Elisabeth Price aaejprice@att.net

MODEL OF GEOTHERMAL ENERGY

INTRODUCTION

Water can be heated through various means by heat contained in the Earth. That hot water can be used to generate electricity, or used directly for heat. This activity models one way the energy contained in the hot water can be used to generate electricity.

OBJECTIVES

Students will turn the energy contained in vaporized dry ice into mechanical energy by spinning a pinwheel.

MATERIALS

- Making an origami pinwheel
    - Approximately 5" squares of lightweight, but stiff pieces of paper
    - Skewers or other pointed stick or wire, at least 6 inches long
- Generating model of geothermal heat used in electricity generation
    - Clear plastic cups with covers into which a straw can be inserted
    - Straw, flexible type if possible
    - Tape or clay to cover or fill the holes around the straw
    - Dry ice, several pieces per cup
    - Hot water
        - Hot pot to heat the water, if necessary
    - Gloves, towels, or wooden tongs for handling ice (or have instructor handle dry ice)

SAFETY

Dry ice must be handled with gloves. This activity may be presented as a demonstration to avoid the possibility of students handling dry ice incorrectly.

PROCEDURE

1) Make the origami pinwheel as follows:
    a) Start with the water bomb base as follows:
        i) Fold the square of paper in half to make rectangles, unfold the paper, and fold the paper in half to make rectangles in the other direction.
        ii) Turn the paper over, fold the paper in half to make triangles, unfold and fold in half to make triangles in the other direction.
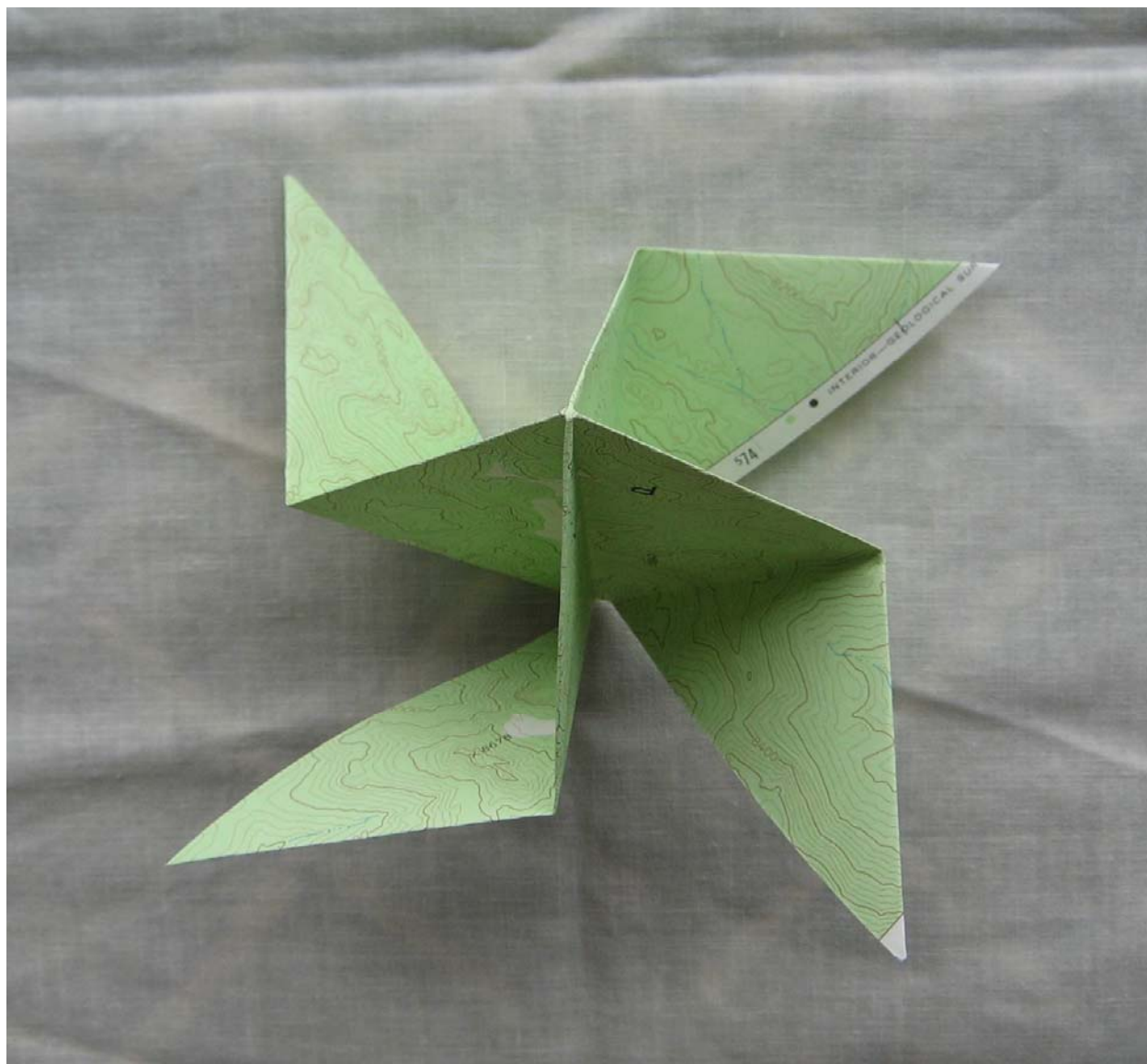
Elisabeth Price aaejprice@att.net
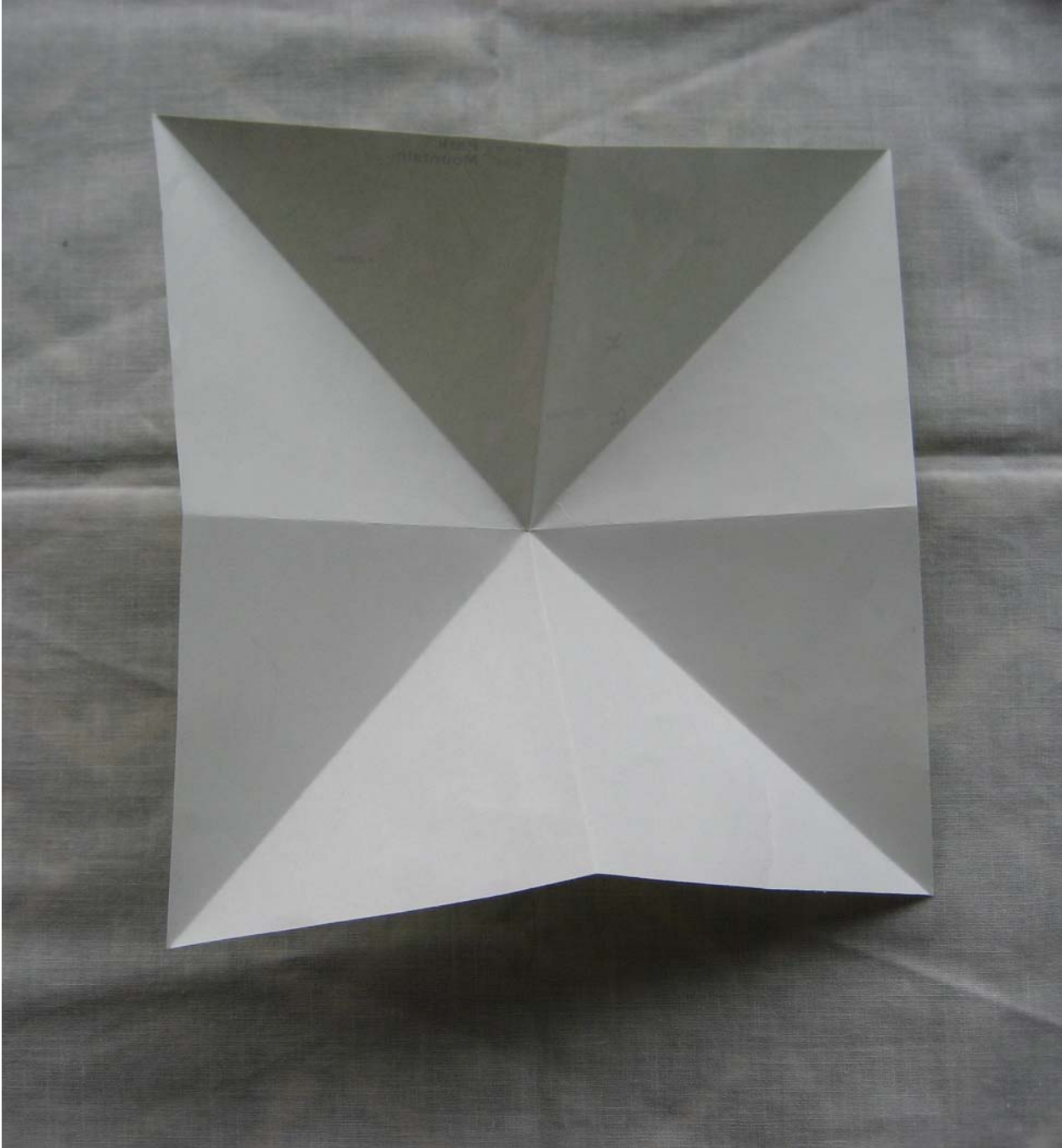
Elisabeth Price aaejprice@att.net

