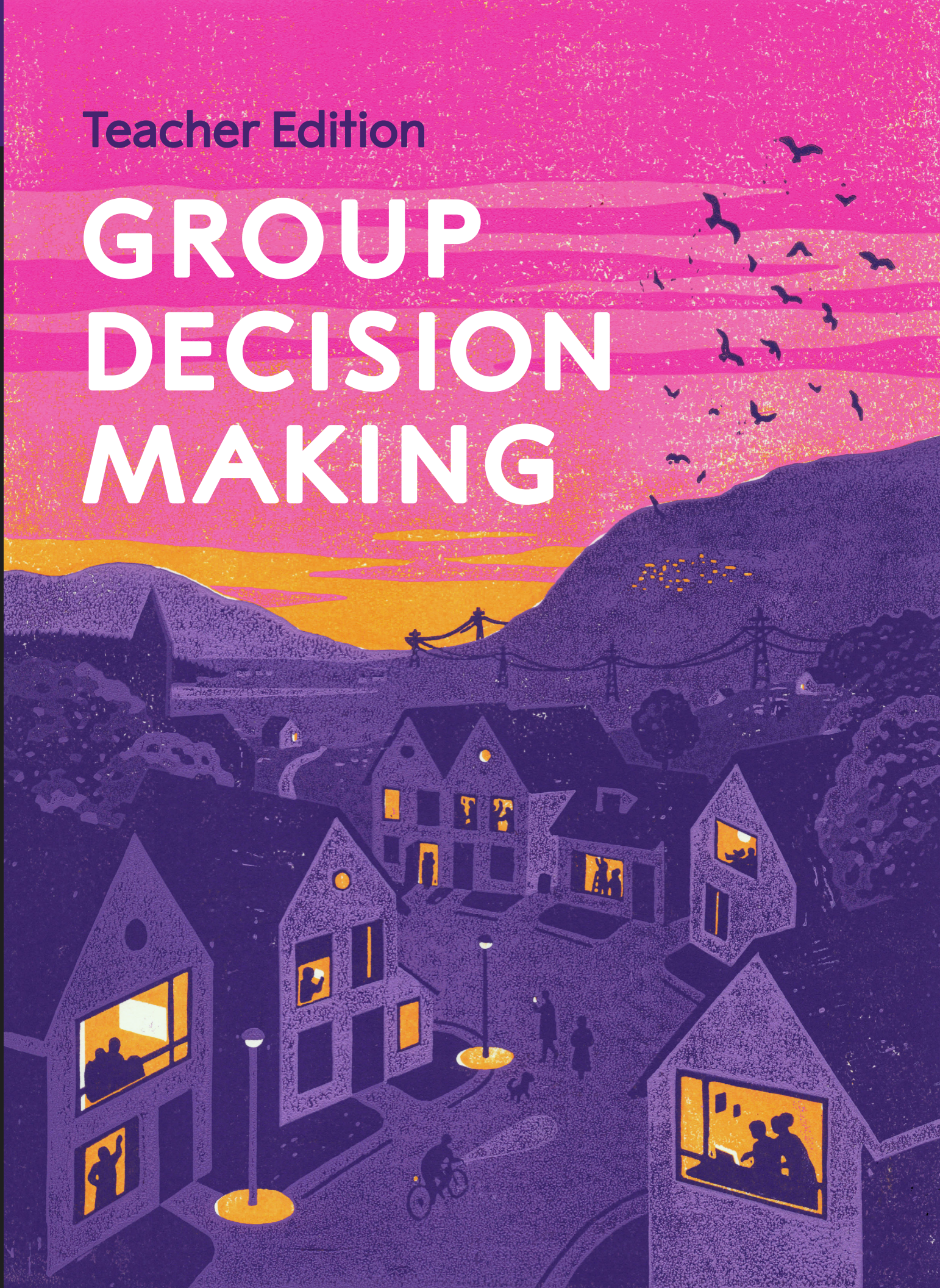
UNIT 6

v 1.0

SCIENTIFIC THINKING FOR ALL : A TOOLKIT

Teacher Edition

GROUP DECISION MAKING



This book is part of the *Scientific Thinking for All: A Toolkit* curriculum that is a high school adaptation of the University of California, Berkeley, "Big Ideas" course titled Sense and Sensibility and Science https://sensibility.berkeley.edu/. It was developed by professors Saul Perlmutter, John Campbell, and Robert MacCoun and represents a collaboration among physics, philosophy, and psychology. *Scientific Thinking for All: A Toolkit* was developed by curriculum developers and researchers at The Lawrence Hall of Science, University of California. The initiative is a cooperation between Nobel Prize Outreach (NPO) and Saul Perlmutter. This work is supported by a consortium of funders including Kenneth C. Griffin, the William and Flora Hewlett Foundation, the John D. and Catherine T. MacArthur Foundation, the Gordon and Betty Moore Foundation, and The Rockefeller Foundation.

SCIENTIFIC THINKING FOR ALL TEAM

PRINCIPAL INVESTIGATOR
Saul Perlmutter

PROJECT DIRECTOR
Ben Koo

PROJECT LEAD
Janet Bellantoni

UNIT 6 AUTHORS
Janet Bellantoni
Kristina Duncan
David House
Maia Binding
Carissa Romano

OTHER CONTRIBUTORS
Manisha Hariani
Tim Hurt
Sara Kolar
Ben Koo
Emlen Metz

FIELD TEST COORDINATOR
Kelly Grindstaff

RESEARCH
Eric Greenwald
Kelly Grindstaff
Devin Cavero

SCIENTIFIC REVIEW
Duncan Callaway
from Energy and Resources Group
at the University of California, Berkeley

PRODUCTION

EDITING
Trudihope Schlomowitz

DESIGN
otherwise

TOOL ICONOGRAPHY
DOT Stockholm

COVER ILLUSTRATION
Merijn Jansen

THE LAWRENCE HALL OF SCIENCE
University of California, Berkeley
Berkeley, CA 94720-5200

SCIENTIFIC THINKING FOR ALL
A TOOLKIT

COURSE DESCRIPTION

Scientific Thinking for All: A Toolkit is a high school curriculum designed to equip students with scientific tools and ideas for using and evaluating information. For example, conceptual scientific tools include modeling and strategies for probabilistic reasoning. Such conceptual tools can be used to interpret evidence, identify uncertainty, manage trade-offs, and develop iterative solutions. Students learn these ideas in the context of real issues at the intersection of science and society, ranging from medical treatments to land use.

The seven-unit curriculum is divided into three major sections, each emphasizing different scientific tools. In Section 1, "Tools for Investigating the World," students are introduced to the nature of science as an iterative process based on observation and measurement and use modeling to represent and predict specific aspects of the world. In Section 2, "Tools for Evaluating Data," students evaluate different types of evidence for causation, discuss appropriate inferences and sources of uncertainty, and identify errors due to human bias. In Section 3, "Applying Science to Everyday Life," students use techniques that encourage effective decision-making and consider science as a lens through which to understand the world.

COURSE DRIVING QUESTION

How do scientific tools and scientific thinking help people address complex challenges?

TABLE OF CONTENTS

UNIT 6

GROUP DECISION-MAKING

UNIT SUMMARY

INTRODUCTION

In this unit, students are introduced to essential concepts related to decision-making in the context of issues related to the implementation of renewable energy systems. They explore how to implement realistic solutions that integrate relevant **facts** with the **values** of community stakeholders. They practice gathering facts through research and experimentation, as well as evaluating **credible sources**. Students envision how energy systems will impact our lives in the future with **scenario planning** when they consider various possible futures that could be affected by a decision. They explore methods of **decision analysis** to help them carefully consider the facts and the values related to the decision. Students learn about the importance of compromise in making group decisions.

UNIT DRIVING QUESTION

How can people make decisions, such as those related to renewable energy, that integrate facts and consider the values of stakeholders?

PRIMARY CONCEPTUAL TOOL

Weaving Facts and Values

UNIT 6

GROUP DECISION-MAKING

KEY CONCEPTS & PROCESS SKILLS

WEAVING FACTS AND VALUES

- Facts support informed decision-making by leading to more accurate predictions about the likely outcomes of different choices.
- Values affect people's decisions. There can be disagreement within a community when people hold a variety of values.
- Decision analysis is the process of breaking down a decision in a way that can help the decision-maker systematically consider elements related to a choice, such as facts and values.

CREDIBLE SOURCES

When gathering facts, first determine whether the source is credible before looking at the information or evidence provided by the source in more depth.

SCENARIO PLANNING

Making optimal decisions includes envisioning a variety of possible futures with more desirable or less desirable outcomes and identifying the choices and trade-offs needed to prepare for those futures.

GROUP DECISION-MAKING

- Community decisions are more likely to be accepted if the values of all stakeholders, especially those who are underrepresented, are considered in the decision-making process.
- When making a group decision where there are conflicting values, a compromise is sometimes necessary.

While each activity focuses primarily on one or two of the concepts outlined in the following table, the concepts are addressed in multiple places throughout the unit. In the table, you can see where in the unit each of these Key Concepts & Process Skills is addressed.

KEY CONCEPTS & PROCESS SKILLS	ACTIVITY 1	2	3	4	5	6	7	8	9	10
Decision analysis is the process of breaking down a decision in a way that can help the decision-maker consider both the facts and values related to a choice.	■			■		■	■	■		
Making optimal decisions includes envisioning a variety of possible futures with more desirable or less desirable outcomes and identifying the choices and trade-offs needed to prepare for those futures.					■	■				
Facts support informed decision-making by leading to more accurate predictions about the likely outcomes of different choices.	■	■		■		■	■	■		
Values affect people's decisions. There can be disagreement within a community when people hold a variety of values.	■	■	■	■		■	■	■	■	■
When gathering facts, first determine whether the source is credible before looking at the information or evidence provided by the source in more depth.		■			■	■				
Community decisions are more likely to be accepted if the values of all stakeholders, especially those who are underrepresented, are considered in the decision-making process.			■				■	■	■	■
When making a group decision where there are conflicting values, a compromise is sometimes necessary.									■	■

UNIT 6

GROUP DECISION-MAKING

UNIT OVERVIEW

ACTIVITY TITLE AND SUMMARY	KEY CONCEPTS & PROCESS SKILLS	GUIDING QUESTION
1. Vanwick's Energy Project CARD-BASED INVESTIGATION Students are introduced to concepts related to the decision-making process through a fictional town that is planning for a renewable energy project. To begin the town's decision-making process, students consider facts and values related to renewable energy. They are presented with statements, and they analyze each statement to decide whether each statement shows a fact, a value, or both. Students then consider how facts and values inform decisions.	• Facts support informed decision-making by leading to more accurate predictions about the likely outcomes of different choices. • Values affect people's decisions. There can be disagreement within a community when people hold a variety of values. • Decision analysis is the process of breaking down a decision in a way that can help the decision-maker systematically consider elements related to a choice, such as facts and values.	**How are facts and values connected to decision-making?**
2. Evaluating Energy Facts INVESTIGATION Students further investigate the role of facts in decision-making. Students engage in the practice of lateral reading to evaluate the credibility of an information source. They use this tool to determine if the source for a claim of fact in the activity is credible. Then, this strategy is applied to the unit scenario to evaluate claims of facts related to renewable energy.	• Facts support informed decision-making by leading to more accurate predictions about the likely outcomes of different choices. • Values affect people's behaviors, opinions, and decisions. There can be disagreement within a community when people hold a variety of values. • When gathering facts, first determine whether the source is credible before looking at the information or evidence provided by the source in more depth.	**How can determining a credible source help you evaluate information?**

ACTIVITY TITLE AND SUMMARY	KEY CONCEPTS & PROCESS SKILLS	GUIDING QUESTION
3. Gathering Residents' Values SURVEY Students further explore the values of the people of Vanwick. Students create a survey to capture the values of residents. Then, they take the survey in the role of one fictional stakeholder. This provides some information on how the people of Vanwick value the issues related to a renewable energy project.. Students analyze the survey results of the stakeholders in Vanwick and are introduced to the concept of weighted values.	• Values affect people's decisions. There can be disagreement within a community when people hold a variety of values. • Community decisions are more likely to be accepted if the values of all stakeholders, especially those who are underrepresented, are considered in the decision-making process.	**How can a survey be used to gather information about community values?**
4. Designing Model Wind Turbines LABORATORY Students design a model wind turbine and perform energy calculations. This lab helps them understand how many wind turbines of different sizes might be needed to meet Vanwick's energy demands. Students make connections between their experience in the lab and how scientists and engineers develop expertise. Students revisit Vanwick's values and think about how facts encountered in the activity can inform how different options might meet those values.	• Decision analysis is the process of breaking down a decision in a way that can help the decision-maker systematically consider elements related to a choice, such as facts and values. • Facts support informed decision-making by leading to more accurate predictions about the likely outcomes of different choices. • Values affect people's behaviors, opinions, and decisions. There can be disagreement within a community when people hold a variety of values.	**How can understanding a model wind turbine help make a decision about using turbines in a community?**

ACTIVITY TITLE AND SUMMARY	KEY CONCEPTS & PROCESS SKILLS	GUIDING QUESTION
5. Scenario Planning CARD-BASED INVESTIGATION Students use the technique of scenario planning to consider the possible energy futures for Vanwick. Students use their imagination to visualize various futures based on factors provided on cards. This tool helps inform a decision by considering a variety of positive and negative possible outcomes in the future. Then, students reflect on how thinking about possible futures can inform decisions made now in Vanwick.	• Making optimal decisions includes envisioning a variety of possible futures with more desirable or less desirable outcomes and identifying the choices and trade-offs needed to prepare for those futures. • When gathering facts, first determine whether the source is credible before looking at the information or evidence provided by the source in more depth. • NGSS Connection: Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.	**How does imagining the future inform current energy decisions?**
6. Energy Storage Model LABORATORY Students model a version of energy storage with a model "gravity battery." Then, students investigate the design and role of this kind of battery, and two others, in the real world. They use credible sources to consider different types of renewable energy storage options for Vanwick. The facts gathered around energy storage inform a decision about which storage is most desirable for a Vanwick stakeholder.	• Decision analysis is the process of breaking down a decision in a way that can help the decision-maker systematically consider elements related to a choice, such as facts and values. • Facts support informed decision-making by leading to more accurate predictions about the likely outcomes of different choices. • Values affect people's decisions. There can be disagreement within a community when people hold a variety of values. • When gathering facts, first determine whether the source is credible before looking at the information or evidence provided by the source in more depth. • Making optimal decisions includes envisioning a variety of possible futures with more desirable or less desirable outcomes and identifying the choices and trade-offs needed to prepare for those futures. • NGSS Connection: Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.	**How can understanding an energy storage model help make a decision about using energy storage in a community?**

ACTIVITY TITLE AND SUMMARY	KEY CONCEPTS & PROCESS SKILLS	GUIDING QUESTION
7. Building Initiative COMPUTER APP Students make a recommendation about which initiative related to buildings should be adopted in Vanwick. The decision supports the efforts of Project REV by reducing greenhouse gas emissions. Students make the decision by weighing facts and values with a computer app. They evaluate three different proposals to evaluate how well each option fulfills the values of the City Council and then make a recommendation.	• Facts support informed decision-making by leading to more accurate predictions about the likely outcomes of different choices. • Values affect people's behaviors, opinions, and decisions. There can be disagreement within a community when people hold a variety of values. • Decision analysis is the process of breaking down a decision in a way that can help the decision-maker systematically consider elements related to a choice, such as facts and values. • Community decisions are more likely to be accepted if the values of all stakeholders, especially those who are underrepresented, are considered in the decision-making process. • NGSS Connection: Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.	**How can a decision-analysis tool help make group decisions?**
8. Stakeholder Recommendation INVESTIGATION Students make a recommendation about the land-use requirements for different types of solar and wind generation for Project REV from the perspective of a stakeholder. To make the decision, they weave facts and values about the land-use requirements for different types of solar and wind generation and incorporate their stakeholder's values.	• Facts support informed decision-making by leading to more accurate predictions about the likely outcomes of different choices. • Values affect people's decisions. There can be disagreement within a community when people hold a variety of values. • Making optimal decisions includes envisioning a variety of possible futures with more desirable or less desirable outcomes and identifying the choices and trade-offs needed to prepare for those futures. • Community decisions are more likely to be accepted if the values of all stakeholders, especially those who are underrepresented, are considered in the decision-making process. • NGSS Connection: Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.	**How can facts and values inform planning for the future?**

