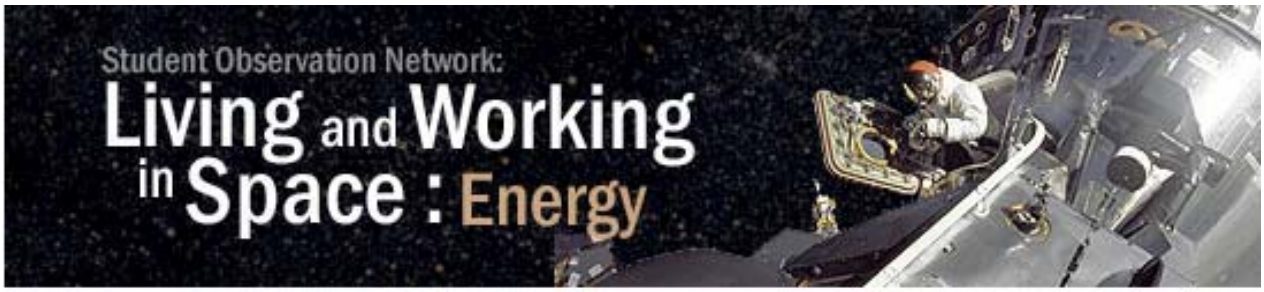
Challenge

Propose a design using solar panels that will supply the energy requirements for a research habitat on the Moon or on Mars. Assume there will be a research crew of six humans and current technology will be used for solar panels.

Overview

You will need background knowledge to design a good solar energy system for exploration of the Moon or Mars. These investigations and activities will help you learn what you need to know.

1. Investigating Solar Cells
   You will learn about solar cells and what variables affect their operation.
2. Electricity and Power
   You will learn about electricity, circuits, and power and use this knowledge to solve a problem on the ISS.
3. Solar Power for Your Home
   You will analyze the power requirements for your home and propose a design that will use solar panels to supply all of your needs.
4. Challenge: Solar Energy for Moon and Mars
   Choose either the Moon or Mars as the location for your research habitat. From what you know about your home power requirements and the power requirements for ISS, estimate the requirements for your research habitat. Then, propose a design for a solar energy system to meet the energy requirements.

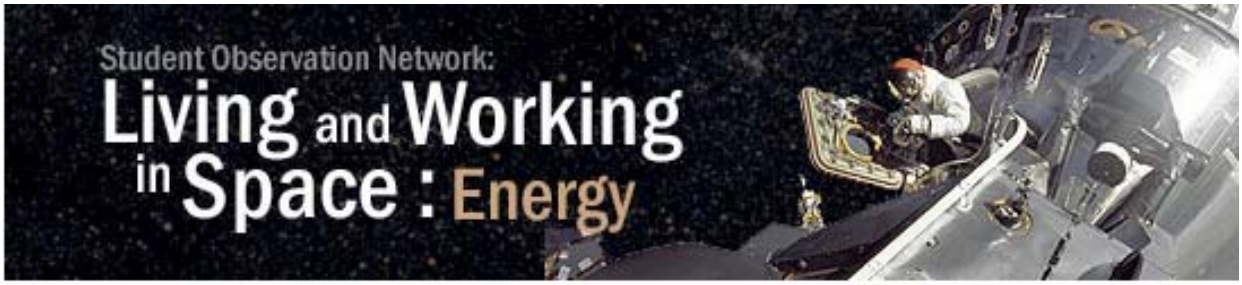


Activity 1. Investigating Solar Cells: Journal Assignment

The Sun radiates, or sends out as light, an enormous amount of energy. The Sun radiates more energy in one second than people have ever used. Only a small part of the radiant energy produced by the Sun strikes the Earth. Yet, every day enough solar energy strikes the United States to supply the energy needs of the United States for about one and a half years. Much of the energy is reflected back into space, evaporates water, or is absorbed by plants, land and water. This still leaves enough to supply our energy needs. Some solar energy is used to heat water, homes, or other buildings. Solar cells can change solar energy into electrical energy.

Answer the following question in your journal as completely as you can. Your entry will be evaluated on the thoughtfulness of your answers and the reasoning you give in support of your answer.

What factors (variables) might affect how much electrical energy a solar cell could produce?



Activity 1. Investigating Solar Cells: Investigation A

Will different colors of light affect how much electrical energy a solar cell will produce?