iii) Hold two opposite corners of the square with the square folded in half to make triangles. Gently push the corners toward the center so the other two corners poke out to make an "evergreen tree."
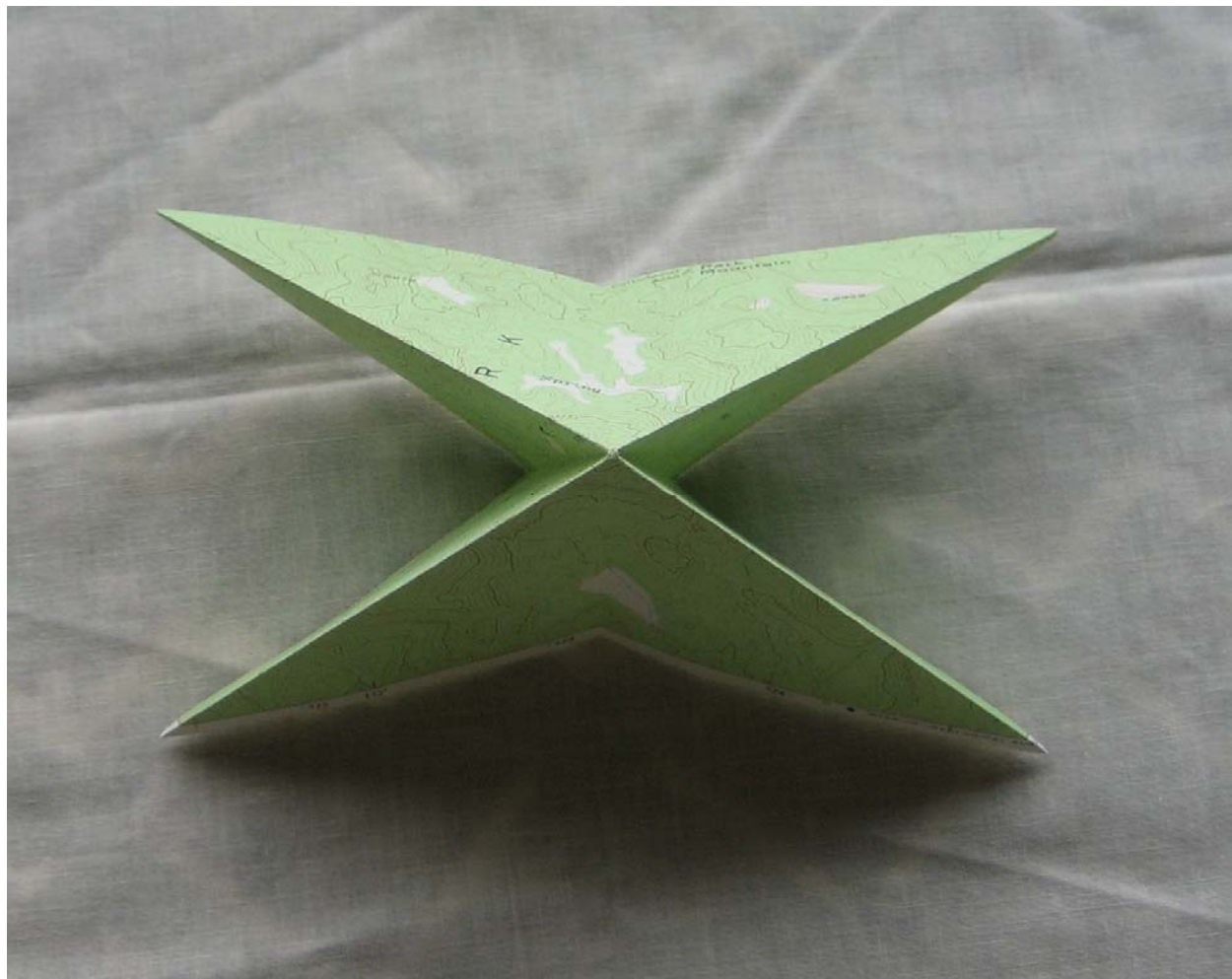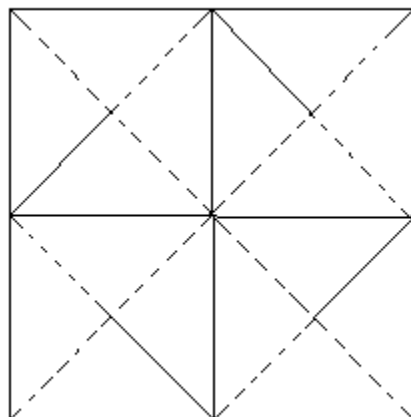
Elisabeth Price aaejprice@att.net

