Lesson Plan Title: Energy Generation Comparison

<table>
<thead>
<tr>
<th>Teacher Name: Jennifer Long</th>
<th>School: Cardinal Newman High School</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject: Introduction to Engineering</td>
<td>Grade Level: 10-12</td>
</tr>
</tbody>
</table>

**Problem statement, Standards, Data and Technology**

**Asking questions and defining problems**
Establish driving question for the lesson plan or define problem students will be solving.

Attach any documents used to establish the driving question or define the problem.

What are the various methods power companies in the United States use to create electrical power, and how do environmental and economic factors affect the choice of energy generation methods for a community?

https://www.eia.gov/energyexplained/index.cfm?page=electricity_in_the_united_states

https://www.washingtonpost.com/graphics/national/power-plants/?utm_term=.d5728388b72b

Students will experiment with various methods of producing an electric current. Once the methods have been introduced, each student will conduct research on one method of production or fuel source and present findings to the class in a “business proposal” format. After a classroom discussion of the presentations, each student will prepare a letter of recommendation “to the boss” for a recommended method of power production for the community. This letter should include valid reasoning weighing the costs and benefits for the recommended method. This method does not need to be the one assigned for the presentation.

**Incorporating Next Generation Science Standards, Common Core, or State Standards**
State the standards that will be covered during this lesson plan. Include all standards which may apply (NGSS, Common Core, or State Standards).

**HS-ETS1.1** Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

**HS-ETS1.3** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

**HSPS1-8** Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

**HSPS2-5** Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic
field and that a changing magnetic field can produce an electric current.

**HSPS3-3** Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

<table>
<thead>
<tr>
<th>Obtaining and evaluating information</th>
<th>Students will complete exploratory labs in electrical power generation. Students will complete research on pros/cons and costs/benefits of various power generation methods.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Analyzing and interpreting data</strong></td>
<td>Students will use information obtained from individual labs and research to create a persuasive paper describing individual recommendations for a future power plant for the community.</td>
</tr>
<tr>
<td><strong>Use of technology and software</strong></td>
<td>Students will use iPads for research and presentation preparation. Students will use Vernier equipment to gather data.</td>
</tr>
</tbody>
</table>

**Collaboration, critical thinking and communication**
### Collaboration
Indicate how students will be collaborating during the implementation of the lesson plan

Students will work in lab groups when completing energy generation exploratory labs.
Students will work in small groups to research and prepare presentations on individual forms of energy production.
Students will participate in roundtable discussion of group findings.

### Critical Thinking
How will the students evaluate the question or defined problem to reach an objective conclusion? How will the students be using the learned content and collected data to be able to critically think about the established question and/or problem on this lesson plan?

Students will complete exploratory labs designed to introduce them to the basics of electrical power generation in different forms. Students will use technology to track efficiency of energy transfer for various modes, noting environmental requirements for each type.

Student groups will each research one method of power production and prepare a presentation for the class. These presentations will be discussed at a roundtable comparing the pros and cons of the various methods of power production.

Each student will prepare a persuasive essay on his/her choice of a production method and justification for the choice.

### Communication
How will the students communicate their findings and conclusion regarding the established question and/or problem?

Students will answer lab research questions upon completion of each exploration.
Groups will make presentations to provide pros/cons and cost/benefit information for various modes of power generation.
Students will participate in a roundtable discussion of presentation materials.
Students will write individual position papers based upon presentations.

