Lessons 15–16
Windmills at Work

Prepare

In Lessons 12–14, students created a generator to better understand how windmills transform the energy of motion into electrical energy. In Lesson 15, students build a key concepts checklist to guide them as they revise the class anchor model. In Lesson 16, students revisit the story of William Kamkwamba. This sets the stage for the engineering challenge introduced in Lesson 17. Students then apply their new understanding of energy to explain how energy is transferred and transformed and answer the Essential Question.

Student Learning

Knowledge Statement

Everything that happens can be explained by the transfer and transformation of energy.

Objectives

- Lesson 15: Model how windmills transfer and transform energy.
- Lesson 16: Explain that energy makes things happen when it is transferred and transformed.

Concept 3: Energy Transformation

Focus Question

How does energy transform?

Phenomenon Question

How do windmills change wind to light? (Essential Question)

Texas Essential Knowledge and Skills Addressed

4.2A **Plan** and implement **descriptive investigations, including asking well defined questions,** making inferences, and selecting and using appropriate equipment or technology to answer his/her questions. (Addressed)

4.2F **Communicate** valid oral and written **results** supported by data. (Addressed)

4.3B **Represent the natural world using models** such as the water cycle and stream tables and identify their limitations, including accuracy and size. (Addressed)

4.3C **Connect grade-level appropriate science concepts with** the history of science, **science careers, and contributions of scientists**. (Addressed)

4.6A **Differentiate among forms of energy,** including mechanical, sound, electrical, light, and thermal. (Addressed)

English Language Proficiency Standards Addressed

2E Use visual, contextual, and linguistic support to enhance and confirm understanding of increasingly complex and elaborated spoken language.

2F Listen to and derive meaning from a variety of media such as audio tape, video, DVD, and CD ROM to build and reinforce concept and language attainment.

Materials

		Lesson 15	Lesson 16
Student	Science Logbook (Lesson 15 Activity Guide, Lesson 2 Activity Guide)	●	●
	Science Logbook (Lesson 16 Activity Guide)		●
Teacher	Hoover Dam Turbines Photograph (Lesson 15 Resource)	●	
	Anchor model	●	
	Driving question board		●
	The Boy Who Harnessed the Wind by William Kamkwamba and Bryan Mealer (2010)		●
	Key concepts checklist developed in Lesson 15		●
Preparation	None		

Lesson 16

Objective: Explain that energy makes things happen when it is transferred and transformed.

Launch 2 minutes

Students have learned a lot about energy throughout the module. Tell students they will update the driving question board with new knowledge and check for unanswered questions.

Explain that students will then discuss how their new knowledge of energy could be used to improve the world.

Learn 31 minutes

Discuss the Driving Question Board 10 minutes

Display the driving question board. Have students discuss which questions they have answered and which questions they still need to answer.

Agenda

Launch (2 minutes)

Learn (40 minutes)

- Discuss the Driving Question Board (10 minutes)
- Revisit *The Boy Who Harnessed the Wind* (20 minutes)
- Conceptual Checkpoint (10 minutes)

Land (3 minutes)

Sample student responses:

- *We have answered almost all our questions.*
- *We still have some questions on the driving question board that we have not answered, but they didn't really fit in as we were figuring out how the windmill worked.*
- *Maybe we can investigate those questions next.*

Coach students to discuss the questions that can now be answered using their new knowledge.

Revisit the list of student-generated phenomena, and allow students time to reflect on how their new knowledge can explain phenomena on the list.

Guide students to continue searching for answers independently to any unrelated questions or phenomena that cannot be explained using what they have learned. If students show significant interest in a particular question, allow them to share what they find with the class in a later lesson.

Revisit *The Boy Who Harnessed the Wind* 20 minutes

▶ How could our knowledge of energy help us make the world better?

- *I could produce light in my basement since it's always dark in there. To get mechanical energy for the generator, I could turn a crank or maybe harness wind from outside.*
- *When I turn off my lights or the TV when I'm not watching it, I'm saving energy since it takes energy to turn them on.*
- *I'm going to be more careful when I ride my bike fast. Since I'm going fast, the bike and I have a lot of energy and could hurt someone in a collision.*

Remind students that another student used his knowledge of energy to solve serious problems in his community. Revisit *The Boy Who Harnessed the Wind* (Kamkwamba and Mealer 2010), and read the book aloud through page 27 this time. After finishing the book, ask student pairs to discuss anything new they noticed and wondered about how William harnessed the wind.

Lead a discussion with text-dependent questions such as those that follow. As needed, reread relevant pages from the book as students discuss the questions, and remind them to cite text evidence to explain their thinking.

Extension

The read-aloud in this lesson does not include the last two pages, which have detailed information about William Kamkwamba. Consider reading and discussing those pages as an extension activity for students.

Content Area Connection: English

Reread *The Boy Who Harnessed the Wind* and discuss how specific words and phrases in the book represent energy (2E).

Content Area Connection: Geography

Use Google Earth™ mapping service to locate William's village of Masitala, Malawi.

Consider providing opportunities for students to research these questions about William and the challenges his community faced. Discuss the geographical characteristics, economy, and culture of Malawi.

English Language Development

As in most class discussions, allow students to consider each question and develop responses individually or with peers before whole-class sharing. Students may benefit from answering the text-dependent questions using a Think–Pair–Share or Jot–Pair–Share. These routines allow individual students to consider their thoughts about each question and then collaboratively discuss the question with peers before sharing with the whole class.

- **What problems did William hope to solve by building a windmill?**
  - *People couldn't see at night. They didn't have money for lights. (Page 2)*
  - *People were starving. There wasn't enough rain, so their crops weren't growing. (Page 7)*

- **How could a windmill solve those problems?**
  - *It could generate electricity for lights. (Page 12) We did that in class!*
  - *It could pump water onto the crops. (Pages 11 and 13) The energy must transfer from the windmill to the pump.*

- **What steps did William take to build his windmill system?**
  - *He went to the junkyard to find scraps of metal, a tractor fan, and other pieces. (Page 15) He also found a broken bicycle and a generator from a bike headlight. (Page 17)*
  - *He asked his friends for help. They chopped trees to make a tower. (Pages 19–20)*
  - *He connected wires to a light bulb. (Page 23)*

- **How do the illustrations on pages 22 and 23 show the types of energy transfer and transformation that make "electric wind"?**
  - *The blue lines show the wind. I think there is a lot of energy in this wind, because the book says it is a "gusting gale." (Page 21)*
  - *The first picture shows that energy is transferred from the wind to the windmill where the blue lines wrap around the blades. (Page 22) On the next page, the wire transfers energy from the windmill to the light bulb. (Page 23)*
  - *The second picture shows mechanical energy from the wind transforming into light. (Page 23) The picture only shows the blue lines for wind and yellow for the light, but we know there's probably a generator between the blades and the light bulb that transforms the energy.*

Discuss that although William was just a young boy, he was also an engineer—he worked to solve an important problem that he identified. Use this as an opportunity to explain to students that anyone can be an engineer. Explain that although some engineers develop a new device to solve a problem, others may refine existing technologies to meet new criteria and constraints, which is what William did.

Conceptual Checkpoint 10 minutes

Ask students to recall the Essential Question, **How do windmills change wind to light?**, and then ask them to respond to the following prompt in their Science Logbooks (Lesson 16 Activity Guide). Students may refer to the anchor model, anchor chart, and key concepts checklist as needed.

▶ **A woman in a neighboring village heard about what William did to transform wind energy into electrical energy. She is excited at the idea of using electricity to pump water. Develop an explanation for how this woman can use a windmill to turn on a water pump and provide enough water for her family. Apply all the knowledge from the key concepts checklist.**

Sample student response:

- *The woman can use a windmill to turn on a water pump. First, mechanical energy transfers from the wind to the windmill, making the blades move. Then the generator transforms mechanical energy into electrical energy by producing an electric current. Next, the current transfers energy through the wires that connect the generator to the pump. That is how wind turns into electricity. When the blades spin faster, they have more energy of motion. This means there is more electrical energy being transferred to the pump, which would pump water faster. I know this because in the windmill model, the light is brighter when there is more wind.*

Teacher Note

Students may want to know more about William and his life in Malawi. Share and discuss videos about William, such as *Moving Windmills: The William Kamkwamba Story* (Kamkwamba 2008) (http://phdsci.link/1160) and *How I Harnessed the Wind* (Kamkwamba 2009) (http://phdsci.link/1004) (2F).

Extension

Many engineers and technicians play a role in designing wind turbines (e.g., electrical engineers, mechanical engineers, aerospace engineers, materials engineers). If students are interested, have them research different types of engineers and what they do. Consider asking engineers in the community to come to class and tell the students about their work.

Content Area Connection: English

As students respond to the Conceptual Checkpoint, they can apply relevant writing strategies. For example, students should use precise language to explain their thoughts and use linking words to connect ideas.

Conceptual Checkpoint

Review responses to assess students' ability to apply what they have learned about energy in a new context.

Evidence

Look for evidence that all students can apply the following key concepts in their responses.

- Energy transformation: Energy is transformed from mechanical energy into electrical energy by a generator.
- Energy transfer: Air transfers energy to the windmill, causing the blades to move. The energy is then transferred by an electrical current through the wires to a water pump.
- Relationship between energy and speed: A stronger wind causes the windmill blades to spin faster (more energy of motion); faster-spinning blades cause the water pump to produce more water.
- Different indicators help identify the presence of energy.

Next Steps

Support students who are missing any key concepts or have mistakenly described transfers and transformations of energy. Meet with those students individually to provide feedback on their work. Work with students to determine whether the gaps in their explanations are the result of inadequate attention to detail or a lack of understanding. In the latter case, work with students individually or in small groups to revisit the physical model of the windmill to talk through each key concept, guiding students to add them to their explanation and models during this discussion.

Land 3 minutes

Have students recall what they have learned about windmills, and discuss the following questions to reflect on energy and the environment.

▶ Do you think windmills are a good way to generate electricity? Why?

- *I think so because wind blows anyway, so windmills are an easy way to generate electricity.*
- *I think they are better than other ways to generate energy, like drilling or building a dam.*

- ▶ What impacts do you think windmills have on the environment?
  - *The windfarm we saw took up a lot of space. If the windmills were on land, you might have to cut down lots of trees.*
  - *You have to get the materials to build windmills from somewhere, so that might be bad for the environment.*

Tell students that in the next lesson, they will use their knowledge of energy to create their own devices to transfer and transform energy. Like William, they will design devices to solve a problem. Share the next lesson's Phenomenon Question: **How can we apply our knowledge of energy to solve a problem?**