Race to Renewables! A lesson about using renewable energy to combat climate change

*Climate Change/Renewable Energy*

# Goals: This first goal of this lesson is to explain to students what climate change is and how it impacts our planet. The second is to help students understand what renewable energy is and how it can be used to offset climate change.

# Age Level: Middle School (6th -8th Grade) or ages 11- 14 years old.

# Approximate Time: This activity will take between 40 minutes to 1 hour depending on class size. This activity can be truncated to only the first two or three renewable energy activities if need be/time runs out.

# Objectives: Following this lesson students will be able to…

1. Define climate change and explain what causes increases/decreases in global warming.
2. Design simple, iterative renewable energy systems to generate ‘energy’ and understand what natural forces impact the availability/success of these systems.
3. Evaluate which system had the greatest energy impact by interpreting a stacked bar graph.

# Learning Standards: This activity/these objectives will meet the following Next Generation Science Standards[[1]](#footnote-1):

* **MS-ESS3-5 Earth and Human Activity.** Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century *(Objective 1).*
  + Science and Engineering Practice: Asking Questions and Defining Problems.
  + Disciplinary Core Idea: ESS3.D: Global Climate Change
  + Crosscutting Concept: Stability and Change
* **MS-ESS3-3. Earth and Human Activity.** Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. *(Objectives 2 and 3).*
  + Science and Engineering Practice: Constructing Explanations and Designing Solutions
  + Disciplinary Core Idea: ESS3.C: Human Impacts on Earth Systems
  + Crosscutting Concept: Cause and Effect, Influence of Science, Engineering, and Technology on Society and the Natural World
* **MS-ETS1-2.** **Engineering Design**. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem *(Objectives 2 and 3).*
  + Science and Engineering Practice: Engaging in Argument from Evidence
  + Disciplinary Core Idea: ETS1.B: Developing Possible Solutions

# Materials: Following are the materials that will need to be gathered/purchased prior to this lesson. They are broken down by activity so that if you wish to shorten the activity, only the relevant materials are listed.

Hydropower

* (1) Large bucket or tub
* (1) Large garden pinwheel with a rod horizontal through the center[[2]](#footnote-2)
* (6) cups
* (3) additional cups with holes poked in the bottom)
* Enough water to fill the bucket/tub to ¾ full
* A tarp to lay down if there is no tile/outdoor area available.
* A stopwatch/timer

Wind power

* (1) Large garden pinwheel with a rod perpendicular to the wheel.
* (1) Hair dryer
* A stopwatch/timer

Solar power

* (4-6) Miniature solar panels
* (1) Digital multimeter
* (2) Light sources (phone or LED flashlights will work well)
* (1) block play dough or clay
* (3) sheets of parchment paper (6” x 6”)
* A stopwatch/timer

Geothermal

* (1) Styrofoam container with lid
* (1) Thermometer
* (x) Large potatoes. Have as many potatoes as you plan on having groups.
* Access to a microwave or oven
* Oven tongs
* (3) cups of sand
* (3) cups of water
* (3) cups of gravel
* A stopwatch/timer

General (optional)

* A dice to randomize results
* Projector and projector screen

# Engage: (10 minutes)

1. Start by introducing the topic of climate change to the students. Ask them what they know about climate change and how it affects the planet. If students seem confused or have not heard of climate change you can choose to show them these quick videos.
   1. [Climate change in 60 seconds](https://www.youtube.com/watch?time_continue=55&v=n4e5UPu1co0&feature=emb_logo) – The Royal Society of London
   2. [What's the difference between weather and climate](https://www.youtube.com/watch?time_continue=86&v=vH298zSCQzY&feature=emb_logo)? – NASA Climate Change
   3. [Climate Change 101 with Bill Nye](https://www.youtube.com/watch?v=EtW2rrLHs08) - National Geographic
2. Define for students the following words: greenhouse gas, fossil fuel, carbon dioxide, and global warming. As a formative assessment ask them to write down their own definition of climate change in their lab notebooks.
3. Show students a graph of fossil fuel usage and carbon dioxide emissions over time. Guide them through understanding the relationship between burning fossil fuels and increasing carbon dioxide levels.
4. Ask students to share what they know about renewable energy or what types of renewable energy there are. Show students examples of each of the types of renewable energy (solar, wind, hydro, geothermal, and biological). Explain to them that there are challenges facing each form of renewable energy. For a great video on the challenges facing renewable energy use the video listed below. Ask students to write down which renewable energy they think would be best for the area they live in (ex. Phoenix) and why.
   1. [Can 100% renewable energy power the world?](https://www.youtube.com/watch?v=RnvCbquYeIM) - Federico Rosei and Renzo Rosei

