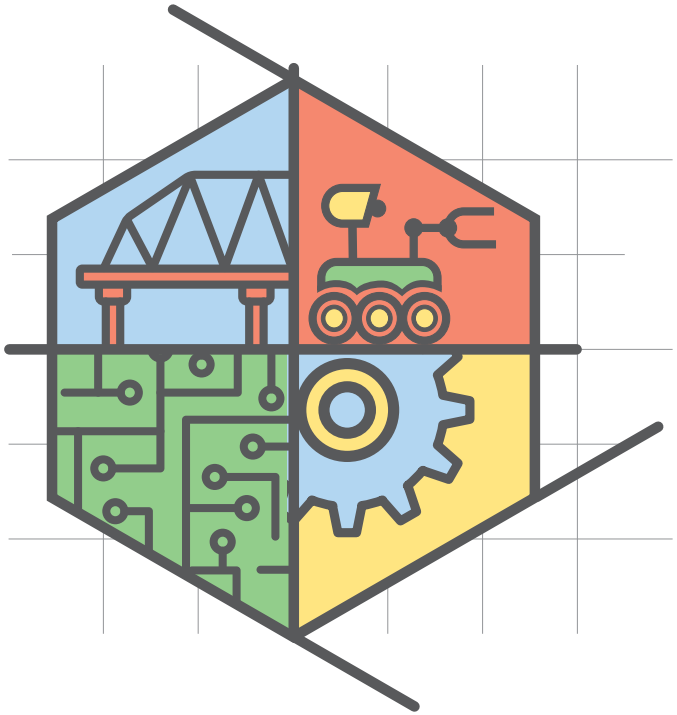

Harnessing Wind Energy

Middle School NGSS Unit

STEM

A digital copy of this document is available on the STEM Materials Center website at:
https://www.stemmaterials.org/harnessing-wind-energy/

STEM
Science
Technology
Engineering
Math

A program of Educational Service District 112 supporting Next Generation Science Standards

Background on the Core Scientific Ideas in this Unit

How can wind energy be used to help broaden access to electricity?

How can it be used to provide relief in areas that have been devastated by a natural disaster?

These are questions that will introduce students to the interactions taking place when humans harness energy from different sources in their environment. Students will develop their skills in Science and Engineering Practices and argumentation by taking a critical lens on energy production and use. Students will study the impacts of using nonrenewable and renewable resources and will apply their understanding to assess the sustainability of different communities (locally, nationally, and globally).

Students will take a close look at the energy production framework for the United States territory of Puerto Rico and will explore the negative effects of nonrenewable energy dependence on a community's ability to survive and recover from a natural disaster. After constructing their own explanation for why certain sources of energy are more sustainable, students will explore the use of wind energy (a renewable resource) in generating power. Through a series of investigations, students will build, refine, and optimize a wind turbine that will generate electricity; their design challenge will involve the creation of a device that may help victims of Hurricanes Irma and Maria recover from power loss caused by these natural disasters. In this way, students will take on a humanitarian approach by developing a clean energy power generator that could be used to bring relief to poverty or disaster stricken populations. Students will then communicate information from their investigations to their classmates and explain the process of constructing their device and the positive impact it may have with the devastated communities in Puerto Rico.

BACKGROUND (cont.)

WHAT WILL STUDENTS KNOW AT THE END OF THIS UNIT?

- Humans use different energy sources to generate power, some which are renewable and some which are not.
- Renewable resources are constant and replenish themselves as they are used. Nonrenewable resources are depleted overtime and do not replenish themselves.
- Sustainable resources are those that are renewable and have limited impact on the environment.
- Oil, coal, and other fossil fuels are nonrenewable resources and will eventually be depleted. Nonrenewable resources also have negative impacts on the environment and human health.
- Wind, solar, and hydro power are renewable resources, as they cannot be depleted and they have minimal negative impact on the environment and on human health.
- On average, the United States uses nonrenewable energy sources (such as natural gas and coal) to generate most of its electricity.
- Countries, such as Puerto Rico, where there is limited industrial and technological development, are often solely dependent on nonrenewable sources for energy, which can create added devastation after a catastrophic event such as a hurricane.
- Wind energy is a renewable and sustainable source of energy that can be used to generate power and sustain communities.
- There are various design features of wind turbines (blade length, blade shape, blade count, etc.) that allow for increased efficiency and effectiveness.

