Solar Updraft Towers Unit Overview

Innovations in Renewable Energy

AUTHOR
Lisa Morgan

DESCRIPTION
Students will combine research, direct observations, and hands on investigation to lead them into an engineering design project involving the construction of a solar updraft tower. During this process, students will make references to specific phenomena they witnessed in the classroom involving convection currents, solar energy, energy generation, and energy transformations involved in these processes. These specific phenomena will be investigated individually and serve as tools to pull design ideas for their final projects.

GRADE LEVEL(S)
3, 4, 5, 6, 7, 8

SUBJECT AREA(S)
Energy Sources, Renewable Energy, Non-Renewable Energy

LEARNING GOAL(S)
1. Students will understand ten **renewable and non-renewable energy sources** on the earth.
2. Students will learn the locations of different energy sources on the earth.
3. Students will learn the history of energy sources and how humans have used them.
4. Students will learn about **innovations** and inventions used to **find, recover, store, and release energy** for human consumption.
5. Students will understand that hot air rises
6. Students will understand why hot water and hot air rise and cold air and cold water sink.
7. Students will learn that wind is produced by warm air rising and cold air sinking.
8. Students will learn that the energy of moving hot air can be converted into other forms of energy.

9. Students will understand that energy from the sun can be converted into heat.
10. Students will discuss the effects of the chimney stack phenomenon.
11. Students will understand that wind energy can be converted into other forms of energy.
12. Students will determine different methods to increase the effectiveness of a wind turbine blade by harnessing and converting the mechanical energy of the wind.
13. Students will determine that thermal energy resulting from the sun's radiation can create an updraft that will power a turbine to spin.
14. Students will identify characteristics of turbine design that improve the success of their device.
15. Students will utilize content from previous phenomena they investigated, such as the chimney stack effect and Norwegian candle toys, to determine how to best harness the energy transformed by their device from the sun.
16. Students will be able to define and explain what a solar updraft tower is.
17. Students will make connections between their previous engineering challenge and a real world solution to the world's growing energy demands.

UNIT LESSON EXPERIENCES

Table 1. Suggested Teaching Time

Lesson/Experience	Time
Engage/Explore	
L1: Where Does Energy Come From?	60 min x 20 = 1200 min (20 hr)*
Explain	
L2: Where Does Energy Go?	60 min x 6 = 360 min (6 hr)
Elaborate/Evaluate	
L3: Wind Power—A Hands on Experience	60 min x 2 = 120 min (2 hr)
L4: Innovations in Renewable Energy	60 min x 3 = 180 min (3 hr)
L5: Learning About Solar Updraft Towers	60 min x 2 = 120 min (2 hr)
Total	50 min x 15 = 750 min (12 hr 30 min)
*This time includes time for researching, drafting, writing, editing, publishing, sharing, and celebrating the informative writing unit. Time can reduced if students are able to complete some as homework.	

NEXT GENERATION SCIENCE STANDARDS

Guiding Phenomenon	Chimney Stack Effect
Supplementary	Swedish Candles

Phenomena	Radiometers Convection cell in water demonstration Paper spiral and lamp

Table 2. Next Generation Science Standards Addressed in This Unit.

Performance Expectation	How is this assessed?
4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.	Students will be assessed on this knowledge for each engineering challenge they complete, both in classroom discussion as well as final presentations. They must be able to relate the basic structure of their design to principles involving the observed energy transformations from different phenomena in the classroom.
4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide.	Students will be required to make predictions about how the turbines they create will interact with air molecules trying to move past them, additionally asking questions as part of a design process in order to determine how they can optimize these structures.
4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.	In discussions, students will consistently be asked how devices they designed, whether it be the wind turbine or solar updraft tower, pull from principles observed in the classroom energy transformation phenomena. Additionally, with their final project, this process will be included in their presentation of solar updraft towers.
4-ESS3-1. Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.	Students present research conducted on various types of energy resources. In this research, they will discuss the environmental impacts of certain fuels through a pros/cons investigation.
3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.	Students will determine criteria for success and constraints surrounding the use of 4x4 pieces of paper to design a turbine blade that will spin fast enough to light the “Firefly” when held up to a fan. Students design, build and test their projects using initially prescribed materials before determining the usage of other beneficial supplies.
3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet	Students will generate, test and compare multiple turbine blade designs based on how well they perform by lighting the “Firefly.” Students identify aspects of various designs determined to be successful relative to their constraints and objective. They will identify multiple design routes,

