Renewable Energy Sprint

Next Generation Science Standards

NGSS Science and Engineering Practices:

- ☐ Asking questions and defining problems
- ☐ Developing and using models
- ☑ Planning and carrying out investigations
- ☑ Analyzing and interpreting data
- ☑ Using mathematics and computational thinking
- ☐ Constructing explanations and designing solutions
- ☐ Engaging in argument from evidence
- ☑ Obtaining, evaluating, and communicating information

NGSS Cross-cutting Concepts:

- ☐ Patterns
- ☐ Cause and effect
- ☑ Scale, proportion, and quantity
- ☐ Systems and system models
- ☐ Energy and matter
- ☑ Structure and function
- ☐ Stability and change

NGSS Disciplinary Core Ideas:

- ☑ ESS3.C Human Impacts on Earth Systems
- ☑ ESS3.D Global Climate Change

Initial Prep Time

Approx. 10 min. per apparatus

Lesson Time

1 – 2 class periods, depending on number of types of car used

Assembly Requirements

- Small Phillips-head screwdriver
- Scissors
- Distilled water
- Salt
- Hot plate or other heating element

Materials (for each lab group):

- Horizon Electric Mobility Experiment Set
- Beaker or other container for holding salt water solution
- Stopwatch

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Lab Setup

- Before the lab starts, you should cut the silicon tubing and prepare the fuel cell as indicated in steps a- c of the “Hydrogen powered car” assembly instructions. This should take no more than a few minutes for each kit.
- The lab involves students building cars powered by different energy sources and seeing how fast each of them can travel 5 meters. Feel free to alter the distance, types and number of cars they build, or even have different groups make different cars as needed.
- If building the salt water battery car, you’ll need a mixture of salt water (15mg salt per 25mL distilled H2O), heated to above 90°C (194°F). Each group will need 25mL of solution per activity.
- The Hydrostik car requires the use of the Hydrofill Pro (sold separately). If you’re building the Hydrostik car, assemble the mini fuel cell as described in step c of the “Fuel cell and hydrogen storage” assembly instructions.
- Lab includes small parts that can go missing easily. Set up a resource area for each lab table or for the entire class to minimize lost pieces.

Safety

- Keep the fuel cells hydrated at all times. If the fuel cells dry out, they can become permanently damaged.
- Do not turn the hand crank generator counter-clockwise while connected to the supercapacitor: this can irreparably damage the supercapacitor.
- Safety goggles should be worn at all times.

Notes on the Electric Mobility Experiment Set:

- After use, be sure to clean out the salt water battery with distilled water. Dry before storing.
- Solar cell may not provide enough power for the car without direct sunlight.
- The hand-crank generator is sturdy, but not indestructible. Two revolutions per second is enough to charge the supercapacitor; more than that is just running the risk of breaking the generator.

Common Problems

- If your hydrogen fuel cell car stops moving while hydrogen is left in the tank, you may need to purge the gases by uncapping the tubes, then perform electrolysis for a few minutes to generate more hydrogen.
- If the salt water battery stops powering the car, the anode plate may need to be cleaned.

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Goals

- ✓ Assemble multiple cars powered by renewable energy
- ✓ Alter the cars to increase their speed
- ✓ Compare the pros and cons of different technologies

Background

What makes a car move? Most cars today are powered by gasoline, but that wasn't always the case. Early cars were powered by kerosene, ethanol, electricity, even steam. In fact, until the electric starter motor became common in 1920, steam cars outsold gasoline cars!

Without a starter, gasoline cars had to be hand-cranked to start, which occasionally caused backfires that suddenly swung the crank backwards, often resulting in a broken arm for the poor person operating it. It's easy to see why steam was more popular!

Steam engine in a 1924 Stanley Steamer

Today, there probably aren't many people who'd favor a return to steam-powered cars. However, there are many other power sources that are receiving attention as the world looks for alternatives to traditional gasoline power in the face of global climate change.

