Module Overview

ESSENTIAL QUESTION

How do windmills change wind to light?

Introduction

> *All the life of the universe may be regarded as manifestations of energy masquerading in various forms, and all the changes in the universe as energy running about from one of these forms to the other, but always without altering the total amount.*
>
> —Sir James Jeans, 1929 (1945, 104)

The module begins and ends with students observing the anchor phenomenon—windmills that harness the wind to generate electricity. Throughout the module, students explore the Essential Question, **How do windmills change wind to light?**, and apply key conceptual understandings to build and refine an anchor model to explain the anchor phenomenon. At the end of the module, students use their knowledge of energy classification, transfer, and transformation to explain the windmill phenomenon and apply these concepts in new contexts during an engineering challenge and the End-of-Module Assessment. Through these experiences, students begin to develop the enduring understanding that energy cannot be created or destroyed, but it can be transferred and transformed to be more useful.

Lessons 1 through 5 address the Concept 1 Focus Question: **What is energy?** Students begin to grasp that energy is why things happen in the world around them. They observe different phenomena that indicate energy is present and classify those energy phenomena in categories. Lessons 1 through 3 introduce the anchor phenomenon through paintings and photographs of windmills as well as through hands-on activities in which students build physical windmill models.

Students are also introduced to William Kamkwamba, a real student from Malawi and the subject of *The Boy Who Harnessed the Wind* (Kamkwamba and Mealer 2010), who built a windmill to generate electricity for his family. In doing so, he helped address famine in his community. Reflecting on William's story, students organize their questions on a driving question board and draw a class consensus model of a windmill. Students will revisit the driving question board and an anchor model throughout the module to build a coherent understanding of energy. Engaging in these practices from the very first lesson allows students to take an active role in the educational process and gives teachers insight into students' background knowledge and current understanding of energy. In Lessons 4 and 5, students observe energy through a series of hands-on Energy Stations. Students classify the energy phenomena that indicate the presence of energy in categories such as sound, light, heat, electricity, and the motion of objects.

Lessons 6 through 9 address the Concept 2 Focus Question: **How does energy transfer from place to place?** Students develop the understanding that energy can transfer (or move) from one object to another through collisions. In Lessons 6 and 7, students plan and conduct investigations to study the relationship between energy and speed. They observe that the amount of energy transferred to an object affects its speed—transferring more energy to an object causes it to move faster. Lessons 8 and 9 focus on collisions. Students conduct an investigation and develop a model to explain how energy can be transferred by moving objects. In observing a moving object colliding with a stationary object, they note that an object traveling at greater speed transfers more energy to the stationary object and pushes it farther than the same object traveling at a slower speed. They apply their understanding of energy transfer to the anchor phenomenon, updating the anchor model to show that energy is transferred from the windmill's blades to its wires and then to the light bulb. Students also notice that collisions typically produce sound and heat, which raises questions about the next concept—energy transformation.

Lessons 10 through 16 address the Concept 3 Focus Question: **How does energy transform?** Students learn that energy transforms when one energy phenomenon changes into any other energy phenomenon. In Lessons 10 and 11, students identify patterns of energy transformation at Energy Transformation Stations. By building a simple generator in Lessons 12 through 14, students observe how a windmill generates electricity by transforming energy of motion. In Lesson 15, students apply their knowledge of energy transformation to the anchor phenomenon for a final revision of the anchor model. In Lesson 16, students revisit *The Boy Who Harnessed the Wind*. This real-world story leads to the next lessons, in which students harness energy to solve a problem in an engineering challenge.

Lessons 17 through 26 allow students to apply their knowledge of energy classification, transfer, and transformation in an engineering challenge and End-of-Module Assessment, further building on their understanding of the Essential Question: **How do windmills change wind to light?** The story of William Kamkwamba shows students that anyone can be an engineer and solve problems in their own community. In Lessons 17 through 22, students participate in an engineering challenge. Students imagine that they are without power after a devastating flood in their town. They build a device to harness energy by using materials from the classroom and home. In Lesson 23, student groups present their devices to the class and summarize their design processes, including their struggles and successes. Students then participate in a Socratic seminar on energy in Lesson 24, revisiting the module questions and synthesizing their understanding. In Lesson 25, students reflect on their study of energy and apply their conceptual understandings in an End-of-Module Assessment. Finally, the class debriefs the End-of-Module Assessment in Lesson 26, giving the teacher and students an opportunity to revisit concepts that need further explanation and clarify misconceptions.