### References

**Teacher’s References**
Include all references used to develop and implement this lesson plan.

- What types of energy plants are in the US?
  - [https://www.eia.gov/energyexplained/index.cfm?page=electricity_in_the_united_states](https://www.eia.gov/energyexplained/index.cfm?page=electricity_in_the_united_states)
  - [https://www.washingtonpost.com/graphics/national/power-plants/?utm_term=.d5728388b72b](https://www.washingtonpost.com/graphics/national/power-plants/?utm_term=.d5728388b72b)
- How does a Coal Steam Power Plant Produce Electricity
- Energy 101 Wind Turbine video
  - [https://www.youtube.com/watch?v=EYYHfMCw-FI&list=PLACD8E92715335CB2&index=6](https://www.youtube.com/watch?v=EYYHfMCw-FI&list=PLACD8E92715335CB2&index=6)
- Energy 101 Geothermal Energy video
| **Student’s References** | What types of energy plants are in the US?  
https://www.eia.gov/energyexplained/index.cfm?page=electricity_in_the_united_states  
https://www.washingtonpost.com/graphics/national/power-plants/?utm_term=.d5728388b72b  
How does a Coal Steam Power Plant Produce Electricity  
http://www.mechanicalbooster.com/2016/08/steam-power-plant.html  
Steam Power  
Energy 101 Wind Turbine video  
https://www.youtube.com/watch?v=EYYHfMCw-FI&list=PLACD8E92715335CB2&index=6  
How do Wind Turbines Work?  
https://www.youtube.com/watch?v=qSWm_nprfqE  
What’s Inside a Wind Turbine?  
https://www.youtube.com/watch?v=LNXTm7aHvWc  
Why Do Wind Turbines Have Three Blades?  
https://www.youtube.com/watch?v=RNPIRfxUTQ4  
Energy 101 Geothermal Energy video  
https://www.youtube.com/watch?v=mCRDf7QxiDk&list=PLACD8E92715335CB2&index=5  
Geothermal  
https://www.studentenergy.org/topics/geothermal?gclid=Cj0KEQjwmv7JBRDXkMWW4_Tf8ZoBEiQA11B2fnHqXnftLADg88ErTVeYo9KAHRuRXEIVX6GRMskdfAmGr8P8HAQ  
How Geothermal Energy Works  
http://www.ucsusa.org/clean_energy/our-energy-choices/renewable-energy/how-geothermal-energy-works.html#WUAUV-vvvDc  
Basics-Geothermal Energy Association  
http://geo-energy.org/Basics.aspx |
Geothermal Basics https://www.energy.gov/eere/geothermal/geothermal-basics
Energy 101 Marine and Hydrokinetic Energy video 
https://www.youtube.com/watch?v=ir4XngHcohM&list=PLACD8E92715335CB2&index=10
How Hyodrokinetic Energy Works 
http://www.ucsusa.org/clean_energy/our-energy-choices/renewable-energy/how-hydrokinetic-energy-works.html#.WUBInOvyvDc
Energy 101 Hydropower 
https://www.youtube.com/watch?v=tpigNNTQix8&index=11&list=PLACD8E92715335CB2
Hydro Power 
https://www.studentenergy.org/topics/hydro-power?gclid=Cj0KEQjwmv7JBRDxkMWW4_Tf8ZoBEiQA11B2frah6SDbXwfxiEx3p7yhJD0X85vLoZNZvTHrxAR21dsaAm7a8P8HAQ
Hydroelectric Power How It Works https://water.usgs.gov/edu/hyhowworks.html
Hydroelectric Power https://water.usgs.gov/edu/wuhy.html
How Hydroelectric Energy Works 
Marine and Hydrokinetic Energy 
https://energy.gov/eere/water/marine-and-hydrokinetic-energy-research-development
Energy 101 Solar PV 
https://www.youtube.com/watch?v=0elhIcPVtKE&index=19&list=PLACD8E92715335CB2
Energy 101 Concentrating Solar Power 
https://www.youtube.com/watch?v=rO5rUqeCFY4&index=24&list=PLACD8E92715335CB2
How Solar Panels Work 
How Do Nuclear Reactors Work? https://www.nei.org/Knowledge-Center/How-Nuclear-Reactors-Work
How Nuclear Power Works 
http://www.ucsusa.org/nuclear-power/nuclear-power-technology/how-nuclear-power-works#.WUBSlevyvDc
Tour of a Nuclear Power Plant https://www.youtube.com/watch?v=_AdA5d_8Hm0
<table>
<thead>
<tr>
<th>Assessment Plan</th>
<th>Students will complete the lab handouts associated with each lab. (Please refer to Appendix for permission from Carolina Labs to include the lab handouts on the DEAP website.) Students will prepare a group presentation discussing the pros and cons of one specific type of power generation. Costs for startup and kilowatt hour costs for the consumer will be discussed. The format of this presentation is as a business proposal to a power company for a specific form of energy production for the community. Students will prepare a persuasive paper describing a recommendation for a power plant based upon information gleaned from the class presentations and personal research.</th>
</tr>
</thead>
</table>
# Resources and Costs

