CLEAN ENERGY BRIGHT FUTURES
A Program of BEF

LESSON PLAN

Solar Updraft Towers: Innovations in Renewable Energy

Lesson 4: Let's Build Our Wind and Solar Energy Toy

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DESCRIPTION
Students will combine what they learned in previous lessons using their investigations of convection-related phenomena to design a device that will convert light energy from the sun into thermal energy and utilize the resulting convection currents. Their primary objective will be to design a device that uses energy from the sun when placed on a sidewalk to spin a turbine similar to the one they designed for their Firefly in the previous lesson.

GRADE LEVEL(S)
3, 4, 5, 6, 7, 8

SUBJECT AREA(S)
Wind Energy, Engineering Design, Solar Updraft Tower, Solar Energy, Energy Transformations

ACTIVITY LENGTH
3 hours

LEARNING GOAL(S)

1. Students will determine that thermal energy resulting from the sun's radiation can create an updraft that will power a turbine to spin.
2. Students will identify characteristics of turbine design that improve the success of their device.
3. Students will utilize content from previous phenomena they investigated, such as the chimney stack effect and Norwegian candle toys, to determine how to best harness the energy transformed by their device from the sun.

STANDARDS REMINDERS

- Before beginning the process of having students build solar updraft towers, it is useful to have them go back and take note of the various types of energy transformations that occurred in the phenomena they observed toward the beginning of the unit. In this process, they can later identify which energy transformations will be useful in the construction of a solar updraft tower.
- When explaining the challenge to them and providing materials, work with students to determine what the criteria for success is and what the constraints will be. The latter is largely determined by the materials provided, but you can also have students come up with new constraints to add to the challenge e.g. limiting height..

CONTENT BACKGROUND

STUDENT BACKGROUND

Students should be familiar with the following:

- Energy and matter-related content from previously observed phenomena, such as the nature of convection currents, absorption rate as determined by color, and the chimney stack effect.
- Basis for how wind turbines work and how to best harness the movement of air by manipulating variables such as pitch, blade size, material used, etc.
- Basics of the engineering design cycle, and how to move back and forth between different stages of the engineering design cycle.

EDUCATOR BACKGROUND

Educators leading this lesson should be familiar with the following:

- The chimney stacking effect and the way updrafts behave.
- This experiment works best when teachers have not explained what a solar updraft tower is to their students and don't show them any pictures of one until after this engineering activity. This will deepen their learning and create a significantly richer engineering design experience if they work a design out on their own, through trial and error.
- The tin can tubes will give away some information about an idea how to build the structure. Encourage students to use the materials any way they want to demonstrate a working device when placed outside in the sun. They will need to figure out on their own that the device requires an entrance for air at the base and an exit at the top in order to have a self-sustained draft, as in the chimney stack effect.

MATERIALS NEEDED

HANDOUTS/PAPER MATERIALS

- Worksheet 6-Solar Updraft Engineering Design

CLASSROOM SUPPLIES (ENGINEERING TABLE)

- Tin cans with tops and bottoms cut out (cut ahead of time for safety)
- Tall plastic or paper cups
- Paper: black, white, and colored
- Foil pieces
- Plain paper for turbines
- Paper clips
- Sharp, Pointy Things: thumbtacks and needles
- Tape
- Small metal caps for the pin to spin in.
- 250W halogen work lights are a good sun model

ACTIVITY SUPPLIES (ENOUGH FOR INDIVIDUALS OR GROUPS OF 2-3)

- (1) Bamboo stick
- (1) Small ball of modeling clay

LESSON PROGRESSION

PLANNING AND PREP

The only prep necessary is getting your engineering table (or tables) of supplies organized and to cut out the tops and bottoms of tin cans available to students on the engineering table.

LESSON SEQUENCE

1. Conduct a discussion of what they learned about the 6 demonstrations they experienced in lesson 2. Have students review the chart that they put together in the second lesson and discuss the function of convection currents and the chimney stack effect in particular.
2. Reveal table of supplies to students. This may be a good opportunity to discuss why certain colors may have been chosen and other variables that they can be thinking about manipulating.
3. Review the turbine design activity. Have students refer to different stages of the engineering design cycle that they underwent during this investigation. Additionally, students should discuss the successes and failures of their design

in order to remind them of the different variables involved in creating successful turbines.

4. Provide students with the design challenge: using the materials available and the science you investigated behind solar energy and convection currents, design a device that utilizes heat from the sun to spin a turbine as a way to convert energy.
5. Hand out "Worksheet 6-Solar Updraft Engineering Design." This worksheet is meant as a way for students to track their progress through a basic engineering design cycle (ask, imagine, plan, create, improve, reflect). Ensure that all students use this tool at least for their first construction process, perhaps pausing to ensure that all groups are working on each step together. This tool may be used more than once, however, depending on whether students wish to start completely over in their design process. Also, sections may simply be repeated, and it is encouraged to manipulate this process depending on the needs of the student groups working on this challenge. *Note: student testing may need to take place inside, and halogen work lights are a great alternative. However, these devices may also work if ample sunlight is coming in through a window.*
6. Pause a time our two throughout the cycle to have a group-wide discussion and allow for students to present their construction in various stages to the class as a whole. It is critical for students to see how their design compares to their peers, additionally explaining together how the content they have learned ties into their design.
7. It is up to you how long you carry out this lesson. It is rich with design opportunities. If you don't have time, it could be sent home as an extended home project.
8. Once students find a design they like, they will want to decorate their new home-made solar updraft towers. Again, provide materials in the classroom or make it a home project.

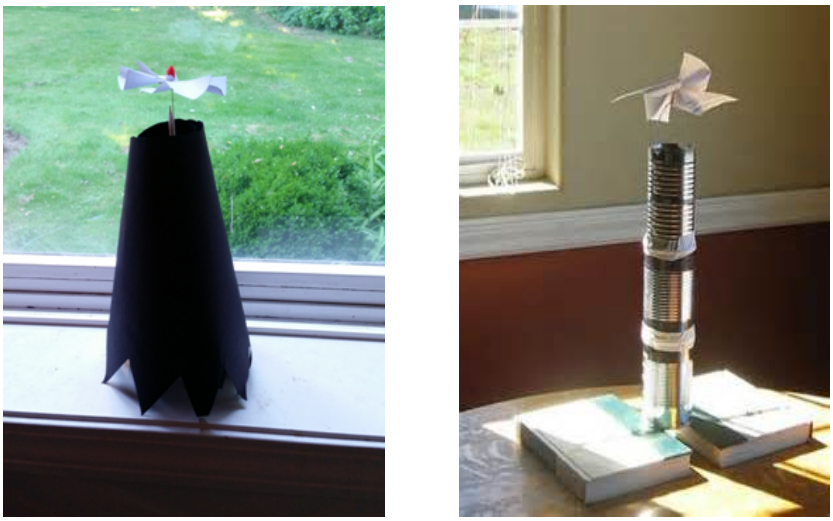

Figure 1. Example Solar Updraft Tower Designs.

ASSESSMENT AND EXTENSIONS

FORMATIVE/SUMMATIVE ASSESSMENT

Students will draw and label the different parts of their project and explain how it works. This can be done on a poster presented to the class, or perhaps using an online tool such as SketchUp or Google Draw. Ensure that there is space for students to share their work with other groups.

LESSON EXTENSIONS

Have students generate questions that could lead to further material exploration, ensuring that one variable is changed at a time. Examples could include: Does the turbine spin faster when the tower is made taller? Does it matter what color of paper the tower is made of? Does it matter what material the turbine is made of?