ACTIVITY TITLE AND SUMMARY	KEY CONCEPTS & PROCESS SKILLS	GUIDING QUESTION
9. Real-World Energy Decisions READING Students read about two contrasting group decisions about renewable energy. In one case, the group decision-making process went well, and in the other, it did not. The cases exemplify how real-world group decision-making takes into account the values of multiple stakeholders. Students analyze the case studies for shared or conflicting values between stakeholders and identify how conflict can be overcome through compromise.	• Values affect people's behaviors, opinions, and decisions. There can be disagreement within a community when people hold a variety of values. • Community decisions are more likely to be accepted if the values of all stakeholders, especially those who are underrepresented, are considered in the decision-making process. • When making a group decision where there are conflicting values, a compromise is sometimes necessary.	**What can support successful group decision-making?**
10. Group Decision for Vanwick DISCUSSION In this culminating activity, students participate in a group decision about Vanwick's energy future. Students review the location recommendations of different stakeholders from Activity 8. They bring those recommendations, as well as the stakeholder roles, into a final recommendation for the City Council. Students draw from the key concepts and process skills of the unit to work together to make a decision that is acceptable to all the stakeholders.	• Decision analysis is the process of breaking down a decision in a way that can help the decision-maker systematically consider elements related to a choice, such as facts and values. • Making optimal decisions includes envisioning a variety of possible futures with more desirable or less desirable outcomes and identifying the choices and trade-offs needed to prepare for those futures. • Facts support informed decision-making by leading to more accurate predictions about the likely outcomes of different choices. • Values affect people's decisions. There can be disagreement within a community when people hold a variety of values. • Community decisions are more likely to be accepted if the values of all stakeholders, especially those who are underrepresented, are considered in the decision-making process. • When making a group decision where there are conflicting values, a compromise is sometimes necessary. • NGSS Connection: Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.	**What should be considered while making a group decision about Vanwick's Project REV?**

ACTIVITY 1

Vanwick's Energy Project

CARD-BASED INVESTIGATION

ACTIVITY 1

Vanwick's Energy Project

ACTIVITY SUMMARY

Students are introduced to concepts related to the decision-making process through a fictional town that is planning for a renewable energy project. To begin the town's decision-making process, students consider facts and values related to renewable energy. They are presented with statements, and they analyze each statement to decide whether each statement shows a fact, a value, or both. Students then consider how facts and values inform decisions.

ACTIVITY TYPE
CARD-BASED INVESTIGATION

NUMBER OF 40–50 MINUTE CLASS PERIODS
1–2

KEY CONCEPTS & PROCESS SKILLS

1. Facts support informed decision-making by leading to more accurate predictions about the likely outcomes of different choices.
2. Values affect people's behaviors, opinions, and decisions. There can be disagreement within a community when people hold a variety of values.
3. Decision analysis is the process of breaking down a decision in a way that can help the decision-maker systematically consider elements related to a choice, such as facts and values.

CONCEPTUAL TOOLS

WEAVING FACTS & VALUES IN DECISION-MAKING

VOCABULARY DEVELOPMENT

decision analysis
any process of systematically considering the information that might affect a decision

electrical power generation
(assumed prior knowledge)
the process of transforming a natural resource such as coal, natural gas, wind, or sunlight into electrical power

fact
information that has been verified by observation or data

opinion
(assumed prior knowledge)
views that an individual or group form about something that may not be based on facts

renewable energy
(assumed prior knowledge)
electricity generation that is fueled by a resource that has a continuing supply, such as sunlight, water, wind, and biomass

value
what an individual or group considers important

TEACHER BACKGROUND INFORMATION

Decision Analysis

Decision analysis is a way of making any decision more systematically by breaking it down into essential elements. It helps decision-makers avoid many common traps that can lead to bad decisions. Unsystematic decisions are often driven by intuition and past experiences, without sufficient consideration of the full range of options, the probabilities of success, and the pros and cons of each option.

Decision analysis is typically used for large, important decisions that will affect many people—for example, in making government policy or to help large companies decide what to invest in. However, many elements of decision analysis can also be useful for ordinary people trying to make better decisions for their lives. Since it is somewhat time consuming, it is not possible to subject every little decision to decision analysis. You wouldn't want to do it every time you were deciding what to wear or what to have for lunch. However, since most such everyday decisions are left to default habits, it can be usefully applied to decisions about what habits to take up. For example, you might not want to use it to decide what to have for a snack each day, but you could use it to support large personal decisions, such as which college to go to, what major to pick, or what career to pursue.

Facts and Values

Talk of values tends to involve terms such as *should, ought, right, wrong, moral, ethical, worthwhile, just, rights,* or *how the world should be* or *how we want it to be*. Talk of facts tends to consist of descriptions of the world as it is. The distinction between facts and values is important because they are often mixed up, although they must be investigated in different ways. The best sources for facts—scientific experts, evidence, and eyewitness accounts—are not necessarily the best sources for values. The most effective way to find true facts is through examination of the evidence or by asking experts who have examined the evidence more thoroughly than we may have time to. Indeed, a large part of the process of science is aimed at finding facts. However, science is not aimed at finding out what is really valuable. The study of ethics and religion often makes arguments about values.

For a statement to be a fact, it must be true and supported by observation and data. However, we can be mistaken about what is true, even when we are inferring from evidence. Partial evidence can lead to reasonable, but false, inferences of fact (see Unit 1: Evidence & Iteration in Science for examples). Since we can be mistaken about what is a fact, it is sometimes useful to talk about a "question of fact" or "claim of fact." Statements of fact aim to describe the world accurately, even if it is not yet clear whether they really succeed in describing the world accurately. As such, claims of fact can be replaced with more accurate or relevant information when it becomes available.

Considering people's values is an important part of group decision-making. The values of people with less power are often left unfulfilled, while people with power are more likely to get their values fulfilled. Thus, more equitable group decisions should elicit and consider the values of all people affected by a decision (the "stakeholders"), including those whose voices are not usually heard. Social science methods, such as polls and interviews, often ask people to report what they value and how they prioritize their values. Facts produced by these methods can help inform decision-makers how values are changing in a society and which values held by a population are not being fulfilled by current systems.

If you plan to do the extension and curate materials for students, do the research and put the materials together before instruction. Sources of information could be government offices, utility companies, and news media articles.

MATERIALS & ADVANCE PREPARATION

FOR THE TEACHER

- VISUAL AID 1.1 "Walking Debate: Do You Agree?"
- VISUAL AID 1.2 "Developing Communication Skills"
- VISUAL AID 1.3 "Understanding Conceptual Tools" (OPTIONAL)

FOR EACH GROUP OF FOUR STUDENTS

- SET OF ENERGY STATEMENT CARDS (13 CARDS)

FOR EACH STUDENT

- STUDENT SHEET 1.1 "Unit Concepts and Skills" (OPTIONAL)

TEACHING NOTES

Suggestions for **discussion questions** are highlighted in gold.

Strategies for the **equitable inclusion of diverse students** are highlighted in pink.

GETTING STARTED (10 MIN)

1 **Elicit students' prior knowledge about energy use in everyday life.**

- Elicit student prior knowledge about energy use by first brainstorming a list of words or ideas associated with it. Ask, What words do you associate with energy when you think about the energy we use in everyday life? In science or in society? Students may describe familiarity with daily activities related to energy use (e.g., using electronic devices and pumping gasoline), scientific ideas related to energy movement (e.g., transformation or generation), issues related to how energy impacts nature (e.g., wildfires or air pollution), and actions related to energy conservation (e.g., efficient appliances or reduction of use).

- Students may have personal experiences with and prior knowledge of issues related to the use of energy in society, such as a lack of reliable service or health problems related to living near a power plant. Engaging students about their experiences can create a stronger foundation for learning. Support students, particularly those with varied life experiences, in sharing their prior knowledge of and personal experiences with this issue. Specifically validate funds of knowledge—not just textbook knowledge, but also family or cultural insights, practices, and personal histories—by eliciting students' observations and experiences as assets to building understanding. Throughout this unit, encourage students to respond to any topics or questions that arise to which they feel a personal connection—during small-group or class discussions, when students respond to relevant Build Understanding items, and when they write reflections in their science notebooks.

2 **Introduce main concepts of the unit.**

- As the title of the unit implies, this unit investigates the process of group decision-making in a fictional scenario related to a community developing a renewable energy plan.

- After students read the introduction, answer any questions related to background information they need in order to understand the context of the unit. Namely, the burning of fossil fuel at electricity generation plants, in vehicles, and in buildings. This combustion releases harmful gases that are building up in the atmosphere and driving climate change. A basic review of this material is found in the Science Review section at the end of the Student Book activity.

- Likewise, if students are not familiar with the basics of how electricity is generated by renewable and nonrenewable sources of energy, review the process by referring them to the Science Review section.

- Let students know how the energy scenario they will explore in the unit is directly related to group decision-making. To successfully reduce the greenhouse gases in the atmosphere, decisions need to be made by groups of people. These groups include ordinary residents, companies, and the government.

3 Introduce weaving facts and values as the primary conceptual tool of the unit.

- Review the term *decision analysis* provided in the student introduction. The principle behind decision analysis is that decision-making benefits from taking the time to examine components of a decision in a systematic way that can support a good outcome. Although the process of decision analysis may look different for different situations, it is an effective conceptual tool for decision-making. In this unit, the primary way students engage in decision analysis is to evaluate facts and values, making it the primary conceptual tool of the unit.

- The scientific toolkit is intended to be a set of conceptual tools that can be applied to everyday life. With each new unit, students will add conceptual tools to their toolkits. Use the optional Visual Aid 1.3, "Understanding Conceptual Tools" to support the multiple contexts that are used with the word *tool,* which is defined as an implement used to carry out a particular function. The word is commonly used to refer to construction tools such as hammers, levels, and tape measures. In a science classroom, examples of scientific tools include beakers, graduated cylinders, and microscopes. In this unit, there is a digital analysis tool that is used to support decision-making. There are also many tools from the last category presented on the visual aid—conceptual thinking approaches that are used to analyze group decisions. In this course, students consider conceptual tools, such as weaving facts and values, as a way of exploring the application of science to everyday life.

- As students build understanding about the importance of weaving facts and values in the decision-making process, they will build a conceptual tool about this idea in their minds and develop skills to utilize it at various points in the unit. You may wish to use Student Sheet 1.1, "Unit Concepts and Skills," to help students organize their learning. This course organizer is designed to help students reflect on their understanding of the conceptual tool, consider how they have used it to analyze problems throughout the unit, and how it may influence their decisions about unit topics.

- While a sample completed course organizer is provided in this activity, students will not be able to complete it at this time; the ideas in the sample response will be built over the course of the unit. At the end of this activity, students can add information about the role of multiple lines of relevant, accurate, and reliable evidence in supporting an explanation. The Vanwick scenario is an example of when students had an opportunity to analyze information related to this idea as well as make a decision.

4 Relate decision-making to facts and values.

- Introduce the idea that, as part of decision analysis, people use information (facts) and people's priorities (values). This activity will explore how to distinguish these two things.
- Do not define *fact* and *value* for students at this point in the activity. They will explore what each word means during the procedure so they may use an operational definition to get started. At the end of the procedure, they are asked to use their experience to come up with a formal definition.
- Ask, Can you provide an everyday example when a fact informed a decision you made? How about a value that informed your decision? A typical response might be: *The cost of chips is lower than an ice-cream, so I bought the less expensive item. I valued quantity of food over quality, so I bought the big-sized less expensive item instead of a more expensive small item.*

PROCEDURE SUPPORT (30 MIN)

5 Facilitate the student investigation of facts and values.

- The scenario presented in Step 1 can be shared with the class in multiple ways. Read it aloud to the class (using a storytelling approach), have individual students read a paragraph aloud while others follow along with the text, or have students read individually or cooperatively in their groups of four.
- Depending on your student population, use oral storytelling to support diverse learners in decoding scientific ideas and constructing meaning and ask questions about the main points of the scenario to ensure comprehension. Students can refer to the text in the Student Book as needed.
- Distribute a set of Energy Statement cards to each group of four. It may be helpful to preread the cards with emerging multilingual learners before diving into the procedure.
- Circulate during Procedure Step 3 to answer questions and note the common issues that may arise over the statements on the cards.

TEACHER'S NOTE: All claims of fact given in this activity are accurate and, therefore, facts. In the next activity, students will go further and learn techniques to verify claims of fact.

- Lead the completion of Procedure Step 4 as a class. Following is a complete and correct sample student response for the cards.

Sample Student Response, Procedure Steps 3–4

FACT

1 There are renewable generation methods that are less expensive to install than fossil fuel plants.

4 Some energy is always lost (as heat, sound, or vibration) when energy is transformed from one kind to another.

5 In 2023, most global energy generation was produced from oil, coal, and natural gas.

9 Wind and solar energy, unlike the process of burning fossil fuels, do not require water to operate.

11 Houses within a half mile of a big solar farm sell for, on average, 1.5% less than houses that are just a little farther away.

12 Most humans think human life matters more than other animals or plant life.
(This one is tricky because it's a fact about a value.)

VALUE

2 Energy sources that do not make noise are preferable.

3 It is better to produce energy locally than to transmit it over long distances.

6 It is essential that no one's electric bill increases.

7 Reducing air pollution to improve the environment is the most important outcome of renewable energy.

8 Power outages should be avoided at all costs.

10 The portability of fossil fuels makes them valuable to society.
(This one is tricky—*valuable* is subjective.)

13 Fossil fuel emissions are negatively impacting our world.
(This one is tricky because it can be argued either way.)

- If your students need more engagement with distinguishing statements, provide the following for additional practice:

  a Science is the most valuable subject at school. *value*

  b Dogs usually have four legs. *fact*

  c The Sumatran tiger is a species worth keeping from extinction. *value*

  d Electricity is valuable to society. *either, depending*

  e Electronic devices affect social norms. *fact*

  f The ocean needs protection from human impacts. *either, depending*

  g Climate change is the most important crisis of our time. *value*

6 Facilitate a discussion by using a Walking Debate in Procedure Step 5.

- Use the literacy strategy of a Walking Debate in Procedure Step 5 to encourage students to discuss their opinions on statements about facts and values. See Appendix 1: Literacy Strategies at the end of the Teacher's Edition for more guidance and information on using the Walking Debate with your students.

- Alternatively, instead of the Walking Debate, students could express their position with a thumbs up/down/sideways. For either approach, invite students who disagree to engage in discussion with one another. Record the tally of the votes before and after discussion. This process in Procedure Step 5 helps students reflect more deeply on what makes a claim a fact, what makes a claim a value, how we can learn about each, and the role each plays in decision-making.

- During the Walking Debate, use Visual Aid 1.1, "Walking Debate: Do You Agree?," to reveal the statements, one at a time. For some students, it may help to provide the statements in advance and work in small groups (pairs or groups of four) to sort the cards into the categories before beginning the Walking Debate.

- To support students' discussion, you may wish to use Visual Aid 1.2, "Developing Communication Skills," to help guide student interactions. Visual Aid 1.2 is a tool to help students effectively participate in class discussions by providing sentence starters that students can use to initiate a conversation and express their ideas.

- In Procedure Step 6, ask students to use their experiences to develop a definition for the words *fact* and *value*. Since students are developing their conceptual understanding of these words during the activity, the definitions are not in the Student Book activity, although they can be found in the Glossary. Review the definitions students generate and compare them to the ones provided here:

  A **fact** is information that has been verified by observation or data.
  A **value** is what an individual or group considers important.