<table>
<thead>
<tr>
<th>Resources Needed</th>
<th>iPad with internet connection</th>
<th>Carolina STEM Challenge ®: Emerging Energies Set (supplies for 30 students) Item # 180966 and additional supplies listed in the manuals.</th>
</tr>
</thead>
<tbody>
<tr>
<td>List all the resources needed (equipment, facilities, materials or any other resources).</td>
<td>Copper wire, batteries, and magnets to build motors.</td>
<td></td>
</tr>
<tr>
<td>Costs</td>
<td>Carolina STEM Challenge ®: Emerging Energies Set (supplies for 30 students) Item # 180966 ($597.95)</td>
<td></td>
</tr>
<tr>
<td>List the estimated cost of implementing this lesson plan.</td>
<td>Additional supplies as listed in teachers manuals approximately $50 Batteries $20</td>
<td></td>
</tr>
</tbody>
</table>

# Implementation Plan

<table>
<thead>
<tr>
<th>Implementation Plan Timeline</th>
<th>Day 1 – Introduction to the topic of electrical energy production and the reasons it is a necessary part of life in the United States. Discussion of various engineering disciplines involved in the design, construction, running, and supplying of various types of power plants. Students will fill out a pre-unit survey to assess beginning knowledge on the topic. Students will brainstorm various ways of producing electricity that are used by utility companies in the United States and research those specifically used by the company supplying electricity to our school.</th>
</tr>
</thead>
</table>
| Establish the timeline to implement the lesson plan. | https://www.eia.gov/energyexplained/index.cfm?page=electricity_in_the_united_states  
https://www.washingtonpost.com/graphics/national/power-plants/?utm_term=d5728388b72b  
https://www.sceg.com/about-us/power-generation  
The Largest Power Plant of the World – Geographic History  
https://www.youtube.com/watch?v=OiogsJ_erYA  
Students will conduct an energy audit at their home for homework. |  |
| Provide an estimate of time and days in order to complete the lesson plan. | Day 2 – Students will review website and view video depicting how a steam generation plant works. http://www.mechanicalbooster.com/2016/08/steam-power-plant.html  
Students will discuss the various ways that steam can be produced in addition to using coal. Students will experiment with power generation using magnets and copper wire to produce a current. Students will discuss the difference between alternating and direct current and the reasons AC is |
prevalent in power transmission within the United States.  
http://science.howstuffworks.com/environmental/energy/power.htm

Day 3-4 - Students will experiment with wind turbines.  
http://www.carolina.com/alternative-energies/carolina-stem-challenge-wind-farm-kit/180964.pr

Day 5-6 - Students will experiment with hydropower by constructing water wheels to power a turbine.  

Day 7-8 – Students will experiment with biofuels.  
http://www.carolina.com/alternative-energies/carolina-stem-challenge-biofuels-kit/180950.pr

Day 9-11 – Students will experiment with geothermal.  
http://www.carolina.com/alternative-energies/carolina-stem-challenge-geothermal-kit/180956.pr

Day 12-13 – Students will experiment with batteries.  
http://www.carolina.com/alternative-energies/carolina-stem-challenge-potato-battery-dilemma-kit/180958.pr

Day 14-15 – Students will experiment with solar power.  

Day 16 – Students will watch video on and discuss nuclear power.  
Tour of a Nuclear Power Plant https://www.youtube.com/watch?v=_AdA5d_8Hm0
Inside a nuclear reactor core – Bang goes the Theory – BBC  
https://www.youtube.com/watch?v=MGj_aJz7cTs
Understanding the Accident of Fukushima Daiichi NPS  
https://www.youtube.com/watch?v=JMaEjEWL6PU

Day 17-19 – Students will prepare group presentations on selected power generation type.