UNIT OVERVIEW

Lesson No.	Duration	Materials Needed	Focus	Assessment Options
1	4-5 days	Computers with internet access	**Engage** • Read about the devastation being faced by Puerto Ricans in the aftermath of Hurricane Maria. • Create a chart showing how the loss of power can impact a region.	Chart "What do we lose when we lose power?" with explanations
2	5-6 days	Computers with internet access Black and white beans (for Renewable Energy Simulation Game)	**Explore** • Study Puerto Rico's power grid and assess how dependence on fossil fuels for power could have amplified devastation. • Analyze and interpret data about how the United States generates most of its energy and compare to local community. • Look at data for local PUD and create a review of how sustainable these sources are. • Create a CER argument supporting one solution to Puerto Rica's problem. • Collect data using a simulation to explain how renewable and nonrenewable resources are different.	CER argument about sustainability of U.S.'s energy production
3	8-10 days	Computer, LabQuest (or Vernier data collection interface), Vernier Energy Sensor, Vernier Variable Load, Safety goggles, 2 wire leads with clips, KidWind Advanced Wind Turbine, Wind Turbine Hub, Blade Pitch Protractor, Ruler, blade materials, scissors and hot glue, Fan, Digital camera	**Explain** • Connect to the storyline by studying how wind energy is being used to generate power. Connect with careers in wind technology. • Build a wind turbine that is able to use wind energy to lift a weight and perform work. • Investigate how speed of wind affects power generation. • Explain how different variables (shape, angle, and solidity of blades) affects how much power is generated.	Presentation communicating findings to class

UNIT OVERVIEW (cont.)

Lesson No.	Duration	Materials Needed	Focus	Assessment Options
4 & 5	4-5 days	Same as lesson 3	**Expand** • Create an investigation to further refine their design and optimize power output. • Focus on one variable to study and collect data to find optimal design features related to that one variable. • Communicate findings from investigations to classmates.	Investigation write-up and presentation of Scientific findings
5	8-9 days	Same as lesson 3, plus: chart paper, colored paper and markers	**Evaluate** • Discuss and describe the problem they are trying to solve. • Design their wind turbine to produce the most amount of power with the most efficient design. • Test the device to assess for functionality and needed adjustments. • Share proposal with device and how it can be helpful to Puerto Ricans who have lost power due to Hurricane Maria.	Engineering Design steps, final proposal and presentation

LESSON 1: Devastation after Hurricane Maria

Strategy: Engage

Materials Needed

Computers with access to the Internet

Students engage with the storyline and set the context for learning (4-5 days).

Driving Question for this Unit: How can Wind Energy improve the lives of people in Puerto Rico who lost access to electricity due to Hurricane Maria? Students will be introduced to the electricity access problem being faced by the people living in the United States territory of Puerto Rico in the aftermath of Hurricanes Irma and Maria. This driving question can be presented at the end of the "engagement" process after there has been discussion about Puerto Rico and the devastation being faced by its citizens.

Engage students by facilitating a discussion where students can share and connect to what they remember (from news, media, discussions) about Hurricane Maria and the devastation it caused in the country of Puerto Rico. What have they heard on the news or from friends, family, teachers, etc.?

Social Studies connection:

Who are the Puerto Ricans? Have a discussion about where Puerto Rico is and what relationship they have with the United States. Have students read this article about the rights of Puerto Rican citizens: https://newsela.com/read/lib-convo-are-puerto-ricans-american-citizens/id/29203/

Have students read and discuss the following Newsela articles about the damage caused by the hurricanes that trudged through the region. Note: Newsela requires teachers to create an account. It is free and each article can be adjusted to differentiate for the reading levels of your students).

https://newsela.com/read/hurricane-maria-puerto-rico/id/35489
https://newsela.com/read/puerto-rico-maria-wifi/id/35731

Other Articles about devastation caused by the hurricane:
http://www.cnn.com/2017/09/25/us/hurricane-maria-puerto-rico/index.html

Discussion/reflection points: What types of disturbance did Hurricanes Irma and Maria cause to Puerto Rico? How were the lives of Puerto Ricans affected by this? What happened to their access to resources?

