

# Lesson Plan: Ovens Using Solar Energy

By Kim Castagna and Jennifer Foster

**Target Grade:** Middle School

**Teacher Prep Time:** 20 minutes

**Lesson Time:** 150 minutes

## Learning Goals:

- Students will design, create a procedural plan, and test the efficiency of a solar oven. Students will then analyze data to determine the similarities and differences among oven designs to create a new oven procedure.

## NGSS:

- **MS-PS3-3** Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.\*
- **MS-ETS1-3** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- **Science and Engineering Practices**
  - Planning and carrying out investigations
    - Planning and carrying out investigations in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions.
      - Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how much data are needed to support a claim.
- **Disciplinary Core Ideas**
  - PS3.A: Definition of Energy
    - Temperature is measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present.
  - PS3.B: Conservation of Energy and Energy Transfer
    - Energy is spontaneously transferred out of hotter regions or objects and into colder ones
  - ETS1.B: Developing Possible Solutions
    - A solution needs to be tested and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem.

- **Cross Cutting Concepts**
  - **Energy and Matter**
    - The transfer of energy can be tracked as energy flows through a designed or natural system.

**Where this lesson fits in:**

- This lesson provides a great ending activity to performance expectation MS-PS3-3 and MS-ETS1-3. During the activity students build solar ovens to capture the energy from the sun to melt their s'mores. In addition, students record the beginning and ending temperatures from inside their ovens and a control placed outside the oven. Students then compare the similarities and differences of the class ovens to design the optimal oven.
- Before this activity students should have learned about the transfers/transformations of energy, specifically solar radiation.

**Materials Needed:**

- Post-its
- Various sizes of boxes
- Aluminum foil
- Black construction paper
- Plastic wrap
- Tape
- Graham crackers
- Ziploc baggies
- Masking tape
- Thermometers that go above 120 °F
- Hershey's chocolate bars (small size)
- Large marshmallows
- Permanent marker
- UV Color Changing Nail Polish (optional – purchased from Educational Innovations, Inc. [www.TeacherSource.com](http://www.TeacherSource.com) \$6.95/bottle)

**Teacher Prep:**

- Place each of the materials (black paper, tape, aluminum foil, plastic wrap) in different containers centrally on a table.
- Set out 4 Baggies, 1 roll of masking tape, 4 marshmallows, 1 permanent marker, 2 thermometers, and 4 whole graham crackers per group of 4 students.
- Copy students worksheets *Solar Energy* and *Solar Oven Recording Sheet* (one per student)
- Copy student worksheet *Solar Oven Procedure* (one per group)
- Make sample solar oven.