Module Map

Anchor Phenomenon: Windmills at Work

Essential Question: How do windmills change wind to light?

Energy can be neither created nor destroyed, but it can be transferred and transformed to be more useful.

Concept 1: Energy and Its Classifications

Focus Question: What is energy?

Energy is why things happen. People can observe phenomena that indicate the presence of energy. It can be useful to classify those indicators into categories such as sound, light, heat, electricity, and the motion of objects.

Phenomenon	Phenomenon Question and Objectives	Texas Essential Knowledge and Skills for Science	English Language Proficiency Standards
Windmills at Work *Phenomenon Question: How do windmills harness the wind?*	Everything that happens in a system is caused by energy. ▪ Lesson 1: Make observations to generate questions about how windmills harness the wind. ▪ Lesson 2: Create a model windmill that generates electricity. ▪ Lesson 3: Ask questions about energy.	5.2B 5.2D 5.2F 5.3B 5.3C 5.6A 5.6B	3C 3E 4C
Energy Indicators *Phenomenon Question: How do we know energy is present?*	Light, sound, temperature change, and motion indicate the presence of energy in a system. ▪ Lesson 4: Observe indicators of the presence of energy. ▪ Lesson 5: Classify indicators of the presence of energy.	5.2D 5.2F 5.3B 5.6A	3A 4C 5G

Concept 2: Energy Transfer

Focus Question: How does energy transfer from place to place?

Energy can transfer between objects through collisions and from place to place through electric currents, sound, heat, and light.

Phenomenon	Phenomenon Question and Objectives	Texas Essential Knowledge and Skills for Science	English Language Proficiency Standards
Effect of Energy on Speed *Phenomenon Question: What is the relationship between energy and speed?*	The speed of an object is related to the energy of the object. ▪ Lesson 6: Describe the relationship between energy and speed. ▪ Lesson 7: Interpret data showing that greater energy input enables greater speed.	5.2A 5.2B 5.2C 5.2D 5.2F 5.2G 5.3A 5.3B 5.4 5.6A	3B 3F 5F
Energy Changes during a Collision *Phenomenon Question: What happens to energy when objects collide?*	Energy in a system can transfer between objects through collisions, causing changes in their motion. ▪ Lesson 8: Predict the transfer of motion energy between objects during a collision. ▪ Lesson 9: Explain the transfer of motion energy between objects through forces in a collision.	5.2A 5.2B 5.2D 5.2F 5.2G 5.3B 5.4 5.6A	2C 4A 5G

Concept 3: Energy Transformation

Focus Question: How does energy transform?

Energy transformation occurs when one phenomenon indicating the presence of energy changes into any other energy phenomenon.

Phenomenon	Phenomenon Question and Objectives	Texas Essential Knowledge and Skills for Science	English Language Proficiency Standards
Changes in Energy Indicators *Phenomenon Question: What do we observe when energy transforms?*	Energy transforms by changing from one form to another. ▪ Lesson 10: Observe transformation of energy to produce motion, light, sound, and temperature change. ▪ Lesson 11: Explain that energy may transform to produce new phenomena, such as motion, light, sound, and temperature change.	5.2C 5.2D 5.2F 5.4 5.6A	3F 4D
Generating Electricity *Phenomenon Question: How do windmills generate electricity?*	A generator can be used to transform motion energy into electrical energy. ▪ Lesson 12: Plan to build generators to transform motion energy into electrical energy. ▪ Lessons 13–14: Build generators to transform motion energy into electrical energy.	5.2F 5.3B 5.3C 5.6A 5.6B	3D 5F
Windmills at Work *Essential Question: How do windmills change wind to light?*	Everything that happens can be explained by the transfer and transformation of energy. ▪ Lesson 15: Model how windmills transfer and transform energy. ▪ Lesson 16: Explain that energy makes things happen when it is transferred and transformed.	5.2A 5.2B 5.2F 5.3B 5.3C 5.6A	2E 2F

