Water Windmill Challenge 2015

4-H AG INNOVATORS EXPERIENCE
PRESENTED BY MONSANTO

NATIONAL 4-H COUNCIL

THE OHIO STATE UNIVERSITY
COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

MONSANTO

Teen Facilitator Guide

Welcome to the 4-H Ag Innovators Experience Water Windmill Challenge!

During this activity, youth will explore the importance of water to food production as they engineer a derrick prototype to hold a high-efficiency, electric water pump for Happy Pastures Farm.

As the Teen Facilitator for this activity, you will help youth learn that:

1. A considerable amount of water is needed for food production.
2. The growing human population demands increased food production, and more food production means higher water usage.
3. Increasing efficient water usage and agricultural productivity requires the application of science, technology, engineering and math (STEM) skills.

Our demand for water will only increase. Future generations will need to become Ag Innovators to figure out how to protect and use our limited fresh water supply wisely.

Background

Water is a precious, non-renewable resource. Only 1 percent of the water found on the earth is fit for human consumption. The rest is salty or frozen into polar ice caps, and no new water can ever be made. Globally, 70% of the world's fresh water is used for agriculture (source: Food and Agriculture Organization of the United Nations).

Every living being needs water. According to the Environmental Protection Agency, the average American family of four uses 400 gallons of water per day. On farms, sprinkler irrigation systems use on average 4,000 gallons per acre per day (source: Penn State Extension). One head of cattle drinks 5 - 20 gallons of water per day, depending on age, weight, and weather conditions.

Over the past 45 years, the human population has doubled. If current growth rates continue, in 80 years the US population will be twice what it is now. As human population grows, so does the need for water. Farmers must step up their production to meet increased demand for food, and more food production requires more water.

Human population has grown from 2.5 billion people in 1950 to over 7.2 billion today.

Track population growth at: http://www.census.gov/popclock

Seasonal temperature fluctuations, uneven distribution of surface water, and low yearly rainfall can make it challenging for farmers to access enough water to raise their products. In some areas of the Midwest, farmers have to go below the ground to find sources of water for their farms. Advances in technology have made this easier. The traditional, mechanically powered windmills that dotted the land 150 years ago are being replaced by high-efficiency wind turbine generators. Sleek, aerodynamic designs with curved blades and heavy, gearless wind turbine motors generate power to pump water quickly and efficiently.

The notion of harnessing the wind as an energy source is not new. In fact, many early settlers used mechanically powered windmills for water pumping. Today, most windmills have transitioned from mechanical power to include a small turbine to generate electricity, which powers an electric water pump. Generally speaking, the higher the tower, the more power a wind system can produce (U.S. DOE, 2014). As a result, wind towers have evolved over time from traditional derrick style towers to modern tubular structures capable of reaching the more powerful winds at elevated heights. However, for the purposes of this learning activity we will utilize engineering principles to maximize the potential of the traditional derrick style tower. Visit **http://energy.gov/eere/wind/frequently-asked-questions-small-wind-systems** for more info.

The 4-H Water Windmill Challenge: Activity Preparation and Facilitation

PREPARING FOR THE ACTIVITY (1 hour)

STEP 1:

Familiarize yourself with the challenge (30 minutes – 1 hour)

- Watch the 4-H Water Windmill Challenge video: http://4-h.org/about/partners/monsanto
- Review the contents of the 4-H Water Windmill Challenge Kit.
- Read through this Guide, thinking through how you will facilitate each step of the activity.