## Lesson Sequence

20 minutes	<b>Beginning Thoughts</b> <ul style="list-style-type: none"><li>• Have students seated in groups of 4.</li><li>• Pass out <i>Solar Energy</i> lab sheet to each student.</li><li>• Read the introduction on detecting ultraviolet radiation together.</li><li>• Walk around and put nail polish on each child's thumbnail</li><li>• Ask students to record the color of the polish in the classroom</li><li>• Have students cover their thumbnail with their other hand, and walk outside into the sunshine.</li><li>• On the count of 3, have students remove the cover, and expose their thumbnail to the sun and notice any differences.</li><li>• Ask students what this means about the sunlight (has ultraviolet rays).</li><li>• Return to class, record the color, and answer question #4 and #5.</li><li>• Together, read the Bizarro cartoon and discuss with partners what it means. Students then record their answer on #6 in their own paper</li><li>• Tell students they will now design and build a solar oven to use these ultraviolet rays to raise the temperature inside to "cook" a s'more.</li></ul>
60 minutes	<b>Oven Lab</b> <ul style="list-style-type: none"><li>• Show students each of the materials that they will have access to and ask them why the materials might be useful.<ul style="list-style-type: none"><li>○ Aluminum foil</li><li>○ Black construction paper</li><li>○ Clear plastic wrap</li><li>○ Tape</li></ul></li><li>• Pass out one of the <i>Solar Oven Procedure</i> sheet to all groups. Assign each group a number.</li><li>• Tell students that they will get 40 minutes to design a solar oven and to write their step-by-step procedures for building their solar oven on the "Solar Oven Procedure" sheet. The teacher must approve each group's procedures before the group may receive their materials.</li><li>• Using their box and materials available, students will build their ovens.</li><li>• As the group builds, one student needs to edit the group procedure in colored pencil on <i>Solar Oven Procedure</i> sheet if any changes are made. (Note: The teacher should either model this to the class and/or walk around the room as the class is building to make sure this occurs. Students do not always understand that they must record any slight changes to their procedure.)</li><li>• Once the ovens are constructed, pass out the <i>Solar Oven Recording Sheet</i>.</li><li>• Have students do a gallery walk to make observations of each solar oven design. Observations in first 3 columns include:<ul style="list-style-type: none"><li>a) Draw Oven Design</li><li>b) Describe Features</li><li>c) Predict Ranking of oven temperature from greatest to least.</li></ul></li><li>• As a class, have the students complete the first 2 columns on the <i>Solar Oven Recording Sheet</i> for the sample oven.</li><li>• Then, have a gallery walk to complete the first 2 columns "Draw Oven Design" and "Describe Features" for all the class ovens before going outside. (If you choose, this can be completed outside as the students are cooking their s'mores.) (See example student work. )</li></ul>

10 minutes	<p><b>Building S'mores</b></p> <ul style="list-style-type: none"> <li>• Each student gets a baggie, large marshmallow, small chocolate bar and a whole graham cracker</li> <li>• Write name on baggie with permanent marker.</li> <li>• Build s'more, place in baggie, and close it.</li> <li>• Place all 4 s'mores inside the solar oven</li> </ul>
15 minutes	<p><b>Outside Testing</b></p> <ul style="list-style-type: none"> <li>• Have students record the beginning temperature of each thermometer on their recording sheet.</li> <li>• Go outside and place 1 thermometer on the ground as a control and 1 thermometer inside the solar oven with the s'more Baggies.</li> <li>• Let the s'more "cook" for 10 minutes.</li> <li>• Once the students have completed the first 2 columns on the <i>Solar Oven Recording Sheet</i> for all the ovens, students should complete the "Predict Ranking" column as their s'mores are cooking in their oven.</li> <li>• Record ending temperature for inside-oven and outside thermometer on the cement for all groups.</li> </ul>
20 minutes	<p><b>Comparing Oven Designs</b></p> <ul style="list-style-type: none"> <li>• Once inside the classroom finish recording temperatures for all groups on lab sheet.</li> <li>• Have student groups, record their final temperature for inside-oven on a post-it and attach it to the oven in plain sight.</li> <li>• Repeat the gallery walk to view each oven and complete the recordings of the last 3 columns on the recording sheet <ul style="list-style-type: none"> <li>a) Highest Temperature</li> <li>b) Final Ranking of oven temperature from greatest to least</li> <li>c) Listing of best characteristics of each oven design</li> </ul> </li> <li>• On the bottom of the <i>Solar Oven Recording Sheet</i>, students describe the similarities of the top 3 ranking ovens.</li> <li>• On the bottom of the <i>Solar Oven Recording Sheet</i>, students describe the differences of the top 3 ranked ovens and the lowest ranked ovens.</li> <li>• Once the <i>Solar Oven Recording Sheet</i> is completed, students may eat their cooked s'more.</li> </ul>
25 minutes	<p><b>Conclusion</b></p> <ul style="list-style-type: none"> <li>• Now, based upon the similarities and differences noticed, students need to write new procedures to design a new, more efficient solar oven.</li> <li>• Then, students should draw their new design incorporating the best design ideas you noticed.</li> <li>• Students need to make sure to label and describe any new changes made from their original design.</li> <li>• Students all need to label all energy transfers/transformations on their diagram.</li> </ul>