Application of Concepts

Task	Phenomenon Question and Objectives	Texas Essential Knowledge and Skills for Science	English Language Proficiency Standards
Engineering Challenge *Phenomenon Question: How can we apply our knowledge of energy to solve a problem?*	The engineering design process can be used to create a device to transfer energy and transform it from an available form into the desired form. ▪ Lessons 17–23: Apply the engineering design process to construct and refine a device that transforms energy.	5.1B 5.2A 5.2B 5.2E 5.2F 5.3B 5.3C 5.6A 5.6B	3E 3F
End-of-Module Socratic Seminar, Assessment, and Debrief *Essential Question: How do windmills change wind to light?*	In a system, specific indicators of energy can be generated through energy transfers and transformations. ▪ Lesson 24: Explain changes in a system as the transfer and transformation of energy. (Socratic Seminar) ▪ Lesson 25: Explain changes in a system as the transfer and transformation of energy. (End-of-Module Assessment) ▪ Lesson 26: Explain changes in a system as the transfer and transformation of energy. (End-of-Module Assessment Debrief)	5.2G 5.2D 5.2F 5.3B 5.6A 5.6B	2F 3G

Focus Standards*

Texas Essential Knowledge and Skills for Science

5.1 Scientific investigation and reasoning. The student conducts classroom and outdoor investigations following home and school safety procedures and environmentally appropriate and ethical practices. The student is expected to

- 5.1A *demonstrate safe practices and the use of safety equipment as outlined in Texas Education Agency–approved safety standards during classroom and outdoor investigations using safety equipment, including safety goggles or chemical splash goggles, as appropriate, and gloves, as appropriate; and*
- 5.1B *make informed choices in the conservation, disposal, and recycling of materials.*

5.2 Scientific investigation and reasoning. The student uses scientific practices during laboratory and outdoor investigations. The student is expected to

- 5.2A *describe, plan, and implement simple experimental investigations* testing one variable;
- 5.2B *ask well defined questions,* formulate testable hypotheses, and select and use appropriate equipment and technology;
- 5.2C *collect and record information using detailed observations and accurate measuring;*
- 5.2D *analyze and interpret information to construct reasonable explanations from direct (observable) and indirect (inferred) evidence;*
- 5.2E *demonstrate that repeated investigations may increase the reliability of results;*
- 5.2F *communicate valid conclusions in both written and verbal forms;* and
- 5.2G construct appropriate simple graphs, tables, maps, and charts using technology, including computers, to organize, examine, and evaluate information.

5.3 Scientific investigation and reasoning. The student uses critical thinking and scientific problem solving to make informed decisions. The student is expected to

- 5.3A *analyze, evaluate, and critique scientific explanations by using evidence, logical reasoning, and experimental and observational testing;*
- 5.3B *draw or develop a model that represents* how *something that cannot be seen* such as the Sun, Earth, and Moon system and formation of sedimentary rock works or looks; and
- 5.3C *connect grade-level appropriate science concepts with* the history of science, *science careers, and contributions of scientists.*

5.4 Scientific investigation and reasoning. The student knows how to use a variety of tools and methods to conduct science inquiry. The student is expected to

- 5.4 *collect, record, and analyze information using tools, including* calculators, microscopes, cameras, computers, hand lenses, metric rulers, Celsius *thermometers,* prisms, mirrors, balances, spring scales, graduated cylinders, beakers, hot plates, *meter sticks,* magnets, collecting nets, and *notebooks; timing*

*The bold text identifies standards that students should master in this module. The italicized text identifies standards that students will develop knowledge of in this module and should master in later modules. Some italicized standards are part of the assessments in this module, but they will be assessed throughout the year.

devices; and materials to support observations of habitats or organisms such as terrariums and aquariums.

5.6 Force, motion, and energy. The student knows that energy occurs in many forms and can be observed in cycles, patterns, and systems. The student is expected to

5.6A **explore the uses of energy, including mechanical, light, thermal, electrical, and sound energy; and**

5.6B **demonstrate that the flow of electricity in closed circuits can produce light, heat,** or sound.

Building Content Knowledge

Kindergarten through Level 2 lay the foundation for understanding force, motion, and energy as students observe and record ways that objects can move and then compare patterns of movement. In Level 3, students demonstrate and observe how pushing and pulling on objects can change their position and motion, and students observe forces acting on objects.