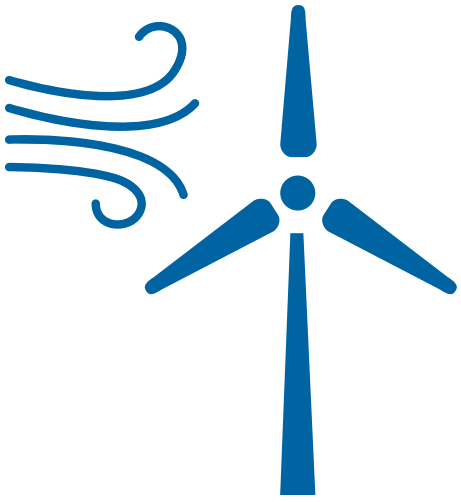
STEP 2:

Gather materials and set up the room (30 minutes – 1 hour)

- Sort contents of the 4-H Water Windmill Challenge Kit into the specified quantities for each team.
- Arrange the testing spot by placing two tables within 5 inches of each other.
- Make sure there is a water source in the room near the testing station sufficient for all teams to test their prototype.
- Get a mop, paper towels, or sponges to clean up any water spills.

Each 2 person team needs:

One 8 X 8 pegboard challenge pad
Access to the Crop-A-Dial Wood Punch provided with kit
Twenty craft sticks
Twenty cable ties
One pair of scissors
Ten 3/16 diameter dowel rods
Two pencils
Two push pins
Two pinwheel patterns
One lanyard



FACILITATING THE ACTIVITY (80 minutes)

STEP 1:

Set the stage for the engineering task by exploring how much water is required for food production through a "Water for Cheeseburgers" warm-up activity (10 minutes)

A major fast-food burger chain in the U.S. sells 75 hamburgers every second, every day. Americans alone eat approximately 50 billion burgers each year.

- Ask youth to estimate how many cheeseburgers they eat each year.
- As a group, brainstorm the ingredients in a cheeseburger.
- Ask youth to estimate how much water is required to produce a single cheeseburger, from farm to table.
- Direct attention to the Water Windmill Teaching Poster (page 5), which lists the amount of water required for ingredients in a cheeseburger. Ask youth to adjust their estimates based on the information in the Teaching Poster.
- Reveal that approximately 675 gallons of water are needed to "grow" a cheeseburger, based on information from Water Footprint Network. Compare this fact to the estimates. Did youth overestimate or underestimate the amount of water needed?
- Next, brainstorm as a group all the ways in which water is used to "grow" a cheeseburger.

(Answers may include: water for cattle to drink; water for irrigation; water for cleaning produce; water for cleaning the milking parlor, slaughter house, packing house, and flour mill; water in bread dough; etc.)

- Ask youth to use their initial estimates of how many cheeseburgers they eat per year to calculate how much water is needed to produce those cheeseburgers (The number of cheeseburgers eaten each year x 675 gallons per cheeseburger = water required to produce those cheeseburgers).

A derrick is a structure composed of a tower that holds and supports weight. It's typically seen on offshore drilling rigs.

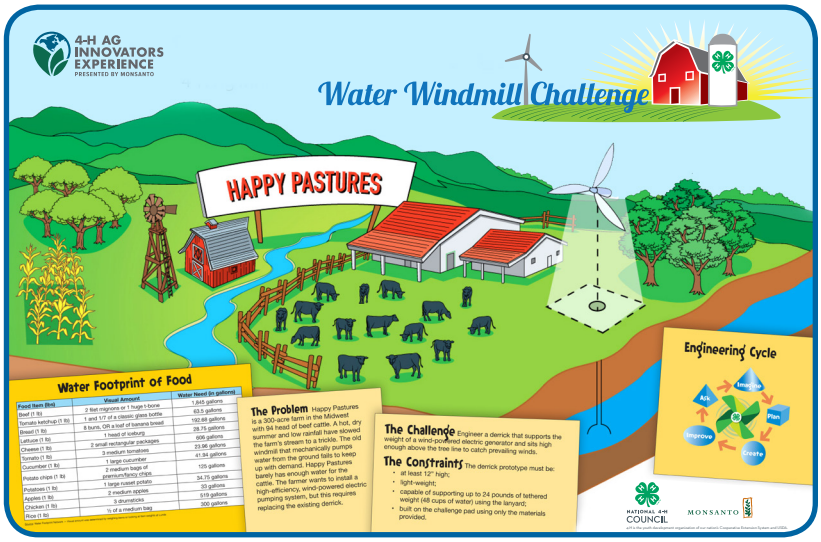
STEP 2:

Present the challenge and hand out supplies (10 minutes)

- Using the Water Windmill Teaching Poster, tell the story of Happy Pastures Farm. Tell youth, "The farmer has hired your company, Wind Power Technologies, to engineer a derrick to support a high- efficiency, wind-powered generator for a new electric water pump."
- Divide the group into teams of two, pairing younger participants with older participants.
- Describe the constraints of the challenge.
- Hand out supplies.

The Problem

Happy Pastures is a 300-acre farm in the Midwest with 94 head of beef cattle. A hot, dry summer and low rainfall have slowed the farm's stream to a trickle. The old windmill that mechanically pumps water from the ground fails to keep up with demand. Happy Pastures barely has enough water for the cattle. The farmer wants to install a high-efficiency, wind-powered electric pumping system, but this requires replacing the existing derrick.



The Challenge

Engineer a derrick that supports the weight of a wind-powered electric generator and sits high enough above the tree line to catch prevailing winds.

The Constraints

The derrick prototype must be:

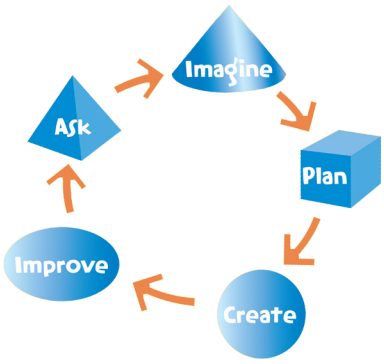
- At least 12" high;
- Light-weight;
- Capable of supporting up to 24 pounds of tethered weight (48 cups of water) using the lanyard;
- Built on the challenge pad using only the materials provided.

STEP 3:

Guide youth through the engineering task (45 minutes)

- Make sure the students understand the constraints of the challenge.
- Tell teams that for extra credit, they can attach the 4-H Water Windmill Challenge pinwheel.
- Remind youth of the Engineering Design Cycle.
- Invite teams to brainstorm solutions, sketch potential prototype designs, and discuss their merits.
- Direct teams to decide on a plan and begin building prototypes, using only the materials provided.
- Supervise teams as they test their prototypes and record their data. Teams may refine their designs and test them again if time allows.

ENGINEERING DESIGN CYCLE



EXTRA CREDIT:

Teams can assemble and attach the 4-H Water Windmill Challenge Pinwheel to their derrick prototypes.

QUESTIONS TO INSPIRE BRAINSTORMING:

How do engineers determine where to start when designing structures?

What structure shape would be strong enough to support 24 pounds (3 gallons) of water?

How can the weight of the prototype be minimized without compromising strength?

What are some possible ways to brace the structure using the available materials?

What are some ways to ensure that the structure is sturdy and won't break with the tethered weight?

Where on the derrick should the lanyard be attached so that the hanging water-weight will be evenly supported by the structure?

Water Windmill Challenge Results

Weigh each derrick in grams before the test and write that number on the challenge pad. Record the water weight held in grams by each derrick after the derrick collapses. Use the formula below to determine each team's final score. The higher the number, the better the design

Important Numbers to Know

Your derrick must hold up to 48 cups in the bucket

Final Score Formula

$$\frac{\text{Water Weight Held (g)}}{\text{Derrick Weight (g)}} = \text{Score*}$$

Team #	Derrick Weight	Water Weight Held (cups/grams)	Final Score

STEP 4:
Compare and Celebrate Results

- Call everyone to attention and discuss the teams' results. The highest final scores indicate the most successful designs.
- As a group, identify unique features of derricks with the highest scores.
- Discuss ideas for a final design to present to Happy Pastures Farm.
- Ask the group what they learned about the relationship between water and agriculture.
- Ask the group why it is important to conserve water.