  TEACHER'S NOTE: Since the definitions of *fact* and *value* are not in the Student Book activities, consider displaying the words and definitions prominently in the classroom for future reference. These two words are used throughout the unit.

7 Discuss some important characteristics of facts and values.

- Emphasize for students how facts and values are both part of decision-making. Values can help you compare facts related to those values and make a decision. Provide a simple example such as choosing a snack.

  Value: Cost is important to me.

  Fact: Of the options, the apple is the least expensive.

  Decision: I will eat the apple.

  It is important that students understand that the facts need to be closely linked to the value to be useful for decision-making. In the choosing a snack example, if the selected fact is that the color of the apple is green, the fact does not inform the decision.

- Ask, What is the difference between an opinion and a value? Students may have trouble distinguishing between these two words, so it is worth clarifying each. Look for responses that show that a value is a stated priority, such as low cost, to be beautiful, or to preserve the environment. Values are all about what we think is good or bad. On the other hand, opinions are about how we go about achieving those values. They are personal judgments that may or may not be true. Examples of opinions are *That costs too much.* or *That is ugly.* Many opinions are shaped by a value but are a different kind of statement.

- To reinforce the relationship between opinion and value, ask students to identify which of the following statements are fact, value, or opinion:

  - A soccer game takes about 90 minutes to complete. *fact*
  - Soccer games are too long to watch. *opinion*
  - Short playing time. *value*

- Ask, Can facts change? Facts can change because reality can change. For example, in 1900, it was a fact that the population of humans on Earth was less than 2 billion. Today, the population of Earth is over 8 billion. Our understanding of what is a fact can also change as we acquire new information and develop a more accurate and more complete understanding of the world. For example, a thousand years ago, it was reasonable for people to believe that Earth was flat. Nevertheless, they were mistaken; so it was not a fact, even though people thought it was. A thousand years ago, Earth was nearly round, as we know today. It would take a long time for humans to collect enough evidence to discover this fact.

- Ask, Can values change? The answer is yes, although not as easily or frequently as an opinion. For example, a student that is not working may value cost; when they become older and have a job, cost may not be as important to them. For others, low cost may always be a priority, regardless of their income. If values change, it is usually a result of an experience or insight.

8 Students use facts and values to make a simple decision.

- In Procedure Step 7, students are presented with conflicting values. In this case, the value of improving the schools as a priority over Project REV. This foreshadows Activity 3 in which students investigate weighted values.

- Provide an example of conflicted values related to renewable energy. When considering whether to build a wind turbine, the fact that wind turbines sometimes kill birds but are environmentally healthier than alternatives cause two values to conflict. We value environmental health, but we also value not accidentally killing birds (which is a small part of general environmental health). The facts about birds and environmental health inform how well the choice—to build the turbine or not—fulfills the values. Be clear that it is not the facts themselves that are conflicted but, rather, two values that are in conflict. This means we must make a trade-off when making decisions. Trade-offs are introduced formally in Activity 5 as part of the decision-making process.

- Support students, particularly emerging multilingual learners, in sensemaking and language acquisition by reviewing the words *accuracy* and *reliability* and supporting the construction of a word wall. You may want to model a sample response as a class to help scaffold student understanding. For this activity, record the terms *fact, value,* and *decision analysis.* Provide additional examples for each term as needed.

SYNTHESIS OF IDEAS (20 MIN)

9 Discuss the role of facts and values in decision-making.

- Discuss how an understanding of facts and values can inform the scenario in Vanwick. Begin by revisiting the goals stated in the scenario in Step 1: *The city hopes to achieve its goal of reducing greenhouse gas emissions, while powering the city into the future.* Then have students conduct a pair-share to answer the question, What facts and values would be helpful to know for Project REV? Students might respond that facts such as the number of solar panels needed, how much power they can generate, and how it can connect to their current system would be helpful facts. Values of the residents would be good to know to learn if Project REV aligns with them or not.

- Have students consider decision-making in the scenario further by considering if they would be able to make a good decision:
  - **a** based on facts alone, without thinking at all about values.
  - **b** based on values alone, without thinking at all about facts.

  Students may feel that facts alone won't lead to a good decision because you need values to decide which outcomes are desirable. However, people bring inherent values to the facts when considering them, so it is impossible to make a decision based only on fact. While making a decision on values alone is possible, it is generally not a good idea because the facts inform which options will bring about the outcome you want.

- Use Build Understanding Question 3 as an example of bringing inherent values to a decision. When presented with facts and asked to make a choice, it is impossible to make a decision without including at least one value. In the biomass example provided in the Sample Response, the question did not mention the value of fresh air, but it was naturally part of the decision.

- Review the term *decision analysis* in the context of making decisions. While weighing facts and values is one method of decision analysis (which students will explore further later in the unit), there is no one way to analyze a decision. Be clear that the conceptual tools provided in this unit that support decision analysis are only a select few. However, emphasize that the point of decision analysis is to have a systematic approach that reduces or avoids irrational factors such as biases and informed beliefs.

- Review student responses to Connections to Everyday Life item 5. Point out that the process outlined in a–c, as simple as it is, is a form of decision analysis. Discuss with students how this process would be different for a group decision. When a group is involved, even a simple decision such as choosing a lunch gets more complicated. Use this question to foreshadow Activity 3 when students will create a survey as a way to gather values in a group.

- Help connect the scenario to decisions currently being made about renewable energy projects to students' own community. Most communities have information about energy projects on the city's or utility company's website. Share any recent news about upcoming projects that will help students relate to Project REV.

- To conclude the activity, evaluate whether your students are able to answer the Guiding Question, How are facts and values connected to decision-making? Use this as a chance to revisit and summarize the key concepts and process skills of the activity. Through this activity, students experienced that identifying important values and relevant facts are a first and fundamental part of decision analysis.

SAMPLE STUDENT RESPONSES

BUILD UNDERSTANDING

The Build Understanding and Connections to Everyday Life questions are intended to guide your understanding. Some of these may be discussed with a partner, be part of a class discussion, or require an individual written response. Your teacher will guide you as to how these questions will be used in your class.

① **Provide an example from this activity where there are conflicting values about Project REV.**

The City Council has prioritized getting the funding for Project REV, but some citizens would rather spend the money and effort to improve the schools.

② **Which of the following statements about deciding to use renewable energy sources are facts and which are values?**

- **a** Building a nuclear power plant is more expensive than other kinds of power plants. *fact*
- **b** The ecosystem damage caused by hydroelectric power is unacceptable. *value*
- **c** Burning biomass gives off a strong smell. *fact*
- **d** Geothermal energy can only be used in certain locations. *fact*
- **e** It is important to keep our hills clear of the ugliness of wind turbines. *value*
- **f** Renewable energy is the most important part of our future. *value*

③ **If you were on a committee deciding which renewable energy source to use in your own community, which statement(s) in Question 2 would most influence your decision? Explain by using the words *fact* and *value*.**

Answers can vary. One sample response follows.

The facts that would influence my decision are burning biomass gives off a strong smell, and building a nuclear power plant is expensive. These facts would influence my decision because they are new to me, and I had not considered them. These facts would influence my decision because of my values. First, I value fresh air and I would not want to live in a town with a strong odor, so I would not support burning biomass where I live. Second, I would be concerned about the high cost of a nuclear power plant as I value having enough money for the town to do many other things, so I would be less likely to support a nuclear power plant in my community.

④ **Explain how using facts and values can be part of a decision analysis.**

When faced with a decision, it could help make the decision by identifying values and then looking at all the choices to see how they fulfill the values. If it was done for all the choices, it could be a systematic way of comparing them. Also, having the right facts makes it easier to compare the choices.

CONNECTIONS TO EVERYDAY LIFE

⑤ **You are at the cafeteria deciding between a salad and a burger for lunch.**

a What are two values you might consider in making this decision?

cost, environmental impact

b Provide a fact for each value that relates to the decision and explain how it influenced your choice.

The burger is priced lower than a salad, and red meat has a higher environmental impact than a plant-based meal. It influenced my choice because I have to decide which of the values are more important.

c How would the decision change if you had to make the choice for a group and you could only choose one kind of meal? Explain in terms of facts and values.

I would need to know facts about other people in the group, like if people had allergies or religious reasons for not eating certain foods. I would also have to figure out what their values were about those facts, like if they valued a plant-based diet over a meat one. It would be much more complicated to decide, and there would always be people who didn't like my decision that I made for them.

⑥ **Your friend Ota says she is looking for a job that is interesting work and provides a good paycheck. She looked into becoming an electrician and learned that it pays over $30 per hour. She thinks electricity is an important part of everyday life, and that appeals to her.**

a **What are the values and related facts to her decision?**

Value: She wants a good-paying job. Fact: Work pays over $30/hr.
Value: The work should be interesting. Fact: Electricity is important to everyday life.

b **How do these facts and values inform her decision?**

If she doesn't think the fact that $30/hr. is enough pay, that value will be in conflict with the value that the work is interesting. Maybe this means that she won't want the job. If she didn't value electricity, she also wouldn't become an electrician.

UNDERSTAND		ANALYZE
CONCEPT	DESCRIPTION	UNIT EXAMPLE(S)

WHAT DECISION(S) WERE MADE OR ACTION(S) TAKEN?

UNDERSTAND		ANALYZE
CONCEPT	**DESCRIPTION**	**UNIT EXAMPLE(S)**
Decision Analysis	*Decision analysis breaks down a decision systematically to consider things related to a choice.*	*facts and values in Vanwick posts* *decision-analysis tool for weaving facts and values: Building Initiative decision and generation sites*
Facts	*Facts support more accurate predictions.*	*Option Ratings in the decision-analysis tool (comparing facts to options)* *renewable generation info to inform Vanwick sites*
Credible Sources	*First determine whether the source is credible before looking at the fact in more depth.*	*Vanwick posts* *battery storage research*
Values	*Values affect people's decisions.*	*stakeholder descriptions with weighted values* *survey responses from stakeholders' perspectives* *location plans from different stakeholder's perspectives*
Values	*Sometimes, people disagree because they have different prioritized values.*	*weighted values on stakeholder cards* *different plans from different stakeholders*
Scenario Planning	*Making optimal decisions includes envisioning a variety of possible futures.*	*stories about the future of Vanwick*
Group Decision-Making	*All stakeholders' values should be considered in the decision-making process.*	*generation location plan was done by multiple stakeholders*
Group Decision-Making	*Sometimes, compromise is necessary to find agreement.*	*went from multiple stakeholder plans to one recommendation*

WHAT DECISION(S) WERE MADE OR ACTION(S) TAKEN?

What battery storage option is best for Vanwick,

What building initiatives are best for Vanwick,

Recommendation to City Council for type and locations of renewable generation.

a When someone calls a claim a fact, they are saying it is true.

b Any belief is just as good as any other, if you really believe it.

c It's generally easy to tell what's true and what isn't.

d Scientists don't know any more about facts than anybody else.

e Anything someone believes with certainty is a fact for that person.

f There can be facts about what people value.

g Scientific experts are good sources of information about what's really valuable.

h An outcome that is likely to result from a given decision is a fact, not a value.

i You can't make a decision based entirely on facts without assuming at least one value.

COMMUNICATION	SENTENCE STARTERS
to better understand	One point that was not clear to me was... What if we tried...? I have an idea. We could try...
to disagree	I see your point, but what about...? Another way of looking at this is... I'm still not convinced that...
to challenge	How do you reach the conclusion that...? What makes you think that...? How does it explain...?
to look for feedback	What would help me improve...? Does it make sense, what I said about...?
to provide positive feedback	One strength of your idea is... Your idea is good because...
to provide constructive feedback	The argument would be stronger if... Another way to do it would be... What if you said it like this...?

CONSTRUCTION TOOLS

SCIENTIFIC TOOLS

SCIENTIFIC TOOLS + TECHNOLOGY

CONCEPTUAL TOOLS

FACT

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 1

VALUE

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 1

1

There are renewable generation methods that are less expensive to install than fossil fuel plants.

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 1

2

Energy sources that do not make noise are preferable.

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 1

4

Some energy is always lost (as heat, sound, or vibration) when energy is transformed from one kind to another.

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 1

3

It is better to produce energy locally than to transmit it over long distances.

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 1

5

In 2023, most global energy generation was produced from oil, coal, and natural gas.

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 1

6

It is essential that no one's electric bill increases.

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 1

9

Wind and solar energy, unlike the process of burning fossil fuels, do not require water to operate.

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 1

7

Reducing air pollution to improve the environment is the most important outcome of renewable energy.

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 1

11

Houses within one-half mile of a big solar farm sell for, on average, 1.5 % less than houses that are just a little farther away.

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 1

8

Power outages should be avoided at all costs.

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 1

12

Most humans think human life matters more than other animals or plant life.

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 1

10

The portability of fossil fuels makes them valuable to society.

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 1

13

Fossil fuel emissions are negatively impacting our world.

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 1

ACTIVITY 2

Evaluating Energy Facts

INVESTIGATION

ACTIVITY 2

Evaluating Energy Facts

ACTIVITY SUMMARY

Students further investigate the role of facts in decision-making. They engage in the practice of lateral reading to evaluate the credibility of an information source. Students use this tool to determine if the source for a claim of fact in the activity is credible. Then this strategy is applied to the unit scenario to evaluate claims of facts related to renewable energy.

ACTIVITY TYPE
INVESTIGATION

NUMBER OF
40–50 MINUTE
CLASS PERIODS
2

KEY CONCEPTS & PROCESS SKILLS

1. Facts support informed decision-making by leading to more accurate predictions about the likely outcomes of different choices.
2. Values affect people's behaviors, opinions, and decisions. There can be disagreement within a community when people hold a variety of values.
3. When gathering facts, first determine whether the source is credible before looking at the information or evidence provided by the source in more depth.

CONCEPTUAL TOOLS

VOCABULARY DEVELOPMENT

claim of fact
a type of claim that you have not yet verified by observation or data

credible source
a source with relevant expertise that provides accurate information that is free from bias

expert
a person with extensive knowledge or skill in a particular subject based on research, experience, or occupation

lateral reading
a research technique used to evaluate a source's credibility as well as confirm the accuracy of facts

TEACHER BACKGROUND INFORMATION

Vertical and Lateral Reading

Vertical reading is the practice of reading within a single source to gather facts and evaluate credibility. This is the way that most students probably tend to approach information sources they encounter online. One might look for signs of credibility within the source—such as the About page, the professional appearances of the page, the name of the website—to determine whether the site is legitimate. As the Internet has grown, and misinformation and disinformation have become more prevalent, these vertical reading techniques have become less effective in helping people determine the credibility of a source.

Lateral reading is a technique used by professional fact-checkers that helps evaluate the credibility of a source as well as verify factual information found online. Using this technique, a website is investigated with simultaneous research from multiple sources, using separate browser windows. This is a more effective approach to determining the credibility of the author and verifying facts than vertical reading. Lateral reading makes use of the wealth of information that can be found online about an author or organization's expertise, reputation, biases, or conflicts of interest. It also provides a way to verify facts across several sources.

Critical Ignoring

Another tool used by professional fact-checkers is called critical ignoring. Critical ignoring is, essentially, being very selective about what is viewed. For efficiency, it is helpful to initially pay attention to some aspects of a search-results list or website while ignoring other parts. Following are some guidelines.

Pay attention to
- search results father down on the results list.
- how the website is related to the research topic.
- basic information about the author, publisher, or organization that owns the website.

Ignore
- sponsored listings at the top of the search-results list.
- all the detailed information on the page until you have verified the author's credibility.
- the About page, which is written by the author and may not be a full representation of the author's background and experience.

Credible Sources

A credible source for science is often written by a scientist, engineer, or experienced professional in the specific field that is relevant to what you are researching. A credible source might also include references to relevant experts and other credible sources with links to those sources. Generally, government research agencies such as the Department of Energy, NASA, NIH, reputable research universities, and well-respected journalism institutions are good places to look for credible sources. If using a news agency, steer clear of opinion pieces, which have an obvious agenda.