Purpose

This investigation will allow you to explore one of the variables that might affect how much energy a solar cell can produce. A solar cell will provide energy for a small electric motor to do work. The motor will turn a disk. More energy will make the motor and the disk turn faster. By covering the solar cell with different colored transparent films, you can test whether one color of light provides more energy to the solar cell.

Materials per Group of Students

1. solar cell
2. small electric motor
3. 10-inch pie round (25.4 cm stiff cardboard disk
4. plastic wheel that will fit over axle of motor
5. glue
6. black marking pen
7. stopwatch
8. black construction paper
9. red, green, and blue transparency film
10. electrical wire to connect solar cell and motor

Procedure

1. Attach the plastic wheel to the shaft of the motor.
2. Make a small dot on the edge of the cardboard disk.
3. Glue the cardboard circle to the wheel so that it will rotate when the motor is turning.
4. Attach the solar cell to the motor. Follow the teacher's instructions.
5. Place the solar cell and motor in bright sunlight. The motor should cause the cardboard disk to spin. If no spinning occurs, check the connections.
6. Watch the dot on the cardboard disk. Start the stopwatch as the dot gets to the top. Count the number of times the cardboard disk spins in 15 seconds. Multiply this number by four to get the number of revolutions per minute. Record this information.
7. Using the piece of black construction paper, cover half of the solar cell. Repeat Step 6.
8. Cover approximately one-fourth of the solar cell with the construction paper. Repeat Step 6.
9. Cover the solar cell with one piece of the red transparency film. Repeat Step 6, and record the data.
10. Repeat Step 9 with each of the different colors of transparency film.

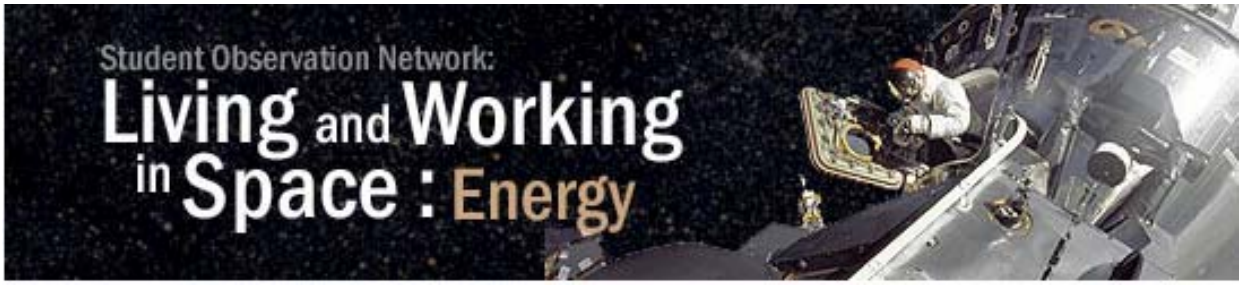
Questions

1. What happened when you covered part of the solar cell with black paper? Why?

2. What is the relationship between the amount of solar cell that is covered and the speed at which the disk turned? Explain.

3. How is the speed of the disk related to the energy provided by the solar cell?

4. How did the colored transparencies affect the solar cells ability to function?



Activity 1. Investigating Solar Cells: Investigation B

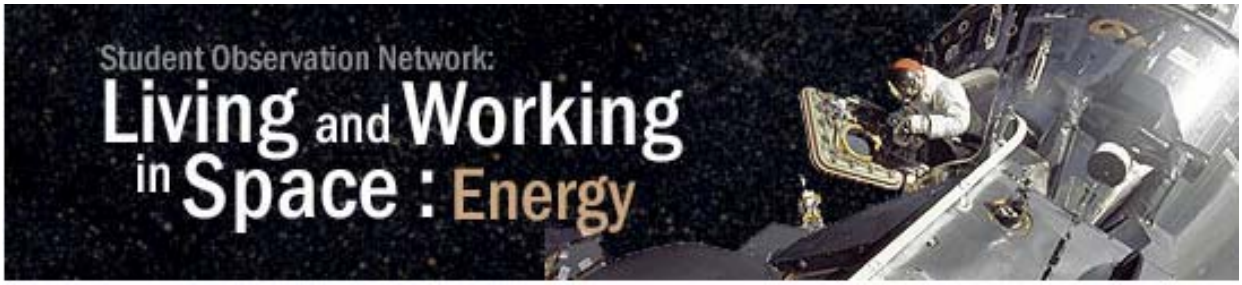
How do other variables affect how much electrical energy a solar cell will produce? Design your own experiments to investigate as many variables as you can.

Purpose

These experiments will help you to understand how design the most effective solar panel system.