the criteria and constraints of the problem.	stating the pros and cons of each.
3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.	Students will plan and carry out fair tests, being careful to change only one variable at a time, such as blade design, number of blades, and the tilt of the blades. Students will create a project that will have movement powered by heat from the sun.

THREE DIMENSIONAL LINKAGES

NGSS focuses not only on content, but also on process and on building bridges between concepts within and across disciplines. The following tables outline the way in which this unit addresses this three-dimensionality.

Table 3. Three-Dimensional Linkages: Disciplinary Core Ideas

Disciplinary Core Ideas	Linkage
PS3.A: Definitions of Energy • Energy can be moved from place to place by moving objects or through sound, light, or electric currents.	Students make observations of different phenomena that demonstrate energy transformations, primarily those involving heat, motion, and light. They use these investigations to drive their engineering design process and discuss how these energy transformations can be harnessed to produce electricity.
PS3.B: Conservation of Energy and Energy Transfer • Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced • Light also transfers energy from place to place. • Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by	Students make multiple observations and have discussions about demonstrations in which energy is transferred by heat and light into motion. Through a discussion of convection currents, they are able to perceive air molecules colliding with other objects to transfer energy. Regarding light, in order to build a successful solar updraft tower, students must determine that darker surfaces will absorb the most light and thus convert this light energy into thermal energy to move molecules in a system. Finally, through their research project, students conceptualize the usage of electric currents to power larger systems, and the importance of selecting thoughtful ways to generate these currents.

transforming the energy of motion into electrical energy.	
PS3.C: Relationship Between Energy and Forces • When objects collide, the contact forces transfer energy so as to change the objects' motions.	Students investigate how energy is transferred through the motion of air particles to turbine blades and how to design turbine blades that make this energy transfer more efficient.
PS3.D: Energy in Chemical Processes and Everyday Life • The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use.	In observing and investigating numerous phenomena involving energy transformations with heat, light, and thermal energy, students can determine specific sources for energy transfer and provide context for certain "invisible" energy interactions.
ESS3.A: Natural Resources • Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not.	Students analyze the pros and cons of various resources used to generate energy early in the unit. They listen to presentations by their peers and collect information about various sources they didn't research. These resources will be compared to solar updraft towers later in the unit.
ETS1.A: Defining and Delimiting Engineering Problems • Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.	Students engage in engineering problems multiple times in this unit, from designing turbine blades for wind turbines to designing entire solar updraft towers. Materials are one of the primary constraints in this process, and students are forced to make specific adjustments to their design based qualities such as turbine shape, colors used, positioning, etc. in order to meet the criteria for success given specific supplies.
ETS1.B: Developing Possible Solutions • Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. • At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to	Students will be conducting research for their engineering projects both through completing their initial research project on renewable energy as well as their observations of convection current phenomena. They will be asked to communicate their thoughts to the class and additionally solve engineering tasks and investigations in groups. Throughout each design process, students will be asked to continuously try to improve their design,

improved designs. • Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved.	which gears them toward identifying failure points and removing the design aspects that lead to these failure points. Many of the potential areas for failure can be addressed through an acknowledgement of scientific principles observed in phenomena.
ETS1.C: Optimizing the Design Solution • Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.	For their major engineering challenges in this unit, students will be asked to continuously redesign. Criteria for success are clear, such as getting an LED to turn on or getting a turbine to spin. Each of these can additionally be expanded to lengthen the process of redesign and make solutions more complex. With each reiteration of a design, students will communicate how the manipulation of different variables affected the success of their design in regards to meeting the criteria for success.

