Argonne National Lab's
Sustainability Workshop
Activity Lesson Plans
http://teachers.anl.gov/lesson_plans

Argonne National Laboratory's

Mission
Argonne integrates world-class science, engineering, and user facilities to deliver innovative research and technologies. We create new knowledge that addresses the scientific and societal needs of our nation.

Vision
We will lead the world in providing scientific and engineering solutions to the grand challenges of our time: sustainable energy, a healthy environment, and a secure nation.

Sustainability is paramount to the work of the Laboratory. As a natural segway to educational outreach, the Sustainability Workshop for Middle School Teachers was conceived, designed and implemented. The goals of this workshop included knowledge and awareness of alternative energy technologies, their advantages and limitations; the key issues and impacts of technologies related to climate change; to extend the resources of sustainability and encourage energy literacy. The teachers were asked to synthesize their experiences and knowledge gained into a useable lesson plan. The plans presented in this unit are a compilation of those lessons.

Solar Cookers

Background information*:*
Solar cookers, also called solar ovens, use the sun's energy to heat food in order to cook it. Although there are many types of solar cookers, they all follow these basic principles:

1) concentrate the sunlight to increase the heating power
2) convert light energy to heat energy
3) trap the heat in a confined space
4) greenhouse effect lets visible light escape, but keeps the thermal radiation from escaping, thereby increasing the trapping effect

Grade level: Middle School

Goals/Objectives: Students will
• explain how technology can be used improve the human condition

• show that solar energy can be easily collected and converted to heat energy
• apply their knowledge of light, energy conversions and transfers to the design challenge
• use experimental and technological design to construct a working solar cooker
• integrate their own (and shared) data to drive design decisions and improvements to a solar cooker
• compare and evaluate the effectiveness of the constructed solar cookers

Activity Description:
Most solar cooker design labs are open-ended, allowing students to choose from many types of cookers and materials. This allows for maximum creativity, but not for a controlled comparison of results as it is difficult to establish and test variables and maintain controls with such a variety of products. In this lesson, students design and construct a solar cooker based upon their shared results as they test variables the class has identified. By limiting the type of solar cooker and allowing for flexibility in the design materials for the preliminary testing phase, the shared data from the preliminary testing will lead to better decisions about what factors increase the amount of heat generated by that solar cooker. The students will be constructing the Copenhagen Solar Cooker invented by Sharon Claussen. (see resources).

Teaching Strategies or Methodology:
Whole group discussion, small group discussion and activity, computer model testing, designing, guided inquiry, measuring, experimental testing, data collection and analysis, sketching, comparing, redesigning, retesting, communication, descriptive and scientific writing.

Materials and Resources Needed:
Reflective placemats (such as those available at Ikea)
Cardboard
Mylar
Aluminum foil
Poster board
Newspaper
Insulators, such as: cotton balls, wool fabric, pine needles, grass, straw
Twist ties
Paper clips
String
Glue
Tape
Hot glue gun
Cutting tools
Cups in a variety of colors, material and sizes (though have several of each)

Thermometers
Timer or stopwatch
Water
Marshmallows
Teacher-made model of a completed solar oven

NOVA Saved by the Sun, Interactive
(http://www.pbs.org/wgbh/nova/education/activities/3406_solar.html)

Teacher's Domain Solar Cooker Activity and Interactive
(http://www.pspb.org/e21/media/SolarCooker.html)

Copenhagen Model Solar Cooker Instructions
http://solarcooking.wikia.com/wiki/Copenhagen_Solar_Cooker_Light

Time Needed: 3-6 class sessions

Procedure:
Introduction of Lesson: 30 minutes
1. Establish the purpose: Why in the 21st century do we even need solar cookers?
Pose and discuss this question after displaying images of technological advances of the modern age. (for example: DNA model, satellite, microwave oven, computer).

2. Read and discuss the following quote from World Health Organization establishing the need for sanitation via heating of food and water in many countries of the world. *"The World Health Organization reports that in 23 countries 10% of deaths are due to just two environmental risk factors: unsafe water, including poor sanitation and hygiene from indoor air pollution due to solid fuel use for cooking."*
http://solarcooking.wikia.com/wiki/Solar_Cookers_World_Network_%28Home%29
Also, Solar Cookers International (a non for profit organization) explains why people use solar cookers: http://www.solarcookers.org/basics/why.html and where they are most useful: http://www.solarcookers.org/basics/where.html.