LESSON 1 (cont.)

Focus question: What do we lose when we lose power? Have students work in teams to brainstorm, "what do we lose when we lose power?" What are some basic services/needs that require access to electricity? Chart student ideas on a large poster which will be referred to throughout the Unit. Example of chart that was created based on current research: http://currents.plos.org/disasters/files/2013/11/Figure-3.jpg

Related Teacher Resource:
Article on the impacts of losing power on health and other factors: http://currents.plos.org/disasters/article/power-outages-extreme-events-and-health-a-systematic-review-of-the-literature-from-2011-2012/

Present students with the driving question: How can Wind Energy improve the lives of people in Puerto Rico who lost access to electricity due to Hurricane Maria? Work with students to build a KLEWS Chart (http://static.nsta.org/files/sc1506_66.pdf) about the Wind Energy and how it might help Puerto Ricans during this crisis. What do we know about wind energy and some of our wonderings? Have students make individual charts and compile a whole-group chart. This is a chart that can be revisited throughout the Unit.

LESSON 2: Where does our energy come from?

Strategy: Explore

Students explore where energy comes from (5-6 days).

Have students read this article about Puerto Rico's power grid: https://www.wired.com/story/after-hurricane-maria-puerto-ricos-grid-needs-a-complete-overhaul/ Have students respond to the questions: What were the main sources of energy in Puerto Rico (Coal? Oil? Gas? Solar? Wind?)? How might the types of energy being used by a state or country affect what happens in the aftermath of a Hurricane? Why can damage be especially devastating to regions that depend only on fuel burning for generating electricity?

Have students think about reflection questions and share with a partner before sharing with the class. How have students' new ideas/reflections changed the KLEWS chart?

Discussion prompts: How might wind energy help to mitigate the problem? What are other forms of energy that could be utilized? Students can read these articles about how TESLA is sending solar-powered devices to Puerto Rico in the aftermath of the disaster:
https://cleantechnica.com/2017/10/01/tesla-powerwalls-solar-panels-sent-puerto-rico/
https://www.bloomberg.com/news/articles/2017-09-28/tesla-is-sending-battery-packs-to-storm-ravaged-puerto-rico

Where does OUR energy come from? Taking a look at U.S. Energy Consumption
Teach Engineering Lesson: "A Closer Look at Oil and Energy Consumption" https://www.teachengineering.org/activities/view/cub_earth_lesson07_activity2
(Use this updated data instead of 2002 data provided in lesson: https://www.eia.gov/energyexplained/?page=us_energy_home). Students analyze and interpret data about the types and percentages of energy sources that are being used by the United States. Students address the following questions: Where does our energy come from? How can we analyze the percentages? How can our piece chart help us understand the breakdown of energy production in the U.S.? What patterns do we see, or what stands out to us when we look at the data?

Math connection:
"Grid and Percent It" lesson: https://illuminations.nctm.org/Lesson.aspx?id=960. This is a Mathematics lesson which helps students tackle the concept of percentages by using 100 square grids as a visual model to represent percents. Prompting questions: What is a percent? How can we use a grid to represent some of the data that the U.S. Energy Information Administration has provided about our energy consumption?

Materials Needed

Computers with access to the Internet

Black and white beans (for Renewable Energy Simulation Game)

LESSON 2 (cont.)

Readworks article: "How the United States Uses Energy" https://goo.gl/hFtY5X. At the end of the activity, talk about the word "sustainable" and what it means.