Table 4. Three-Dimensional Linkages: Science and Engineering Practices

Science and Engineering Practices	Linkage
Asking questions and defining problems	L1: Students will research the nature, source, extraction, history, and use of an energy source. During this process they will generate their own questions about the source. L2: Students generate questions about each demonstration and investigation. L3: Students will ask questions about how to build a successful turbine blade that will spin fast enough to light the red light on the "Firefly." L4: Students ask, "How can I use what I learned in lesson 2 about Norwegian candle spinners, Radiometers and the Chimney stack effect to design a structure that will trap and generate energy from the sun, when set outside on the sidewalk?" L5: Students will research Solar Updraft Towers. They write down questions they have.
Developing and using models	L2: Students discuss how each of the phenomena used in this lesson acts as a model for demonstrating the movement of hot water and air. L3: Students will develop and use turbine blades referring to the Swedish Candle Spinner and Paper Spiral Models for ideas. L4: Students will incorporate insight from previous phenomena modeling convection currents as well as their own self-crested models of wind turbines to select design routes.
Planning and	L2: Students make predictions and tinker with supplies to

carrying out investigations	determine whether or not their predictions were correct. L3: Students will plan their turbine blade, cut it out, and test it. L4: Students plan and build multiple designs, determining the successfulness of each design.
Analyzing and interpreting data	L1: Students will analyze 3 advantages and disadvantages of an energy source that will require their analysis of simple data about the effects or usage of that energy source. L3: Students will analyze if their turbine design was built correctly enough to spin fast enough to light the red light on the firefly. They will track how independent variables may have affected this success rate.
Using mathematics and computational thinking	
Developing explanations and designing solutions	L1: Students develop explanations about what they have learned from their research of a specific energy source and discuss potential solutions related to global energy use. L2: Students discuss and record explanations for each of the experiments on their response sheet. L3: Students will use their own experience and the experience of classmates to develop explanations for successful and unsuccessful turbine blade designs. L4: Students use trial and error to keep improving their designs, one variable at a time while explaining why each design may or may not work successfully
Engaging in argument from evidence	L1: Students obtain information from research and discuss their findings with other students, ensuring that they have reliable sources for the information they provide. L3: Students will use the evidence of the firefly lighting up and other test results to engage in argument about successful blade design. L4: Students make design changes based on what they see and hear from other students who are having success with their designs. They are able to articulate why each of these changes are made based on the performance of their updraft tower
Obtaining, evaluating, and communicating information	L1: Students obtain information about an energy source. They plan, write, evaluate edit, publish and share information with class members, parents and the community. L2: Students share and discuss what they have written about each experiment and demonstration. They will use a KDW sheet to keep track of how their thinking changed, if it did. L3: Students will obtain information through trial and error about what makes a successful turbine blade design according to size, blade design and the tilt of the blades. Students will communicate this information to one another. They will also write up an explanation of what makes a successful turbine blade for

	the 'Firefly." L4: Students take notes, draw sketches and share their successes and failures with one another during regularly scheduled check-ins and sharing sessions. L5: Students discuss the pros and cons they have learned from multiple sources about Solar Updraft Towers as a relatively new renewable energy solution

Table 5. Three-Dimensional Linkages: Crosscutting Concepts

Crosscutting Concepts	Linkage
Patterns	L1: Students learn about patterns in the history of energy retrieval and use by man. L2: Students compare similarities and differences of five different hot air and hot water experiments.
Cause and effect: mechanism and evaluation	L1: Students learn about cause and effect on the environment for specific energy sources. L2: Students investigate the effect that hot air and hot water have on various items. L3: Students will determine how the independent variables manipulated in their blade design affect the success of their overall project. L4: Heat from the sun creates an updraft that causes moving air to spin a turbine on the project
Scale, proportion, and quantity	L1: Students learn about scale, proportion and quantity of different energy sources in regards to our total energy use. L3: Students will manipulate scale and proportion to design a turbine blade that will spin successfully when held up to a fan. L4: Students run tests to determine how big to build their structure and how big to make the turbine for spinning. L5: Students will evaluate updraft towers of scales much larger than the one they built, eliciting questions about the needs of these larger designs.
Systems and system models	L1: Students learn about systems of energy retrieval, storage and use. Students learn about the energy grid. L3: Students will build a system as they design a turbine blade, attach it to the firefly, hold it up to the fan and spin the rotor fast enough to light up the light. L4: Students are creating a system by creating a model that absorbs heat from the sun, and transfers it to moving parts in their design. L5: Students use the model they created as a reference for looking at larger updraft towers, comparing their innovations with those in place.
Energy and	L1: Students learn about the difference between renewable and non-renewable resources, which entails a discussion of matter

