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HYDRO ENERGY AND HYDROPOWER

| SuperNOVA | 1 Hour | Grade 3/4

SUPERNOVA
DALHOUSIE UNIVERSITY | HALIFAX, NOVA SCOTIA

OVERVIEW

Description
Participants will learn about hydro energy as a renewable, clean energy source. They will build their own water turbine to use hydropower to lift a load.

Learning Outcomes
- Overview of clean energy sources.
- Water as a source of energy; hydroelectricity harnessed from hydropower plants.
- Energy transformations.

Outline *(with time indications/estimations)*
1. Clean energy and examples (5 mins)
2. Hydropower (5 mins)
3. Build your own hydropower station (40-50 mins)
4. Debrief (10 mins)

Materials:

Item (*be very descriptive*)	**Quantity Per Group** (*with units*)	**Quantity Per Camp** (*with units*)
Styrofoam Cup	1	N/A
Large Plastic Cup (ex. Solo cup)	2	N/A
Small Paper Cup	1	N/A
Skewer	1	N/A
Large Straw (skewer fits inside)	1	N/A
750 mL Plastic Bottle	1	N/A
String	40 cm or more	N/A
Rubber Band	1	N/A
Glue Bottle	1	N/A
Roll of Tape	1	N/A
Scissors	1	N/A
Small Items (coins, rocks, marbles)	1	N/A
Cup of Water	1	N/A

SAFETY CONSIDERATIONS

- Precautions for Instructor and Participants.
- Please use caution, and explain each safety measure to the participants. Ensure any incidents are reported appropriately.
- Indicate with an ‘x’ next to the items that apply to this activity.
- This activity will be messy, please prepare to clean up your mess, at multiple stages.

Material/Chemical Safety	
	SDS Required (*attach in write up)*
	Electrical Components
	Food & / or Potential Allergens
	Other:
Equipment Precautions	
X	Sharp Objects: Scissors / Staplers / Scalpel
	Burn Risk: Glue Guns / Hot Plate / Flame
	Tools
	Other:

Digital Safety [ ] Yes [ ] No	
Special Clean-up Required? (indicate below)	
	Yes
Safety Equipment or Protection	
	Goggles / **Gloves**
	Lab Coat
	Fire Extinguisher
	Other:
Other Safety Precautions? (indicate below)	

KEY INFORMATION

Information on the activity topic(s) that is necessary for the Instructor to be familiar with. ***(Suggested 300 words)***

Clean Energy and its Sources: Clean energy is energy that is renewable and from zero-emission sources that do not pollute the environment when used. Renewable energy sources are infinite or are constantly replenished sources. Clean fuels are any fuel source that produces less emissions than traditional fossil fuels. An important distinction between clean energy compared to green energy is that clean energy is derived from sources that do not release air pollutants while green energy is derived from natural sources. Some examples of clean energy sources include solar energy (solar panels), wind energy (wind farms), and geothermal energy (volcanoes for electricity generation). Clean fuel sources include electric, biogas, hydrogen, and alcohol (ethanol) fuels.

Energy Transformations: Energy exists in many different forms, such as kinetic, gravitational (potential), electrical, or chemical energy. An energy transformation is a process which converts one form of energy into another; any type of energy use requires an energy transformation. Examples of energy transformation include an object falling gaining velocity (potential energy into kinetic energy), heat generated when rubbing hands together (kinetic energy into thermal energy), or flowing/falling water spinning a turbine (kinetic energy into mechanical energy).

Hydropower: Hydropower (or hydroelectric power) is energy extracted from flowing/falling water sources using hydraulic turbines and electric generators and is an example of renewable energy. The kinetic energy of falling water turns the blades of a turbine, producing mechanical energy. The spinning turbine drives a shaft connected to electric generators, creating electric energy. Dams or diversion structures create elevation differences in water, which allows the water to fall onto the turbines with greater energy. The Hoover Dam is an example of a hydroelectric power plant. Although hydropower does not use the burning of fossil fuels to produce energy (thus has a smaller carbon footprint during operation), hydropower is not considered clean energy. Water reservoirs used in hydro dams can produce large amounts of greenhouse gasses, such as CO_2 and methane, from decaying vegetation or from organisms. Overtime, the amount of produced gasses are reduced but initial construction has a large, negative environmental impact.

LESSON PLAN AND PROCEDURE

- *Should reflect Overview-Outline.*
- *Include any necessary inclusion and/or adaptation information.*
- *Refrain from including additional background information on the topic, instead refer back to the Key Information section, where necessary.*
- *Make note if anything needs to be prepared beforehand.*

Clean Energy, Clean Fuels, and Examples (5 minutes)

1. What is clean energy? Clean energy is any energy source that is renewable, creates zero-emissions when produced, and produces no pollution when used.
    a. Ask students for examples of clean energy they know (solar, wind, hydro, etc.) as well as some local examples (Maritime Link used to deliver hydroelectric power from Newfoundland; Wreck Cove hydroelectric plant in Cape Breton; land and offshore wind farms across the province).
    b. What do we need energy for?
        i. Energy is used whenever work is being done, such as raising a hand, running, heating up food, operating machinery, etc. Energy is converted from one form to another and is used to do work.
2. What are clean fuels? Clean fuels are any fuel that produces less emissions than traditional fossil fuels,
    a. Ask students about what machines/processes we depend on fuel for (cars, rockets, heating, cooking, etc.). Help the students understand that fuel is a source of energy that we use to power the services we rely on.
    b. Fossil fuels supply about 80% of the world's energy. Ask students about the environmental impact of using fossil fuels.
    c. Some alternatives to using fossil fuels include electric, biogas, hydrogen, and alcohol (ethanol) fuels.

Hydropower (5 minutes)

3. Steer students towards hydropower as a source of clean energy and explain how it produces clean fuel in the form of electrical energy.
    a. Hydropower is used to generate electricity through the flow/falling of water onto turbines, which spin an electric generator (potential energy -> kinetic energy -> mechanical energy -> electrical energy). The generated electricity can be used to power/heat homes, operate machines and electronics, and much more.

Build your own Hydropower Station (50 minutes)

4. Students will build their own hydropower station to lift a load.
    a. Energy is transformed as follows:
        i. Potential Energy (water held above turbines)
        ii. Kinetic Energy (water falling onto turbine blades)
        iii. Mechanical Energy (shaft lifting load)
    b. Students will test how much weight the station can lift.
        i. Time how long it takes for the station to lift an empty cup, ¼ filled cup, half cup, and full cup.

Activity Procedure: The procedure will be split into 3 sections: Initial part assembly, assembly of the hydropower station, and running the experiment.

Initial Part Assembly

1. In the middle of the styrofoam cup, cut a 2.5cm slit perpendicular to the opening as seen in the figure below. Add an equal size slit about 2.25cm beside the first one and continue until 8 slits are cut, equally spaced apart. Look to Figure 1 for details.

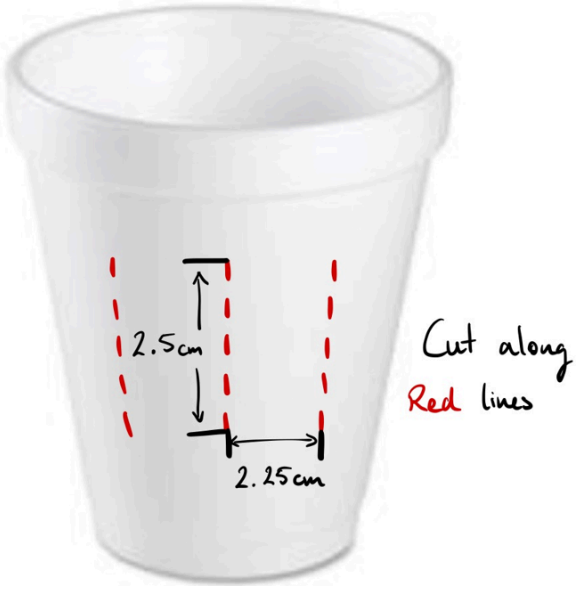


Figure 1: Cut perpendicular slits in the styrofoam cup, making sure to keep spacing between them consistent.

2. From the bottom of the cup, poke the skewer through the center. This will act as the driveshaft for the turbine.
3. ****MAY NEED ADULT SUPERVISION**** Cut the top and bottom off of the plastic bottle, then cut 8 strips measuring about 11.5cm long and 2.5cm wide from the sides of the bottle. These are the blades of the turbine.
4. Insert a turbine blade into the slits made on the styrofoam cup until it touches the skewer. Glue each blade onto the skewer and continue adding blades until all 8 are attached to the shaft of the turbine. The turbine should look like the image seen in Figure 2. Put the turbine aside and begin the next step.



Figure 2: A completed styrofoam cup turbine.

5. Stack 2 large plastic cups together with their bottoms facing each other. Glue the bottoms together.

6. Take the large straw and cut it into a length of 11.5cm. Tape the cut straw across the top of the opening of the stacked cups. You can now place the stacked cup assembly aside.
7. ****MAY NEED ADULT SUPERVISION**** Poke 2 hopes holes in the paper cup close to the opening. The holes should be opposite each other. Take the string and feed it through the 2 holes. Tie the ends of the string over the center of the cup to create a handle, with a long section of string stemming from the handle. Refer to Figure 3 for details.