       iv) Fold these other "wings" to each side to make an isosceles right triangle with two flaps at each of the 45 degree corners.

  b) Make the pinwheel

      i)   Fold each of the 4 corners in the same direction by folding the top 45 degree angle to the top 90 degree corner, lining up the cut edge with the fold bisecting the base of the isosceles triangle going up to the 90 degree corner.
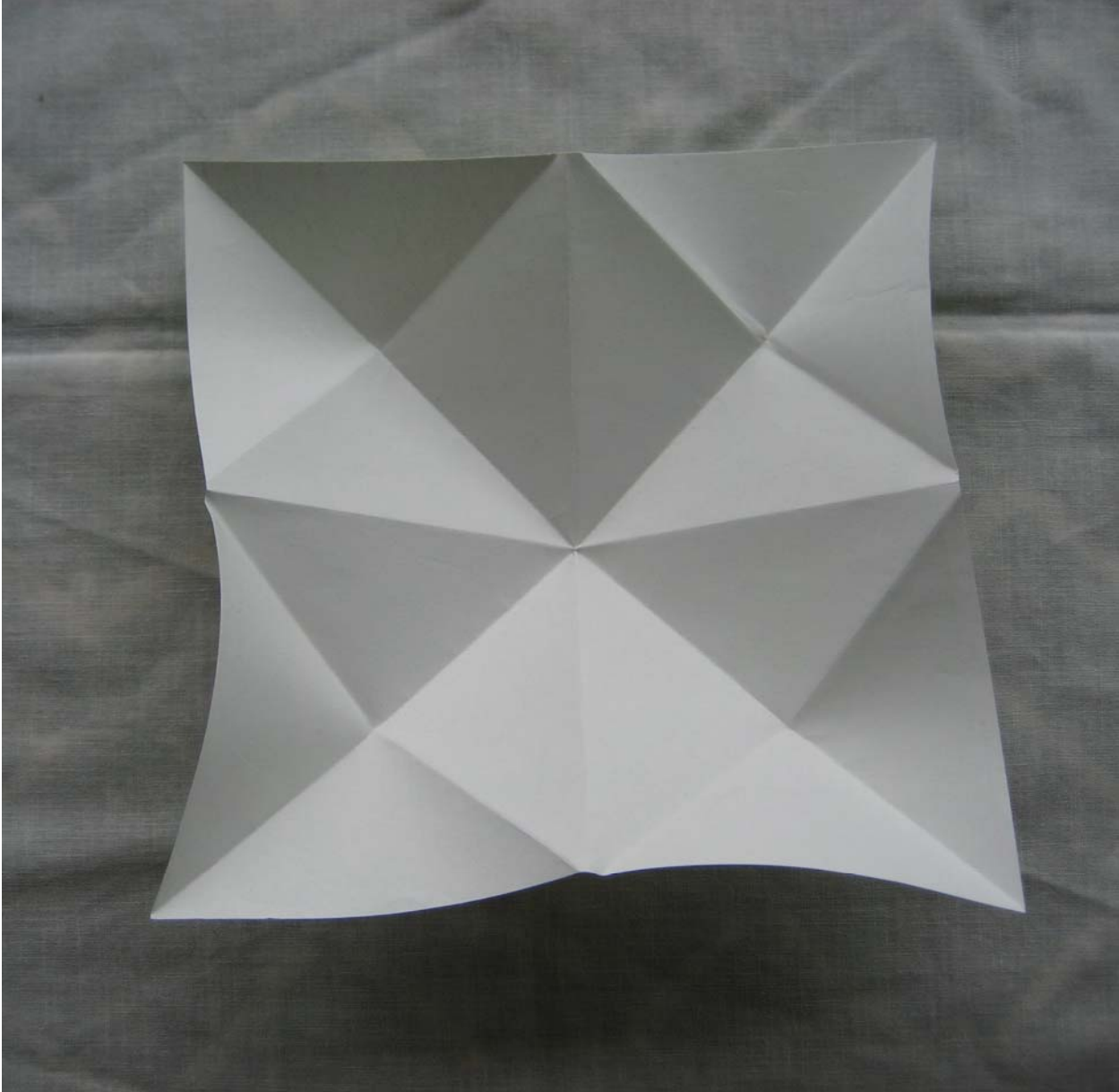