matter: Flows, cycle, and conservation	cycles on our planet as well as the nature of energy. L2: Students observe and test the way hot air and hot water rises. Students observe and test the way hot air and hot water cause various objects to rise and spin. L3: Students will understand how wind flows across a turbine blade its mechanical energy is converted into electrical energy. L4: Students investigate the transfer of energy through matter using convection currents generated by the sun.
Structure and function	L1: Students learn about the structure and function of the various energy sources they research. L3: Students will understand the structure and function of a windmill in regards to the successful structure of turbine blades. L4: Students identify key components of successful turbine and tower structure, such as blade pitch and ventilation areas.
Stability and change	L1: Students research the stability and change of various energy sources they research.

COMMON CORE STATE STANDARDS

- CCSS.ELA-LITERACY. RI.4.3: Explain events, procedures, ideas, or concepts in a historical, scientific, or technical text, including what happened and why, based on specific information in the text.
- CCSS.ELA-LITERACY.RI.4.4: Determine the meaning of general academic and domain-specific words or phrases in a text relevant to a grade 4 topic or subject area.
- CCSS.ELA-LITERACY.RI.4.5: Describe the overall structure (e.g., chronology, comparison, cause/effect, problem/solution) of events, ideas, concepts, or information in a text or part of a text. Compare and contrast a firsthand and secondhand account of the same event or topic; describe the differences in focus and the information provided.
- CCSS.ELA-LITERACY.RI.4.7: Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears. Explain how an author uses reasons and evidence to support particular points in a text.
- CCSS.ELA-LITERACY.RI.4.9: Integrate information from two texts on the same topic in order to write or speak about the subject knowledgeably.
- CCSS.ELA-LITERACY.W.4.5: With guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, and editing.
- CCSS.ELA-LITERACY.W.4.6: With some guidance and support from adults, use technology, including the Internet, to produce and publish writing as well

as to interact and collaborate with others; demonstrate sufficient command of keyboarding skills to type a minimum of one page in a single sitting.

- CCSS.ELA-LITERACY.W.4.2.A: Introduce a topic clearly and group related information in paragraphs and sections; include formatting (e.g., headings), illustrations, and multimedia when useful to aiding comprehension.
- CCSS.ELA-LITERACY.W.4.2.B: Develop the topic with facts, definitions, concrete details, quotations, or other information and examples related to the topic.
- CCSS.ELA-LITERACY.W.4.2.C: Link ideas within categories of information using words and phrases (e.g., another, for example, also, because).
- CCSS.ELA-LITERACY.W.4.2.D: Use precise language and domain-specific vocabulary to inform about or explain the topic. Provide a concluding statement or section related to the information or explanation presented.
- CCSS.ELA-LITERACY.**SL.4.1.A**: Come to discussions prepared, having read or studied required material; explicitly draw on that preparation and other information known about the topic to explore ideas under discussion
- CCSS.ELA-LITERACY.CCRA.SL.1: Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasive
- CCSS.ELA-LITERACY.CCRA.SL.4: Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.
- CCSS.ELA-LITERACY.CCRA.SL.5: Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentation.

CONTENT BACKGROUND

STUDENT BACKGROUND

At the start of this unit, students should be familiar with the following:

- A basic knowledge of non- renewable energy sources including coal, natural gas, petroleum, propane and uranium.
- A basic knowledge of renewable energy sources including biomass, wind, geothermal, hydropower and solar.
- Library books, magazines and student friendly websites about specific energy sources are great. *These two educational websites are replete with kid friendly research information and endless lesson plans and activities K-12.*
  - NEED-National Energy Education Development Project (need.org)
  - Energy Kids (energykids.eu)

EDUCATOR BACKGROUND

Educators leading this lesson should be familiar with the following:

- A basic knowledge of non- renewable energy sources including coal, natural gas, petroleum, propane and uranium.
- A basic knowledge of renewable energy sources including biomass, wind, geothermal, hydropower and solar.
- Resources for students and teachers:
  - NEED-National Energy Education Development Project (need.org)
  - Energy Kids (energykids.eu)
  - *These two educational websites are replete with kid friendly research information and endless lesson plans and activities K-12.*
  - Knowledge of existing library books, magazines and student friendly websites about specific energy sources.

