SCIENCE BUDDIES®

Leaky Clues to Dam Design: How Reservoir Height Affects Hydroelectric Power Production

Areas of Science	Energy & Power (http://www.sciencebuddies.org/science-fair-projects/project-ideas/energy-power)
Difficulty	
Time Required	Very Short (≤ 1 day)
Prerequisites	Access to a bathtub or other area suitable for testing with water.
Material Availability	Readily available
Cost	Very Low (under $20)
Safety	Use caution when poking holes with the nail.

Abstract

It's hard to believe that the same water that you use every day to quench your thirst, cook with, bathe in, swim in, and wash your trick—it can make electricity! Electricity can be generated through the *flow* or through the *fall* of water. A big, fast-flowing river, for that provides enough pressure to turn the blades of a turbine and run an electric generator. This same pressure can also be creat great height. Dams are the way we store water and raise it to a great height to create pressure. The more water that is stored, the becomes, and the greater the pressure that is available to run an electric generator. In this energy and power science fair project, poke holes at different points along the dam wall to investigate the places where the pressure and the potential for generating ele

Objective

To determine the best location on a dam to generate electricity by investigating how the height of water above a hole in the dam v from that hole.

Credits

Kristin Strong, Science Buddies

This science fair project was inspired by the science activity outlined in the following source:

- Newton's Apple. (2006). *Locks and Dams.* Retrieved February 13, 2009, from http://www.newtonsapple.tv/TeacherGuide.p (http://www.newtonsapple.tv/TeacherGuide.php?id=1041)

Cite This Page

General citation information is provided here. Be sure to check the formatting, including capitalization, for the method you are using and upd

MLA Style

Science Buddies Staff. "Leaky Clues to Dam Design: How Reservoir Height Affects Hydroelectric Power Production." *Science Bu*
https://www.sciencebuddies.org/science-fair-projects/project-ideas/Energy_p029/energy-power/dam-design-how-reservoir-height-
Accessed 6 Mar. 2020.

APA Style

Science Buddies Staff. (2020, January 12). *Leaky Clues to Dam Design: How Reservoir Height Affects Hydroelectric Power Prod*
https://www.sciencebuddies.org/science-fair-projects/project-ideas/Energy_p029/energy-power/dam-design-how-reservoir-height-

Last edit date: 2020-01-12

Introduction

Electricity is a big part of your life. Can you imagine not being able to turn on a light, the TV, the computer, or your video game co easily wash and dry your clothes, or keep your food cold? When the power goes out in a big storm, it's a big deal! It is always a h turned back on.

From where does all that electricity come? Electricity is a *secondary* energy source, meaning that it has to be made from some o gas, oil, nuclear power, wind, or water. When electricity is made from the force or energy of *moving water*—water that is flowing o (*hydro* means "water").

Hydroelectricity has been around since the late 1800's. Today, **hydropower** is a popular way to **generate** electricity, supplying th needs, and reaching more than 1 billion people. Hydroelectric power has several advantages. Unlike **fossil fuels,** water is a sour can be naturally replenished at a rate faster or similar to the rate that people use it up. Hydroelectric power is also low-polluting, c lakes, and the power can help with flood control and irrigation. Its disadvantages are that it can damage animal **habitats** or **ecos** flooding, such as the Teton Dam and Johnstown flood catastrophes, which you can read about in the Bibliography. Engineers wei disadvantages before deciding whether or not to build a hydroelectric power plant.