      ii)   Place the figure onto the skewer with the point of the skewer touching the top 90 degree angle.

Elisabeth Price aaejprice@att.net

c) Summary picture
    i) Dashed lines are mountain folds
    ii) Solid lines are valley folds

Elisabeth Price aaejprice@att.net

Elisabeth Price aaejprice@att.net

2) Generate gas to turn turbine (pinwheel)
   a) Insert straw into hole in cup cover
   b) Plug holes around straw with tape or clay
   c) Place several pieces of dry ice into the cup
   d) Add hot water
   e) Quickly cover cup with cover and attached straw.
   f) Hold pinwheel over dry ice gas and entrained water particles that are coming from the straw to make the pinwheel move.
3) Relate model to geothermal electricity generating process
   a) The geothermal electricity generating process uses a gas to turn a turbine that in turn generates electricity.
   b) The gas can be obtained in one of two ways:
      i) Steam generated directly from the superheated water from the geothermal source
      ii) Vapor of an organic compound, usually isopentane, formed from heating the liquid isopentane with hot water from the geothermal source. In this situation, the hot water from the geothermal source does not touch the isopentane, but heats pipes that carry the isopentane. Isopentane has a relatively low boiling point (28 C) (http://www.ilo.org/public/english/protection/safework/cis/products/icsc/dtasht/_icsc11/icsc1153.htm) so the geothermal water can be of a lower temperature than that used to generate steam to directly turn the turbine. This type of plant is called a binary plant because it uses two fluids to generate the electricity: geothermal water and isopentane. Because our model uses hot water (substituting for geothermal water) and a second chemical, dry ice (solid CO_2), our model represents this binary type of process.
   c) Limits of model
      i) The model here mixes the hot water directly with the second chemical (dry ice instead of isopentane). This doesn't occur in a binary plant in which the two chemicals are kept separate.
      ii) The geothermal water is returned to the heat source of the geothermal system.
      iii) The second chemical vapor (isopentane) is recovered after it turns the turbine, condensed, and returned to be heated again.

EVALUATION

1) How is the energy that turns the turbine generated?
2) What is one difference between our model and a real binary geothermal electricity generating process?
3) Why might a binary plant be better than a plant that uses water steam generated directly from the geothermal fluid?