STEP 5:
Wrap-up

- Recognize and thank Monsanto and the National 4-H Council, sponsors of the Water Windmill Challenge.
- Direct youth to complete the required student evaluations.
- Fill out the 4-H Water Windmill Challenge Participant Group Data Collection Sheet.
- Congratulate yourself on a job well done!

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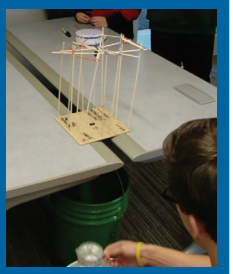
AT THE TESTING STATION

- Remind teams to attach the lanyard to the derrick prototype with the metal clip passing through the hole on the challenge pad.
- Weigh each derrick with the challenge pad and lanyard attached. Using a marker, write this weight (in grams) along with the team number on each team's challenge pad.
- Position the challenge pad over the opening between the tables. Then attach the handle of the bucket to the lanyard's metal clip.



- Add water to the bucket one cup at a time to the bucket until you reach the maximum of 48 cups (3 gallons) or until the structure collapses.
- Note the number of cups the derrick was able to support. Multiply this number of cups by 237 to convert it to grams of water weight.
- Record the water weight in grams that each prototype was able to hold on the Challenge Results Score Sheet.
- Encourage teams to talk over what worked and what didn't in their design.

4-H Water Windmill Challenge

Dear Participant:
You are being given this survey because you are part of a 4-H program or project, and we are surveying young people like you to learn about your experiences.

This survey is voluntary. If you do not want to fill out the survey, you do not need to. However, we hope you will take a few minutes to fill it out because your answers are important.

This survey is private. No one at your school, home, or 4-H program or project will see your answers. Please answer all of the questions as honestly as you can. If you are uncomfortable answering a question, you may leave it blank.

This is NOT a test. There are no right or wrong answers, and your answers will not affect your participation or place in the program in any way.

Thank you for your help!

Section I: Water Windmill Challenge
Please indicate how much you agree or disagree with each statement (Select one response in each row by marking the appropriate box ☐).

	Yes	Kind of	No
Did you think it was important to work in a group to accomplish the task during the Water Windmill Challenge?	☐	☐	☐
I had to use communication skills with my team in order to accomplish the Water Windmill Challenge?	☐	☐	☐
I think water windmills are a good way to increase food production for our world to have more food?	☐	☐	☐
I am more interested in science and agriculture after participating in the Water Windmill Challenge?	☐	☐	☐
I have a better understanding of how to design and create an object to solve a problem after participating in the Water Windmill Challenge?	☐	☐	☐