Different technologies have advantages and disadvantages. Some of them (like the possibility of breaking your arm with a hand crank) can be solved with new inventions, while others (like the carbon dioxide in engine exhaust) are too closely tied to how the technology works to be eliminated.

Here are some examples of technologies that could be used to power cars and how they work:

- Solar panels – Change light to electricity to power an electric motor.
- Supercapacitors – Store electricity in a capacitor to power an electric motor.
- Fuel cells – Use hydrogen, split from oxygen in water, to generate an electric current and power a motor.
- Batteries – Store electricity chemically and use it to power an electric motor.
- Metal hydrides – Store hydrogen chemically and use it in a fuel cell to power an electric motor.

You may notice that many of these technologies seem very similar. At some point, they all have to turn a motor in order to get the car to move. But how they get the energy to do that is very different, and that will affect how the car performs when powered by each of them. Whatever technology they run on, we want cars to do many different things: they should accelerate quickly, operate reliably, and be able to be refueled easily. Today we will test just one aspect of the job that a car is supposed to do: provide energy quickly.

During this activity, we will build cars powered by different technologies, modify them to try to increase their power output, and determine which type of car can complete a 5-meter drag race in the fastest time.

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Solar Car Procedure

1. You'll need the car frame, red and black wires, the solar panel, and the solar panel support to assemble the solar car.
2. Look at the top of the car frame to see where you should attach the solar panel support. Make sure the solar panel support fits securely onto the top of the frame.
3. Place the solar panel on top of the support.
4. Connect the wires from the motor to the red and black plugs nearest to them on the front of the frame.
5. Use the other red and black wires to connect the solar panel to the other plugs on the front of the frame.
6. Make sure the car is in direct sunlight, and it should start to run.
7. Use the stopwatch to time how long it takes for your car to go 5 meters. Repeat and record your results in the table below.

Trial	Time (sec):	Laps:	Distance (m):	Observations:
1				
2				
3				

Fuel Cell Procedure

1. You'll need red and black wires, the fuel cell, battery pack, H2 and O2 cylinders, two lengths of tubing, and a syringe to assemble the fuel cell.
2. Insert the cylinders into the frame of the car. Fill them with about 40 mL of distilled water.
3. Uncap the tube on the O2 side of the fuel cell.
4. Fill the syringe with distilled water and fill the fuel cell using the syringe.
5. Replace the cap on the O2 tube.
6. Insert the fuel cell into the frame of the car in front of the cylinders. Attach the H2 and O2 sides of the fuel cell to the H2 and O2 cylinders with the longer tubes, which will prevent the hydrogen and oxygen gases from escaping.
7. Connect the battery pack to the fuel cell using the red and black plugs, then turn on the battery pack. You should see the fuel cell start to generate hydrogen and oxygen gas.
8. Once you see bubbles start to escape the H2 cylinder, turn off and disconnect the battery pack.
9. Connect the loose red and black wires to the fan or LEDs to start generating electricity.

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10. Use the stopwatch to time how long the fuel cell car takes to complete the race. Record your results below.

Trial	Time (sec):	Observations:
1		
2		
3		

Salt Water Battery Procedure

1. You'll need red and black wires, the salt water battery (white bottom and blue top), syringe, and a graduated cylinder to assemble the salt water battery.

2. Get salt water solution from your teacher and put it in the graduated cylinder. Make sure to get at least 25mL. And be careful, it's hot!

3. Using the syringe, transfer 15mL of the salt water solution into the bottom of your battery.

4. Snap the blue top of the battery onto the white bottom.

5. Attach one red wire to two red plugs on the left and right sides of the battery at the back.

6. Connect the wires from the motor to the red and black plugs nearest to them on the front of the frame.

7. Connect the loose wires from the battery to the other plugs on the front of the frame.

8. Use a stopwatch to time how fast the battery can make the car complete the race. Record your results below.

9. When you're finished with the salt water battery, rinse the top and bottom with distilled water.

Trial	Time (sec):	Observations:
1		
2		
3		

Supercapacitor Procedure

1. You'll need red and black wires, the capacitor, and the hand-crank generator to use the supercapacitor.
2. Connect the capacitor to the hand-crank generator using the set of red and black wires.
3. Gently turn the hand-crank clockwise to generate current and charge the capacitor. Charge the capacitor for at least 60 seconds.