Procedure

1. Create a list of three to five variables that might affect how much electrical energy a solar cell will produce.
2. Design an experimental procedure to test each variable. If you have three variables, you will have three different procedures.
3. Perform each experiment and record the data.
4. Make a conclusion about what variables affect solar cells.

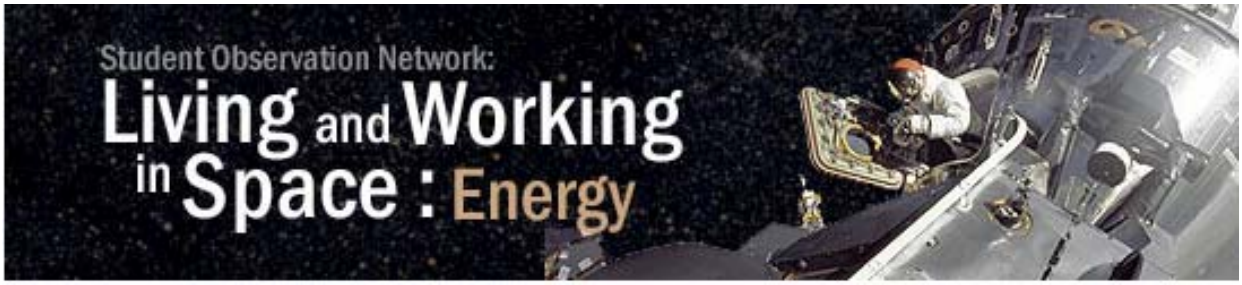


Activity 2. Electricity and Power

Through computer simulations and laboratory work with electricity, you will learn about electricity, circuits, and power and apply this knowledge to solve a problem on the ISS.

Procedure

Go to Web site *Electricity and Power in Space* http://iss.cet.edu/electricity/default.xml and follow directions.



Activity 3. Solar Power for Your Home

Analyze the power requirements for your home and propose a design that will use solar panels to supply all of your needs.

Background

The ultimate goal for the "Solar Energy for Space Exploration" activity is to propose a design for a solar energy system that will provide energy for a research habitat for six researchers on the Moon or Mars. But it is easier to start with an environment you know. Designing a solar energy system for your home lets you start with an environment you know well.

Many Earth-bound applications of solar cells use a dual source of electrical energy. Most homes get electrical energy from the local power grid. The local power grid gets its electrical energy from coal burning, hydroelectric, or nuclear power plants. Most solar homes receive electricity from the solar panels and are connected to the local power grid. When the solar panels are producing more energy than a home can use, the excess is 'pumped out' to the grid and the homeowner receives credit. When the home cannot get enough electrical power from the solar panels (at night or during cloudy periods), the local power grid supplies what is needed.

For this challenge you are required to provide all of the energy from the solar panels. This is to prepare you for the problems of a design for a lunar or Martian research habitat. NASA will not be able to provide a local power grid on the Moon or Mars for a long time.

Procedure

This problem requires creative problem solving. There are no definite procedures, but there are some guidelines you may find helpful:

- Find out what you already *know*.
- Think and talk about in your design groups what you *want* to learn.
- Do research and record what you *learn* so you can use it in your design.

The following questions may be helpful in guiding you.

- What are the power requirements for your home?
- Are the power requirements constant, or do they vary during the day and during the year?
- How much solar energy is available where your home is?
- Does the amount of available solar energy change during the day and during the year?
- What can you do if your solar panels produce more energy than your home requires?
- What happens if your solar panels don't provide enough energy for short periods?

Resources

Surface Meteorology and Solar Energy (http://eosweb.larc.nasa.gov/sse/)
This NASA site will provides you with information about the amount of solar energy available throughout the year where you live.

