Grade Level: Middle School, 6-8
Time: Two 50-minute class periods
Lesson could be divided into two separate lessons: one overview and poster-making lesson, and one hydro and experimentation lesson.

Standards:
From the Next Generation Science Standards DRAFT version, May 2012 (see "Detailed Standards" at end of lesson plan for detailed descriptions):
MS.ESS-HI Human Impacts (a, b, c, e)
MS.ETS-ED Engineering Design (a, c, e, f)

From Common Core State Standards:
Writing:  ELA-Literacy.WHST.6-8.7
ELA-Literacy.WHST.6-8.9
Reading: Informational Texts:  ELA-Literacy.RI.7.7 (Also RI.6.7)
Speaking & Listening:  ELA-Literacy.SL.7.1 (Also SL.6.1, SL.8.1),  ELA-Literacy.SL.7 (Also SL.6.4, SL.8.4)

Objectives: The student will:
• Understand the different alternative energy sources, focusing specifically on those available and used in Idaho.
• Synthesize pros and cons of different types of energy sources.
• Discuss his/her own relationship with alternative energy sources.
• Explain how a hydrodam uses water to generate electricity.
• Demonstrate how a change in the load affects the system.

Background Information:
This lesson plan consists of an introduction of various alternative energy sources in use in Idaho, an activity for students regarding these, then a more in-depth discussion of hydropower, with a demonstration and hands-on experiment for hydro.

An initial lesson on traditional energy sources would best precede this lesson, and that knowledge can be incorporated into the discussions that happen here.

Materials:
• Computer with connection to projector or TV
• For Activity 1
  o Poster paper/tagboard
  o Markers/colored pencils
  o Computers or other internet research device and website guidance OR printouts of Intermediate NEED Energy Infobook (see Activity 1 below)
• Hydropower “map” handouts
• For Activity 2 (each group will require one full set of materials):
  o Empty, clear 2-liter pop bottle
  o Wood dowels, longer than bottles, approximately 1.5-2 ft (1 per bottle)
  o String
  o Water
**Intro/Brainstorm**

*Guiding question:* “What are some energy sources that we know exist?”

Begin by asking students if they know of any alternate energy sources (these could possibly be recalled from prior lessons, and compared to the ones that have already been discussed). For the purposes of this lesson we can define *alternate energy sources* as alternatives to fossil fuels, such as natural gas or oil. We want to finish with at least these listed on the board:

- Nuclear
- Geothermal
- Hydro (water)
- Solar (Sun)
- Wind

*Guiding question:* “Why do we need these energy sources?”

There are many possible answers here (for example: to power electric lights, to run buildings, to heat homes). Guide the conversation as necessary or desired. Explain that we will focus on **ELECTRICITY** used by homes and businesses, as opposed to fuel for vehicles.

**Activity 1**

This activity is meant to give fodder for discussions both in this lesson and in subsequent lessons.

*Guiding questions:* “What does each of these energy sources do? For example, how does solar take the sun’s energy and convert it to usable electricity for us? What are the benefits and costs (pros/cons) of each?”

Divide students into individuals, pairs, or trios (chosen or assigned, whichever works best for the class) to make posters for the alternate energy sources that have been brainstormed. Students can be allowed to choose which energy source they want with the teacher filling in the gaps, or topics can be assigned.

Options for **information sources** for the students to create their posters:

- Distribute each group the associated pages from the Intermediate NEED Energy Infobook \(^1\) to give them a resource to consult.
- Distribute entire printout (or electronic version) of Infobook so that students must
determine where to find their information.

- Provide specific websites (NEED², NREL³, also see Additional Resources section) and computer access for students to conduct their research.
- Provide general guidance for conducting internet/computer-based research, and allow students time to learn about their topic.

Give approximately 20-30 minutes (more or less as desired and appropriate) to create poster. Then have students present.

**Video 1**
Show Teachers’ Domain video on energy sources. Highlights pros and cons. ~6 min
http://www.teachersdomain.org/resource/phy03.sci.phys.energy.energysource/

Discussion Questions:

- What are the energy sources discussed in the video?
- What are the pros and cons of each type? Were there any you hadn’t thought of before?
- Is there a “best” energy source? Why do you think one may be the best? Or, if we can not decide which is best, why can’t we?
- What main sources of energy do you use on a daily basis? Do you know where the electricity to run your home comes from?
- Why are the renewable energy sources currently being used considered to be unable to meet our total energy needs?

If you divide this lesson into 2 parts, this is the recommended break point. Next lesson can begin with a video intro.