3. Share a photo showing refugee camp in Chad in which refugees use wood as fuel, and discuss the ecological and health problems that result. For example, http://www.wfp.org/photos/somali-woman-cooking-for-family-worlds-largest-refugee-camp or http://anneholmes.photoshelter.com/image/I0000uZhEQd1p54o

4. Share with the students a variety of solar cookers types, and identify similarities and differences in how they work. For example, Solar Cookers

International has sample pictures and descriptions of cookers along with an explanation of how each solar cookers workshttp://www.solarcookers.org/basics/how.html

5. Distribute Student Handout – *Got Sun? Get Cooking!* – and discuss their design challenge. http://www.pbs.org/wgbh/nova/education/activities/3406_solar.html Encourage students to explore virtual solar cookers for homework at http://www.pspb.org/e21/media/SolarCooker.html

Construct and Test Solar Cookers: 2-5 classes
Part One – Build and Test Solar ovens with one variable changed

1. Explain the solar panel challenge and show students the materials available. Allow time for the students to discus the project. Demonstrate to the students the teacher made solar cooker model the students will be exploring.

2. Brainstorm a list of variables to be investigated by the class, and identify the controls. Plan how to best distribute the test variables between groups or even between classes. (Examples of variables to test include size/area of reflective surface, amount (mass or volume) of food being cooked, smoothness of surface, type of cooker material, cooking container color, type of insulation, angle of sunlight, height of solar oven, amount of time, weather conditions, month of year).

3. Preliminary Variable Testing: Explain that their first design will be to determine how **one** variable affects temperature of solar cooker, each group will share this data and their graphs with the class. Allow the students to figure out how to measure the temperatures reached by the solar cooker. If preferred, provide some instruction on how to collect temperature data, ask students to make a data table. You may want to set up a control group of simply a container of water with a thermometer in it. (It's temperature should increase only a degree or two.) Once all teams have had an opportunity to test their cookers, allow students to view each others' designs. Have students share the collected data for each cooker and analyze the success of each cooker variable. After this analysis, have the students use the information to improve their designs.

Part Two – Design, draw and build second solar oven with additional modifications
4. Final Design: For the second design, require a diagram or sketch. Students may change one or more variables to construct the most effective solar cooker. They will complete questions on the student handout and will write a reflection summary describing how data from the first design and their class data guided their second design.

Closure, Sharing, and Reflection: 20 - 40 minutes
Part Three – Reflect, share and debrief.
5. Students will discuss and compare each team's final design and results. If allowed, the students may use their solar cookers to roast marshmallows..

Assessment:
Use a teacher-created rubric as a summative assessment for: the thoroughness of the students' designs, involvement in discussions, cooperative teamwork, safety behavior, quality of experimental data, graphs, re-design improvements, and written responses to questions. Be sure to include the students' explanations of how they used data to refine their first design and improve on it. Students with special needs may use diagrams with labels and sentences, or oral explanations to support design modifications rather than longer written summaries. The assessment information can inform teacher instruction for the following school year.

To assess student ability to transfer what they have learned, the teacher may want to ask questions such as the following (from Teacher's Domain): What are the limitations of using a solar cooker? Describe how they may be overcome. Using what you learned, what exterior and interior colors and materials would you want in a car if you lived in a hot sunny climate? What colors and materials would you pick if you lived in a cold sunny climate? How might you use the principles of solar radiation in other parts of your life or home?

Extensions and Resources:
The lesson may be extended by allowing students to use **any** recycled materials found around the house, in addition to materials provided at school. Students may also be encouraged to research and build a different type of solar cooker. A deeper exploration of the design constraints of cost, durability and portability could be added to the design challenge. A good template for thoroughly testing the variables of a box solar cooker can be found at Teacher's Domain here http://www.pspb.org/e21/media/Solar_Cooking_v105_SH.pdf

Solar Cooker Design Challenge movie
http://www.youtube.com/watch?v=zVOHmyy06g0

NASA's Solar Oven Activity
http://www.nasa.gov/pdf/544871main_E3_SolarOven_C4.pdf

NOVA's Solar Oven Activity (companion to Saved by the Sun video)
http://www.pbs.org/wgbh/nova/teachers/activities/3406_solar.html

Teacher's Domain Solar Cooker Interactive
http://www.pspb.org/e21/media/SolarCooker.html

Teacher's Domain Solar Cooker Handout
http://www.pspb.org/e21/media/Solar_Cooking_v105_SH.pdf

Penn State Public Broadcasting, teacher resource page
www.teachersdomain.org/asset/psu06-e21_doc_solarcooking-teacher

Teach Engineering Cooking With the Sun Activity
http://www.teachengineering.org/view_activity.php?url=collection/duk_/activities/duk_solaroven_tech_act/duk_solaroven_tech_act.xml

Solar Energy Background Info and Readings for Students
http://www.re-energy.ca/docs/solar-heat-bg.pdf

Solar Cooker Plans
http://www.solarcooking.org/plans/

Why Build Solar Cookers? NGOs, cooking for Peace - see July 2012 video
http://solarcooking.wikia.com/wiki/Solar_Cookers_World_Network_%28Home%29

Principles of Solar Cooker Design
mailto:?body=http://laboutloud.com/2012/03/episode-76-not-another-lab-report/