# Explore: (10 minutes per activity)

1. Have all stations you wish to use during the class set up prior to the start.
   1. For the hydropower station: Fill the tub/bucket with water, lay the pinwheel across the center and secure it, and have the cups at the ready.
   2. For the wind power station: Find an outlet to plug the hairdryer into.
   3. For the solar power station: Test that the light sources, solar panels, and digital multimeter are working properly.
   4. For the geothermal station: Heat the potatoes in a microwave or oven for 10 minutes so they are very hot (use caution). Place them in the Styrofoam container with the lid on to conserve heat. Have the cups of gravel, sand, and water ready.
2. Explain to students that their goal is to use a combination of renewable energy sources to meet a target carbon dioxide reduction. They will work as part of teams to achieve maximal energy production. You can use the graph shown below in Figure 1 or a replica if you like. In this graph the goal is indicated by a dotted red line. As they use different renewable energies their scores will be entered, and the team bar will go up! The team that does the best at each challenge will get 20 pts, second 15, third 10, fourth 5, and fifth or below 0. Teams will also not get any points if they fail the challenge.

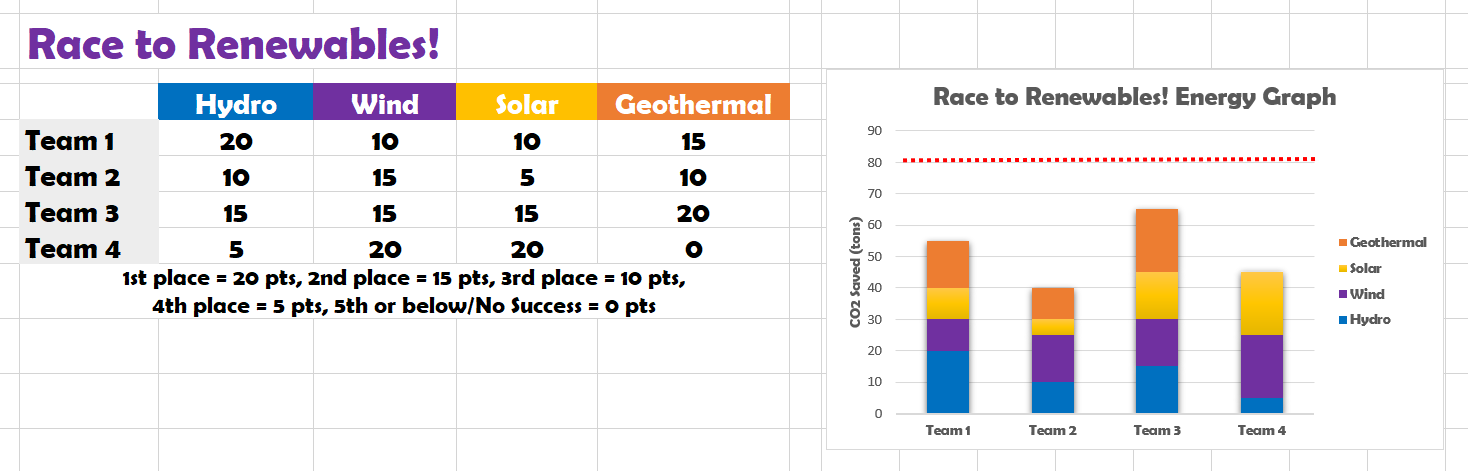


Figure 1. Example table and graph to draw/display for the race

1. Hydropower instructions: Explain that the faster you can spin a turbine, the more energy you can generate. Give each team 1 minute to use three cups to scoop water and get the pinwheel to spin as fast as possible. Count the rotations of the pinwheel and record it.
   1. Have the students role a dice to determine the additional challenge for the second round. If they role a 1 or 2, they get 3 extra cups to scoop water. If they role a 3 or 4, they get three cups with holes. If they role a 5 or 6, an opposing team gets two cups to try and get the pinwheel to spin the other direction. Give them one minute to try the challenge again.
2. Wind power instructions: Explain that the direction you blow a pinwheel increases or decreases its speed. Give each team 1 minute to try and get the pinwheel to spin as fast as possible. Count the rotations of the pinwheel and record it.
   1. Have the students role a dice to determine the additional challenge for the second round. If they role a 1 or 2, they get a hair dryer set to low to power the pinwheel. If they role a 3 or 4, they get a hair dryer set to high to power the pinwheel. If they role a 5 or 6, an opposing team gets to blow on the pinwheel in the opposite direction to try and stop the fan. Give them one minute to try the challenge again.
3. Solar power instructions: Explain that the distance and angle solar panels are from the sun affects how much energy they can produce. Give the students 2 minutes to arrange the solar panels in a shape and angle they think are best for capturing the light of the sun (in this case your phone/flashlight) held two feet above the table/surface you are working on. After two minutes turn your phone on and record the voltage from the solar panel array using the digital multimeter.
   1. Have the students role a dice to determine the additional challenge for the second round. If they role a 1 or 2, they get a second light source added. If they role a 3 or 4, one parchment paper sheet is added in front of the light source. If they role a 5 or 6, three parchment paper sheets are added in front of the light source. Record the voltage under these conditions.
4. Geothermal power instructions: Explain the potato represents the hot earth core and that the distance and materials between it and the surface affect how much geothermal heat there is. Put one potato at the bottom of the Styrofoam container and tell students that they have to choose three cups of either gravel, sand, or water to add to the container. After they’ve chosen and added the substrate to the container, add the thermometer (so the end is just submersed/buried ~ ½ inch). Watch the thermometer for temperature change for one minute and record the change[[3]](#footnote-3).
   1. Have the students role a dice to determine the additional challenge for the second round. If they role a 1 or 2, they will take out 1 cup worth of substrate. If they role a 3 or 4, they have to add 1 cup. If they role a 5 or 6, they have to add 2 cups. Watch the thermometer for temperature change for one minute and record the change.