**Video 2**
Show video on Hoover Dam: its construction, operation, and pros and cons. (~4 min)
http://www.teachersdomain.org/asset/phy03_vid_hooverelec/

Discussion Questions:

- Has anyone been to the Hoover Dam? What was it like? (Big?)
- Do we know of anything like this nearby? (Lucky Peak, Cascade, Post Falls, Dworshak, American Falls)  
  - See http://fwee.org/nw-hydro-tours/hydroelectric-projects/hydroelectric-projects-in-idaho/ for more all over Idaho.⁶
- Ask some video comprehension questions to reinforce info from video
  - What is hydroelectric power? What is the role of the turbine in generating electricity? Of magnets?
  - What are the pros and cons of constructing large dams?
  - How has the Colorado River been affected by the construction of the Hoover Dam?
Dam Operation
Guiding question: How does a dam produce electricity?

HydroTour handout – walk through “steps” of the dam (enlist students to participate and explain), and solicit explanations for how this is converted to electricity. Optional: Hand this out prior to watching the video so the students can use it as a reference in their viewing and discussion.

Demonstration & Activity
From “Building a ‘Turbin-ator’” (Activity 7 from NREL’s “REACT: Renewable Energy Activities – Choices for Tomorrow”)

Students will learn that rotors, blades and water speed are also factors that determine how much electricity can be generated by hydropower (a dam).

Students will make a “hydro-mill” and design an experiment that measures the relationship between amount of water, speed, the number of turns of the rotor (turbine), and the weight of objects pulled in by the string. Students should limit the variables listed above.

The original instructions from NREL do not specifically say to drill a hole in the bottom of the bottle, but without this hole there is no way to construct an axle around which the hydromill can spin. It is very difficult to cut or poke a hole in the bottom of a plastic bottle and using a drill with large (1/4” minimum) drill bit is recommended. Please drill these holes ahead of time and remember that you may need to enlist help if you are not comfortable with operating a drill (a school shop might be a good resource).

Try showing the students a fully-constructed “mill” and then unleashing them with their own sets of materials to conduct experiments.

1. Assemble building materials and have students work independently or in small groups.
2. Construct the hydro-mill as follows:
   a. Cut little “doors” length-wise into a plastic soda bottle and bend the doors open to create the turbine blades. This is assuming the bottle already has a hole drilled in the bottom, as per note above.
   b. Fasten a string to the neck of the bottle so that when the water flow causes the bottle to spin, the string is wound up. You can tie objects of varying weights to the other end and the mill pulls them in as the string rolls up, and ask the students what the weights represent. (This can also model the shaft of a turbine being turned.)
   c. Using the sink, pour water over the mill to make it turn.
   d. As a generic test, pour a fixed amount of water over the hydro-mill and measure the turns it makes. Students will need to experiment with the number of "doors"
and their position.
3. Instruct students to design an experiment that measures any two factors relating to the hydro-mill. Use one factor as a constant, another as a variable. Hand out "Hydro-Mill Experiment" as a guide for students to use.

Assessment:
- Ongoing formative assessment of students’ participation in class and general understandings of the activities (poster & hydro plant).
  - Research methods and comprehension
  - Discussion participation, attentiveness, comments
- Assessment of poster
  - Inclusion of appropriate pros and cons
  - Sufficient description of function of particular energy source
  - Communication of understanding of what their energy source provides for the community
- Assessment of experiment(s) created with hydro plant and demonstration of understanding
  - Was the student able to complete the experiment? Did the student understand the purpose of the variables?
  - Lab book entries with appropriate hypothesis/es, measurements, and observations.
  - Possible lab report write-up with experimental design
  - Rubric provided in NREL REACT Activity 7

Additional Content:

Demonstration of pinwheel under running water
This can be conducted at any point where the teacher deems it appropriate. It could be used to first introduce the second half of the lesson. Or it could be used at the very beginning as a kind of “hook.” Another option is to use it at the end, and then ask the students why this crude model actually fails to completely represent a hydrodam.
Use this activity to further demonstrate the function of a dam.

Dam and Landscape Research
Have your students choose a dam and research not only the energy generation from the dam, but also the effect that dam has had on the surrounding landscape and wildlife.

References from Lesson Plan:

http://cms.need.org/node/30
2 NEED Website: http://www.need.org/ (National Energy Education Development Project)
3 NREL Website: http://www.nrel.gov/ (National Renewable Energy Laboratory)
4 Video 1: From Teachers Domain website (WGBH, Public Television), “Energy Sources”
http://www.teachersdomain.org/resource/phy03.sci.phys.energy.energysource/
ALTERNATIVE ENERGY SOURCES

HYDROELECTRIC POWER

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5 Video 2: From Teachers Domain website (WGBH, Public Television), “Hoover Dam”
http://www.teachersdomain.org/asset/phy03_vid_hooverelec/

6 Idaho Dams: From the Foundation for Water and Energy Education, NW Hydro & Tours, Hydroelectric Projects in Idaho

7 Hydro Tour Handout: From the Foundation for Water and Energy Education, NW Hydro & Tours, Walk Through a Hydroelectric Project
http://fwee.org/education/tours/

8 NREL’s REACT: Renewable Energy Activities – Choices for Tomorrow:
http://www.nrel.gov/docs/gen/fy01/30927.pdf

9 Pinwheel Demonstration: From the BLM Environmental Education & Training site, Learning Landscapes: Rivers Run Through It – The Columbia River Basin (2009)

Additional References:

USGS Water Science School – Hydroelectric Power Water Use
http://ga.water.usgs.gov/edu/wuhy.html

Tennessee Valley Authority – Energy (Fossil, Nuclear, Wind, Hydro):
http://www.tva.com/renewable/index.htm

National Geographic – The Great Energy Challenge
http://environment.nationalgeographic.com/environment/energy/great-energy-challenge/?source=NavEnvEnergy

National Geographic – Wind Power

National Geographic – Solar Energy

National Geographic – Solar Power Video

Argonne National Laboratory – Wind Energy Development
http://windenis.anl.gov/guide/basics/index.cfm

U.S. Department of Energy – Solar
http://energy.gov/science-innovation/energy-sources/renewable-energy/solar

Nuclear Regulatory Commission – Power Reactors
http://www.nrc.gov/reactors/power.html

Nuclear Regulatory Commission – Students’ Corner
http://www.nrc.gov/reading-rm/basic-ref/students.html

MIT Study on Future of Nuclear Power (Press Release)
http://web.mit.edu/nuclearpower/

Renewable Energy World – Geothermal (also other energy sources)
http://www.renewableenergyworld.com/rea/tech/geothermal-energy

NREL Geothermal Energy Basics
Alternative Energy Sources

Hydroelectric Power

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http://www.nrel.gov/learning/re_geothermal.html

Energy Quest – Energy Story, Chapter 11: Geothermal Energy
http://www.energyquest.ca.gov/story/chapter11.html

Detailed Standards:

From the Next Generation Science Standards DRAFT version, May 2012:

MS.ESS-HI Human Impacts
a. Use system models and representations to explain how human activities significantly impact the geosphere, the hydrosphere, the atmosphere, the biosphere, and global temperatures.
b. Generate and revise qualitative explanations from data for the impacts on Earth’s systems that result from increases in human population and rates of consumption.
c. Design engineering solutions for stabilizing changes to communities by using water efficiently, minimizing human impacts on environments and local landscapes by reducing pollution, and reducing the release of greenhouse gases.
e. Use empirical evidence to evaluate technologies that utilize renewable energy resources.

MS.ETS-ED Engineering Design
a. Evaluate ideas for solving an environmental problem to determine which designs best meet the criteria and constraints of the problem and take into account scientific principles and short- and long-term consequences.
c. Compare different designs by building physical models and running them through the same kinds of tests, while systematically controlling variables and recording the results to determine which design performs best.
e. Refine a design by conducting several rounds of tests, modifying the model after each test, to create the best possible design that meets the most important criteria.
f. Communicate information about a proposed solution to a problem, including relevant scientific principles, how the design was developed, how it meets the criteria and constraints of the problem, and how it reduces the potential for negative consequences for society and the natural environment.

From Common Core State Standards:

Writing
ELA-Literacy.WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.
ELA-Literacy.WHST.6-8.9 Draw evidence from informational texts to support analysis reflection, and research.

Reading: Informational Texts
ELA-Literacy.RI.7.7 Compare and contrast a text to an audio, video, or multimedia version of the text, analyzing each medium’s portrayal of the subject (e.g., how the delivery of a speech affects the impact of the words). (Also RI.6.7)

Speaking & Listening
ELA-Literacy.SL.7.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6-8 topics, texts, and issues, building on others’ ideas and expressing their own clearly. (Also SL.6.1, SL.8.1)
ELA-Literacy.SL.7.4 Present claims and findings, emphasizing salient points in a focused, coherent manner with pertinent descriptions, facts, details, and examples; use appropriate eye contact, adequate volume, and clear pronunciation. (Also SL.6.4, SL.8.4)

Reading: Science & Technical Subjects
ELA-Literacy.RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.
ELA-Literacy.RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
ELA-Literacy.RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).