<table>
<thead>
<tr>
<th>Lesson Plan Title:</th>
<th>Elon the way, we Musk use batteries!</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher Name:</td>
<td>Jim Lindsey</td>
</tr>
<tr>
<td>Subject:</td>
<td>Environmental Science</td>
</tr>
<tr>
<td>Grade Level:</td>
<td>11 - 12</td>
</tr>
<tr>
<td>School:</td>
<td>TBD</td>
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### Problem statement, Standards, Data and Technology

<table>
<thead>
<tr>
<th>Asking questions and defining problems</th>
<th>How do batteries work, and how can we store enough solar power to supply human demand?</th>
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<tbody>
<tr>
<td>Attach any documents used to establish the driving question or define the problem.</td>
<td><a href="https://www.spiral.ac/index.php/sharing/59bct6k/elon-musk-debuts-the-tesla-powerwall">https://www.spiral.ac/index.php/sharing/59bct6k/elon-musk-debuts-the-tesla-powerwall</a></td>
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<tr>
<td></td>
<td><a href="https://www.youtube.com/watch?v=9kXTqNqxK3s">https://www.youtube.com/watch?v=9kXTqNqxK3s</a></td>
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| Incorporating Next Generation Science Standards, Common Core, or State Standards | State Standards (Indiana Environmental Science Standards) - SEPS.1 Posing questions (for science) and defining problems (for engineering); SEPS.2 Developing and using models and tools; SEPS.3 Constructing and performing investigations; SEPS.4 Analyzing and interpreting data; SEPS.5 Using mathematics and computational thinking; SEPS.6 Constructing explanations (for science) and designing solutions (for engineering); SEPS.7 Engaging in argument from evidence; SEPS.8 Obtaining, evaluating, and communicating information; 11-12.LST.1.1; 11-12.LST.2.1; 11-12.LST.2.2; 11-12.LST.2.3; 11-12.LST.4.1; 11-12.LST.4.2; 11-12.LST.4.3; Env.2.1; Env.2.2; Env.2.4; Env.2.9; Env.7.1; Env.7.5; Env.7.6; |
| State the standards that will be covered during this lesson plan. Include all standards which may apply (NGSS, Common Core, or State Standards). | The unit will start with two short videos and a reading selection, from which students should draw information for formulating questions and hypotheses. Then, they will work together collaboratively on two experiments to learn and understand batteries with a short video to help in comprehension, followed with mathematical computations for understanding differences of scale. |

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<tr>
<th>Obtaining and evaluating information - How will students be obtaining and/or collecting the information?</th>
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### Analyzing and interpreting data - How will students be analyzing and interpreting the collected data?

1. Students will recognize the importance of renewable energy sources and energy storage solutions such as batteries.
2. Students will test, analyze, and justify different materials for creating the best battery.
3. Students will build, test, and analyze a “Powerwall” (Elon Musk’s name for a battery bank)
4. Students will complete mathematical equations to account for scale differences between theirs and what Mr. Musk is proposing.

### Use of technology and software - Indicate the type of technology and software students will be using in order to implement this lesson plan.

Students will be watching videos, answering “Jump Start” Questions on Socrative.com, to sharpen their focus each day, “Plickers” questions during the class periods as spot formative assessments, Google docs and sheets to document hypotheses, procedures, and data, and a “Canvas” on-line quiz at the end.

In addition, students will be using technology to research, design, and build batteries…..Then later, battery banks….Then test them. Lastly, students will write up a summation report of the entire research activity.

### Collaboration, critical thinking and communication

#### Collaboration - Indicate how students will be collaborating during the implementation of the lesson plan

Students will discuss their observations of the material presented in the videos, work together to develop a hypothesis and to test it, and will then analyze the data and make observations about the comparison of their experiments to the real world. They will also need to work together to successfully build the “battery bank” like Elon Musk’s model, and analyze their efforts/data.

#### 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 observe, evaluate, and discuss the videos and handout reading about how batteries are built and function, then will experiment with building various batteries of their own, testing them then evaluating the data. Later, they will then learn how to connect batteries to build a “PowerWall”, collect voltage data, then do scale adjustment mathematics to determine the efficiency and economics of large-scale solar power storage for society.

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

Students will take a quiz about batteries and the PowerWall at the end of the unit, and write a summary report of their findings as well, complete with data tables and explanations.
### References

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

- References Cited - Are all references cited?
  3. https://www.youtube.com/watch?v=9kXTqNqxK3s

**Student’s References** - Include all references students will need to complete this lesson plan.

  3. https://www.youtube.com/watch?v=9kXTqNqxK3s

### Assessment Plan

**Assessment Plan**

How will the students be assessed during and/or at the end of the lesson plan?

- Include resources that will be used to assess the students for the lesson plan.

- “Jump Start” Questions on Socrative.com at the start of each class period.
- “Plickers” questions during the class period to assess their focus and degree of “On Task”
- Data collection and analyzing through Google Sheets and Google Docs
- Final Activity Write up
- Final Quiz over Jump Start and Plickers questions as well as data collected.
<table>
<thead>
<tr>
<th>Resources and Costs</th>
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<tbody>
<tr>
<td><strong>Resources Needed</strong> - List all the resources needed (equipment, facilities, materials or any other resources).</td>
</tr>
</tbody>
</table>
| (per group) | (10) #10 zinc washers ($0.03/washer)  
(10) pennies  
(1) LED bulb ($1.99)  
vinegar ($1/bottle)  
extric tape ($1/roll)  
thin cardboard  
voltmeter |
| (per student) | IF option is available, 2 pack Lithium battery - $2.21  
If not, Class set of 50 Standard Alkaline AA batteries - $7.60 |
| **Costs** - List the estimated cost of implementing this lesson plan. Include all costs related to equipment, materials and any resource critical to the implementation of the lesson plan. |
| $35 - $45, depending on financial situation with regard to options for higher quality batteries or lower quality batteries. |