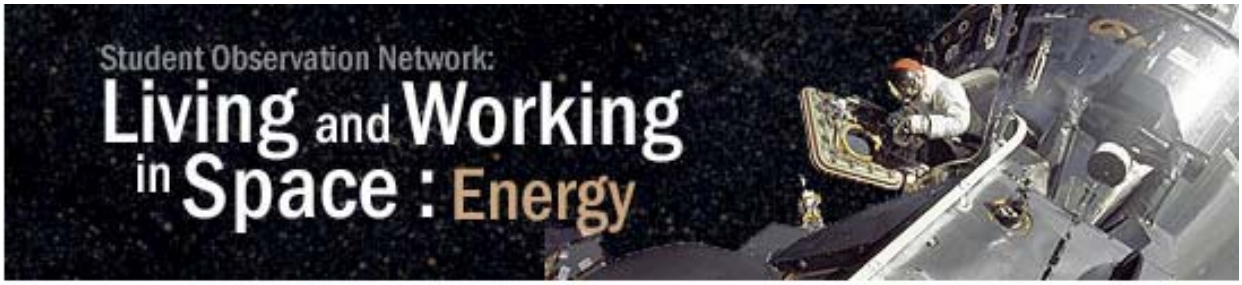
1. Click on Meteorology and Solar Energy.
2. Get data tables for a particular location either by selecting '"Click on a desired map location"' or by "Enter latitude and longitude."
3. Register by using your e-mail address and a password. This login is secure, and registration will not lead to unwanted e-mails.
4. If you chose to find your location with a map, click on the image of the globe to re-center near your location and choose zoom levels. You will probably have to re-center and zoom a few times. If you chose to use latitude and longitude, type in the correct values.
5. When you select a location, you will get options for data. Until you know what you need, click Submit. This will give you all of the data.

Additional Internet Resources

Solar Energy Technologies Program
http://www1.eere.energy.gov/solar/photovoltaics.html

Roofus' Solar and Efficient Home
http://www1.eere.energy.gov/kids/roofus/index.html

Solar Power Basics
http://www.solarelectricpower.org/index.php?page=basics&subpage=pv&display=



Activity 4. Final Problem: Solar Energy for Moon or Mars

Choose either the Moon or Mars as the location for your research habitat. From what you know about your home power requirements and the power requirements for the ISS, estimate the requirements for your research habitat. Then, propose a design for a solar energy system to meet the energy requirements.

First, find out about solar power and ISS. Find out how the power requirements of the ISS are met.

Background

The ISS is like a home—only it is isolated in space 330 to 390 kilometers above the Earth. It has electric appliances. Some of those appliances need to stay on. Some of the appliances can and should be turned off when the astronauts leave the room. The following resources will help you to understand how ISS gets the energy necessary to run all of the equipment and experiments and how much power the equipment needs. This information will help you to plan the research habitats for the Moon or Mars.

Procedure

Designing a solar energy system for the Moon or Mars requires creative problem solving. There are no definite procedures, but there are some guidelines you may find helpful:

- Find out what you already *know*.
- Think and talk about in your design groups what you *want* to learn.
- Do research and record what you *learn* so you can use it in your design.

The following questions may be helpful in guiding you:

- What are the power requirements for your home?
- What are the power requirements for ISS?
- How might the power requirements for six researchers for an extended period of time be different?
- Are the power requirements constant, or do they vary during the day and during the year?
- How much solar energy is available where your research habitat is?
- Does the amount of available solar energy change during the day and during the year?
- What can you do if your solar panels produce more energy than your research habitat requires?
- What happens if your solar panels don't provide enough energy for short periods?

Resources

(Your teacher will give you printed copies of # 1, 2, and 4. You can link to the Web resources directly.) Read and interpret the information carefully. Decide what is important to the problem you have to solve.

1. **Interview with a PHALCON**
   Steven Johnson works in ISS Mission Control at Johnson Space Center in Houston, Texas. In this interview he discusses some important solar panel issues
2. **Solar Arrays for the International Space Station**
   This short article shows pictures of solar cells, solar panels, and solar arrays and gives some basic information about the size and number.
3. **Power to the Station** (http://liftoff.msfc.nasa.gov/news/2001/news-stationpower.asp)
4. **Model Space Station – Power Loads and Assembly Sequence**
   Find out the energy requirements for a model space station. This is a simplified version of the ISS.
5. **The Inconstant Sun** http://science.nasa.gov/headlines/y2003/17jan_solcon.htm
   How much energy does the Sun provide? The Sun's intensity decreases as its energy spreads as it travels to Earth. The amount of energy at the outer atmosphere of Earth is called the solar constant, but it isn't totally constant.
6. **Measuring Solar Radiation** http://son.nasa.gov/lawis/energy/problem/solar_constant.pdf
   This article discusses the solar constant and one mission to measure the changes in the solar constant.

Design Solution to Problem

Now you should have enough information to design the solar energy system for a research station on the Moon or Mars. You will have to make some assumptions. What do you think those assumptions are? Make certain that your assumptions are clearly stated and reasonable considering what you know. Your solution will be evaluated on careful thinking, clear presentation, and support of your solution with evidence. Your teacher will give you requirements about the type of presentation you need to make.