In Level 5, students build on their knowledge of force, motion, and energy as they investigate energy indicators and transformation and determine the relationship between speed and energy. Students begin the Energy Module by making observations to generate questions about how windmills harness the wind. Students are introduced to the book *The Boy Who Harnessed the Wind* (Kamkwamba and Mealer 2010), and they create a model windmill. Students use the model windmill to create an anchor model that is used throughout the module to apply their learning of energy and electricity (5.3B). Students ask questions about the windmill phenomenon and the concept of energy that drive their learning throughout the module.

Throughout Concept 1, students explore the Concept 1 Focus Question: **What is Energy?** They first explore uses of energy and observe indicators of the presence of different forms of energy. They then use their observations to classify indicators of energy into categories, such as sound, light, temperature change, and motion (5.6A).

In Concept 2, students design an investigation to describe the relationship between energy and speed (5.2A). Through analysis of their data and interpretation of patterns (5.2D), students find that transferring more energy to an object allows it to move with more speed. Students then build on their understanding by investigating how energy can transfer between objects through collisions, causing changes in the objects' motion.

In Concept 3, students develop a model to show how energy transforms (5.3B). They identify patterns and relationships in their observations to understand that energy that is transferred by light, sound, and heat may transform to produce new energy phenomena, such as motion, light, sound, and temperature change. Students then plan and build generators to transform motion energy into electrical energy (5.6A, 5.6B). Students revise the class anchor model (5.3B) to show how windmills transfer and transform energy and explain that energy makes things happen when it is transferred and transformed (5.6A). Students revisit the story of William Kamkwamba in preparation for the engineering challenge, during which they design a device that transforms energy from an available form into the desired form (5.2A, 5.6A). Students then reflect on their learning about energy and apply their understanding of energy to a new context in the End-of-Module Assessment.

Key Terms

In this module, students learn the following terms through investigations, models, explanations, class discussions, and other experiences.

- Collision
- Energy
- Energy transfer
- Energy transformation
- Generator
- Indicators of energy
- Speed
- System

Safety Considerations

The safety and well-being of students are of utmost importance in all classrooms, and educators must act responsibly and prudently to safeguard students. Science investigations frequently include activities, demonstrations, and experiments that require extra attention regarding safety measures. Educators must do their best to ensure a safe classroom environment.

The hands-on, minds-on activities of this module focus on energy. Students use various materials to investigate aspects of energy when visiting energy stations, build a windmill model by using Snap Circuits® by Elenco®, conduct experiments, construct a generator, and design and build their own device. Some of the more important safety aspects to implement in this module follow:

1. **Teachers must explain and review safety expectations to students before each activity.**
2. **Students must listen carefully to and follow all teacher instructions.** Instructions may be verbal, on classroom postings, or written in the Science Logbook or other handouts.
3. **Students must demonstrate appropriate classroom behavior (e.g., no running, jumping, pushing) during science investigations.** Students must handle all supplies and equipment carefully and respectfully.
4. **Students and adults must wear personal protective equipment (e.g., safety goggles) during investigations that require the use of such equipment.** In this module, anyone working with wires, ball bearings, and spinning fan or windmill blades must wear goggles.
5. **Debris must be cleaned up immediately.** During investigations, items can fall to the floor even when everyone is careful. Immediate removal of debris from the floor is essential to help prevent slips and falls.

6. **Students must never place any materials in their mouth during a science investigation.**
7. **Put away all food and drinks during science investigations.** Food and drinks can be easily contaminated by investigation materials. Additionally, spilled food or drinks can disrupt investigations.
8. **Monitor student activity on the internet.** If students are permitted access to the internet for science research purposes, their activity must be monitored to ensure that it conforms with school and district policies.

More information on safety in the elementary science classroom appears in the Implementation Guide. Teachers should always follow their school's or district's health and safety guidelines. For additional information on safety in the science classroom, consult the Texas Education Agency–approved safety standards (5.1A).

Additional Reading for Teachers

Energy: Stop Faking It! Finally Understanding Science So You Can Teach It by William C. Robertson and Brian Diskin (2002)

Teaching Energy across the Sciences, K–12 by Jeffrey Nordine (2016)

Additional Reading for Students

Energy Island: How One Community Harnessed the Wind and Changed Their World by Allan Drummond (2015)