<table>
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<tr>
<th>Implementation Plan</th>
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<tbody>
<tr>
<td><strong>Implementation Plan Timeline</strong></td>
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| Establish the timeline to implement the lesson plan.  
Provide an estimate of time and days in order to complete the lesson plan. |
| Day 1 – “Jump Start”, Introduction, 1st Elon Musk video, discussion and student brainstorming about problems with Solar Power, begin homework reading “Chemistry Innovations in Sustainable Development – Lesson 12: Green Chemistry: Making Better Batteries” (Students will understand they should be reading critically and noting important key words and concepts). |
| Day 2 – “Jump Start”, Students will conduct the “Build a Better Battery” experiment, making comparison tests and collecting data, “Plickers” Questions to check for comprehension during period, exit ticket at end of period |
| Day 3 – “Jump Start”, Students will discuss the previous day’s experiment, comparability to real life battery needs and issues, and the potential for using batteries on a grander scale. Watch 2nd Elon Musk video and discuss potentials, issues, and ideas. Exit ticket. |
| Day 4 – “Jump Start”, Students will watch YouTube video showing how to do a DIY “PowerWall”, then will work together to make one, testing it for voltage. Homework – Math computations to adjust for scale – (600, 6,000, 60,000, 600,000, and 6 million batteries as opposed to 60 in class). |
| Day 5 – “Jump Start” Quiz – 5 Jump Start questions from first four days, picked at random. Finish data collection, write scientific summaries, discuss findings as a class. |
Jump Start Questions:

Mon.: 1 – What is a battery? (a) Something that stores energy
   (b) A piece of machinery that conducts chemical reactions to provide energy
   (c) None of these
   (d) A & B

2 – T/F - Batteries can only provide a limited amount of power for short periods of time.
3 – Short Answer – Can batteries power homes? (Yes or no).

Tues.: 1 – What is the biggest problem with Solar power? (a) It is only available part of the day
   (b) It can only be used for heat (c) It is only available in the summer
   (d) Storage

2 – T/F – Per Elon Musk, Sustainable Energy is the biggest problem we have to solve this century
3 – Short Answer – How can an electric car help? (It is more efficient to use the source fuel to create
   electricity than power an internal combustion engine)

Weds.: 1 – What is an electrolyte? (a liquid or gel that contains ions and can be decomposed by electrolysis)
2 – T/F – A battery provides energy through alternating current.
3 – Short Answer – What four things comprise a “cell” of a battery? (A cathode (+) terminal, an anode (-)
   terminal, an electrolyte, and an external charge)

Thurs.: 1 – What are the two most common types of batteries today? (Alkaline and Lead-Acid)
2 – T/F – The Lithium-ion battery has low energy for its mass
3 – What was the first production car to use lithium-ion batteries? (The Toyota Vitz CVT 4)

Fri. Quiz: Pick five of the above questions, two points each.

Plickers Questions:

Tues.: T/F – I understand how batteries work.
   A battery needs a cathode, anode, external charge, and _____?
   (a) case (b) warning label (c) electrolyte (d) wires
   The chemical reaction in a battery is called: (a) fusion (b) fission (c) electrocution
   (d) electrolysis

Exit Ticket:

Tues.: What is sustainable energy? (the provision of energy such that it meets the needs of the present
   without compromising the ability of future generations to meet their own needs.)

Weds.: What is the curve that shows the growth of CO₂ concentration in the atmosphere? (The Keeling Curve)
Math Worksheet:

Scale It Up!
Do the Math........How much power could you get from 600 batteries? 6,000? 60,000?
(Remember, this is THEORETICAL, AND we know there is more to it than just connecting batteries.)

Read THIS excerpt from Battery University’s Website:

Series/parallel Connection
The series/parallel configuration shown in Figure 6 enables design flexibility and achieves the desired voltage and current ratings with a standard cell size. The total power is the product of voltage-times-current; four 3.6V (nominal) cells multiplied by 3,400mAh produce 12.24Wh. Four 18650 Energy Cells of 3,400mAh each can be connected in series and parallel as shown to get 7.2V nominal and 12.24Wh. The slim cell allows flexible pack design but a protection circuit is needed.

Parallel
This configuration provides maximum design flexibility. Paralleling the cells itself well to series/parallel helps in voltage management. Li-ion lends configurations but the cells need monitoring to stay within voltage and current limits. Integrated circuits (ICs) for various cell combinations are available to supervise up to 13 Li-ion cells. Larger Li-ion batteries, and measure voltage and cell to handle larger packs need custom circuits, and this the Tesla Model 85 that devours over Figure 6: Series/ parallel connection of four cells (2s2p).

1.) Make the connections with your current. Record the results below:

<table>
<thead>
<tr>
<th></th>
<th>2 batt.</th>
<th>4 batt.</th>
<th>6 batt.</th>
<th>12 batt.</th>
<th>18 batt.</th>
<th>24 batt.</th>
<th>30 batt.</th>
<th>60 batt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.) Solve for the theoretical voltage and current of 600 batteries:
3.) Solve for the theoretical voltage and current of 6,000 batteries:
4.) Solve for the theoretical voltage and current of 60,000 batteries:
5.) What problems can you foresee with building such a battery structure? (Hint – Check the reading above!)