VOCABULARY

Balance	Geothermal Energy	Renewable Energy	Structure
Biomass	Hub	Recovery	Turbine
Blade Pitch	Hydropower Energy	Release	Turbine blade
Chimney Stacking Effect	Innovation	Solar	Updraft
Coal	Natural Gas	Solar Energy	Uranium
Convection	Non-renewable Energy	Solar Updraft Tower	Used
Drag	Petroleum	Source	Wind Energy
Electrical Circuit	Propane	Spiral	
Friction	Radiometer	Storage	

MATERIALS NEEDED

HANDOUTS/PAPER MATERIALS

- Worksheet 1: Rockin Resources Café Handout
- Worksheet 2: Publishing Ideas Handout
- Worksheet 3: Scoring Rubric for Energy Report
- Worksheet 4-KWL Water Wind Heat
- Worksheet 5-Phenomena Chart
- Worksheet 6-Solar Updraft Engineering Design

CLASSROOM SUPPLIES

- Possible items to help students publish: fallen tree branches and sticks, empty boxes, poster board
- Scissors
- Tape
- Glue
- 4 glass bottles or jars that can be inverted on top of one another
- Food coloring blue and red or blue and yellow
- Water
- A Solar Bag (can be purchased inexpensively online.)
- A Norwegian or German Candle Spinner (can be purchased inexpensively online)
- Paper and scissors for cutting spiral
- A lamp without a shade
- Needle and string
- A radiometer (can be purchased inexpensively, online)
- Box fan for testing turbine designs
- Tin cans with tops and bottoms cut out (cut ahead of time for safety)
- Tall plastic or paper cups
- Paper: black, white, and colored
- Foil pieces
- Paper clips
- Sharp, Pointy Things: thumbtacks and needles
- Small metal caps for the pin to spin in.
- 250W halogen work lights are a good sun model

ACTIVITY SUPPLIES (PER GROUP OF 3-4 STUDENTS)

- Computer or tablet for research
- Recharge Labs Firefly Classroom Pack (RL-FIREFX, includes 10 firefly models with motors and lights)
- 10 unsharpened pencils to be used as handles for the "Fireflies"
- (1) Bamboo stick
- (1) Small ball of modeling clay
- Projector or other YouTube video-playing device
- Computer queued up with EnviroMission Video – "EnviroMission and the Solar Updraft Tower on the Discovery Channel" video on YouTube by Brett Rodli (https://youtu.be/xb-mQcvGczo)

UNIT PROGRESSION

LESSON SEQUENCE

LESSON 1: INFORMATIVE WRITING—WHERE DOES ENERGY COME FROM?

This lesson is a non-fiction research writing project, which includes a differentiated choice menu and list of ideas for publishing the completed project. Each student will choose one of ten energy sources to research, including coal, natural gas, petroleum, propane, uranium, biomass, wind, geothermal, hydropower and solar. He or she will write a report on the chosen energy source, complete 3 differentiated projects on the energy source, choose a way to publish the research, and participate in an Energy Celebration to present their findings in a creative way to classmates, parents, school and community members. Students will work alone for this project, but are encouraged to share ideas, sources, and findings.