Day 20 – Student Presentations and roundtable discussion. Students prepare position paper for homework.
### Presentation Rubric

#### Energy Presentation

<table>
<thead>
<tr>
<th></th>
<th>15</th>
<th>10</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Content</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Includes all necessary content</td>
<td>•</td>
<td>missing only one or two pieces of required content</td>
<td>missing more than two pieces of necessary content</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Coherence of ideas</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>presents information clearly, concisely and logically</td>
<td>•</td>
<td>Information is not always clear</td>
<td>information is not clear</td>
</tr>
<tr>
<td>information presented is appropriate to the assignment</td>
<td>•</td>
<td>not all information is relevant</td>
<td>not all information is relevant</td>
</tr>
<tr>
<td>plusses and minuses are both addressed</td>
<td>•</td>
<td>does not address opposing views completely</td>
<td>does not address opposing views</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Organization</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Introduction and conclusion are clear and interesting</td>
<td>•</td>
<td>Has introduction and conclusion, but they are not clear or interesting</td>
<td>Does not include introduction or conclusion</td>
</tr>
<tr>
<td>Time is well organized, no part of the presentation is too long or too short</td>
<td>•</td>
<td>Time of presentation is not well divided</td>
<td>Time requirement not met. Time for sections not well divided.</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Physical</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good eye contact</td>
<td>•</td>
<td>Only brief eye contact. Looks at notes or presentation too often.</td>
<td>No eye contact</td>
</tr>
<tr>
<td>Gestures natural</td>
<td>•</td>
<td>Gestures not natural</td>
<td>No gestures</td>
</tr>
<tr>
<td>Appears comfortable</td>
<td>•</td>
<td>Some fidgeting</td>
<td>No poise</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Voice</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speaks clearly and at a good pace</td>
<td>•</td>
<td>Speaks clearly most of the time</td>
<td>Mumbles</td>
</tr>
<tr>
<td>Speaks loudly enough for all to hear</td>
<td>•</td>
<td>Sometimes speaks too quickly</td>
<td>Speaks too quickly</td>
</tr>
<tr>
<td>Does not stumble over words</td>
<td>•</td>
<td>Sometimes hard to hear</td>
<td>Does not talk loud enough</td>
</tr>
<tr>
<td>Uses correct form for a business presentation</td>
<td>•</td>
<td>Stumbles over words sometimes</td>
<td>Stumbles over presentation</td>
</tr>
<tr>
<td>Appears to have practiced</td>
<td>•</td>
<td>Not entirely successful at presenting as a business proposal</td>
<td>Not presented in the context of the assignment</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Visuals</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visuals add to the presentation</td>
<td>•</td>
<td>Visuals sometimes distract from the presentation</td>
<td>No visual aids</td>
</tr>
<tr>
<td>All visuals either student prepared or correctly cited on the slides themselves.</td>
<td>•</td>
<td>Not all citations completed correctly</td>
<td>No citations on visual aids</td>
</tr>
</tbody>
</table>

Please be sure to include the following information in your class presentation:

- How does your method convert the primary energy source to the secondary energy of electricity?
What are at least four types of engineering that are involved in this industry?

What are the environmental and human impacts both positive and negative?

What is the public perception for this technology? How hard would it be to sell it to the public?

How is the source product obtained? Where would it have to come from to supply a plant in our community? What additional infrastructure is necessary?