# Explain/Expand: (5 minutes, 1 minute after each activity)

For each of the activities above there is a reason why each of the challenges were included.

* For hydropower explain that the extra cups represent an area with more or faster flowing water, the cups with holes represent the loss of water due to evaporation/changing seasons, and the opposing team members using cups of water represents how water is also used for other sources such as drinking or farming.
* For wind power explain that the hairdryer usage represents areas that have higher velocity winds blowing through them and are better for wind power and that the opposing team member represents an area that has winds that change direction.
* For solar power explain that the extra light source represents areas that have more sunlight throughout the year while the parchment paper covered light represents more cloudy areas.
* For geothermal power explain that some areas of the earth are closer to the earth’s magma core and are better for geothermal systems.

# Evaluate: (5 minutes)

1. Direct students attention to the graph. Ask them the following questions below. The goal is to help students understand the complexity of reducing carbon dioxide emissions and the challenges of each type of renewable energy.
   1. Who won the race?
   2. Which teams reached the target carbon dioxide goal?
   3. Is one renewable energy source the best?
   4. How could they have gotten more points in this race?
2. For a summative assessment ask students to write down what each of the renewable energy sources was and what they think the biggest challenge facing its implementation is. Also ask them to reconsider which renewable energy would be best to implement in their area (i.e. Phoenix).

# Further Actions: If student are interested in this topic, please take time to share with them ways to study/learn about renewable energy, practice energy conservation, or learn more about climate change. Close with challenging them to design better systems to create/capture renewable energy.

# Lesson Modifications: This lesson is designed to be modular in nature. You can choose the energy stations that best suit the abilities/skills of your students. Choosing only one or two of the systems may allow you to move at a slower pace or focus more on those systems. You can also implement multiple trials for each energy system to allow students to practice the station.

# Lesson Reflection: There is a lot of information and a lot of activities covered by this lesson plan. Giving examples the students can relate to is an important part of this lesson. Comparing global warming to a ‘planetary blanket’ or turbine rotation to a ‘exercise bike’ might aid students in adding this knowledge to their own. From a Constructivist Learning Theory standpoint students will likely come to class with preconceived notions and ideas about what climate change is. This increases the importance of the first engage step in building their understanding of what climate change and renewable energy is. Students will also be challenged in this lesson in a Developmental Learning Theory standpoint to move from a concrete operational stage to a formal operational stage with the move from the rate at which the turbine spins to the energy it reduces. Make sure these connections are clear and students are not overwhelmed with terminology.

# Resources: These resources were used to gain inspiration for this lesson plan. Please feel free to use them to learn more about this topic.

1. [The most important thing you can do to fight climate change: talk about it](https://www.youtube.com/watch?v=-BvcToPZCLI&feature=emb_title) - Katharine Hayhoe
2. [How to Talk To Kids About Climate Change](https://www.npr.org/2019/10/22/772266241/how-to-talk-to-your-kids-about-climate-change) – NPR
3. [zerofootprintYouthCalculator](http://www.meetthegreens.org/features/carbon-calculator.html) - PBS Kids
4. [Climate Change Is Scaring Kids. Here’s How to Talk to Them](https://www.nytimes.com/2019/06/27/science/climate-change-children-education.html) - NY Times.
5. [How to talk to kids about climate change without scaring them](https://mashable.com/article/climate-change-talking-to-kids/) – Rebecca Ruiz
6. [How I Talk to My Daughter About Climate Change](https://www.theatlantic.com/family/archive/2018/04/raising-kids-climate-change/554969/) – The Atlantic
7. [5 Tips for Talking to Kids About Climate Change (Without Freaking Them Out)](https://www.rainforest-alliance.org/articles/how-to-talk-to-kids-about-climate-change) - Rainforest Alliance

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1. More information about the NGSS standards can be found at <https://www.nextgenscience.org/> and on this site the standards listed can be searched for more information. [↑](#footnote-ref-1)
2. Alternatively, a waterwheel can be constructed by hot gluing plastic sheet to a center rod. [↑](#footnote-ref-2)
3. Bonus learning! This is an excellent opportunity to also teach students about thermal conductivity and about how some materials (air, gravel, sand) are better at transmitting heat than others (water). [↑](#footnote-ref-3)