Looking at our local PUD:
Students are provided with data (and can do additional research) about the Utility company in their region and the sources of energy that are used to provide their communities with electricity. What types (and what percentages of the different types) of energy are being used? Are they sustainable or non-sustainable? Is their county doing a good job of reducing impact to the environment or not?

Clark County Statistics (look in "Fast facts about Clark Public Utilities")
https://cdn5.clarkpublicutilities.com/wp-content/uploads/2016/08/2015-Owner-Manual2.pdf
https://www.clarkpublicutilities.com/about-cpu/public-documents/integrated-resource-plan/

Skamania: https://www.skamaniapud.com/wp-content/uploads/JUNEJULY2015.pdf

Klickitat: http://www.klickitatpud.com/news/kpudNews/fuelReport.aspx

Ask students to become "yelp" reviewers and to use data to make a claim and assign a rating to their Public Utility company out of 5 stars (5 being an excellent job and 1 being not so good). They should use the ideas they discussed about sustainable and non-sustainable practices to write their reviews. Why does their PUD earn that specific star rating? There may be disagreement between students' ratings which is encouraged. Teacher can facilitate a discussion where students justify their star ratings and read their reviews to the class. They "star rating" should include their numerical rating and should be supported by evidence and reasoning. Ask students to include a CER argument as a part of their "Yelp" review.

Resources for Teachers:

- Videos about sustainability:
  https://www.youtube.com/watch?v=eEis6O9m0Ow
  https://www.sustain.ucla.edu/about-us/what-is-sustainability/

- Video about renewable energy: https://www.youtube.com/watch?v=B8WuEyL-YNY

Discussion prompt: What makes the kite boarder move or what makes the cell phone charge? https://www.youtube.com/watch?v=MZcWd-9wx40 Where does the energy in each example come from? Have students work in teams to map out their initial ideas and create a visual diagram of the two scenarios. Ask students to use arrows, captions, and "zoom-in" and "zoom-out" boxes to explain their thinking.

LESSON 2 (cont.)

Renewable Energy Simulation game (Lesson 4): http://extension.oregonstate.edu/clackamas/sites/default/files/lesson_4.pdf Students will participate in a simulation and collect data to model what happens to nonrenewable and renewable resources over a number of years. Before the simulation, discuss students' current understanding of renewable and nonrenewable resources. Discuss the terms "renewable" and "nonrenewable" with students. Students can then work in teams to discuss the chart provided in Lesson 3 (http://extension.oregonstate.edu/clackamas/sites/default/files/lesson_3.pdf). Students must work in teams to categorize each source of energy as either nonrenewable or renewable. Then they will work their team to construct an explanation and use a visual model (SEPs) showing how they were able to categorize each resource. In their explanation, students can discuss the following questions: How did they begin to decide whether the source was renewable or nonrenewable? What questions were brought up? Was there any disagreement? Students present the strategies and method they use to the class. Have students engage in the simulation and activities described.

Students will begin to build an understanding of how different types of energy can be harnessed and used for various purposes.

- Show students this stop animation video about renewable vs nonrenewable resources: https://www.youtube.com/watch?v=pBTnVoEIb98
- PBS Video: Energy Production: http://www.pbs.org/wgbh/nova/labs/lab/energy/1/3/

CER Argument (formative assessment): In this lesson, students have studied the various sources of energy that are being used to generate electricity. Puerto Rico has previously been highly dependent on fossil fuels for generating energy, and this infrastructure has been seriously damaged by the hurricane. TESLA has tried to provide aid by donating solar panel generators to the region. In this Unit, we are focusing on using Wind Energy to help solve the power access problem in the aftermath of the Hurricane. Have students look at the following design solution ideas and to pick the one that they feel would meet the best criteria for success. Provide them with access to computers so they can research the **time, costs, and restraints** of each design solution and pick the one that will be most helpful to the population in need.

> Option 1: Reconstruct Puerto Rico's old power grid by fixing damage that was caused by the hurricane without changing the structure and energy sources.
>
> Option 2: Reconstruct Puerto Rico's power grid using a renewable energy source (wind or solar).