Many people use Wikipedia as an information source. Scientific studies have shown the information contained on Wikipedia pages to be fairly accurate most of the time, and often more accurate than other popular sources. However, most digital literacy experts do not consider Wikipedia a credible source because the articles can be changed by anyone at any time. Most academic institutions do not allow citing Wikipedia as an information source.

One strategic way to use Wikipedia is to gather basic information about a topic on the site and then refer to the citations at the bottom of the article to find more sources to verify information, using lateral reading.

MATERIALS & ADVANCE PREPARATION

FOR THE TEACHER

- VISUAL AID 2.1 "Fact or Fiction?"
- VISUAL AID 2.2 "Evaluating Online Information"

FOR EACH PAIR OF STUDENTS

- COMPUTER WITH INTERNET ACCESS

FOR EACH STUDENT

- STUDENT SHEET 2.1 "VanwickForum Notes"
- STUDENT SHEET 2.2 "Lateral Reading"
- STUDENT SHEET 2.3 "Evaluating Claims of Fact"

Decide how you want student groups to be configured for the evaluating facts part of the procedure, as outlined in Teaching Step 5. If you are having students evaluate more than one claim of fact, copy the appropriate number of Student Sheet 2.3, "Evaluating Claims of Fact" for students.

If you plan to do the extension and curate materials for students, do the research and put the materials together before instruction. Sources of information could be government offices, utility companies, and news media articles.

TEACHING NOTES

Suggestions for **discussion questions** are highlighted in gold.

Strategies for the **equitable inclusion of diverse students** are highlighted in pink.

GETTING STARTED (10 MIN)

1 **Present two statements for students to evaluate their credibility.**

- Remind students that in the last activity, they distinguished between fact and values. Explain that this activity is a further investigation into facts. In this activity, students will focus on gathering facts via credible online sources.
- Begin the activity by engaging students in an exercise of distinguishing factual information from fake information. Display Visual Aid 2.1, "Fact or Fiction?," and have students give a show of hands, or conduct a pair-share, about whether each statement is likely to be factual or not. After collecting student opinions, reveal the correct answers.
  - Statement 1 is **TRUE**, based on the National Geographic Channel show "How Hard Can It Be?"

    A team of scientists, engineers, and pilots successfully launched a house, using weather balloons.
  - Statement 2 is **FICTION.** It is a popular conspiracy theory.

    A recent emergency alert system sent a test signal to cell phones around the country to activate nanoparticles that have been introduced into people's bodies.

2 **Leverage student experience with evaluating sources in their day-to-day life.**

- Ask, Have you ever seen, believed, or shared untrue information online? How did you realize the information was false? Student responses will vary, but many will report that they have believed and/or shared posts, articles, or videos that contained questionable information without verifying it first. They may have only realized it was false after posting it. Discuss places students are likely to go to verify information such as news sources, Google Image searches, or YouTube.
- Discuss how confident students are at evaluating information. Some students may think they are great at evaluating information online, while others are less confident in their evaluating skills. Students may rely on multiple sources or look to peers to determine if information is accurate.

- Connect why it is important to get reliable information when making decisions. Allow students to provide simple examples, such as when someone provides the wrong information and it negatively impacts them, or when they wasted time and money for something online that was not as advertised. Use these examples to point out that some types of decisions, especially those with a big impact or a very important outcome, require information that is trustworthy.

PROCEDURE SUPPORT (60 MIN)

3 Model how to identify claims of fact, values, and opinions in the VanwickForum posts.

- Before beginning, review the definition of *fact* that students developed in the last activity. Recall that facts must be verified by data or observation. When people make a statement containing information to make a point, it is often a claim of fact. A claim of fact is distinct from a fact because the person who has been given the claim of fact has not yet verified it. Claims of fact may be factual or not, but its status is yet to be determined.
- In Procedure Step 3, provide each student with a copy of Student Sheet 2.1, "VanwickForum Notes." On the board, model how to break down the statements, using the first post: "@JamieLovesHistory." Complete the first row of the table with students, which leaves four remaining posts for students to evaluate. A model response is shown in the Sample Student Response to Student Sheet 2.1 at the end of this activity.
- If you have students who require additional support in analyzing the text, you may want to photocopy the VanwickForum posts from the Student Book and have them mark claims of facts (underline) and values (circle) directly on the page.

4 Support students as they find and evaluate credible sources for information about the VanwickForum posts.

- In Procedure Step 4, assign each group one claim of fact from the posts to research. Some posts include more than one claim of fact. For a complete list of the claims in the posts, see the Sample Student Response for Student Sheet 2.1, "VanwickForum Notes."
- Initially, each student needs to look for a source related to their claim of fact. Some guidelines for choosing a source are as follows:
  - Avoid sponsored posts at the top of the search results.
  - A credible source for this topic would be best if written by a renewable energy expert such as a scientist or engineer. A credible source might also include an article that cites relevant experts and other credible sources and provides the links to those sources.
  - Do a brief scan of the source to make sure it is relevant to your topic before continuing with the evaluation.

- Support lateral reading in Step 5 with Student Sheet 2.2, "Lateral Reading." Students may need additional clarification around the ideas of bias and conflict of interest, which are criteria for evaluating the credibility of a source. As students work, circulate around the room and check that students are using multiple browsers as they work. Remind students to focus on evaluating the credibility of the source first instead of looking for facts from the source.

- For students with limited experience evaluating online sources, model the practice with a Think Aloud technique. Find a credible website, such as the Department of Energy for the @JamieLovesHistory post, and talk through how to complete the web analysis concurrently with filling out the student sheet.

- When groups have finished evaluating their sources (using Student Sheet 2.2), provide each student with Student Sheet 2.3, "Evaluating Claims of Fact." In Procedure Steps 6 and 7, have students record their findings as a group.

5 Students find information to support or refute their assigned claim of fact.

- Only after students verify that a source is credible should they look for information that supports or refutes their assigned claim of fact (in Procedure Step 8). If needed, review what it means for a claim to be supported or refuted by evidence.

- If you have students who need more support with Internet research or reading comprehension, you might consider assigning them straightforward claims, such as those in @JJAms and @StarshipEarth17.

- One possible sample student response for Student Sheet 2.3 is shown at the end of this activity. Table 2.1, shown on the next page, summarizes what students should find across all the posts.

TABLE 2.1
Claim of Fact Summary

CLAIM OF FACT	SUPPORTED OR REFUTED	
POSTED BY @JAMIELOVESHISTORY		
They (wind turbines) cast huge flickering shadows all day long that can be a health problem.	**REFUTED**	*No known health effects related to shadow flicker*
	Sample source	*WINDExchange US Department of Energy: Wind Energy Projects and Shadow Flicker*
Wind turbines cause health problems.	**REFUTED**	*Scientific studies have not found any health effects related to wind turbine noise, though they do confirm that there are correlations between self-reported levels of annoyance and the distance from the turbines.*
	Sample source	*PBS NOVA: Can Wind Turbines Make You Sick?*
POSTED BY @STARSHIPEARTH17		
The air pollution from the coal plant aggravates my asthma.	**SUPPORTED**	*A study showed that asthma symptoms decreased after a local coal plant was decommissioned.*
	Sample source	*Columbia Mailman School of Public Health: Asthma Hospitalizations Drop After Power Plants Reduce Emissions*
A solar farm won't produce as much pollution, so the region could have better air quality.	**SUPPORTED**	*Many states have started installing solar projects to replace fossil fuel plants in order to reduce emissions. The regions show lower amounts of air pollutants such as nitrous oxides and greenhouse gases than when it was powered by coal-fired plants.*
	Sample source	*US Department of Energy: Improving Air Quality with Solar Energy*
POSTED BY @SHINYPEARL		
Renewable energy projects only create jobs in the short term while they are being constructed.	**REFUTED**	*Renewable energy projects create short-term and long-term jobs. While it is the case that for wind and solar, a higher proportion of jobs created are for the shorter-term construction phase, there are still longer-term jobs created. Additionally, people who have skills working in fossil fuel industries, construction, or manufacturing are able to transfer their skills to renewable energy–related jobs.*
	Sample source	*New York Times: As Oil Companies Stay Lean, Workers Move to Renewable Energy*
There are more jobs in the coal industry than there are in the renewable energy industry.	**REFUTED**	*There are now more Americans working in the clean-energy industry compared with the fossil fuel industry by a margin of nearly 3 to 1.*
	Sample source	*Forbes Magazine: Renewable Energy Job Boom Creates Economic Opportunity as Coal Industry Slumps*

TABLE 2.1
Claim of Fact Summary

CONTINUED

CLAIM OF FACT	SUPPORTED OR REFUTED	
POSTED BY @JJJAMS		
Solar panels can only produce energy when it is sunny out.	**REFUTED**	*Solar panels generate at peak capacity on cloudless, sunny days. However, they can still generate smaller amounts of electricity in cloudy or raining weather.*
	Sample source	*US Department of Energy: Busted: Common Solar Myths and Misconceptions*
You can't meet the energy needs of the city at night with just solar panels.	**SUPPORTED**	*Solar panels can only function when there is light. They transform light energy into electrical energy. The only way to power something at night from solar is to use the solar to charge a battery system during the day.*
	Sample source	*How Stuff Works: Is There a Way to Get Solar Energy at Night?*
POSTED BY @GRANNYSMITHJR		
Buildings account for 70% or more of electricity usage in the US.	**SUPPORTED**	*Buildings account for 76% of all electricity use and more than 40% of all energy use in the US. (Note: Electricity is a subset of energy use. Make sure that students are looking at the correct numbers.)*
	Sample source	*Quadrennial Technology Review: An Assessment of Energy Technologies and Research Opportunities*
Making buildings more energy efficient would help reduce greenhouse gas emissions from buildings.	**SUPPORTED**	*New homes and commercial buildings could cut their emissions by 70% with efficient design and use of renewables.*
	Sample source	*ACEEE: Energy Efficiency Can Slash Emissions and Get US Halfway to Climate Goals*

6 **Reinforce the main ideas behind lateral reading.**

- Before beginning the last step, Procedure Step 10, pause and lead a class discussion about students' experience evaluating the credibility of the sources. Ask, What features did you find in a more credible source compared to a less credible source? Make a list on the board. Responses will vary, but a sample of ideas is shown here.

  More credible sources:

  - *written by scientists*
  - *written by a journalist that focuses on the relevant field*
  - *include references and links to actual research*

  Less credible sources:

  - *did not contain references list*
  - *links provided went to other websites that did not provide research*
  - *not written by an expert*
  - *written by someone whose experience was in a different field*

- Address the following facts about websites as they come up to help students avoid overconfidence in their research.

  - Anyone can make a professional-looking website.
  - Anyone can pay to have ads, or not, on their website.
  - Domain names such as .com, .org, .net are freely available for purchase. Anyone can buy a .org website. However, .gov and .edu domains are more restricted.
  - The site's About page is drafted by the author who can tailor the information to fit their needs.
  - A lot of information doesn't mean it is good information.

- Display Visual Aid 2.2, "Evaluating Online Sources," which reviews three major steps for evaluating information online. These steps are helpful for ensuring that students can find good-quality information for whatever topic they are researching.

- Support students, particularly emerging multilingual learners, in sensemaking and language acquisition by adding terms to the word wall. For this activity, post the terms *claim of fact, lateral reading,* and *credible sources.* Provide additional examples for each term as needed.

SYNTHESIS OF IDEAS (10 MIN)

7 Discuss with students how verified facts impact decision-making.

- In Procedure Step 10, Revisit the Vanwick posts and elicit any changes in viewpoints as a result of the activity. Have students reflect on how their findings about the claims of facts changed their ideas about the posts. Have students review and reflect on the posts they thought were credible early in the procedure. Identify the misconceptions students may have had about renewable energy, both from supported and refuted facts.
- Ask, Why is it important to have the correct information when you are making decisions? Students' responses will vary but should highlight that using incorrect information could lead to a poor decision, or at least to a different decision than if they had verified facts. If this is a decision about something important, such as health, it could cause harm. Or If it is a decision about cost, they could end up paying more than was necessary.
- Review responses to Build Understanding item 2 where students identify a questionable post. Use this to reflect on how the tools introduced in the activity could be used in their day-to-day lives when they follow people on social media, especially if that information is informing decisions.
- Finish the activity by revisiting the Guiding Question, How can determining a credible source help you evaluate information? Use responses to this question to formatively assess the key concepts and process skills related to credible sources.

EXTENSION (10 MIN)

8 Use the Extension as an opportunity for advanced learning.

There are a variety of fake news games online where students can challenge themselves on their ability to distinguish fake news from real news, as well as learn more about misinformation and disinformation. Though often focusing on current events, online games are a fun way to review ideas related to credible sources and what makes online information trustworthy. Try them out before using them with students, as some of them can be quite lengthy and vary in content.

SAMPLE STUDENT RESPONSES

BUILD UNDERSTANDING

① **Write a 2–3 sentence post that shows your own thinking about renewable energy. Include your value and a relevant fact in the post.**

I really value protecting the environment. According to the EPA (https://www.epa.gov/greeningepa/renewable-energy-epa), renewable energy sources reduce greenhouse gas emissions. But I need to know what other environmental effects they have before I can make a decision about Project REV.

② **Think of an article or social media post that you read that had questionable information in it.**

- **a Describe the post.**
- **b What negative outcomes could result from sharing this information?**
- **c How would you advise others on how to avoid sharing noncredible information?**

Answers can vary. One sample response is shown here:

- **a** *The post said that taking vitamin E supplements makes you healthier.*
- **b** *It could have the negative outcome of encouraging people to spend money on something not proven to work; people may take too much, which could be harmful to their health; people may think they don't have to eat well because they are taking a supplement.*
- **c** *Look at research from a credible source about the effect of vitamin E supplements on human health before believing and sharing.*

③ **How can using credible sources help you make decisions?**

When making a decision, it is helpful to use information that you trust is accurate. Otherwise, you might make a decision by using wrong information, which can lead to a bad outcome.

CONNECTIONS TO EVERYDAY LIFE

④ **Imagine you follow a popular online influencer. A recent post he made generated a lot of arguments in the comments. You decided to try lateral reading to evaluate the post. You found the following:**

POST

Solar panels are bad for the environment! Almost 90% of them end up in landfills after 5 years of use. We should invest in cleaner fossil fuel technology like natural gas instead.

SOURCE

Social media post made by **@ImaSmarTee**, a popular fashion Influencer.

WEB SEARCH SUMMARY

@ImaSmarTee is an undergraduate student majoring in business at a local university. He regularly posts videos commenting on the latest fashion trends. One of his website sponsors is Big Oil Co., a local oil and energy company that gives the influencer money to promote the use of synthetic (fossil fuel–based) fabrics in clothing.

a Should this source be considered credible? Explain why or why not.

No, this source is not credible because the author is not an expert studying or working in the field of energy. His expertise is in fashion, and he is sponsored by an oil company supporting his work, which could represent a conflict of interest.

b Should someone make a decision to buy solar panels based on the information in the post? Explain why or why not.

No, @ImaSmarTee is not an expert on energy or solar panels, so who knows if this information is correct. Someone could read this post and decide that it is not worth it to get solar. But this information might not be correct. If you need to make an important decision, you should do your research and make sure your information is correct.

POSTED BY	WHICH PART(S) OF THE STATEMENT IS A CLAIM OF FACT?	WHICH PART(S) OF THE STATEMENT IS A VALUE?
@JamieLovesHistory		
@StarshipEarth17		
@ShinyPearl		
@JJJams		
@GrannySmithJr		

POSTED BY	WHICH PART(S) OF THE STATEMENT IS A CLAIM OF FACT?	WHICH PART(S) OF THE STATEMENT IS A VALUE?
@JamieLovesHistory	• *Wind turbines cast huge, flickering shadows all day long that can cause health problems for people.*	• *having a beautiful view* • *health*
@StarshipEarth17	• *The air pollution from the coal plant makes the air quality unhealthy, which aggravates my asthma. A solar farm won't produce as much air pollution, so the region will have better air quality.*	• *healthy air quality* • *lowering air pollution* • *health*
@ShinyPearl	• *Renewable energy projects only create jobs in the short term while they are being constructed.* • *There are more jobs in the coal industry than there are in the renewable energy industry.*	• *jobs* • *local economy*
@JJJams	• *Solar panels can only produce energy when it is sunny out.* • *You can't meet the energy needs of the city at night with just solar panels.*	• *reliability of energy source* • *access to food for citizens*
@GrannySmithJr	• *Buildings account for 70% or more of electricity usage in the US.* • *Making buildings more energy efficient would help reduce emissions from buildings.*	• *reducing emissions*

Claim of fact _____

Find a relevant information source and record the information about it below.