How expensive is it to build this type of facility? How long does it take before this type of facility will produce energy? What is the life expectancy for this technology? How hard is it to get a new power plant of this type approved?
<table>
<thead>
<tr>
<th></th>
<th>10</th>
<th>7</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>persuasion</td>
<td>Takes a position, provides relevant support, addresses disadvantages</td>
<td>Takes a position but provides uneven support. Does not address disadvantages.</td>
<td>Provides no support or minimal support for position.</td>
</tr>
<tr>
<td>organization</td>
<td>Focused and well organized, good transitions</td>
<td>Essay unorganized. Transitions need improvement.</td>
<td>No apparent organization.</td>
</tr>
<tr>
<td>sentence structure and word choice</td>
<td>Good variety and word usage.</td>
<td>Sentence structure simple and unvaried. Word choice mostly accurate.</td>
<td>Run-on sentences or sentence fragments. Word choice poor.</td>
</tr>
<tr>
<td>grammar</td>
<td>Few errors that do not distract from understanding</td>
<td>Frequent errors, but they do not interfere with understanding</td>
<td>Errors interfere with understanding</td>
</tr>
</tbody>
</table>

For this essay you must use your knowledge from the class’s research presentations to make a decision on your personal recommendation for a form of energy production for the local power company to pursue. You DO NOT have to write on the method that you personally researched. You may write on the method that you really think would be best. You should state your preference, give the reasons for your choice, and address the positives and negatives of your choice and why the negatives are outweighed by the positives. This is a PERSUASIVE essay and you must attempt to convince me to use this method with your reasoning. Be sure to include the following information:

- What power generation method do you recommend?
- What are your reasons for recommending this method?
- What are negatives of this method?
- Why do the benefits outweigh the negatives?
<table>
<thead>
<tr>
<th>Energy Type</th>
<th>Positives</th>
<th>Negatives</th>
<th>General Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>coal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>natural gas</td>
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<td></td>
<td></td>
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<tr>
<td>petroleum</td>
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<td></td>
<td></td>
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<tr>
<td>biofuel</td>
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<tr>
<td>geothermal</td>
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<td>hydro</td>
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<td>hydrokinetic</td>
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<tr>
<td>wind</td>
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<tr>
<td>nuclear</td>
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<tr>
<td>solar</td>
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</tr>
</tbody>
</table>

Energy Production Test

1. In a thermal power plant, how is energy converted from thermal energy to electricity?

2. Why is AC power used for transmission in the United States?

3. Why are coal, oil, natural gas, and propane called fossil fuels?

4. What gas is caused by the complete combustion of fossil fuels?

5. What is the cleanest form of fossil fuel?

6. Name four different types of renewable energy.

7. Why are the types of energy production that you named in the prior question referred to as renewable energy?

8. What is the disadvantage of hydropower?

9. Which energy resource has the least ecological impact when used in the production of electrical energy?
10. What is the difference between direct and indirect solar power?

11. What type of mechanical energy does a wind turbine convert to electricity?

12. What is a common complaint that people use against wind power?

13. Name two types of crops that are used to create biomass.

14. What is the difference between a fusion nuclear reactor and a fission nuclear reactor?

15. What is the main reason that people are concerned about nuclear power plants?
Appendix: Carolina Labs approval

From: Crystal Risko <crystal.risko@carolina.com>
Date: June 20, 2017 at 11:22:34 AM EDT
To: Jennifer Long <jlong@cnhs.org>
Subject: Re: Reference to your product on a lesson plan

Hi Jennifer,

That's not a problem at all. Please let me know if I can help you with anything else.

Sincerely,
Crystal

Sent from my iPhone

On Jun 20, 2017, at 11:10 AM, Jennifer Long <jlong@cnhs.org> wrote:

I just want to put the link to your website for ordering the lab.

Sent from my iPad

On Jun 20, 2017, at 8:42 AM, Crystal Risko <crystal.risko@carolina.com> wrote:

Hi Jennifer,

What from the lab will be placed on the website?

Thank you,
Crystal Risko

Sent from my iPhone

On Jun 19, 2017, at 6:38 PM, Jennifer Long <jlong@cnhs.org> wrote:

Hello Ms. Risko,

I was given your contact information by a customer service representative at Carolina Biological. I am attending the Duke Energy Academy at Purdue University. We, as teachers, are required to submit a lesson plan that will be posted on the Purdue website. I would like permission to reference your product #180966 Carolina STEM Challenge Emerging Energies Set on my lesson plan. Please contact me to let me know whether that is possible, and any steps that are necessary for me to follow.
Thank you for your assistance,
Jennifer Long