Students will then pick one of these design solutions and create a CER claim identifying which solution will be more effective and why. Students can also outline the similarities and differences between the two solutions to identify the best features of each design, which can then be consolidated into one redesigned solution.

LESSON 2 (cont.)

Possible articles to direct students to:
http://time.com/4963240/hurricane-maria-puerto-rico-electrical-grid/
http://www.latimes.com/nation/la-na-puerto-rico-power-20170925-story.html
https://www.rmi.org/news/resilient-rebuilding-puerto-rico/
https://www.engadget.com/2017/09/30/puerto-rico-power-energy-crisis-hurricane-maria-prepa-tesla/

Connect with the storyline:

With your group, take a look how Puerto Rico generates most of its energy. Then ask students work in teams to discuss how their energy production might be affected by a Hurricane. Is Puerto Rico using renewable or nonrenewable energies? Why would a hurricane be impactful to Puerto Rico's energy supply? Have students write down their ideas and revisit the KLEWS chart to make any changes or additions.

Optional Extensions (depending on access to materials):

Renewable Energy with Vernier-Experiment 2: What is energy? Students will burn a candle or use gel chafing fuel to measure how much each energy source can heat water in 5 minutes. Explain the difference between potential and kinetic energy and give examples of both--refer back to these two concepts throughout the lab. Identify the units that are used to measure energy. Connect back to the CCC of energy and reconnect to previous lesson and discussions about renewable and nonrenewable energy.

Renewable Energy with Vernier-Experiment 3: Energy Audit. Students will measure electricity usage by several devices in the classroom and at home. They will calculate energy usage per person in the come and come up with ways to conserve energy at home or school. Students can use digital media to create a meme to promote their energy conservation strategy with the class and community.

Materials Needed for Vernier Experiments 2 & 3

- Vernier handouts
- Vernier LabQuests
- Surface temperature sensor
- Fuel samples (Candle and gel chafing fuel, or other fuel source)
- Ring stand and 10 cm ring
- Utility clamp
- 50 mL graduated cylinder
- Slit stopper
- Balance
- Small can
- Cold water
- Matches
- Safety goggles
- Multiple devices that use electricity

LESSON 3: Harnessing Energy with Wind Turbines

Strategy: Explain

Students work on building their understanding of turbines and explain how wind energy works (10 days).

Show this PBS video to introduce Wind Energy and to initiate discussion:
http://www.pbs.org/wgbh/nova/labs/lab/energy/2/3/

Connect with the storyline:

Present students with the driving question: how can we use wind energy to improve the lives of people affected by hurricanes in Puerto Rico? Ask students what they will need to study further in order to answer this question. Revisit the KLEWS chart and see if students have any modifications or additions. Facilitate a discussion where student voice is present and student thinking becomes visible. Why is wind energy a great renewable resource that can be used in the aftermath of a Hurricane? How might it benefit the people of Puerto Rico?

Career connections:

There are many careers related to the development and maintenance of Wind Technology. You can start to make this connection by asking students, what types of jobs might exist in the wind sector? Have students work in teams to brainstorm and then share their ideas. **Show the following videos about wind tower technicians:**

- Wind Tower Technician Training: https://www.youtube.com/watch?v=zmVpcsHvLNQ
- A Day in the Life Turbine Technician: https://www.youtube.com/watch?v=J6Gykr__pzQ

Discuss students' responses. What wonderings do they have after watching these videos? What skills will they need to develop in order to be successful in solving their problem?

Note: To learn how to connect to professionals in the field who are working with Wind Technology you may want to visit the following sites and connect with the institutions listed below. Additional opportunities for hosting professional guests in the classroom or planning field trips may be available through your district's partnership with the Southwest Washington STEM Network.

Northwest Renewable Energy Institute: http://www.nw-rei.com/
Columbia Gorge Community College: https://www.cgcc.edu/career-tech-ed/em-tech

Materials Needed for Vernier Experiment 6

- KidWind Advanced Wind Turbine
- Wind Turbine Hub
- Weightlifter spool and bucket
- safety goggles
- balance
- stopwatch
- 1 m of string
- Blade Pitch Protractor
- blade materials
- meter stick
- 10-15 washers
- scissors
- hot glue and tape
- fan

LESSON 3 (cont.)