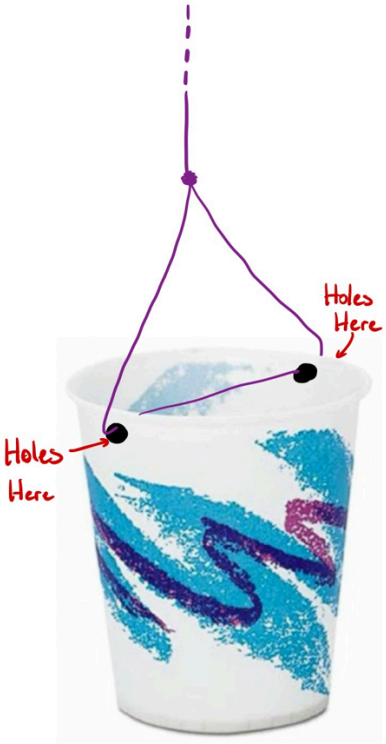


Figure 3: The paper cup with its string handle attached. It will be used to hold the load that the hydropower station will lift.

Assembly of Hydropower Station

8. Take the stacked cups and the styrofoam cup. Stand the stacked cups up with the attached straw on the top. Now slide the skewer from the styrofoam cup into the straw on the stacked cups, making sure that the skewer (driveshaft) is sticking out the end of the straw. You should now have a base (stacked plastic cups) with a turbine attached to it (styrofoam cup).
9. Take the paper cup with the string and tie it to the end of the driveshaft that is sticking out from the straw. Take the rubber band and wrap it around the tied string to prevent the string from falling off. Your completed hydropower station should look like Figure 4.



Figure 4: A completed and functioning hydropower station!

10. You now have a hydropower station! Put the station in a water-safe area, such as a large bucket, a sink, or outside.

Running the Experiment

1. For the first pass of the experiment, students will use no weights inside the paper cup.
2. Students will pour water over the turbine blades and observe the rate at which the paper cup rises.
    a. For added accuracy, a student could be in charge of timing the experiment. Begin timing when water first touches the turbine blades and stop the timer when the paper cup reaches the top.
3. Students will now add weights into the cup, first to ¼ of the cup, then to ½, and then finally fill the cup. Repeat steps 1 and 2.
    a. For the best accuracy it is important that students use the **SAME WATER FLOW RATE** ie. turn on the sink to the same setting, pour water from a bottle at the same rate AND height.

** For added complexity and fun, you could have some groups use turbines with LESS blades and compare their results to groups with more blades. For groups that use less blades, they could try and experiment with larger blades than the standard ones from this experiment.

Debrief

- *Discuss how water is used as an energy source.*
- *When the load is light, how quickly is the cup lifted?*
    - *If possible, at what weight does the station fail? What could help the station overcome such a load?*
        - *Pour water from a higher height, turn the sink on to a higher setting, more turbine blades, wider turbine blades, etc.*
- *With different loads, is the amount of energy used the same?*
    - *The energy used is the SAME; lighter loads move FASTER.*

SuperNOTE
One sentence summary of activity, including basic learning outcomes. Remember to copy this into the SuperNOTES Spreadsheet!

REFERENCES & RESOURCES

Clean Energy, Clean Fuel, and its Sources

- https://cleanenergycanada.org/about-us/#our-mission
- https://www.twi-global.com/technical-knowledge/faqs/clean-energy
- https://www.eia.gov/energyexplained/what-is-energy/#:~:text=People%20use%20energy%20for%20a,Light
- https://reposenergy.com/understanding-clean-fuels/
- https://www.who.int/tools/clean-household-energy-solutions-toolkit/module-7-defining-clean
- https://www.eesi.org/topics/fossil-fuels/description#:~:text=Fossil%20fuels%E2%80%94including%20coal%2C%20oil,percent%20of%20the%20world's%20energy.

Energy Transformations

- https://energyeducation.ca/encyclopedia/Energy_transformations

Hydropower

- https://www.energy.gov/eere/water/hydropower-basics
- https://natural-resources.canada.ca/our-natural-resources/energy-sources-distribution/renewable-energy/hydroelectric-energy/25792
- https://blogs.edf.org/energyexchange/2019/11/15/long-considered-a-clean-energy-source-hydropower-can-actually-be-bad-for-climate/
- https://waterkeeper.org/news/hydropower-is-not-clean-energy/

Hydropower Experiment

- https://www.education.com/science-fair/article/water-produce-energy/
- https://www.sciencebuddies.org/science-fair-projects/project-ideas/Energy_p021/energy-power/using-hydropower-to-lift-a-load
- https://www.ontariosciencecentre.ca/science-at-home/explore-more/power-up-the-science-of-energy/build-a-hydro-power-machine

DOCUMENT TITLE NAMING CONVENTION

Title
Be concise, but descriptive. The Title *must* reflect the title in the write up document itself, the SuperNOTE, and the camp schedule.