Hydroelectricity is made through the *flow* or *fall* of water. A big, fast-flowing river, for instance, contains a lot of moving energy tha the blades of a turbine and run an electric generator. This same water pressure can also be created though through the *fall* of wa we store water and raise it to a great height to create water pressure. Dams are among some of the biggest manmade structures

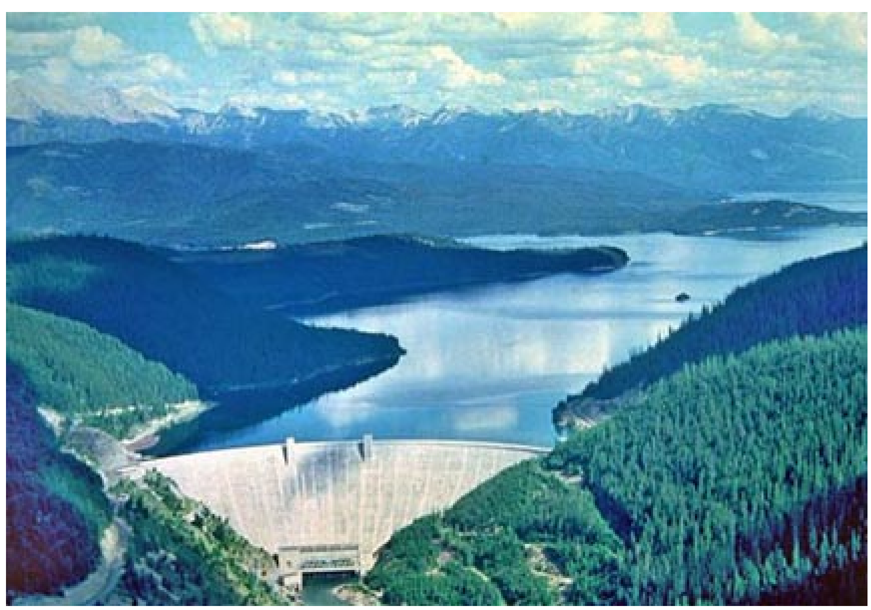

Figure 1. This photo shows the Hungry Horse Dam in the state of Montana. (Bonneville Power Administration, United Sta

Dams block the flow of a river or stream and create a lake or **reservoir** behind them, which acts as a source of *stored energy* (a l of stored energy). The dam raises the surface water up to a great height, giving it **potential energy,** the potential to do work. Wat dam by way of a special intake gate called a **penstock.** It's kind of like one of those water tunnels you slide through at a water pa penstock and turns the blades of a **turbine,** which is connected through a metal shaft to an **electric generator.** As the turbine tur rotate past copper coils and **alternating current** is made. This current is then *transformed* in a **transformer** to a higher-**voltage** (long distances to homes in cities far away from the power plant.

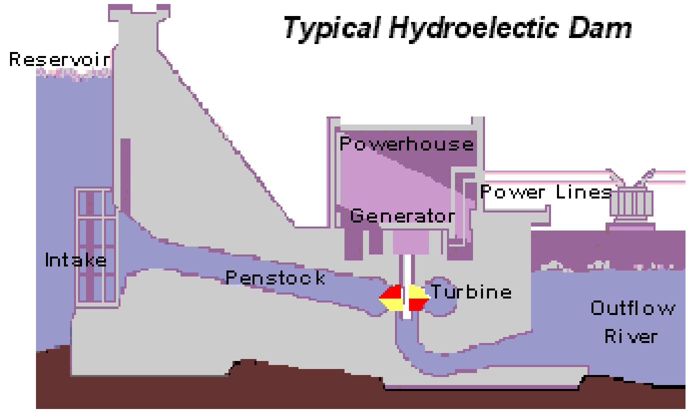

Figure 2. This animation shows how a hydroelectric power plant makes electricity. (United States Geolog

What determines how much electricity a hydroelectric power plant can produce? There are several factors, but two of the most im the dam, and the distance from the surface of the reservoir to the penstock. These determine how much energy can be released way, from the reservoir. You can *approximate* the hydroelectric power production of a dam with this equation:

Equation 1:

Power = Water Flow Rate × Acceleration Due to Gravity × Reservoir Height × Coefficient of Ef

- Power is in watts (W).
- Water flow rate is in kilograms per second (kg/s).
- Acceleration due to gravity is 9.81 meters per second squared (m/s^2).
- Height is in meters (m).
- Coefficient of efficiency ranges from 0 to 1, with modern power plants having the highest efficiency.