How does a wind turbine work?

Have students work independently to create an initial model of a wind turbine. This model absolutely does not have to be correct, it will be adjusted and optimized through the rest of the Unit. Remind students that a wind turbine uses wind to generate electricity. What are the important parts of a wind turbine? What function do they perform and what is their structure? How are they connected? Connect to the Cross Cutting Concept (CCC) of Energy by asking these prompting questions: How is energy transferred and concerted using a wind turbine? Where does the energy go and what form does it take? Use arrows to represent the flow of energy. Use captions to explain the structure and function. Use zoom-in or zoom-out boxes to explain your thinking.

Show students videos to illustrate the structure and function of parts of a wind turbine.

- What's inside a wind turbine?: https://www.youtube.com/watch?v=LNXTm7aHvWc
- How do Wind Turbines work?: https://www.youtube.com/watch?v=qSWm_nprfqE

Renewable Energy with Vernier-Experiment 6: Mechanical Power

Before students start checking for amount of power produced. Students will need several class sessions time to construct their initial prototype of a wind turbine. Allow students to explore materials and discuss building ideas with their group. Have students refer to their initial models for ideas and to work as teams to create a plan for how they will build their turbine. What are the different materials provided and what function do they serve? How will they be connected? In this experiment, the turbine will not yet be used to generate electricity. Instead, the power of the wind will be used to pull up a mass of weights a certain distance. Once students have a plan, allow for the building process. At the end of the experiment, ask students to draw a diagram explaining how the wind energy was able to lift the weight. How was energy being transferred?

Renewable Energy with Vernier-Experiment 8: Exploring Wind Turbines

Students will then connect answer the question: How does the speed of the turbine affect how much power it generates? Students explore how wind Turbines turn and study the relationship between the speed of the wind turbine turning and the amount of power it generates. Students will engage in an authentic engineering task where they are conducting an investigation, analyzing and interpreting data, and communicating their ideas (SEPs) while deepening their understanding of DCI ETS1.C (Optimizing the Design Solution). The Vernier Energy Sensor can be used to check the current and voltage values being generated by the Turbine. Students can study how the speed of the turbine affected the amount of power output by the turbine.

Materials Needed for Vernier Experiment 8

- Computer
- LabQuest
- Vernier Energy Sensor
- Vernier Variable Load
- 2 wire leads with clips
- safety goggles
- KidWind Advanced Wind Turbine
- Wind Turbine Hub
- Blade Pitch Protractor
- blade materials
- scissors
- hot glue
- fan

LESSON 3 (cont.)

Renewable Energy with Vernier-Experiment 10 & 11

These two Vernier Lessons can be used to guide students' basic investigations of turbine efficiency. Student take-aways: what works and what doesn't work? How does the shape, angle, and solidity of the blades affect how much power is generated? How can we create a prototype that is more efficient?

Model Adjustments and Scientific Findings Share-out: Have students revisit their working models of the wind turbine. What information have they learned that might change their initial model? What adjustments can they make to their initial drawing to more accurately represent a wind turbine that is functional and effective? Groups will synthesize a short presentation to share their findings with their teammates, engaging in a key SEP (Obtaining, Evaluating, and Communicating Information). What did they discover about how the varying structure of different parts of the turbine affected its functionality? Structure and function is a CCC that can be tied into students' investigations of how different design elements and structures impact the functionality of that part. The entire class may be given access to data collected from all teams so they can use it when constructing their turbines?

Materials Needed for Vernier Experiments 10 & 11

- Computer
- LabQuest (or Vernier data collection interface)
- Vernier Energy Sensor
- Vernier Variable Load
- Safety goggles
- 2 wire leads with clips
- KidWind Advanced Wind Turbine
- Wind Turbine Hub
- Blade Pitch Protractor
- Ruler
- Blade materials
- Scissors and hot glue
- Fan
- Digital camera

LESSON 4: Investigating Efficiency

Strategy: Expand

Students expand their understanding of wind energy by investigating and optimizing turbine design (4-5 days).

Renewable Energy with Vernier Experiment 12: Turbine Efficiency
Students pick one variable and create an investigation to refine their design and optimize power output. This will allow students to further expand towards mastery of DCI (Core Idea) ETS1.C (and PE MS-ETS1-4). Each team of students can choose to specialize in one variable (blade length, number of blades, pitch, shape, width, blade material) and can share their findings as a whole group. The following prompts can be used to scaffold the process:

- What is the real-world problem that you are trying to solve?
- What is the goal of the investigation?
- What variable will your team be investigating? What variables will you be controlling?
- How will you collect your data?
- How will you analyze your data?

Formative assessment: How will you work with your group to communicate your findings to the class in a way that will be useful to them (poster, graph, slides, or handout?). In the next part of the lesson, students will be working in teams to create their final prototype design of the turbine, what information would be useful to the rest of the class and how can they share it?

After groups are ready to share their findings, have them present to the class. Then give some time after the presentations for teams to discuss all the data that was presented to them by their peers. What did they learn from other groups that was helpful? Was the information shared by other groups consistent with their findings? How can this collective data be used in the final engineering process? What design features will they adopt? Are there any findings that they wonder about? Encourage students to follow-up with other groups about questions they may have about the findings.

Have students revisit their individual working models and create adjustments to optimize the design. At this point, students may want to create a brand new model that incorporates everything they have learned so far. **This may serve as another formative assessment opportunity for teachers.**

Materials Needed for Vernier Experiment 12

- Computer
- LabQuest (or Vernier data collection interface)
- Vernier Energy Sensor
- Vernier Variable Load
- Safety goggles
- 2 wire leads with clips
- KidWind Advanced Wind Turbine
- Wind Turbine Hub
- Blade Pitch Protractor
- Ruler
- Blade materials
- Scissors and hot flue
- Fan
- Digital camera

LESSON 5: Turbines Optimized

Strategy: Evaluate

Students and teacher can evaluate what they have learned throughout the Unit by applying their understanding of wind energy to build an efficient device that is able to generate electrical energy for use (6-7 days).

This is an engineering design lesson which has been adapted from activities in **Renewable Energy with Vernier Experiment 15: Maximum Energy Output. Students will revisit the problem faced by Puerto Rico.**

Ask: Allow students time to think about the problem they are trying to solve. Ask students to reconnect with the KLEWS chart and the work they have done throughout the Unit. What is the problem we are trying to solve? Who are we trying to help? What are the needs that have to be met? How will our turbine be helpful to people in Puerto Rico?

Design: Before providing students with materials, ask them to plan their devices. What types of materials might they want to use? What constraints will they have? What types of features can they create in their device to optimize efficiency? When students have had a chance to think individually and then to come together as a team to discuss and consolidate their ideas, provide students with materials to start building. Encourage students to use the data that was collected previously while selecting some of their design features.

Check: Students will test their device to test for efficiency. Is the device working properly? Are results replicable? Is the device easy to use and is it durable? Does it perform the intended function? Will it improve the quality of life for people who are affected by a lack of power in Puerto Rico? Are there any barriers or constraints you are experiencing? How can these constraints be addressed?

Share: How will you present your proposed solution to a larger audience? What was the problem you were trying to solve and how does your device help to solve that problem? How does your device reduce negative impact to the environment? Students can create a presentation that explains the problem they were faced with and how their device helps to solve that problem by improving Puerto Rican's access to electricity in the aftermath of natural disasters.

Summative assessment: Students' projects/presentations can serve as a summative assessment. Students engaged in the SEPs of asking questions, constructing explanations and designing solutions, and communicating information while addressing the CCC of Energy and Systems.

Materials Needed

- Computer
- LabQuest (or Vernier data collection interface)
- Vernier Energy Sensor
- Vernier Variable Load
- Safety goggles
- 2 wire leads with clips
- KidWind Advanced Wind Turbine
- Wind Turbine Hub
- Blade Pitch Protractor
- Ruler
- Blade materials
- Scissors and hot flue
- Fan
- Digital camera
- Chart paper, colored paper and markers

How This Unit Supports Next Generation Science Standards

MS-ETS1 Engineering Design

The materials/lessons/activities outlined in this activity are just one step toward reaching the Performance Expectations listed below. Additional supporting materials/lessons/activities will be required. NGSS connections are derived from the Evidence Statements for the Performance Expectations listed below.

Peformance Expectation	Connections to Classroom Activity
MS-ETS1-1: Define the Criteria and Constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions. MS-ETS1-2: Evaluate competing design solutions using a systematic process. MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify best characteristics that can be combined into a new solution. MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.	• Students learn about the crisis of power loss being faced by Puerto Ricans in the aftermath of Hurricanes during the Summer/Fall of 2017 • Students study how Puerto Rico's dependency on fossil fuels for generating energy amplified difficulties due to damage caused by the hurricane and learn about how renewable sources of energy can be a more sustainable source of energy production • Students explore the use of wind energy to generate electricity by creating wind turbines. • Students develop a framework for conducting an investigation to collect data on how different variables influence the efficiency of a wind turbine. • Students construct an argument explaining how their variable affects power output and what features can optimize wind turbine design. • Students design and build a wind turbine that possesses features of optimization that were found during investigations. • Students construct an argument to describe how their wind turbine can be helpful in solving the problem of power-outage being faced by Puerto Rican's in the aftermath of the hurricanes.

How This Unit Supports Next Generation Science Standards (cont.)

SCIENCE & ENGINEERING PRACTICES	
Asking Questions and defining Problems	• Students define the problem being faced by Puerto Rican's in the aftermath of Hurricanes Irma and Maria.
Developing and Using Models	• Students ask questions about why the devastation is amplified due to the country's dependency on fossil fuels.
Analyzing and interpreting data	• Students ask questions about the sustainability of the fuel mix being used by the United States to produce electricity and construct an argument to answer this question.
Engaging in argument from evidence	• Students ask questions about the sustainability of the fuel mix being used by their local PUD to produce electricity for their community and construct an argument to answer this question.
Using Mathematics	• Students design and conduct investigations to collect data which is analyzed to define optimal features of a wind turbine.
Communicating Information	• After analysis and interpretation of their data, students communicate their findings to their peers.
Constructing Explanations and designing solutions	• Students develop and refine a model for how a wind turbine converts energy from one form to another.
Conducting Investigations	• Students build a device which uses data from their investigations to create an efficient device which can produce electricity.
	• Students describe the engineering process they used to construct their device and communicate (to a larger audience) how the wind turbine may help to provide relief to Puerto Ricans in the aftermath of the hurricanes.

How This Unit Supports Next Generation Science Standards (cont.)

DISCIPLINARY CORE IDEAS	
Defining and Delimiting Engineering Problems Developing Possible Solutions Optimizing the Design Solution	• The problem being faced by Puerto Rica is influenced by the fact that most of their energy comes from nonrenewable resources. • Understanding the benefits of using renewable energy will allow for the creation of devices which will help create sustainable solutions for communities. • Using systematic processes and collecting data can help to identify optimum design features which can help to improve a device. • Repeating an investigation to collect and refine data can help to optimize design solutions. • Models can help in the development, testing, and optimizing of a design solution.
CROSSCUTTING CONCEPTS	
Influence of Science, engineering, and technology on society and the natural world Energy Cause and Effect Structure and function	• Students study how the use of certain types of resources, such as fossil fuels, can cause increased environmental impact, and decreased ability for a community (or nation) to be resilient in the aftermath of a natural disaster. • Different sources of energy have different impacts on the environment. Sustainable resources are those that are renewable and can be easily accessed by a community for long-term use. • Energy can be transferred from one form to another—there are many energy sources that are used to generate electricity. • The structure of different parts of a wind turbine can produce increased efficiency within the constraints of the design problem.