Website URL _____

Name of site/title _____

Who is the author? _____

What type of website is it (.gov, .edu, .com, .org)? _____

What date was the page published/last updated? _____

Who is the intended audience? _____

Purpose of the site (to inform, entertain, persuade) _____

Does the site provide facts, opinions, or both? _____

Open a separate browser window to evaluate the site for evidence of credibility.
Look for other sources that describe the site, author, or its related institution (company, organization, or university). Use the other sources to answer the next three questions.

Is there evidence of expertise?
(Does the author have appropriate education or relevant experience? A strong reputation among peers? Do they work at a reliable organization, institution, or university? Are references acknowledged in the source? Are the references credible?)

Is there evidence of conflict of interest?
(Where does their funding come from? What other organizations do they partner with? Might these connections influence their writing?)

Is there any indication of bias?
(Is it politically neutral? Does there seem to be some kind of agenda—political, social, environmental? If there is a bias, what is it?)

Claim of fact *Wind turbines cast huge shadows that can affect people up to 5 miles away.*

Find a relevant information source and record the information about it below.

Website URL *https://windexchange.energy.gov/projects/shadow-flicker*

Name of site/title *United States Department of Energy—WINDExchange*

Who is the author? *No specific author listed, but it comes from the Office of Energy Efficiency & Renewable Energy*

What type of website is it (.gov, .edu, .com, .org)? *.gov*

What date was the page published/last updated? *Unknown*

Who is the intended audience? *People in the community, decision-makers/stakeholders*

Purpose of the site (to inform, entertain, persuade) *Inform and educate*

Does the site provide facts, opinions, or both? *Facts*

Open a separate browser window to evaluate the site for evidence of credibility.
Look for other sources that describe the site, author, or its related institution (company, organization, or university). Use the other sources to answer the next three questions.

Is there evidence of expertise?
(Does the author have appropriate education or relevant experience? A strong reputation among peers? Do they work at a reliable organization, institution, or university? Are references acknowledged in the source? Are the references credible?)

While the exact author of this website is unknown, The About page lists experts from several research laboratories that, when researched further, have good reputations in the research community. The article does have a link to a research study from the Lawrence Berkeley National Laboratory. Thus, I would say that WINDExchange has appropriate expertise on this subject.

Is there evidence of conflict of interest?
(Where does their funding come from? What other organizations do they partner with? Might these connections influence their writing?)

It does not seem to have a conflict of interest. It is a government-sponsored website, so I suppose there could be a conflict of interest that stems from what the government decides to spend money on. The website focuses on giving factual information about mostly utility-scale wind projects, but also has information about community and small wind.

Is there any indication of bias?
(Is it politically neutral? Does there seem to be some kind of agenda—political, social, environmental? If there is a bias, what is it?)

I can't find any indications in other websites to indicate that WINDExchange has biases. But it is a little difficult to evaluate because many of the websites that reference the site are also government websites. WINDExchange is a website that only gives information about wind power, so I guess it might be seen as having a bias toward renewable energies. However, the purpose of the website is not to give any information about any other types of energy sources to begin with. There are many nongovernment sites that cite WINDExchange as a source to find more information about wind power.

Claim of fact _____

GROUP MEMBER	INFORMATION SOURCE (WEBSITE)	CREDIBILITY RANKING 1–5 (LOW–HIGH)	INFORMATION RELATED TO THE CLAIM OF FACT	IS THE CLAIM OF FACT SUPPORTED OR REFUTED?

Claim of fact *Wind turbines cast huge flickering shadows that can be a health problem to people.*

GROUP MEMBER	INFORMATION SOURCE (WEBSITE)	CREDIBILITY RANKING 1–5 (LOW–HIGH)	INFORMATION RELATED TO THE CLAIM OF FACT	IS THE CLAIM OF FACT SUPPORTED OR REFUTED?
Student 1	*WINDExchange US Department of Energy* *https://windexchange.energy.gov/projects/shadow-flicker*	*5*	• *shadow flicker only occurs at certain times of day (when the Sun is low)* • *total shadow flicker time is only a few hours a year* • *people with epilepsy have seizures triggered by flashes more than 120 flashes per minute. A 3-blade wind turbine shadow would flicker at 60 flashes per minute*	*refuted*
Student 2	*American Clean Power Association* *https://cleanpower.org/*	*4*	• *shadow flicker occurs mostly at sunrise and sunset* • *cites a study from health experts showing that there's no evidence that shadow flicker negatively affects health*	*refuted*
Student 3	*UK Department of Energy and Climate Change*	*5*	• *the frequency of flickering caused by the wind turbine rotation should not cause significant risk to health*	*refuted*
Student 4	*Frontiers in Public Health* *https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4063257/*	*3*	• *annoyance is associated with shadow flicker* • *many scientific papers show that there are no health effects likely from shadow flicker or noise from wind turbines*	*refuted*

STATEMENT 1

A team of scientists, engineers, and pilots successfully launched a house into the air, using weather balloons.

STATEMENT 2

A recent emergency alert system sent a test signal to cell phones around the country to activate nanoparticles that have been introduced into people's bodies.

Evaluating Online Information

① FIND A SOURCE

Find a relevant source.

- Steer clear of sponsored websites.
- Make sure the source is relevant to your research topic.
- Record basic information about the source like the *URL, author's name, organization, audience, purpose, etc.*

② USE LATERAL READING

Is the source credible?

Open another window and search while you read your source. Determine:

- Is the author an expert?

  Relevant experience, good reputation, cites research/other credible sources

- Is there a conflict of Interest?

  Funding sources, associated organizations

- Is there indication of bias?

  Political leaning or social agendas, past writings that show bias

③ VERIFY FACTS

Find out if the information repeated across multiple credible sources.

ACTIVITY 3

Gathering Residents' Values

SURVEY

ACTIVITY 3

Gathering Residents' Values

ACTIVITY SUMMARY

Students further explore the values of the people of Vanwick. Students create a survey to capture the values of residents. Then they take the survey, each playing the role of a different fictional stakeholder. This provides some information on how the people of Vanwick value the issues related to Project REV. Students analyze the survey results of the stakeholders in Vanwick and are introduced to the concept of weighted values.

ACTIVITY TYPE
SURVEY

NUMBER OF 40–50 MINUTE CLASS PERIODS
2

KEY CONCEPTS & PROCESS SKILLS

1 Values affect people's decisions. There can be disagreement within a community when people hold a variety of values.

2 Community decisions are more likely to be accepted if the values of all stakeholders, especially those who are underrepresented, are considered in the decision-making process.

CONCEPTUAL TOOLS

WEAVING FACTS & VALUES IN DECISION-MAKING

GROUP DECISION-MAKING

VOCABULARY DEVELOPMENT

stakeholders
the set of people who will be affected by the outcome of a decision

weighted value
a value that includes a number showing its relative importance to other weighted values

TEACHER BACKGROUND INFORMATION

Weighted Value

A value's weight for a community is a function of both how commonly and how strongly that value is held. There is no one right way to weigh these two attributes of values. While it would be easier to weight values based solely on the frequency of the value or strength of the value from the person who cares the most, that approach is problematic. For example, a value that is held weakly by everyone, such as everyone in a class saving 20 cents, should not receive the heaviest weight just because everyone would like it a little. This weighting of the most commonly held values is a common way of thinking, but it can lead to inequitable decisions. For example, a value weighting based entirely on frequency across the community might lead to taking the land of a few farmers who have lived there for generations because it is preferred to an alternative location by everyone else, even though it is only a weakly held value. On the other hand, if the person with the strongest value preference gets priority, that one person may wind up exercising tyranny over the majority. An example of this is if one person desperately wants to sell a shared property because they need the money, while everyone else would like to keep it. While selling the property would make the one owner very happy, it is not fair to everyone else.

MATERIALS & ADVANCE PREPARATION

FOR THE TEACHER

- INTERNET ACCESS TO SURVEY PROGRAM
- VISUAL AID 3.1 "Example Survey Questions"

FOR EACH GROUP OF FOUR STUDENTS

- SET OF STAKEHOLDER CARDS (4 of the 8 cards)
- INTERNET ACCESS TO SURVEY PROGRAM

FOR EACH STUDENT

- STUDENT SHEET 1.1 "Unit Concepts and Skills" (OPTIONAL)

Although each group needs 4 cards, there are 8 different stakeholders shown on the cards. It does not matter which stakeholders are assigned to the groups, as long as they are all represented in the survey. Decide if you would like to assign the cards at random or have half the class use one set of 4 cards while the other half of the class use the remaining 4 cards.

Review the software for making a survey and create an example survey to share with students.

TEACHING NOTES

Suggestions for **discussion questions** are highlighted in gold.

Strategies for the **equitable inclusion of diverse students** are highlighted in pink.

GETTING STARTED (10 MIN)

1 **Introduce the purpose of survey data.**

- Have students read the introduction and review the newly introduced word *stakeholder* as it will continue to be incorporated in the decision-making process as the unit progresses.
- When reviewing the description of group decision-making provided in the introduction, make clear that when an individual makes a decision with the aim to satisfy the needs and values of others (as in the previous example of the burger and salad), it is not actually a group decision. A group decision involves input from multiple people.
- Have students share their experiences completing surveys and share some examples. Ask students to describe the different situations in which they have completed a survey or questionnaire. They may include situations such as a marketing survey, a government form, or even teacher-directed questions in class.
- Ask, What do you think the people who create surveys do with the information they gather? Students may not have thought about how the data is applied, but they should be able to see that a basic use would be for product development. Discuss other uses, such as selling data to advertisers, census-taking, political ambitions, and more. A simple example might be product-survey responses compiled about the question *How would you rate this product on a scale of 1 (low) to 5 (high)?* The company might make a different decision about the product in the future if the average response was 1 compared to 5.

PROCEDURE SUPPORT (60 MIN)

2 Familiarize students with the data that can be collected with surveys.

- Review the scenario in the Student Book that describes that the goal of the activity is to gather the values of the Vanwick residents around issues related to Project REV. Before beginning to generate questions, have students brainstorm the types of things people might value in the community, in general, before discussing values about renewable energy. Then ask, How can you find out people's values relevant to Project REV? Accept all responses as students consider how to find out what people value. If they miss it, suggest a survey as one common way to get a lot of information with less effort than some other approaches.

- Emphasize that the survey results should identify the values of the people of Vanwick instead of facts about the project. Since facts can be gathered without participation from the residents, the survey should focus on finding out what is important to residents. For example, if a student says that they need to know the cost of each proposal, ask them what values would lead them to need that information—for example, the value of keeping costs low.

3 Support students as they develop a survey.

- Many students have experiences taking surveys but not creating them. Check students' background in this area and provide direct instruction if needed. Walk students through how to build the survey electronically in the program available to the class. Provide an example and model how to create different kinds of questions and responses. Show students how to create items that include short answers, multiple choice, short response, matching, rank ordering, and anything else you can think of.

- During the procedure, make sure students have a clear understanding that they need to compile the responses into a summary that will show an overall view of the values. Questions with quantitative responses or multiple choice allow for that. For example, if the survey question asks residents to put the values in order from most important to least important, students can assign a number to each value, based on the priority it was given by a resident—the highest priority might be 4, and the lowest priority might be 1. Students can then calculate the average priority for each value.

- Use Visual Aid 3.1, "Example Survey Questions," to demonstrate strong questions (rank ordering, linear-scale grids), mediocre questions (series of multiple choice, open-ended), and poor questions (short answers).

- Make sure the questions cover the necessary range. It is very important that students create a survey that captures as many values as possible. Students have a tendency to create questions that only addresses one or two values, which is not enough for students to be able to see prioritized values in the data. One option is to provide a master list of all the values that appear (see Table 3.1: Summary of Data from Cards) to guide their questioning.

- For students who need more support in generating questions, consider providing a list of questions from which they can select, or have them create a combination of self-generated and selected questions.

- To compile the final survey from student questions, use whatever method makes the most sense. Students could evaluate the questions on a scale of 1 to 5, they could vote on the questions, or the questions could just be selected by the teacher.

4 Support students' role-playing in Procedure Part B.

- In Procedure Part B, students complete the survey in the role of the stakeholder they are given. Before students do so, it might be helpful (after they read their cards) to have them describe the characteristics and values of their stakeholder to others in their small groups. For emerging multilingual learners, students could describe this orally, through pictures and diagrams, through poetry, or with music. For example, you could have them choose a song that they think best embodies their stakeholder's character and explain why that song suggests that person's values.

- When students complete the survey, make sure they complete it in the role of the stakeholder and not as themselves. The answers should reflect the values described on the card they have been assigned. You may want to assign one stakeholder per pair so they can complete the survey together.

- For better accessibility to the intention of each of the stakeholders, you may choose to have similar stakeholders from different groups get together and complete the survey as a group.

5 Develop the concept of a weighted value.

- When students present the data, aggregate it as a class to show the most common values that appear for the responses. The stakeholder cards are written so some values are more common than others. Students should find that the most common values are:
  - reduction of greenhouse gases
  - not obstructing views
  - job number and security

- In Procedure Step 8, a well-constructed survey should show the approximate values in Table 3.1: Summary of Data from Cards. This information will vary depending on the survey, so the following summary is provided to check for consistency with the survey data collected. For the individual stakeholders, the values on the cards are roughly listed by how important that value is to them.

TABLE 3.1
Summary of Data from Cards

STAKEHOLDER VALUES	HIGHEST PRIORITY	MODERATE PRIORITY	LESSER PRIORITY
reducing greenhouse gases	*Jackson Moore* *Thomas Cho* *Roman Kozlov*	*Miguel Ortiz*	
maintaining natural views (location)	*Diya Khan*	*Olivette Allard* *Thomas Cho*	*Amber Wogan*
maintaining/ adding jobs	*Olivette Allard*	*Flora Salazar*	*Thomas Cho* *Jackson Moore*
stable electric/ energy bills		*Thomas Cho* *Amber Wogan*	*Roman Kozlov*
not disrupting quiet (location)	*Flora Salazar*		*Miguel Ortiz*
health and safety	*Miguel Ortiz*	*Jackson Moore*	
support business/ economy	*Amber Wogan*	*Roman Kozlov*	
reliable energy source			*Diya Khan* *Flora Salazar*
preserve historical sites		*Diya Khan*	
home values			*Olivette Allard*

- In Procedure Step 9, emphasize that when looking closely at the values of the community, they should be weighed by both how important a value is AND how common the value is. However, when aggregating the data, students should be careful not to weigh values by frequency only. This could inadvertently result in a most common value that is only weakly held by the community.

Sample Student Response, Procedure Step 9

- reducing greenhouse gases
- location: views
- jobs
- location: noise
- electric bills
- health and safety
- supporting businesses
- reliable energy
- preserve historical sites
- home values

- Responses to Procedure Step 10, as shown in the following sample student response, should identify the most values previously listed. Answers will vary. The following list shows an example where the student weighs all mentions of the values equally.

Sample Student Response, Procedure Step 10

reduction of greenhouse gases	*34*
not obstructing views	*33*
job number and security	*33*
Total	***100***

If students assume that stakeholder values on the cards are listed in priority order, they might decide to weigh the common values differently. A sample response may be similar to the following:

reduction of greenhouse gases	*45*
not obstructing views	*35*
job number and security	*20*
Total	***100***

- While identifying the top three values is important because students will use these three values later in the unit, the actual weights that students decide on are not critical for this activity.