In this power and energy science fair project, you will investigate how the distance between the surface of the reservoir and the p penstock. Do you think a deeper reservoir will create a different flow than a shallow reservoir? It's time to find out!

Terms and Concepts

- Hydroelectricity
- Hydropower
- Generate
- Fossil fuel
- Renewable energy
- Habitat
- Ecosystem
- Water pressure
- Dam
- Reservoir
- Potential energy
- Penstock
- Turbine
- Electric generator
- Magnet

- Alternating current
- Transformer
- Voltage
- Bernoulli equation

Questions

- What are the advantages and disadvantages of hydroelectric power?
- What are the parts of hydroelectric power plant?
- How does a hydroelectric power plant make electricity?
- What factors are important in determining how much electricity a hydroelectric power plant can produce?
- What are the different types of dams?

Bibliography

These sources describe the parts of a hydroelectric power plant and how it makes electricity:

- Bonsor, K. (2009). *How Hydropower Plants Work.* Retrieved February 13, 2009, from http://science.howstuffworks.com/hy *(http://science.howstuffworks.com/hydropower-plant.htm)*
- Energy Information Administration. (2008, October). *Energy Kid's Page: Hydropower—Energy from Moving Water.* Retriev http://www.eia.doe.gov/kids/energyfacts/sources/renewable/water.html *(http://www.eia.doe.gov/kids/energyfacts/sources/renewable/water.html)*
- Perlman, H. (2008, November 7). *Hydroelectric power: How it works.* Retrieved February 17, 2009, from https://water.usgs *(https://water.usgs.gov/edu/hyhowworks.html)*

These articles describe two historic dam failures:

- Wikipedia Contributors. (2015, September 19). Teton Dam. *Wikipedia: The Free Encyclopedia.* Retrieved January 28, 201 https://en.wikipedia.org/w/index.php?title=Teton_Dam&oldid=681759648 *(https://en.wikipedia.org/w/index.php?title=Teton_Dam&oldid=681759*
- Wikipedia Contributors. (2016, January 22). Johnstown Flood. *Wikipedia: The Free Encyclopedia.* Retrieved January 28, 2 https://en.wikipedia.org/w/index.php?title=Johnstown_Flood&oldid=701117162 *(https://en.wikipedia.org/w/index.php?title=Johnstown_Flood&*

This source discusses the Bernoulli equation, which describes the way liquids move and provides an equation for calculating the of the reservoir:

- The Millennium Mathematics Project Contributors. (2009). *Testing Bernoulli: A Simple Experiment.* Retrieved February 17, http://plus.maths.org/issue2/bottle/index.html *(http://plus.maths.org/issue2/bottle/index.html)*

Visit these pages, from PG&E, a California power, gas, and electric company, for more information about electricity:

- Pacific Gas and Electric Company. (2002). *Electricity Generation and Distribution.* Retrieved March 4, 2009, from http://www.pgesafetyeducation.com/school/energy-science/tellmemore/index.html *(http://www.pgesafetyeducation.com/school/energy-scien*
- Pacific Gas and Electric Company. (2002). *Alternative Energy Sources.* Retrieved March 4, 2009, from http://www.pgesafe science/tellmemore/alternative.html *(http://www.pgesafetyeducation.com/school/energy-science/tellmemore/alternative.html)*

For help creating graphs, try this website:

- National Center for Education Statistics (n.d.). *Create a Graph.* Retrieved February 17, 2009, from https://nces.ed.gov/nce *(https://nces.ed.gov/nceskids/CreateAGraph/default.aspx)*

Materials and Equipment

Note: This science fair project requires access to a bathtub, garage, or outdoor area where you can experiment with slow-flowing water.

- Plastic milk jug, 1-gallon
- Permanent marker
- Ruler, metric
- Small nail, 1 inch long
- Duct tape
- Tape measure
- Stepping stool, or bricks or blocks of wood
- Timer
- Lab notebook
- Graph paper

.