Section II: Tell us about You

1. How old are you?_____Age (in years)

2. Which of the following best describes your gender? (Mark **one** box ☐). ☐ Female ☐ Male

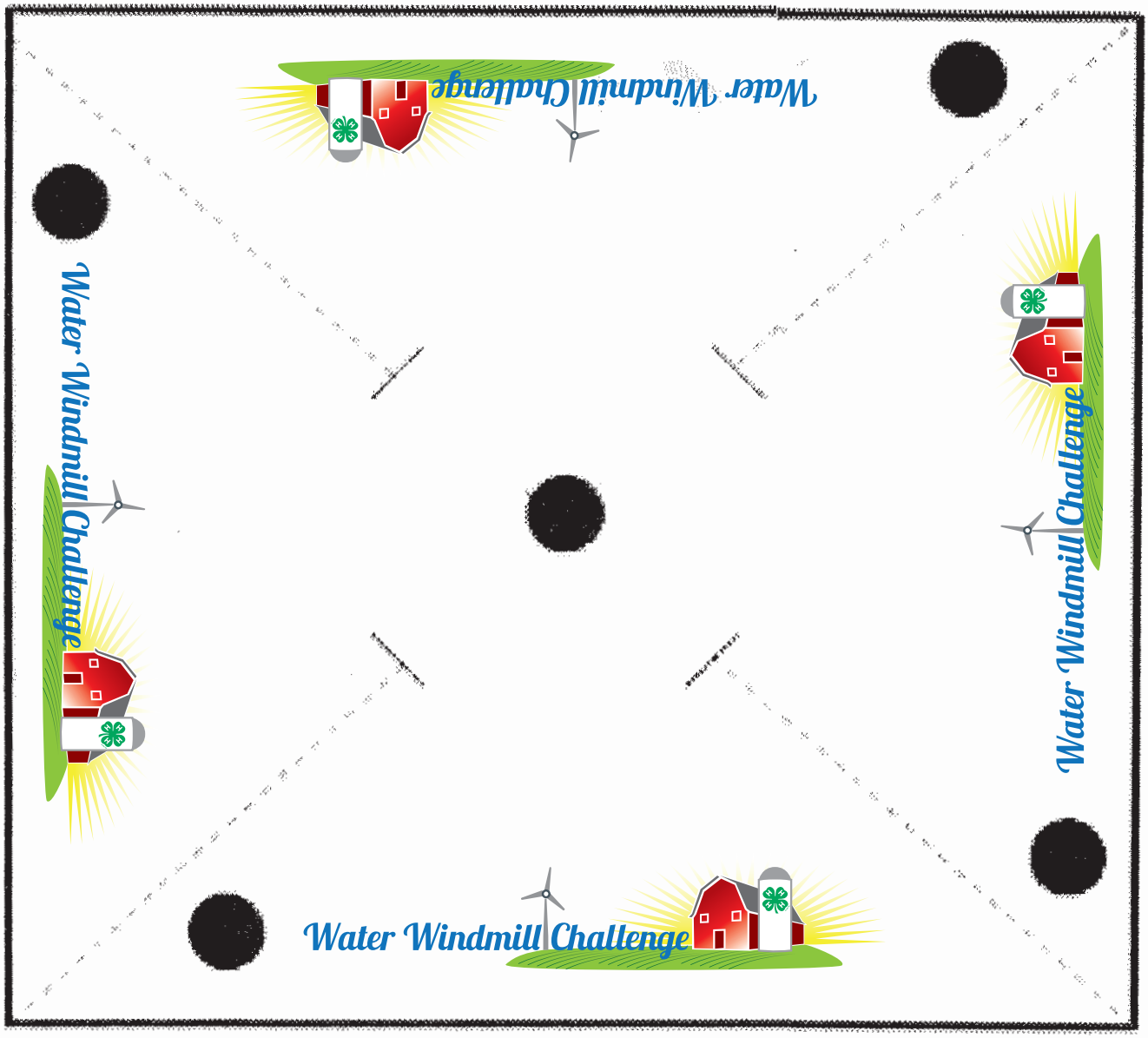
3. Which of the following best describe your race? (Mark **each** box ☐ that applies to you.)
   - ☐ American Indian or Alaskan Native
   - ☐ Asian
   - ☐ Black or African American
   - ☐ Native Hawaiian or Other Pacific Islander
   - ☐ White

4. Which of the following best describe your ethnicity? (Mark **one** box ☐).
   - ☐ Hispanic or Latino
   - ☐ Not Hispanic or Latino

5. Which of the following best describes the primary place where you live? (Mark **one** box ☐).
   - ☐ Farm
   - ☐ Rural (non-farm residence, pop. < 10,000)
   - ☐ Town or City (pop. 10,000 – 50,000)
   - ☐ Suburb of a City (pop. > 50,000)
   - ☐ City (pop. > 50,000)

Appendix: 4-H Water Windmill Challenge pinwheel pattern

Instructions: Cut out the 4-H Water Windmill Challenge pinwheel pattern along the black lines, then cut along the dotted lines. Next, gather the corners by aligning each corner dot with the center dot. Place a push-pin through all dots into the eraser end of a pencil. Attach the pinwheel to the top of the derrick prototype.