- When discussing the weighted values, encourage students to compare how the weighting could change the outcome in Vanwick. For example, if a resident's highest weighted value is not obstructing views, then they might not choose wind turbines as part of the Project REV plan. If that value has less weight than reducing greenhouse gases, they might be willing to choose a wind turbine to achieve the more important value.

- If you have begun a word wall, add the terms *group decision-making*, *stakeholder*, and *weighted value*. Due to the abstract nature of these terms, it may help to provide an additional simple example for each term, such as the following:
  - Choosing a restaurant with friends is a group decision.
  - Students are stakeholders in the school cafeteria because they are affected by what food is served.
  - If you are a musician, you may value the quality of a recording more than the colors chosen for its cover.

SYNTHESIS OF IDEAS (20 MIN)

6 Use the Build Understanding section to further explore gathering values in a community.

- Discuss student responses to Build Understanding item 1, which emphasizes the advantages and disadvantages of using a survey to identify people's values. If students lack the background experience to know what a representative sample is, review what it means and discuss whether they felt their survey was completed by a representative sample.
- The responses to Build Understanding item 2 will indicate if students are considering those whose values were not included in the survey data. With the class, discuss why some people's values may not be represented. Reasons people's ideas might not be reflected in the survey could include:
  - They were not able to complete the survey.
  - They were not willing to complete the survey.
  - They did not have opportunity to complete the survey.
  - They misunderstood questions on the survey.
  - They filled out the survey but their perspective was not a frequent enough response to be prioritized (weighted).

  Discuss possible outcomes related to missed data in group decision-making. Values could be missed or not prioritized. This could greatly impact the decision made for the group and could result in a negative outcome for that stakeholder whose values were not adequately captured in the survey. Good group decision-making looks to elevate voices that might not get heard otherwise.

TEACHER'S NOTE: If students have completed the previous unit, Evidence & Causal Relationships, they may recognize the importance of a large representative sample. Point out that unrepresentative samples create systematic error, and samples that are too small create random error.

- Ask, What are some strategies that could be used to learn about stakeholders' values that might not be well represented in your survey? Student responses could vary but could include ideas about going to the places that people in that community gather—such as community centers, markets, workplaces—and offer for them to take the survey there. Another idea would be to try to find a representative from a different community to share values on behalf of their community.
- You may wish to revisit Student Sheet 1.1, "Unit Concepts and Skills," to help students formally organize the ideas introduced in the unit so far. Students can place the headings of the main ideas—facts, credible sources, and values—into the organizer and add examples from their classroom experiences in Activities 1–3. See the end of the Activity 1 Teacher's Edition for a sample student response.
- Finish the activity by revisiting the Guiding Question, How can a survey be used to gather information about community values? Evaluate if your students are able to identify the essential ideas of values and weighted values through answering this question.

EXTENSION (10 MIN)

7 Use the Extension as an opportunity for advanced learning.

Students can connect the scenario to energy issues in their own community. By surveying their family and friends with the same survey used in the activity, they can get a sense of the values around renewable energy in their community. Ask students to determine the top three weighted values in their community and compare them to those in Vanwick.

SAMPLE STUDENT RESPONSES

BUILD UNDERSTANDING

① **a What are the advantages of using surveys to gather information about stakeholders' values?**

One advantage is that you can reach a lot of people all at once by sending out a survey electronically. Another advantage is that people are used to responding to a question by ranking their answer with a 1–5 scale, and that is helpful when making a summary.

b What are the disadvantages of using surveys to gather information about stakeholders' values?

One disadvantage is that the people who answer surveys are often self-selected, so you don't get a representative sample.

② **There are many challenges to capturing all perspectives in a community by using a survey. Whose values might not be captured in a survey? Why?**

People might not take the survey because they don't have time due to work or family/caregiving obligations, they are not literate, they may not be able to read or write the language in which the survey is presented, or they don't have access to a computer to complete the survey. These barriers to participating in a survey result in some perspectives being underrepresented in the survey results.

③ **How might identifying the values of different stakeholders be useful to the decision-making process?**

Identifying stakeholders' values is helpful because that information can tell you what various people want in an outcome. Also, if there is conflict, knowing values can identify the problem so it can be worked out.

④ **Imagine two students talking about renewable energy sources. One says, "I think switching to renewable energy sources is the most important action to save the planet, but having steady jobs in energy generation is important, too." The other student says, "My mom's steady job at the fossil fuel plant is the most important thing to my family, although I think renewable energy sources do help the environment."**

a What, if any, similar values do these two students share?

They have similar values that steady jobs in energy generation is important and switching to renewable energy sources is also important.

b Why might they disagree about which energy source is best for their community?

They might disagree because they have different weights on the values. Their most important values do not match, so there could be conflict. For example, the second person thinks their parent's job is the most important consideration, so they are not likely to agree to any action that would jeopardize that job.

CONNECTIONS TO EVERYDAY LIFE

⑤ Think about a significant decision that you must make in the near future.

Answers can vary. One sample response follows.

a Record the decision and make a list of all your values related to it.

Should I try to find a job in a coffee shop?

Values related to working: Need some money, don't want to do math, hate standing still, like social interaction

b Weight the values, as you did in the procedure, with points that add up to 100.

need some money	*50*
don't want to do math	*5*
hate standing still	*10*
like social interaction	*3*

c Does the decision benefit from assigning weights to your values? Explain why or why not.

Yes, this is helpful because it makes me realize that I have not wanted to work at a coffee shop because I hate doing math. So I am a little scared to be working at the register, but that value is actually not as important as the others, like making money and being social.

EXAMPLES OF STRONG QUESTIONS

Multiple Choice Scale or Grid

Responses can be averaged to compare across values.

`Answer the questions about Project Rev on a scale of 1 to 5 (1= not important, 5 = extremely important).`

QUESTION	1	2	3	4	5
How important to you is reducing greenhouse gases?					
How concerned are you that the new energy sites will disturb the beauty of the land?					
How much do you value a plan that would grow business and support the local economy?					
How important is keeping electricity costs low?					
How important is keeping your electric bills low?					
How concerned are you that the plan will affect the health or safety of people?					
How important is it that the plan provides local jobs?					

EXAMPLES OF MEDIOCRE QUESTIONS

Multiple Choice

Questions can compare only two values at a time, so there is additional analysis required after the data is collected.

Is reducing greenhouse gas emissions more important to you than keeping electricity costs low? (Choose one.)

○ YES ○ NO ○ THEY ARE EQUALLY IMPORTANT ○ THEY BOTH DON'T MATTER

Is reducing greenhouse gas emissions more important to you than having Project REV provide new jobs? (Choose one.)

○ YES ○ NO ○ THEY ARE EQUALLY IMPORTANT ○ THEY BOTH DON'T MATTER

Is reducing greenhouse gas emissions more important to you than the project affecting views of the local countryside? (Choose one.)

○ YES ○ NO ○ THEY ARE EQUALLY IMPORTANT ○ NEITHER ONE MATTERS

Paragraph/long answer

Responses show most or least important values and important reasoning, but it is difficult to compare responses.

Which of the following values is most important to you and why? (Choose one.)

- ○ reducing greenhouse gases
- ○ keeping noise down
- ○ providing new jobs
- ○ keeping natural views
- ○ supporting local businesses
- ○ maintaining low electric bills

If there are aspects of the Project REV plan that you are against, what are they and why is this important to you?

EXAMPLES OF POOR QUESTIONS

These questions elicit opinions rather than values.

Are you okay with the plan?

This asks for an opinion only and does not ask about a value(s) that motivates that opinion.

Do you think Project REV will create a lot of new jobs?

This is a question about fact, not value.

Would you be okay with putting a wind turbine near your house?

This asks for opinion only and does not ask about a value(s) that motivates that opinion.

How do you think Project REV would affect you?

This is an open-ended question that could elicit opinions about facts or values, or neither.

OLIVETTE ALLARD

CONTRACTOR

As a contractor, I do electrical work frequently, so I know how important electricity is to our everyday lives. I think Project REV is a great way to increase job opportunities for electrical workers in the area. Transitioning to renewable energy generation will mean the whole system will need to be upgraded. There will be jobs that help increase the capacity of the system as well as jobs to upgrade the electrical power transmission lines and improve distribution. At the same time, I am worried that Project REV is going to put this new infrastructure, along with the solar panels and wind turbines, in an area that will disrupt our beautiful landscape. We have ruined so much forest already by running transmission lines to faraway places. Furthermore, ruining the natural world surrounding Vanwick might make this a less desirable place to live. I'm worried this change to Vanwick might decrease my home's property value, and I could lose money.

VALUES

- creating jobs
- maintaining beautiful views
- keeping value of home

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 3

THOMAS CHO

OFFICE WORKER

At the office, I see the energy bill for our building when it comes in. I know how much natural gas we burn in the furnaces all winter just to keep our large building heated. When I think about all the buildings in the area that all emit a lot of fossil fuels with our heating systems, it feels like we are just burning up our future! Project REV can change that, so I am thrilled it is happening. My high-rise building has a beautiful view of the Distant Hills Open Space Preserve, so I don't want to disrupt that because I see it every day. I feel lucky because I have friends who will need new jobs when the coal plant is closed. I hope Project REV will give them at least short-term work helping build everything for the new energy system.

VALUES

- reducing greenhouse gases
- maintaining beautiful views
- creating jobs

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 3

DIYA KHAN

VANWICK HISTORICAL SOCIETY MEMBER

I go hiking every week in the Gentle Hills area, and I heard that they are thinking of installing wind turbines or solar panels for Project REV there. What a horrible idea! Solar panels will take up so much room in that area that the hiking trails could be ruined. I am not so sure I want to hike the trails anyway if I am just looking at a sea of black panels. I think it is important to not have any changes to the land so we can preserve our history and way of life in Vanwick. Plus, I've heard from a family member that solar panels and wind turbines only work when the weather is sunny and windy. We might use all our resources to install these huge devices, and they may not even work when the weather conditions aren't right. I don't understand why Project REV wants to replace a reliable energy source with one that doesn't work all the time. This Project REV is not the answer!

VALUES

- maintaining beautiful views
- preserving historical places
- reliability of supply

ROMAN KOZLOV

FARMER

I run a small farm, and I was born and raised in Vanwick. As someone who works on the land, I want to help take care of it. My family and I love this place and want to help move it into a good future. I have started lowering our greenhouse gas emissions on the farm in other ways, so I support Project REV. I'd be willing to have renewables installed on my land, especially wind turbines installed in my fields. I think wind turbines are the coolest, and I wonder if we could run the whole city off of them! I'm looking forward to someday replacing my diesel-powered tractors with electric versions. If I could get the electricity for the electric tractors from renewable energy, that would really help bring down the greenhouse gas emissions from my farm. Plus, I think it will support my business because the changes I'm willing to make for Project REV will reduce my overall energy costs for the farm to help keep expenses down.

VALUES

- reducing greenhouse gases
- supporting business
- not increasing energy bills

JACKSON MOORE

HIGH SCHOOL STUDENT

I'm a student at Vanwick High School. I really care about what happens to our environment in the future, and I completely support Project REV. It is about time we worked together to address this issue! It has been difficult knowing that the biggest challenge of our time is lowering our greenhouse gas emissions, but as an individual, I am only able to do small things toward this goal. My mom works at the power plant that is closing down, so I am worried that she won't be able to get another job. If she can't find permanent work after the plant closes, I may have to work a lot more at my after-school job. However, I am grateful that she will no longer be subjected to the poor air quality near the plant.

VALUES

- reducing greenhouse gases
- creating jobs
- supporting health and safety

MIGUEL ORTIZ

HOSPITAL WORKER

I'm a medical worker at Vanwick General Hospital. I am very happy that we are considering replacing the coal plant with renewable energy options. I have worried for a long time about the greenhouse gas emissions that coal plants put into the atmosphere. At my job, I see a lot of people with health effects from the coal plant, such as asthma that can be triggered by the air pollution. Something else that's really important to me is to make sure the new infrastructure for energy generation is quiet. The hospital setting is sometimes very hectic, and I really value quiet time at my home in Vanwick to keep a balanced lifestyle.

VALUES

- reducing greenhouse gases
- supporting health and safety
- keeping noise down

FLORA SALAZAR

VANWICK CITY LIBRARIAN

I am excited that Project REV will bring money into our city, but I am most concerned about installing wind turbines. I know someone who knows someone who says that wind turbines can be very noisy. I want to make sure there aren't any devices such as wind turbines or electrical substations where I live near City Park. They could disrupt me at home. Getting solar panels instead of wind turbines sounds better to me, but how can they be reliable if they don't work at night? I don't want to close the library early when it gets dark! I have lived and worked in Vanwick for a long time, and I just love the community of readers that are here. I hope this gets worked out because I don't want friends to lose their jobs in Vanwick.

VALUES

- keeping noise down
- maintaining jobs
- reliability of supply

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 3

AMBER WOGAN

SMALL BUSINESS OWNER

I own a restaurant in downtown Vanwick that has been in my family for three generations. As someone who has lived and worked in Vanwick my whole life, I hope that Project REV is good for all the small businesses in town. My biggest concern about Project REV is if there will be an increase in the cost of electricity for consumers due to the change in electrical systems. I am not sure my business could afford to pay more for electricity that runs the restaurant. We already pay a lot to keep the lights, heat, stoves, and ovens running. I hope that Project REV doesn't stop tourists from visiting the town to enjoy the Nature Forest, City Park, and Gentle Hills Open Space Preserve because they are full of unattractive solar panels and wind turbines.

VALUES

- supporting businesses
- not increasing electric bills
- maintaining beautiful views

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 3

ACTIVITY 4

Designing Model Wind Turbines

LABORATORY

ACTIVITY 4

Designing Model Wind Turbines

ACTIVITY SUMMARY

Students design a model wind turbine and perform energy calculations. This lab helps them understand how many wind turbines of different sizes might be needed to meet Vanwick's energy demands. Students make connections between their experience in the lab and how scientists and engineers develop expertise. Students revisit Vanwick's values and think about how facts encountered in the activity can inform how different options might meet those values.

ACTIVITY TYPE
LABORATORY

NUMBER OF
40–50 MINUTE
CLASS PERIODS
3

KEY CONCEPTS & PROCESS SKILLS

1. Decision analysis is the process of breaking down a decision in a way that can help the decision-maker systematically consider elements related to a choice, such as facts and values.
2. Facts support informed decision-making by leading to more accurate predictions about the likely outcomes of different choices.
3. Values affect people's behaviors, opinions, and decisions. There can be disagreement within a community when people hold a variety of values.

CONCEPTUAL TOOLS

WEAVING FACTS & VALUES IN DECISION-MAKING

VOCABULARY DEVELOPMENT

energy transformation
the change of energy from one type to another, such as from chemical to thermal energy

power
the rate at which energy is transformed

variable
a feature, factor, or result that can change or vary

watt
(assumed prior knowledge)
the unit of power that is one joule per second

TEACHER BACKGROUND INFORMATION

Energy Transformations

The term *energy transformation* refers to the change of energy from one type (such as potential energy) to another (such as kinetic energy). Examples of common energy transformations are listed in Table 4.1: Common Energy Transformations on the next page.

Measuring Power

Power is the concept of "energy per time." The power of a device is the rate at which energy is transformed and is given as

$$P = E/t$$

where **P** is the power (in watts, W),
E is the energy (in joules, J), and
t is the time (in seconds, s).

For electrical power, this relationship is equivalent to

$$P = IV$$

where **P** is the power output of the turbine (in watts, W),
I is the current generated by the turbine (in amps, A), and
V is the voltage generated by the turbine (in volts, V).

The unit for power in the International System of Units (SI) is the joule/second, which is a watt. Watts are a measure of how much energy, in joules, is used per second. For example, household devices are categorized by the amount of power they draw, which can vary from just a few watts to a few hundred watts. A 100-watt computer consumes twice the energy than a 50-watt computer over the same time period.

