SCIENCE NORTH SCIENCE NORD
SUDBURY, ONTARIO, CANADA

Energy and Society Electricity and Magnetism **Grade 11 – Going Off Grid**

Lesson Plan

Assessment	AFL, AOL
Cross-curricular	

Big Ideas

- Energy can be transformed from one type to another.
- Energy transformation systems often involve thermal energy losses and are never 100% efficient.
- Electricity and magnetism have many technological applications.
- Technological applications that involve electromagnetism and energy transformations can affect society and the environment in positive and negative ways.

Learning Goals

- I can describe a way to improve the use of renewable energy by use of a household battery.
- I can name some drawbacks to the use of a household energy storage battery.
- I can use the terms anode, cathode, battery, voltage, electric potential, power, and efficiency.
- I can demonstrate how the voltage of a battery is affected when battery cells are placed in series or parallel.
- I can solve problems involving the relationship between power, energy and time.

Specific Expectations:

D2. investigate energy transformations and the law of conservation of energy, and solve related problems;
D 2.5 solve problems involving the relationship between power, energy, and time
D3. demonstrate an understanding of work, efficiency, power, gravitational potential energy, kinetic energy, nuclear energy, and thermal energy and its transfer (heat).
D3.2 explain the concepts of and interrelationships between energy, work, and power, and identify and describe their related units
F1. analyse the social, economic, and environmental impact of electrical energy production and technologies related to electromagnetism, and propose ways to improve the sustainability of electrical energy production;
F1.2 analyse the efficiency and the environmental impact of one type of electrical energy production (e.g., from hydroelectric, fossil fuel–burning, wind, solar, geothermal, or nuclear sources), and propose ways to improve the sustainability of electrical energy production

Description:
In this lesson students will make a saltwater battery to learn about battery technology. They will demonstrate how the voltage of a battery is affected when battery cells are placed in series or parallel. This lesson should be used after completing the unit Energy and Society, and when learning about the efficiency and environmental impact of energy production (in Electricity and Magnetism). It is helpful if students have already learned about electrical circuits – voltage, work, power, series and parallel circuits and efficiency. **This lesson is intended for the university level.**

Materials
Tesla's Powerwall Event: The 12 Most Important Facts video
Battery Power visuals
Creating a Salt Water Battery (Student)
Salt Water Battery Activity Group Materials:
Ice cube tray
2 cups of water
2 tablespoons of salt
15 Canadian pennies, pre-1997 (these contain approximately 98% copper, which is the anode)
30 cm^2 of Aluminum foil (~98% aluminum, which is the cathode)
Solar LCD calculator with solar panel removed
15 paper clips
Multimeter
Tape
An empty container or basin for underneath the ice cube tray
Could you run your household on a Tesla Powerwall questions (Student and Teacher)
Website:
https://rosedalephysics.wikispaces.com/SPH3U+Unit+4+Energy
Further Power and Efficiency Questions (Student and Teacher)

Safety Notes
Students are to be careful when using electrical devices.

Introduction
Energy production and conservation is an issue, which increasingly affects all of humanity and has repercussions both economically and politically both in Canada and globally. Energy generation affects the environment, regardless of the source. Habitats may be destroyed to create more hydroelectric, wind, or tidal capacity. Pipelines may be built and there may be an increased risk of oil spills or radiation leaks.

To help alleviate the situation, people are being encouraged to use renewable resources when possible while also continue to practice energy conservation. Using renewable energy, such as that collected from the sun by solar panels or from wind turbines seems to be the way forward for electricity generation. But what happens at night? When it is cloudy out? Or when there isn't enough wind? In order for renewable energy to be widely adopted, the most efficient method of distribution and storage would be for every household to produce and store their own energy for their own electrical uses.

There are a variety of energy storage solutions on offer from companies such as Orison SimpliPhi, Bosch, and Samsung. The first, and most popular by far, has been the introduction of the Powerwall from Tesla Motors. Elon Musk from Tesla Motors has been a charismatic figure in innovating and selling energy storage solutions for cars and homes.