Monsanto is a sustainable agriculture company that delivers technology-based solutions and agricultural products that support farmers all around the world. As the population increases and access to land and water for agriculture decreases, Monsanto remains focused on enabling farmers to produce more from their land while conserving the world's natural resources. Monsanto is supporting the 4-H Ag Innovators Experience because today's participants will provide tomorrow's foundation for a prosperous, knowledgeable and innovative agricultural workforce. Visit http://www.monsanto.com for more information, read the company blog at http://www.monsantoblog.com, and follow us on Twitter: https://twitter.com/MonsantoNews.

Thank you notes should be addressed to:

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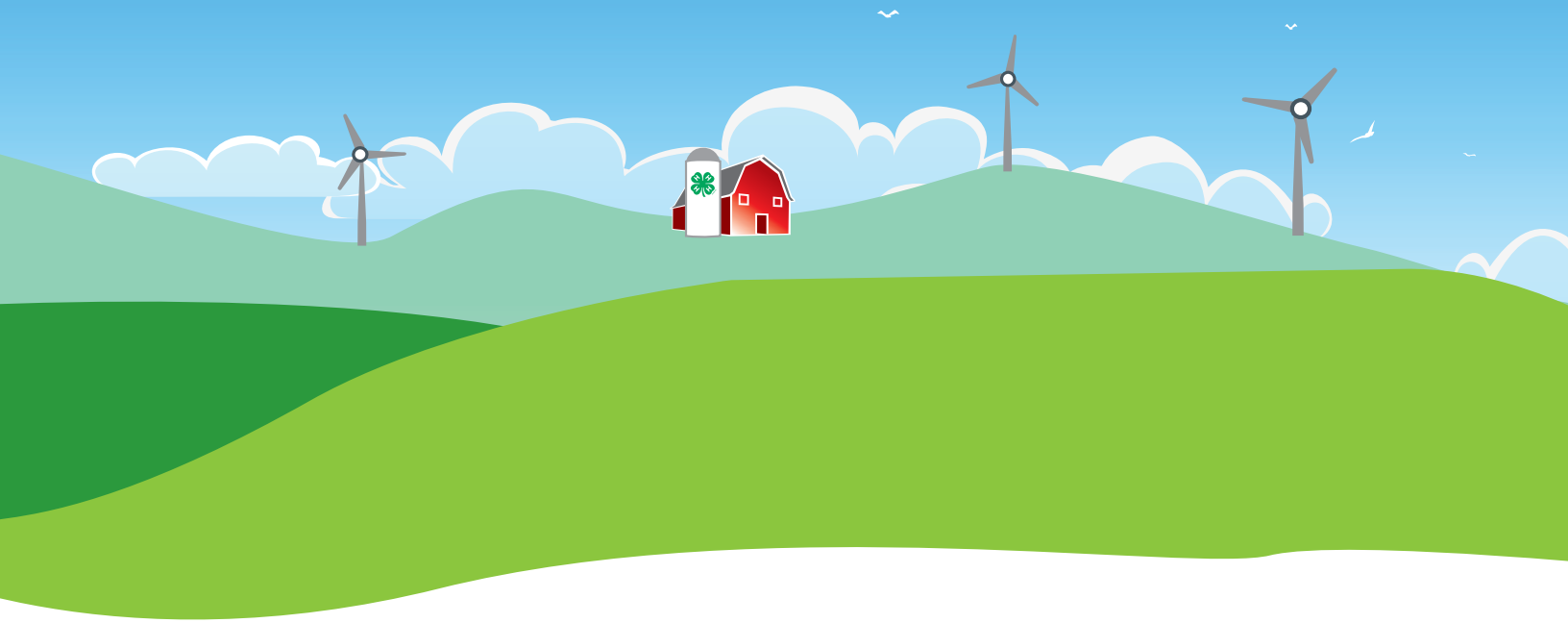

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4-H is the youth development organization of our nation's Cooperative Extension System and USDA.