- L1 Day 1: Discussing and Defining Energy. Students research energy on web and try to define energy. Student questions are tracked in a central location.
- L1 Day 2: Select Research Topic (Energy Source). Students select an energy source to research and are given the expectations for the project.
- L1 Days 3-5: Begin Research. Students research questions from worksheet 1: "Rockin' Resources Café".
- L1 Days 6-8: Write Rough Draft. Students write rough draft of report from their notes.
- L1 Days 8-10: Create Final Copy of 2 "Side Dishes". Students select two "side dishes" from worksheet 1: "Rockin' Resources Café" and write a rough and final draft for these.
- L1 Days 11-14: Begin Research. Students select and complete a "dessert" from worksheet 1: "Rockin' Resources Café".
- L1 Day 15: Write Bibliography. Students select and complete a "dessert" from worksheet 1: "Rockin' Resources Café"

LESSON 2: WHERE DOES ENERGY GO?

Students investigate 6 phenomena related to the way that water and air transport and transfer heat. The demonstration activities act as unique phenomena in which students can generate questions to lead subsequent investigations with each activity in learning centers. Through gaining content from investigations with these phenomena, students will gain insight into how energy conversions work in a solar updraft tower.

LESSON 3: WIND POWER—A HANDS ON EXPERIENCE

Students work in teams to design successful turbine blades for the "KidWind Firefly" to light up an LED. This will scaffold them nicely into Lesson 4 when they design their own paper turbine for a Solar Updraft Tower toy.

LESSON 4: LET'S BUILD OUR WIND AND SOLAR ENERGY TOY

Students combine what they learned in previous lessons using their investigations of convection-related phenomena to design a device that will convert energy from the sun using convection currents. Their primary objective will be to design a device that uses energy from the sun when placed on a sidewalk to spin a turbine similar to the one they designed for their Firefly in the previous lesson

LESSON 5: LEARNING ABOUT SOLAR UPDRAFT TOWERS

Students learn about real-world solar updraft towers that are being planned and built around the world to help solve energy problems by using unlimited power from the sun. This will provide real world context to the engineering challenge they engaged in during the previous lesson.

ASSESSMENT AND EXTENSIONS

FORMATIVE ASSESSMENTS

- L1: Formative assessments will be given during the various stages of the writing process. For example, students will be required to write all of their information on large notecards. They will be assessed on the completeness of their writing using a rubric. Students will be required to write their final drafts from their notecards to encourage sentences written in their own words and not copied from the text.
- L2: Students will be assessed on the completeness and thoughtfulness of the probing questions on the worksheet for this lesson.
- L3: This activity can last one to several days. Students will create turbines until they are able to light the firefly when held up to the fan. Students will take turns demonstrating their successful turbine design and giving a brief explanation of their design journey. Students will also be assessed on their design and test chart they created throughout the activity.

SUMMATIVE ASSESSMENT

- L1: Rubric (Worksheet 3-Scoring Rubric For Energy Report) will be used to assess completeness, neatness and presentation.
- L4: Students will draw and label the different parts of their project and explain how it works. This can be done on a poster presented to the class, or perhaps using an online tool such as SketchUp or Google Draw.
- L5: Students will be assessed on the quality of answers and completeness of their Solar Updraft Towers KWL worksheet.

UNIT EXTENSIONS

- L1: This lesson can stand on its own and used as a Nonfiction Informational Writing Unit. It is also used as an introductory lesson for Lesson 2, 3, and 4 of this unit. Lesson one's purpose is to get the students thinking about renewable and non-renewable energy sources. Furthermore, to help students understand the role money, time, location, innovation, and public support play in the development of new ways to use energy sources, with particular focus on solar updraft towers, for this unit.
- L2: These demonstrations offer many opportunities for further discussion and experiments. Depending on the discussion reached by your students in their filling out of the chart and as a whole class, it is possible to determine methods in which groups of students can continue to investigate how each of these scenarios function more closely using the materials at hand.
- L3: Check out the MacGyver Kit at REcharge Labs, in which students design an entire windmill from found items instead of just the turbine blades.
- L4: Have students generate questions that could lead to further material exploration, ensuring that one variable is changed at a time. Examples could include: Does the turbine spin faster when the tower is made taller? Does it matter what color paper the tower is made of? Does it matter what material the turbine is made of?
- L5: Continue discussion of the role money, time, location, innovation and public support play in the development of new ways to use energy sources.
- L5: Write a letter to the innovators and companies found in videos and research.