Students should begin by watching the video:
Tesla's Powerwall Event: The 12 Most Important Facts
http://www.bloomberg.com/news/articles/2015-05-01/tesla-s-powerwall-event-the-11-most-important-facts
Tom Randall
May 1, 2015
Retrieved January 27, 2016

Using the Battery Power Visuals (See Link), review some concepts about energy, circuits and batteries.

Action

Saltwater Battery (See Link)
Most household (and camp) batteries are "dry" batteries and made up of rare elements that must be mined from the earth, however, in pairs, we can demonstrate the same chemical energy storage principles by creating a "wet" battery.

Group Materials:

- Ice cube tray
- 2 cups of water
- 2 tablespoons of salt
- 15 Canadian pennies, pre-1997 (these contain approximately 98% copper, which is the anode)
- 30 cm^2 of Aluminum foil (~98% aluminum, which is the cathode)
- Solar LCD calculator with solar panel removed (try the Dollar Store)
- 15 paper clips
- Multimeter
- Tape
- An empty container or basin for underneath the ice cube tray

Instructions:

1. Fill a container with 2 cups of water and 2 tablespoons of salt.
2. Tape the pennies into the ice cube tray, one penny per cube. Place them such that they are taped to the divider between cubes (the side of the cube) and the tape is looped under the penny in the tray (instead of overtop).
3. Fold up small pieces of aluminum foil (around 2 cm squared) and tape them, similarly, into the cubes on the other side of the dividers.
4. Connect the anode and the cathode with a bent paper clip.
5. Pour saltwater into each cell of the ice cube tray. Make sure each metal is covered, but do not fill the cube to the top.
6. Measure the voltage of the battery using the voltage setting of the multimeter. Put the black lead into the anode side, and the red lead into the cathode side.
7. Now, attach the calculator and see if the battery can power it.

Discussion Questions

1. Draw a diagram of your “wet battery”, label the anode(s) and the cathode(s).
2. How do you think your battery works to create an electric potential difference?
3. Draw a schematic of how the cells in your battery are connected. What is the voltage of your battery?
4. Try measuring the voltage for just one cell, then two cells, etc. Plot the Voltage versus number of cells. Use a ruler and label each axis. Based on this graph, how many cells would you need to power the calculator?
5. Based on the graph, are the cells connected in series or parallel? How do you know?

Activity adapted from
https://www.clarkson.edu/highschool/k12/project/documents/energysystems/LP_3fuelcell.pdf.

Students should discover that voltage increases when batteries are in series and stays the same when batteries are in parallel. Similarly, for an identical household load (same current in the circuit), the power capability of a battery increases when the batteries are hooked up in series. Teachers may use the discussion questions in class or collect the diagram, schematic, and graph.

Consolidation/Extension

Students should complete “Could you run your household on a Tesla Powerwall?” questions to discuss in class (See Link).

1. Complete an average Home Energy Use Calculation for your home for **one month** (30 days) using the website and worksheet “Home Energy Use” http://www.hydroone.com/MyHome/SaveEnergy/Tools/calc_main.htm
2. How much would your family pay in electricity bills (“hydro”) just for electricity (not including distribution charges or debt retirement) for one month based on a price of $0.128/kWh for mid-peak energy use?
3. How many of these Powerwall batteries would your family require (fully charged) at 92% efficiency, to operate your household for **one day**? Should these batteries be connected in series or in parallel?
4. If each 7 kWh Powerwall battery costs $3000 (USD), how long before your Powerwall units would pay for themselves?
5. List two drawbacks of using this new technology. Is it worth it?

For the class discussion, teacher can refer to “Could you run your household on a Tesla Powerwall?” answers to questions (See Link).

Student then complete **“**Further Power, Energy, and Efficiency Questions” (Student and Teacher) (See Link) as a Summative task.