TABLE 4.1
Common Energy Transformations

EXAMPLE	ENERGY TYPES BEFORE TRANSFORMATION	ENERGY TYPES AFTER TRANSFORMATION	DESCRIPTION OF TRANSFORMATION
Solar-powered calculator	light	electric, light, thermal energy	When sunlight hits the solar panels, it transforms into electricity used to run the calculator and light the screen.
Pool being heated by Sun	light	thermal energy	Electromagnetic energy from the Sun is transformed into thermal energy that warms the pool.
Candle	chemical potential energy	light, thermal energy	When burned, the chemical potential energy of the wax and wick are transformed into light and thermal energy.
Soccer player eating sports snack	chemical potential energy	thermal energy, motion (kinetic)	The chemical potential energy in food is metabolized by the soccer player and transformed into mechanical motion of playing and thermal energy that keeps the body warm.
Shocked by doorknob	motion (kinetic), electric (static)	electric, sound, light	The potential electric energy is stored up in person as an electric charge as feet rub against the floor while walking. When touching the doorknob, the energy is released from the person to the doorknob into electricity, light, and sound.
Singer	sound	electric	The singer's voice is transformed from sound to an electric signal that records the voice data.
Furnace (gas-powered heater)	chemical potential energy	thermal energy, light, sound	The chemical potential energy in the furnace's oil is burned and transformed to thermal energy and some light and sound.
Waterfall	gravitational potential energy	motion (kinetic), sound	Water falling over the dam loses gravitational potential energy and gains kinetic energy—until at the bottom it has been transformed into kinetic and some sound energy.
Photosynthesis	light, chemical potential energy	chemical potential energy, thermal energy	The plant absorbs sunlight and uses the energy to chemically combine CO2 and water into chemical potential energy for food.

TABLE 4.1
Common Energy Transformations

CONTINUED

EXAMPLE	ENERGY TYPES BEFORE TRANSFORMATION	ENERGY TYPES AFTER TRANSFORMATION	DESCRIPTION OF TRANSFORMATION
Lightbulb	electric (current)	light, thermal energy, sound	A lightbulb transforms electrical energy into light, thermal energy, and sometimes sound.
Bow and arrow	elastic potential energy	motion (kinetic), sound, thermal energy	The elastic potential energy of the bow is transferred to the arrow and transformed into motion and sound and a little thermal energy.
Combustion engine	chemical potential energy	thermal energy, sound, motion	The chemical potential energy of the gas is transformed into thermal energy coming out of the engine, the motion of the pistons, and the sound of combustion.
Fan	electric (current)	motion (kinetic), sound, thermal energy	When plugged in, the electricity is transformed into the motion of the blades, some sound, and thermal energy.
Water boiling	thermal energy	motion (kinetic), thermal energy	The thermal energy of the stove is transferred to the water, which results in steam.
Foam	elastic potential energy	motion (kinetic), thermal energy	The elastic potential energy is transformed into the motion of the foam and a little thermal energy when released.
Sun's core	nuclear energy	light, thermal energy	Inside the Sun, energy is released when hydrogen nuclei are fused and give off electromagnetic light and thermal energy.

Power and Energy

Power is often confused for energy. Informally speaking, power is the rate of energy delivery, whereas energy is the total of what was delivered over the time period in question. Electrical energy is measured in an energy unit known as the kilowatt-hour (kWh). The common term for the amount of energy drawn is *energy consumption*. This term is misleading, however, because it suggests that the energy is used up and has disappeared when it has actually been transformed and moved.

Current, Electric Potential, and Voltage

When electrons move around a circuit, an electrical current is said to flow. The amount of current (I) depends on how much charge (q) moves in a certain amount of time (t). Electrical current is measured in amperes, named for the French scientist André-Marie Ampère. One ampere is the current that is flowing at a point in a circuit when one coulomb of charge flows past that point in one second. Current is often measured with a device called an ammeter.

Electric potential is an important concept because it leads to the idea of electric potential difference. Electric potential difference is the arithmetical difference in electric potential between a final and initial location. For example, when energy is applied in order to move a charge from a potential of 10 V to a place that has a potential of 15 V, the potential difference between the lower and higher potential is 5 V. The electric potential difference is an important concept because it is what drives electrical energy through a circuit from one location to another.

Having a potential difference between two locations due to separated charges is fundamental to all electrical circuits. When a circuit, battery, capacitor, or power source provides a potential difference, it is commonly called voltage. The voltage between two terminals means that energy can do work in the circuit as the charges seek equilibrium. As long as there is a potential difference and a conducting path, charge will flow. The energy released in this way forms a current that runs devices in the circuit.

Small vs. Large Wind Turbines

In terms of power generation, large wind turbines, such as those found in utility-scale wind farms, are capable of generating more power than smaller wind turbines. This is a result of several factors—wind speeds increase at higher altitudes and larger rotor diameters and larger blades can cover a larger swept area, increasing the amount of energy collected from the wind. Generally, the size of utility-sized turbines has increased over the years, leading to increasing megawatt generation. Small wind turbines, also sometimes referred to as residential wind turbines, are not commonly used but can supplement household electricity or bringing electricity generation to places that can't be connected to the grid. Small wind systems work best in locations that are consistently very windy at low altitudes. They have many applications such as water pumping on farms or light manufacturing. New technologies, such as the Aeromine rooftop renewable energy system, are being developed to collect wind energy in urban areas but have yet to gain widespread popularity in part due to cost, lower energy generation than wind farms, and legal restrictions related to where they can be located.

MATERIALS & ADVANCE PREPARATION

FOR THE TEACHER

- VISUAL AID 4.1 "Scoring Guide: Decision-Making (DM)" (OPTIONAL)
- ITEM-SPECIFIC SCORING GUIDE: Activity 4, Build Understanding item 1
- LARGE BOX FAN

FOR EACH GROUP OF FOUR STUDENTS

SUGGESTED MATERIALS FOR THE MODEL TURBINE INCLUDE:

- 1.5 V – 3 V MOTOR–GENERATOR
- TURBINE HUB THAT FITS ON THE SHAFT OF THE MOTOR
- 5–10 SMALL DOWELS
- SHEET OF CARDSTOCK OR THIN CARDBOARD
- RING STAND OR SIMILAR
- 2 WIRES WITH ALLIGATOR CLIPS
- VOLTMETER OR MULTIMETER
- PROTRACTOR
- RULER
- SCISSORS
- TAPE

FOR EACH STUDENT

- STUDENT SHEET 4.1 "Wind Turbine Design Testing"
- STUDENT SHEET 4.2 "Writing Frame: Decision-Making" (OPTIONAL)
- SCORING GUIDE: Decision-Making (DM) (OPTIONAL)
- SURVEY RESULTS FROM ACTIVITY 3

Determine what materials you will use in the lab and if you need to modify the procedure based on the materials you are using. Go to Appendix 3: Laboratory Setup Instructions to see how to put together a model turbine. Modify the model setup instructions for your students as needed, based on the materials you will be providing.

A suggested option is to use commercial wind turbine kits that include motor–generators, blades, gears, pulleys, and other essential items. For example, Kid Wind, distributed by Vernier Science Education, carries all the basic components to build a turbine. Essential for this activity is the motor–generator and the turbine hub.

Several of the materials in this activity are also used in Activity 6: Energy Storage Model. The materials that are used in both activities are:

- 1.5 V–3 V motor generator
- turbine hub
- voltmeter or multimeter
- 2 wires with alligator clips
- ring stand
- scissors
- tape
- ruler

For best results, use a box fan instead of a circular one. The diameter of the fan should be larger than the diameter of the turbine models that students will be building.

Familiarize yourself with operating the voltmeter or multimeter, if necessary. The voltmeter or multimeter should be set to measure DC (direct current) for a range of 0 V–3 V (ideally to a hundredth of a volt). If needed, provide instructions for students on how to use the voltmeter during the procedure.

Consider building one model turbine in advance for demonstration purposes. If materials are in short supply, this model could be used to gather data for the class.

TEACHING NOTES

Suggestions for **discussion questions** are highlighted in gold.

Strategies for the **equitable inclusion of diverse students** are highlighted in pink.

GETTING STARTED (30 MIN)

1 **Review concepts related to energy, electricity, and energy transformations.**

- This activity is based on the principle of energy transformation—specifically, transforming kinetic energy into electrical energy. This activity assumes that students already have a basic understanding of energy transfer, transformation, and the Law of Conservation of Energy. If helpful, review the concepts of energy and energy transformation in the Science Review found in the Student Book.
- Depending on your student population, you may wish to emphasize important energy vocabulary and the relationship of these ideas to one another with a word sort. This approach presents one set of words where one word is not related to the others and another set of words that encompass the remaining words. The following three word sorts can be used to support a review of basic energy ideas. For more information on a word sort, see Appendix 1: Literacy Strategies.
- Have students copy the lists of words that follows. Instruct them to look for a relationship among the words within each list. Then, ask them to cross out the word or phrase that does not belong and to highlight the word or phrase that includes the others on the list. Note that there may be more than one correct answer to a single word sort.

LIST 1

efficiency
energy transformation
chemical energy
thermal energy
light

LIST 2

potential energy
kinetic energy
total energy
Law of Conservation of Energy
motor

Sample Student Response

LIST 1

~~efficiency~~
energy transformation
chemical energy
thermal energy
light

An energy transformation happens when wood is burned by the chemical energy in the wood, transforming into thermal energy and light that is then released into the environment.

LIST 2

potential energy
kinetic energy
total energy
Law of Conservation of Energy
~~motor~~

When potential energy is transformed into kinetic energy, the Law of Conservation of Energy says that the total energy is the same before and after the transformation.

2 The class reviews ideas related to energy transformations, using an example of a gas generator.

- Point out that with the exception of solar panels and batteries, electricity is transformed from generators of some type. The process requires energy transformations to take one form of energy and use it to turn a generator, which creates a different type of energy in the form of electricity. Refer to the diagram in Science Review in the Student Book to review these ideas.
- Use a Think Aloud to trace the path of energy transformations in a common diesel generator:
  1. liquid diesel fuel (chemical energy stored in bonds between atoms)
  2. burning releases heat and gases (chemical → hot gases, light)
  3. hot gases, under pressure, turn turbine blades (mechanical energy → rotational energy)
  4. generator turns (rotational energy → electrical energy)
- Contrast the use of a generator with solar panels (the latter does not spin a shaft of a generator). Solar panels have only one major energy transformation, and it is electromagnetic light to electricity. This is done when light is absorbed by semiconductors in the panel that charge electrons, causing them to flow as a current.
- Ask, What role does the generator play in releasing greenhouse gas emissions? Use this question as a formative assessment on whether students understand the significance of a generator run by fossil fuels or one spun by wind or water. Student responses should show they understand there is a big distinction between the generator shaft that is turned by hot gases from burning something, compared to shafts that are not. The former releases greenhouse gases; the latter, such as those generators turned by wind turbines and hydro (water), does not.

PROCEDURE (75 MIN)

3 Introduce the challenge of designing the model wind turbine.

- Elicit student ideas about what makes one wind turbine produce more power than another. If students do not bring it up, make sure to describe the following variables they will be testing in the lab: number of blades, blade size, blade shape, and blade angle (the angle of the blade relative to the plane of rotation). Review the concept of a variable and how it is important to change only one variable at a time when you are conducting an experiment. This allows the experimenter to know if it is that variable and not a different one causing any changes. You might gather student predictions about how various variables might affect the performance of the wind turbine.
- Review how to assemble the basic pieces of the turbine model, using the materials you have available (see Advance Preparation). Give students any special instructions that are related to the materials they will be using.
- Demonstrate how to test the turbine by connecting it to the voltmeter and putting it in front of the fan.

TEACHER'S NOTE: Set a standard fan speed, model orientation, and distance away from the box fan for testing purposes.

- Assign students to groups and decide which of the four variables each group should investigate: number of blades, blade size, blade shape, and blade angle. As groups get to work designing and testing the turbines, circulate and assist as needed.

4 Support students as they work in groups to design, build, and test wind turbine models.

- Provide each student with a copy of Student Sheet 4.1, "Wind Turbine Design Testing." Review the data table headings and clarify what students should write in each column. A Sample Student Response for this table is found at the end of this activity.
- Some of the following design considerations may be helpful for students as they work through iterations to their model:

DESIGN CONSIDERATIONS

Blade angle

If the blades have no pitch angle at all (they are flat and in line with the plane of rotation), the turbine will not rotate. For groups that are testing a factor other than blade angle, a default of between 10 degrees and 20 degrees is recommended. Testing blade angle is most easily done by having one student hold a protractor perpendicular to the blade, with 0 angle in line with the plane of rotation. Another student then measures the angle (pitch) of each blade against the plane of rotation as shown in Figure 4.1: Side View of Model Turbine.

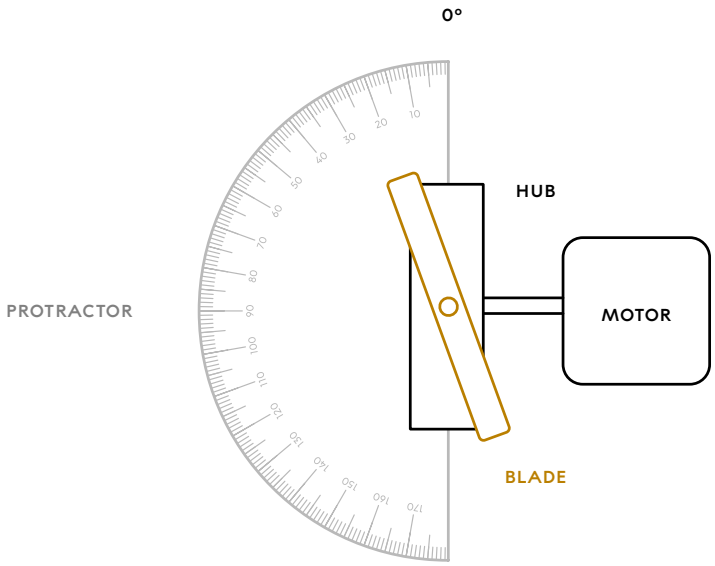


FIGURE 4.1
Side View of Model Turbine

Number of blades

Make sure the blades are evenly spaced apart. It may help to keep the area that is attached to the hub compact so more blades can easily be added.

Blade size

Students can choose to modify either the blade length, the blade width, or both. Blade size incorporates the total area of the blade. Encourage students to initially change only one of those variables at a time.

Blade shape

Students can change the whole blade shape or just the tip of the blade. They can also fold the blade or add onto the blade to change the three-dimensionality of the blade.

5 Change student groups to develop expertise and then design the model turbine.

- In Procedure Step 8, create new groups by instructing pairs of students to meet with a pair from another group that tested the same variable. The purpose of this is to create a group of experts for each variable who can broaden their expertise by discussing their experimental results with one another. Review the idea presented in the Introduction that an expert can include a person(s) who has firsthand experience with experimentation in a particular subject. Connect this idea with those presented earlier in the unit when students learned that it is important to gather facts from credible sources, which are dependent upon experts.
- Emphasize that for their particular variable, the new group members are more likely to know facts about that variable than others and that they can gain further expertise by discussing within their group of experts.
- In Procedure Step 9, instruct students to form into their final groups with one expert from each variable. This group will design the complete model turbine, using the combined expertise of all four variable experts.

6 Lead a class discussion that compares similarities and differences in the designs.

- Have students share the design aspects that impacted the output (voltage) of their models. Ask, How did each variable contribute to the output of the generator? Answers may vary based on the materials that were used and the designs that groups come up with. Generally, the different variables may affect the performance of the designs in the following ways:

IMPACT OF VARIABLE ON DESIGN

Blade angle

Designs with very small blade angles may not spin very fast as the air can't move through the design. Designs with very large blade angles may not capture enough wind to spin.

Number of blades

Designs with 2–3 blades seem to be optimal for this size and type of wind turbine. Turbines with 1 blade will not spin evenly. Having more than 3 blades makes the hub heavier, which can influence how fast the hub can spin and, thus, reduce the voltage measurement.