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4. Disconnect the hand-crank generator from the capacitor and connect the capacitor to the plugs on the front of the frame. Secure the capacitor in the middle of the frame.
5. Connect the wires from the motor to the red and black plugs nearest to them on the front of the frame.
6. Use a stopwatch to time how fast the capacitor can make the car complete the race. Record your results below.

Trial	Time (sec):	Observations:
1		
2		
3		

Metal Hydride Procedure

1. You'll need red and black wires, the mini fuel cell, purge valve, silicon tubing, clamp, hydrostik, and the pressure regulator to assemble the hydrostik generator.
2. Push the silicon tubing through the clamp until the clamp is about halfway along the tubing.
3. Attach one end of the tube to the pressure regulator by unscrewing the cap, threading the tubing through the cap, pushing the tubing onto the regulator, and screwing the cap back on.
4. Screw in the pressure regulator to the top of the hydrostik.
5. Attach the other end of the tube to the nozzle of the mini fuel cell.
6. Place the fuel cell in the frame of the car with the nozzles facing forward.
7. Use the loose red and black wires to connect the red and black plugs on the fuel cell to the other red and black plugs on the front of the frame.
8. Open the clamp and press the purge valve for two seconds on the fuel cell. This will allow hydrogen to enter the fuel cell and cause the car to start running.
9. Use a stopwatch to time how fast the fuel cell can make the car complete the race. Record your results below.
10. When the hydrostik is empty, use the Hydrofill Pro to refill it.

Trial	Time (sec):	Observations:
1		
2		
3		

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Experimentation

1. Choose two or three technologies that were the fastest to complete the track. Discuss with your group ways you could improve the car to make each of them go faster. Write down your best ideas here:

Light Color:	Observations:
	1. 2. 3.
	1. 2. 3.
	1. 2. 3.

2. Now build your car using each technology and try the ideas you thought of to see what happens to the car's speed. Record what you changed, how you changed it, and the results below:

Technology:	Changed What?:	Changed How?:	Time (sec):	Distance (m):

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Analysis

1. Make a scientific claim about what you observed while racing your cars.

Claim should reference the car's performance and its source of power.
Example: "The supercapacitor provided the most electrical energy to the car."

2. What evidence do you have to back up your scientific claim?

Evidence should cite data in Observations and/or Experimentation sections.
Example: "Our fastest time for completing the track was 8.6 seconds, when we charged the capacitor for twice as long during our experiments."

3. What reasoning did you use to support your claim?

Reasoning can draw from Background section and/or other materials used in class.
Example: "When the car is moving faster, it must have more energy than when it was moving slower."

4. Design an experiment that would test how a particular technology you used today could be improved to increase the amount of energy it produced. Describe your experiment below:

There are many possible answers, but students should describe the particular characteristic of the technology they want to change, explain how they think it could improve the amount of energy produced, and have clear control and experimental groups in their description.

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Conclusions

1. What would be the biggest drawback to using the technology that completed the race the fastest in a full-sized car? What makes this problem the biggest drawback?

There are numerous possible acceptable answers depending on the technology chosen: availability of fuel, recharging time, weight, cloudy days, and more. Regardless of what they choose, students should be able to explain why the drawback they chose is such a major issue.

2. What is a possible way that you could overcome this drawback?

Again, there are many acceptable answers, which will depend upon the technology chosen and the particular drawback described above. Students should be able to weigh the possibilities of overcoming it and suggest a plausible solution, though it need not be one known to work in real life.

3. Do you think the technology that ran the race the fastest would be the most practical solution for a renewable energy source to power a full-sized car? Why or why not?

Students could answer "Yes" or "No" so long as they can back up their response with data from their experiments or information they know about the way that this technology and/or the other technologies they experimented with would work on a full-sized car.