CLEAN ENERGY INSTITUTE
UNIVERSITY of WASHINGTON

Model Sustainable Town

Overview:

This free-form activity challenges elementary students to create a physical model of a sustainable town that includes energy production from renewable sources, energy storage and distribution in a grid Students can use printed cut and fold templates for common structures or build their own from scratch

Essential Question:

What does it take to make your town sustainable?

Background:

Some define **sustainability** as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Often this includes the use of **renewable** energy such as solar, wind, biofuels or hydro electric power. Is helpful to think about the town as a system with energy inputs and energy outputs and waste. The focus of the model could be about the electrical grid which will have **generation**, electrical **distribution**, and possible energy **storage.** Other inputs and outputs such as food, water, waste, materials and transportation can also be included in a systems model.

Research Connection:

Researchers are trying to find ways to make full use of renewable energy sources using large scale storage systems such as batteries and ways to forecast energy supply and demand.

NGSS Standards:

Standard Number	Standard text
4-ESS3-1	Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.
4-PS3-2	Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
4-PS3-4	Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.
3-5-ETS1-1	Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

<u>Learning Objectives</u>

After this activity students should be able to describe

1. What energy and materials move into an out of a town?
2. Measures that can be taken to improve sustainability
3. How solar and wind sources could work with battery storage to achieve constant power.
4. How solar is also use to grow plants, heat homes and perform other tasks.

Grade:- 1st – 6th grade

Time: 1-2 hours

Materials:

- Cut and Fold templates printed on card stock
- Tape
- Butcher paper to cover table
- Marking pencils, paint, scissors, construction paper, hot glue
- Recycled materials cardboard tubes, plastic salad trays, plates
- Copper tape, Motor, wire, batteries, solar cell
- LEDs with resistors

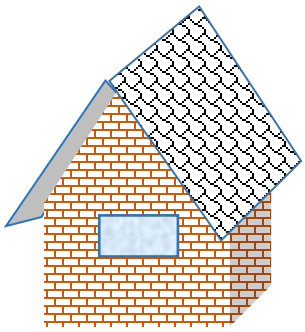
Procedure:

Introduction:

Does anyone know what the word sustainable mean? (Explore student prior knowledge about sources of energy, renewables, solar, conservation, recycling, organic etc.) Sustainable means that something can keep going on forever without running out or breaking. Today we are going to build a model sustainable town. What are the things that people in our town need to survive? (Look for things like food, water, air, energy, houses, heating, clothing, school, cars, plants, animals, soil). Guide the construction with a series of prompts for each necessity. How can people get their energy? Will solar energy run out? What happens when the sun goes down? (need batteries, use other sources).

Construction Tips

Solar house



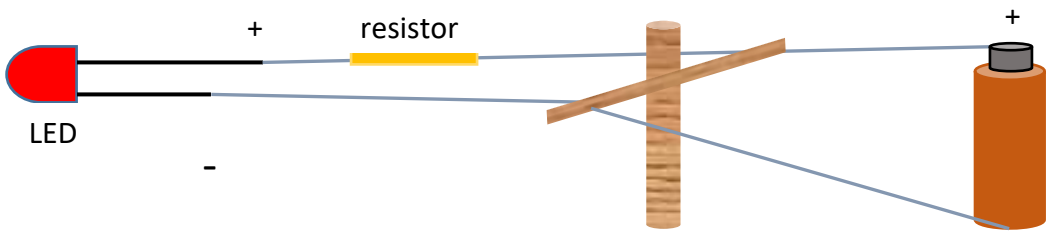
1. Print the solar house on card stock.
2. Cut out the shape following all solid blue lines.
3. Fold on the dotted lines. Fold the roof eaves under so that the roof hangs over the side of building.
4. Fold up the bottom and tape the wall seam and wall to floor seams.
5. Fold the roof closed and tape roof peak.
6. Attach a 1.5 or 3 volt solar panel on the house and use copper foil tape to make a circuit with an LED. Note that the longer lead of an LED should go to the positive (red) wire of a cell. Test the house under a strong light or the sun.
7. Orient all the houses towards south.

Discussion

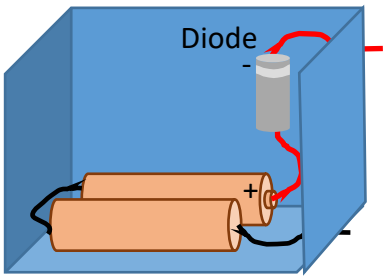
- Why should solar houses be pointed toward the south? (In the northern hemisphere the sun is always south of the zenith at noon.)
- What might limit the power available to solar houses? (area of cells, shading by buildings)
- What could be done to keep the light throughout the day and night? (add storage)

Electrical Grid

1. Explain that the simple solar houses are not connected to any outside energy supply, they off the grid. We need an electrical grid to bring energy to and from the houses. Identify where our town's power external power source will be. (wind farm, solar farm, hydroelectric dam, etc.) You can model any of these sources without actually having them generate by placing a battery within.
2. Identify the generation source is located and use copper tape or thin copper wire to make a complete circuit between the LEDs on the houses and the battery or solar generation source. Note that circuits are always a loop with two conductors which are kept separate until they connect to a load or a generation source.
3. If you are using thin wire construct some powerlines from dowels or twigs and hang the wires around cross bars. Groups of students could add LED to their houses and tap into the grid. Be sure to keep track of the polarity and put a small resistor in the circuit to keep from burning out the LED.



Energy Storage Unit

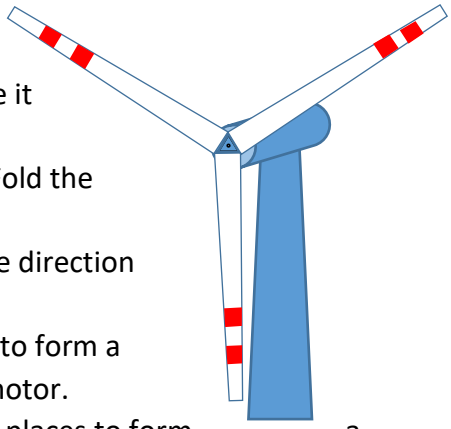


1. Place a rechargeable battery in a single or double batter clip inside the storage unit.
2. Measure the voltage of the battery using a multimeter.
3. If you want the system to hold its charge for a longer time include a diode in series in the circuit. Face the arrow of the diode towards the positive lead of the battery, or end with the stripe towards the negative end. This allows electricity to flow from the solar cell when the cell voltage is higher than the battery, but no current will flow through the solar panel when the battery has a higher voltage than the cell, (at night)
4. Connect the lead from the storage to copper tape placed on the outside of the storage unit.
5. Connect the storage unit to one or more solar cells. Measure the voltage before and after charging.

Discussion

- Where does the storage system get its power? (from wind or solar)
- When does the storage system absorb energy? (when the electricity coming from the sources is higher voltage than the battery)
- When does the storage system give up its energy? (when a load is connected to the battery and a complete circuit is formed.)
- What would it take to keep a house supplied with power all night? (a big enough battery and enough charging power)
- What does the diode do in the circuit? (It prevents the electricity leaking out through the solar cell when the cell is not producing a charging voltage.)

Wind turbine



1. Cut out the three wind blades. Fold the blade gently along the dotted line. Notice that the line is not in the middle. The narrow half will be the flat side of the blade, the wider half will be the curved side of the blade. You may need to run your thumbnail along the middle of curve section to give it a gentle airfoil like an airplane wing.
2. Run a strip of adhesive tape along the printed side of the flat edge. Fold the other side over and complete the seal.
3. Cut out the hub and attach the blades so that each is facing the same direction
4. Attach the hub to a plastic gear.
5. Roll up the cowling with the small electric motor at one end. Tape it to form a cylinder. Press gear on the completed blade on to the shaft of the motor.
6. Cut out the tower. Roll it into a cylinder. Fold the top inwards in two places to form a curved saddle.
7. Place the turbine blade and cowling into the saddle on top of the tower and tape it in place.
8. Attach the wind tower to a piece of cardboard with tape and fix this to the table.
9. Spin the blade while measuring the current coming from the wires of the motor (now a generator).