Leaky Clues to Dam Design: How Reservoir Height Affects Hydroelectric Po

https://www.sciencebuddies.org/science-fair-projects/project-ideas/Energy_p029/energy-power/dam-design-how-reserv production (http://www.sciencebuddies.org/science-fair-projects/project-ideas/Energy_p029/energy-power/dam-design-how-reservoir-height-affects-hydroelectric-power-production)

PDF date: 2020-03-06

Experimental Procedure

Note: Your milk jug will serve as a model of a reservoir, with one side of the milk jug acting as a model of a dam wall.

Preparing Your Milk Jug

1. Rinse the milk jug out so that it's clean.
2. Throw away the jug cap.
3. With the ruler and the permanent marker, make three marks on the wall of the milk jug that is opposite the handle:
    a. Make the first mark in the center of the wall, 3.5 inches up from the bottom.
    b. Make the second mark 1 inch to the left of the center mark and 1 inch up from the bottom.
    c. Make the third mark 1 inch to the right of the center mark and 6 inches up from the bottom.
4. Press the nail into each mark until it pokes through the wall of the milk jug. Once the nail pokes through, rotate it in a circle defined, circular hole. Be careful with the sharp nail.

Figure 3. This photo shows how to punch holes in the milk jug and how to rotate the nail around the hole to crea

5. Cover the three diagonal holes with a strip of duct tape, as shown in Figure 4, pressing on the tape gently to seal the holes

Figure 4. This photo shows how to cover the holes with duct tape.

6. Take your milk jugs to the area where you plan to do the testing, such as a bathtub, a garage, or an outdoor area where it water. Ask your parents where to test if you are unsure about where a good area might be.

Testing Your Milk Jug

1. Write down in your lab notebook what you think will happen when you fill the milk jug up with water and remove the piece streams from the holes will be longer than the others? What do you think will happen to the length of the streams over time
2. Make three data tables in your lab notebook, like the one shown below.

Stream Lengths Data Table 1

Time (min)	Lowest Hole Stream Length (cm)	Middle Hole Stream Length (cm)	Highest Hole Stream Length (cm)	Rese
0				
1				
2				
3				

3. Place your milk jug in the test area on top of the stepping stool, stacked bricks, or blocks.

4. Extend a tape measure from the base of the milk jug out about 18 inches and lock it so that it stays in place in front of the

Figure 5. This photo shows how to set up of the milk jug, stepping stool, and measurin

5. Fill the milk jug up to the top with tap water.
6. Get your timer ready and reset it to zero.
7. Remove the duct tape from the milk jug and immediately start the timer. This will be your starting time (time = 0 min).
8. Measure and write down the length of each water stream in your data table. Then immediately, with the ruler, measure and the bottom of the milk jug to the surface of the water), and record your measurement in the data table.
9. Repeat step 8 each minute, until the level of water in the milk jug reaches the level of the lowest hole.
10. Repeat steps 5–9 two more times for your two other data tables.

Analyzing Your Data Table

1. Make three line graphs (one for each data table) that show time (in minutes) on the x-axis and stream length (in cm) on the the line graph by hand or use a website like Create a Graph (http://nces.ed.gov/nceskids/createAgraph/) to make the graph on the comp
2. Go to your data table and calculate the difference between the reservoir height and the hole height for each hole *when the* difference the same for all the holes?
3. Looking at your line graphs, do the shapes of the line graphs look the same for all three trials? Which hole produced the lo produce the longest stream length over the entire test time? Which hole produced the shortest stream length? Did this hol the entire test time? Based on your results do you think the water pressure on a dam wall is greatest at the bottom of a da If you were building a dam, where would you make the dam the strongest? Where would you place the penstock? At which electricity can be produced? Based on the results of your experiment, can you predict what would happen if you made a h height, in the dam wall? Would the stream lengths all be the same? Give it a try and see!

.

If you like this project, you might enjoy exploring these related careers: