STEM SQUAD

# Solar Cooker

The mission of the Engineers Without Borders organization (EWB-USA) is to design and implement sustainable engineering projects to meet basic human needs. To support that goal, you have been tasked with designing a solar cooker that uses energy from the sun for “fuel,” effectively costing nothing to operate.

## DESIGN REQUIREMENTS

- Placement profile: 1 cubic meter
- Ability to load and retrieve food easily
- Construction materials should not emit any noxious fumes when heated

## TESTING EQUIPMENT

- Vernier Interface
- Stainless Steel Temperature Probe
- UVA/UVB Sensor

## DELIVERABLES

- Prototype
- Detailed design specifications (so the unit can be replicated exactly)
- Daytime temperature and UVA/UVB log (8 hours)
- Maintenance requirements
- Projected cooking time
- Impact statement on the benefit of your design to the environment

## CONSTRAINTS

- Construction materials must be readily available (recycled materials are encouraged)
- Budget limited to $5

## JUDGING CRITERIA

- Maximum cooking temperature
- Heat retention
- Ease of construction
- Ease of operation
- Placement profile (size; location)
- Method of storage
- Durability
- Aesthetics
- Material availability
- Cost

# Teacher Tips

## OBJECTIVE

Students will design and build a container for cooking with energy from the sun.

## BACKGROUND

Solar cookers convert sunlight into heat energy. They are a low-cost, pollution-free method of food preparation. Under normal conditions, solar cookers can reach temperatures between 80–120°C (175–250°F). Since food cooks at around 80–90°C (175–195°F), solar cookers are hot enough to fully cook food, but not to burn it or dry it out. Food preparation just takes longer than using a conventional oven.

There are three common types of solar cookers: box, panel, and curved concentrator. *Box cookers* have transparent tops for sunlight penetration, dark bottoms for heat absorption, and reflective sides to reflect the heat back toward the cooking pot. They can accommodate multiple pots and typically reach temperatures around 70–135°C (160–275°F). *Panel cookers* are built from a series of reflective panels arranged in an open profile in such a way as to direct sunlight onto a dark cooking pot. Instead of covering the entire device with a transparent top to retain heat, the cooking pot is typically placed under an inverted glass bowl or sealed in a clear, heat-resistant cooking bag. Panel cookers are the simplest and cheapest to make, but their temperature range is the lowest of the three designs. A *curved concentrator* is built from a 360° parabolic reflector with the food placed at the focal point of the parabola. Curved concentrators can achieve very high temperatures, but they are difficult to construct, require frequent repositioning to keep the food at the focal point, and can cause serious eye damage from misdirected reflections.

Students should consider four major factors during the design process:

- Sunlight concentration–A shiny, reflective surface concentrates the sun's light into the cooking area. The more concentrated the energy, the better the heating capability.
- Heat absorption–A dark surface on the bottom of a box cooker and/or the placement of food inside a dark pot improves the conversion of sunlight into heat.
- Insulation–A sealed cooker reduces convection losses to cooler outside air, especially on windy days. Dark, tight-fitting lids on cooking pots help retain heat and moisture.
- Transmissivity–A sheet of glass or plastic wrap across the top of the cooker allows the transmission of visible light, and traps infrared thermal radiation from heated surfaces.

## TEACHER PROCEDURE

1. Instruct the class on the purpose of a solar cooker. Students should be able to discuss the benefits of using the sun as an alternative energy source.

2. Conduct preliminary tests using the UVA or UVB sensor to determine the angle of the sun for optimum solar energy. (**Note**: This value will vary depending on the season of the year.)

3. Have students design and build a solar cooker.

4. Create a preliminary temperature profile with the solar cooker for one 8-hour day.

5. **Optional**: Allow students additional time to make modifications to their original designs based on UV and temperature data.

6. Collect a second temperature profile for an 8-hour day.

7. Have students make predictions as to the time of day and amount of time required to cook an item of food you specify, and then proceed with cooking the food item.

## TIME ALLOTMENT

This project is moderately long, requiring 3–7 class periods.

As a minimum, this activity requires one class period to create a UV profile, one to two days to design and build the solar cooker, and one day to collect temperature data. If you are short on time, students can cook their food items simultaneously while collecting temperature data, however they will have anomalies in their temperature profiles whenever they open their solar cookers to add or retrieve food. Ideally, you should give students the opportunity to rework their designs based on initial data results (two to three additional class periods). This is an excellent learning example that things do not always operate as you expect.

## CONSTRUCTION TIPS

The quality of construction has a significant impact on the effectiveness of a solar cooker. If students are using aluminum foil sheets, they should be sure to use the shiny side and affix it to the cooker with a minimum of wrinkling. All leaks should be sealed to aid in heat retention. A rigid glass cover allows greater sun penetration than a flexible cover of plastic wrap. To speed cooking, the food container should be slightly elevated above the bottom of the cooker.

Be aware that the recommended safe operating range for the Stainless Steel Temperature Probe is -40°–135°C (-40°F–275°F). The maximum temperature the sensor can tolerate without damage is 150°C (300°F). If your solar cooker is generating temperatures outside this range, you should substitute the Vernier Wide-Range Temperature Probe or the Thermocouple for data collection.

## PERFORMANCE

The foods you choose to cook will somewhat affect your success. Marshmallows and hot dogs work very well, because they can be threaded onto a wooden skewer for suspension within the cooker. Rice is also good, because students will notice a definite change in the structure of the grains as they expand. Be aware that foods will take longer to cook due to the lower temperatures in a solar cooker. Foods will also cook better at noon when the sun is high in the sky than later in the afternoon when the sun is lower. The most intense cooking will occur between 10:00 am and 2:00 pm.

There are several factors that will affect the cooking time of your solar cooker:

- time of year and day
- amount of sun and wind
- latitude
- color and thickness of cooking pot (darker and thinner is better)
- quantity and size of food (smaller is better)
- amount of water (less is better)

Theoretically, if the solar cooker is well insulated, it should work equally well on a cold, sunny day as a hot, sunny day. However, the angle of the sun in winter is significantly lower than in summer requiring that the cookers be tipped at a fairly large angle to maximize solar radiation. No matter the season, you must have a cloudless, sunny day for best results.

## RESOURCES

- http://solarcooking.org/plans/
- http://en.wikipedia.org/wiki/Solar_cooker
- http://www.builditsolar.com/Projects/Cooking/cooking.htm
- http://solarcooking.wikia.com/wiki/Category:Solar_cooker_plans