Questions

- Where would be the best place to locate a wind turbine? (open area where it is windy)
- What is a disadvantage of wind power? (you can't predict when it will be blowing very accurately)

Tips for success

- Once your team has brainstormed what the town needs, assign groups to specifically build each component on the list (have teams making buildings, wind turbines, storage, food sources, green spaces such as parks etc.)
- Have them try to "drive" their solar cars through the town with a hand held spotlight.
- Have teacher or volunteer help to keep kids relatively on track and focused

Extensions:

- Arrange the houses facing south and then draw roads.
- Add solar cars from the CEI SunDawg bags
- Add a greenhouse made from a clear plastic salad box.
- Use boxes labeled "recycling center, bicycle barn
- Create terrain in the backdrop paper to form a location for a hydroelectric dam and lake.
- Add a community solar farm

Resources:

https://www.teachengineering.org/activities/view/cub_solarcity_activity1
https://www.teachengineering.org/lessons/view/cub_energy_lesson02

Sources:

- Copper tape $12. 98 http://www.amazon.com/Copper-Conductive-Adhesive-Width-Length/dp/B009KB86BU
- LEDs with resistors $8.99 https://www.amazon.com/dp/B077XBFZH9/ref=psdc_2314207011_t4_B00H98OS2W
- Small electric motor- $1.49 http://www.ebay.com/itm/111079176644
- AA 1.5 v battery holder. https://www.amazon.com/WAYLLSHINE-Dozen-Battery-Holder-Black/dp/B013GNC08C/ref=sr_1_2?s=pc&ie=UTF8&qid=1485454472&sr=8-2&keywords=battery+holder+1.5v
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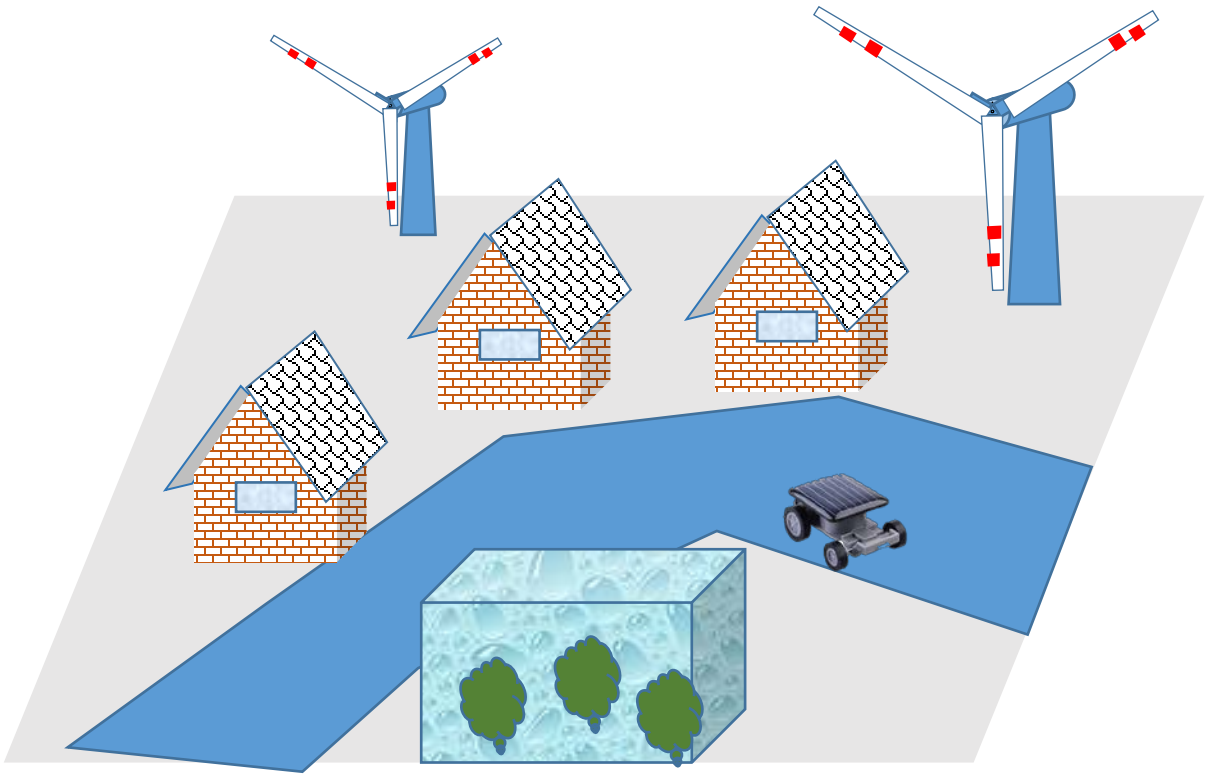
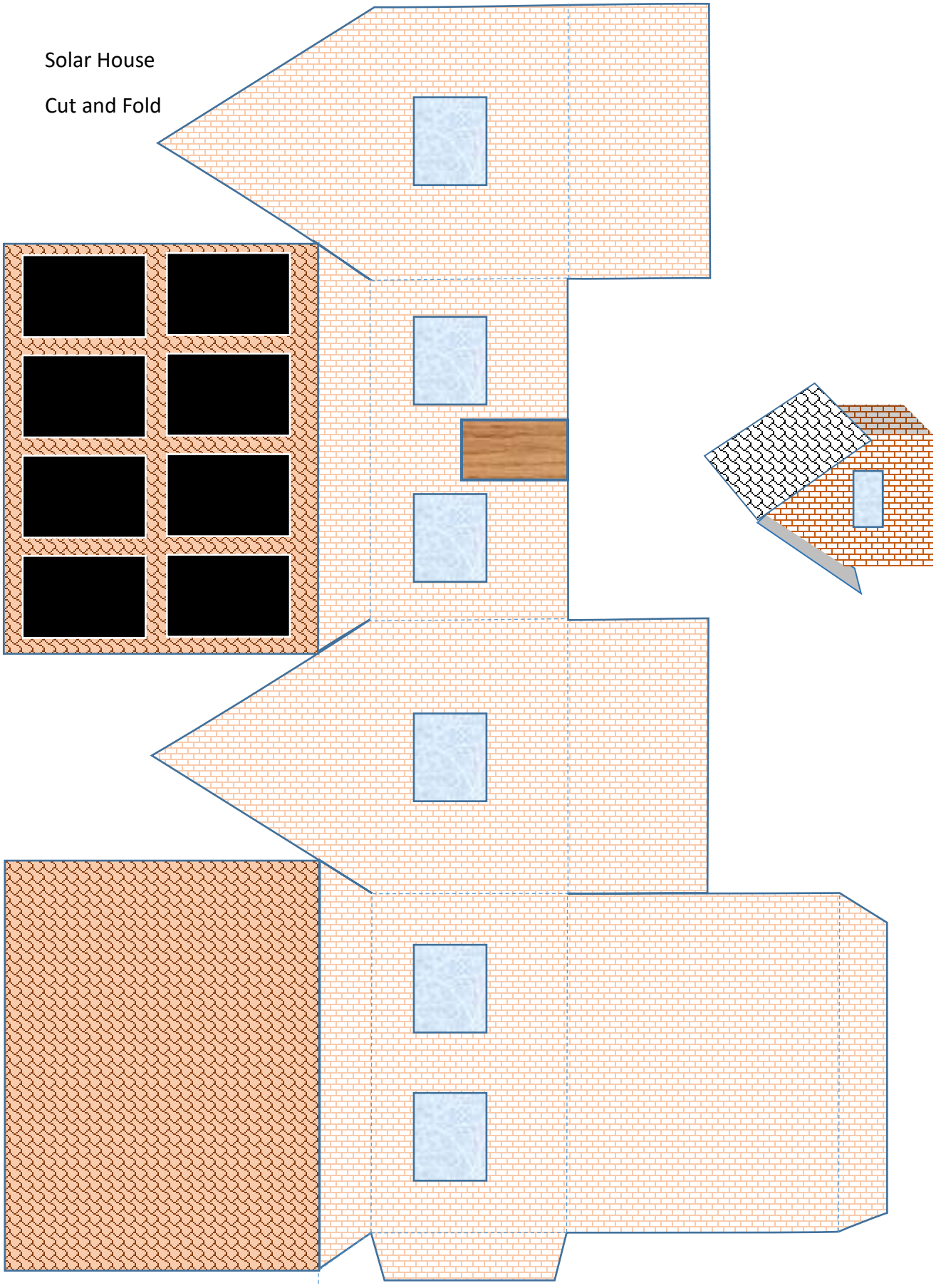
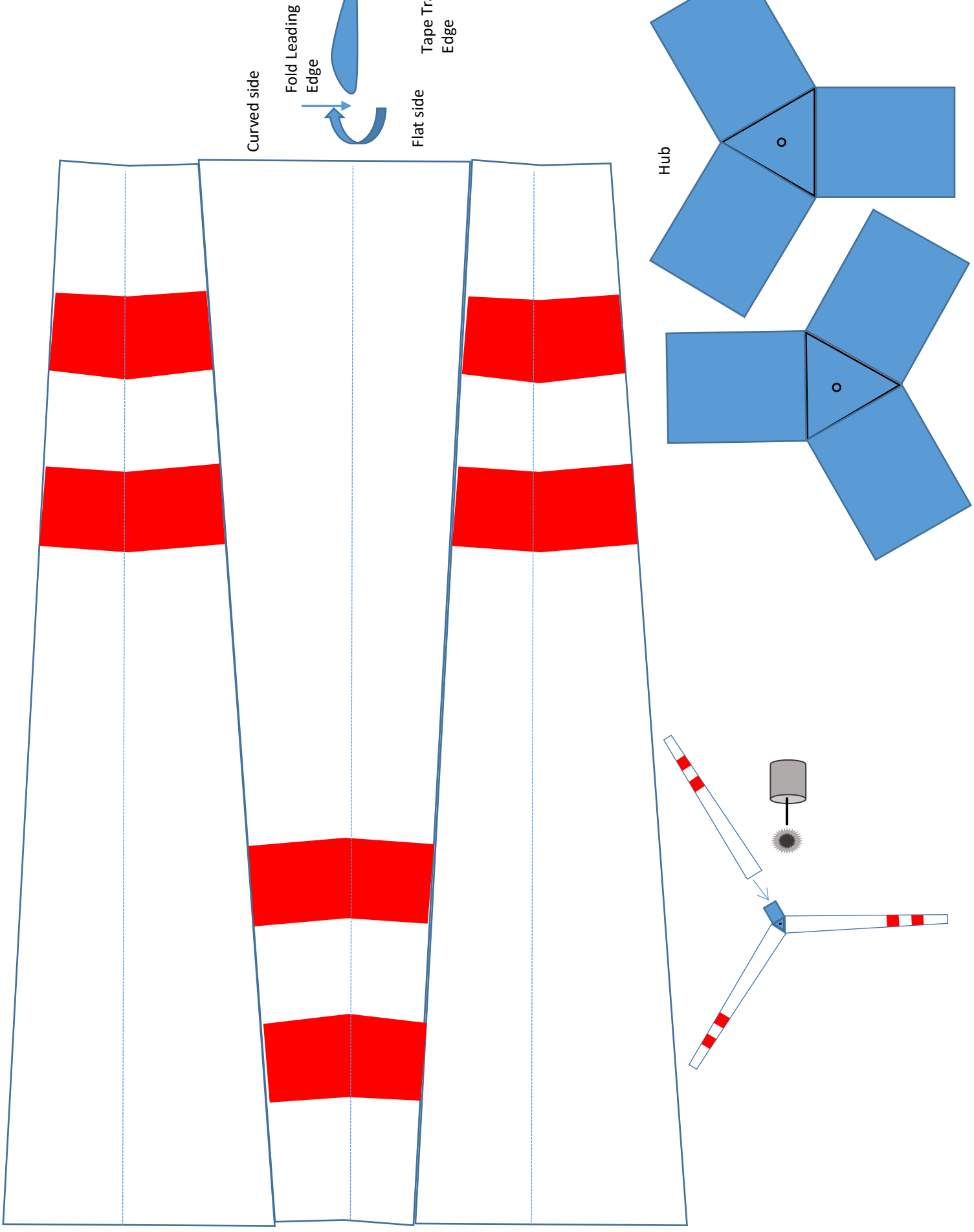
PLANS



Solar House

Cut and Fold





Wind Turbine Tower

1. Assemble tower as cone
2. Fold top edge in to form saddle
3. Roll motor into paper tube
4. Place gear on motor
5. Attach turbine blades to gear