Blade size

The rotor hub will spin faster when the blades can capture more of the energy from the wind. Larger blades can cover a large swept area and may lead to higher voltage readings. However, larger blades also weigh more, which can limit how fast the hub can spin and may reduce the voltage measurement.

Blade shape

The shape of the blade affects the aerodynamics of the design and how effectively air can move around the blades of the turbine. Designs that incorporate a three-dimensional element into the blade design may have more effect on the aerodynamics of the blades.

- Have students share their ideas for further design changes they think might improve their results. Suggestions include making the structure stiffer, so less energy is lost when spinning; making the whole thing bigger; and/or making larger blades bigger but with a lighter material that does not add a lot of weight.

- Discuss the role of iteration of design in the activity. Ask students to compare the results of their work when they ran multiple experiments informed by their previous experiments compared to running the same number of experiments done simultaneously. This comparison should allow students to clearly see how they learned from each trial and were able to apply that knowledge as they iterated.

TEACHER'S NOTE: If students have completed the previous unit on iteration, Evidence & Iteration in Science, they may recognize the importance of building knowledge through the process of iteration. Connect the ideas from this activity to the ones in the previous unit.

- Conclude the design portion of the activity by highlighting students' experiences establishing facts during the design iteration. Emphasize how important the role of test results (facts) was to inform their design decisions. Ask, How did the facts you gathered during testing help you produce a better design than if you had just spent extra time thinking about it? Expect students to reflect on how the process of gathering testing data helps confirm, or does not confirm, the expected outcome. Without that step, students wouldn't know if what they predicted was benefitting the design.

7 Students estimate the power generated by the wind turbine.

- In Procedure Step 14, students estimate the number of classroom model turbines it would take to power a laptop. This allows students to get a perspective on the power numbers that were calculated in Step 13, which is to say, only a small amount of power was generated by their models in relation to everyday devices. These quantities are quickly put into perspective when compared to Vanwick's current power generation of 500 MW.

Sample Student Response, Procedure Step 14

1.85 V x 0.1 A = .185 watts per model

$$\frac{60\ W}{.185\ W/model} = 324\ models$$

When reviewing this estimation, discuss some of the limitations of the data used for this calculation, such as the provided estimated current and variations in the designs.

8 Students calculate power estimates in Procedure Step 15.

- Estimates for the turbines needed to power Vanwick's current electrical power needs, completed in Procedure Step 15, show that the available space for wind turbines is not enough to power the current power needs, so this is an obvious problem for the community.

Sample Student Response, Procedure Step 15

0.01 MW x 5 small turbines = 0.05 MW

8 MW x 52 large turbines = 416 MW

Total: 416.05 MW < 500 MW currently supplied

- When discussing the implications for the power estimates in Procedure Step 16, make sure students identify some of the limitations of the calculation. Important limitations to consider are 1) Vanwick's needs will be greater in the future (subsequent activities reveal that this is estimated to double in the future) and 2) the calculation shows what generation is possible, not what has yet to be decided by Vanwick. Given that the stakeholder values from Activity 3 revealed that noise and nice views are a priority, the town is not likely to choose all the locations possible.

SYNTHESIS OF IDEAS (30 MIN)

9 Introduce the assessment for Build Understanding item 1.

- Build Understanding item 1 is a decision-making assessment item. This first opportunity should be used to introduce your students to the Decision-Making (DM) Scoring Guide. As this is the first opportunity for students to review the scoring guide, you may wish to have them work in pairs or small groups to discuss and/or write their responses, using the scoring guide to help develop their responses. See Appendix 2: Assessment Resource, at the end of the Teacher's Edition for more guidance and information on using the Scoring Guide with your students.

- Do not share the item-specific version of the Scoring Guide (Item-Specific Scoring Guide: Activity 4, Build Understanding item 1) with students as it provides specific information on how to respond to the question prompt. Review the item-specific scoring guide to support scoring this specific item.

- Visual Aid 4.1, "Scoring Guide: Decision-Making (DM)," can be used to assess Build Understanding item 1. Point out the scoring levels (0–4) and review the criteria for each score. Explain that the scores are based on the quality of students' responses and reflect student growth over time. The scores do not correspond to letter grades. A Level 3 response is complete and correct. A Level 4 response signifies that the student has both achieved and exceeded the acceptable level of response. At first, many students will write Level 2 responses, and they should strive to achieve Level 3 or Level 4 responses. Let students know that you would like them to improve by at least one level as they progress through the unit. As a class, discuss what a Level 4 response to Build Understanding item 3 would include. You may develop a Level 4 exemplar as a class or share with students the

Level 4 responses from the provided sample responses. To help students better understand the three levels, discuss how they are different and ask students for ideas about how to improve from Level 2 to Level 3 and from Level 3 to Level 4.

- For some students, you may wish to support a specific level of growth—this can be particularly helpful if students have an Individualized Educational Plan (IEP), a 504 plan, or other specific educational goals. Growth from a Level 1 to a Level 2 may indicate significant progress for a student and should be recognized as such. Additionally, assessments can be a good opportunity to have students evaluate one another's work and provide initial feedback for revisions prior to submitting their responses to you.

- Sample responses for Levels 1–4 are provided in the Build Understanding section. Review these responses to get an idea of what is expected for each level, alongside the Item-Specific Scoring Guide. See Appendix 2: Assessment Resource at the end of the Teacher's Edition for more guidance and information on using the Scoring Guides and assessment system with your students.

- An optional support is provided with Student Sheet 4.2, "Writing Frame: Decision-Making." A writing frame can support diverse learners, particularly emerging multilingual learners, in decoding scientific ideas, constructing meaning, sensemaking, and language acquisition. This strategy, which has been deemed effective for emerging multilingual learners, was built on and adapted from strategies for English-proficient learners. You may wish to provide students with the writing frame to compose their responses or simply as a reference or checklist to help them organize how they will respond. Consider posting an enlarged version of the writing frame on a classroom wall for students to refer to now and in future assessments. For more information on a Writing Frame, see Appendix 1: Literacy Strategies.

  TEACHER'S NOTE: The Writing Frame is identical in all activities, despite different prompts, because it coincides with the Scoring Guide. For this activity, the two optional prompts are not used but will be in subsequent activities as student understanding of decision-making further develops.

- Conclude the activity by formatively assessing the core concepts of the activity. Evaluate if your students are able to identify the essential ideas of the activity by summarizing the key concepts and process skills.

EXTENSION (10 MIN)

10 **Use the Extension as an opportunity for advanced learning.**

Students design a solution to address the problem of birds being killed in the blades of wind turbines. Students make designs (in the medium of their choosing) to mitigate bird deaths at wind farms and then share their ideas with someone. Finally, students investigate how other engineers have addressed this problem and compare their designs with some of the solutions presented in the field.

SAMPLE STUDENT RESPONSES

BUILD UNDERSTANDING

① DM Scoring Guide

Some community members think that Vanwick should use only wind turbines to power the city. If this were the case, some of the wind turbines would need to be located close to residences, near the school, and in the city park. Review the stakeholder values surveyed in Activity 3. Do you think Vanwick should decide to use all the wind turbines possible to power the city?

Explain your decision, including the following:

- **the relevant facts and stakeholder values and how they affected your decision.**
- **the predicted outcome(s) of your decision.**

Level 4 response

I do not think Vanwick should use all wind turbines to power their city. I have decided this based on several facts and values. The facts I used to inform my decision are that Vanwick needs 63 large turbines to meet their power needs. Although Vanwick does have the space to install this many turbines, the turbines would need to be located close to residents' homes, near the school, and in the city park. I also considered the stakeholder values from the survey of Vanwick residents, and one of the top values for many residents is to not have the renewable energy sources close enough to see or hear. Therefore, I think that Vanwick should use as many wind turbines as they can, without building them close to homes, schools, or the park. The outcome of this would be a partial solution to their energy needs, but they would need additional renewable sources of energy to provide the rest of the power needed by their residents.

Level 3 response

I do not think Vanwick should use all wind turbines to power their city. I have decided this based on the fact that they would have to build turbines near people's homes. One of the top values from the survey was to not have renewable energy sources close enough to see or hear. If they do not build enough wind turbines to provide all the power they need, the outcome will be that they won't have enough power, or they will need to find other renewable sources.

Level 2 response

I do not think Vanwick should use all wind turbines. They need 63 large turbines, and that is a lot. People don't like the noise from the wind turbines, so they should not use all wind turbines.

Level 1 response

I do not think Vanwick should use all wind turbines. People like solar panels more because they are better.

② **Facts about the maximum amount of power generated by different-sized wind turbines were presented in this activity. However, the actual power generated at any given moment is usually lower than the maximum generation rate. For example, the average power generated by a wind turbine is 20%–40% below the maximum.**

a Make a list of variables that can affect the amount of power produced by wind turbines.

Variables for wind include amount and direction of wind, weather condition, time of year, design of turbine.

b How would these variables affect the number of turbines needed to meet Vanwick's power needs?

You would need to install more wind turbines to meet your power needs because if the factors listed above cause there to be less power generated than expected, then you will not be able to meet the power needs unless you have more units installed or a different kind of generation as backup.

CONNECTIONS TO EVERYDAY LIFE

③ **Imagine you know someone who has an electric car. It is charged by plugging it into an electrical grid. The grid is powered by a coal power plant. They make the following claim of fact:**

This vehicle provides zero emissions to the atmosphere.

a Do you agree or disagree with their claim of fact? Explain.

I disagree with their claim. The fact that the grid is powered by a coal power plant means that there are emissions associated with the generation of the electricity that powers the car. Also, there might be emissions related to the manufacturing of the vehicle.

b Suppose the person provided an information source to their claim of fact. Would that change your thinking about the claim of fact? Explain why or why not.

It depends on the type of information source they give. If it is not from a credible source, then I would need my friend to find one to make me rethink my position.

REFERENCES

Sivak, A. (2019, May 22). AI-backed sensors help reduce wind turbine risks to protected birds. *Earth Island Journal*. Retrieved from https://www.earthisland.org/journal/index.php/articles/entry/sensors-reduce-wind-turbine-risks-to-birds/

STUDENT SHEET 4.1	WIND TURBINE DESIGN TESTING	NAME

VERSION	VARIABLE BEING TESTED	DESIGN DESCRIPTION OR DRAWING	DESIGN REASONING	MAX VOLTAGE (V)	OBSERVATIONS
1					
2					
3					
4					
5					

VERSION	VARIABLE BEING TESTED	DESIGN DESCRIPTION OR DRAWING	DESIGN REASONING	MAX VOLTAGE (V)	OBSERVATIONS
1	*blade angle*	*2 blades, opposite each other, trapezoid shape* *blade angle of 45°*	*Having the blade at 45° will work better than 0° because the wind will catch and move it.*	*0.45 V*	*Having the blades exactly opposite each other works better.*
2	*blade angle*	*2 blades, opposite each other, trapezoid shape* *Blade angle of 20°*	*The blade will not work as well at 20° to catch the air.*	*1.35 V*	*The smaller angle causes the blades to move faster!*
3	*blade angle*	*2 blades, opposite each other, trapezoid shape* *Blade angle of 0°*	*The blade may work even better by catching all the wind.*	*0 V*	*The blades do not move at all now. They need to be at least at a slight angle.*
4	*number of blades*	*Blade angle of 20° and all are a trapezoid shape* *4 blades spaced evenly apart*	*More blades might go faster by catching more wind.*	*1.10 V*	*It wasn't quite as fast. Maybe because the blades make it heavier to turn?*
5	*number of blades*	*Blade angle of 20° and all are a trapezoid shape* *3 blades spaced evenly apart*	*Maybe it will go faster because of less weight.*	*1.18 V*	*It still wasn't quite as fast as just 2 blades.*

I/we/they have decided

The value(s) that I/we/they are weighting most heavily is

One fact related to the value is

A second fact related to the value is

Together, these facts and values affect the decision because

The likely outcome of this decision is

(OPTIONAL) **The trade-offs of this decision were**

(OPTIONAL) **This decision involved compromising about**

I/we/they have decided

that Vanwick should not use only wind turbines.

The value(s) that I/we/they are weighting most heavily is

that Vanwick residents don't want to see or hear the renewable energy sources.

One fact related to the value is

that they need 63 wind turbines to get enough power.

A second fact related to the value is

that they have space to build this many if they build them near homes, the school, and the park.

Together, these facts and values affect the decision because

it means that they can't build all the wind turbines they would need without building them where people would see or hear them.

The likely outcome of this decision is

that they will need another source of renewable energy.

(OPTIONAL) **The trade-offs of this decision were**

N/A

(OPTIONAL) **This decision involved compromising about**

N/A

VISUAL AID 4.1 | SCORING GUIDE: DECISION-MAKING (DM)

WHEN TO USE THIS SCORING GUIDE:

This Scoring Guide is used when students are explaining a decision (sometimes in the form of a recommendation) that incorporates relevant facts and values and predicts possible outcomes.

WHAT TO LOOK FOR:

- Response incorporates and explains the effects of relevant facts and stakeholder values on the decision.
- Response identifies trade-offs (if appropriate).
- Response describes any compromises made (if appropriate).

LEVEL	GENERAL DESCRIPTION
Level 4 **Complete and correct**	The student explains a decision made from two or more options that incorporates: • one or more relevant stakeholder values. • the facts associated with those values. • how the facts and values affected the decision. • predicted outcome(s) supported by the relevant facts. • any trade-offs made as a result of weighing the relevant facts and values (if appropriate). • any compromise made by stakeholders (if appropriate).
Level 3 **Almost there**	The student explains a decision made from two or more options that incorporates most of the following, BUT one or more may be insufficiently described: • one or more relevant stakeholder values • the facts associated with those values • how the facts and values affected the decision • predicted outcome(s) supported by the relevant facts • any trade-offs made as a result of weighing the relevant facts and values (if appropriate) • any compromise made by stakeholders (if appropriate)

LEVEL	GENERAL DESCRIPTION
Level 2 **On the way**	The student provides a clear and relevant decision, BUT the explanation of supporting facts and values is incomplete.
Level 1 **Getting started**	The student provides a clear and relevant decision BUT provides inaccurate or unrelated facts, unrelated values, and/or an illogical explanation of the decision.
Level 0 **Missing or off task**	Student response is missing, illegible, or irrelevant.
X	The student had no opportunity to respond.

WHEN TO USE THIS SCORING GUIDE:

This Scoring Guide is used when students are explaining a decision (sometimes in the form of a recommendation) that incorporates relevant facts and values and predicts possible outcomes.

WHAT TO LOOK FOR:

- Response incorporates and explains the effects of relevant facts and stakeholder values on the decision.
- Response identifies trade-offs (if appropriate).
- Response describes any compromises made (if appropriate).

LEVEL	GENERAL DESCRIPTION	ITEM-SPECIFIC DESCRIPTION
Level 4 **Complete and correct**	The student explains a decision made from two or more options that incorporates: • one or more relevant stakeholder values. • the facts associated with those values. • how the facts and values affected the decision. • predicted outcome(s) supported by the relevant facts. • any trade-offs made as a result of weighing the relevant facts and values (if appropriate). • any compromise made by stakeholders (if appropriate).	**The student explains their decision about whether Vanwick should use all wind turbines, incorporating the following:** • 2–3 relevant facts (number of turbines needed to meet energy needs, how much space is available, where turbines would be built if all turbines needed are built) • stakeholder value of not wanting to see/hear renewable energy sources • meeting stakeholder value leads to the all-wind-turbine option not being possible • outcome is not enough renewable power or additional renewable sources needed **However, additional relevant facts, values, and outcomes may be considered.**

LEVEL	GENERAL DESCRIPTION	ITEM-SPECIFIC DESCRIPTION
Level 3 **Almost there**	The student explains a decision made from two or more options that incorporates most of the following, BUT one or more may be insufficiently described: • one or more relevant stakeholder values • the facts associated with those values • how the facts and values affected the decision • predicted outcome(s) supported by the relevant facts • any trade-offs made as a result of weighing the relevant facts and values (if appropriate) • any compromise made by stakeholders (if appropriate)	**The student explains their decision about whether Vanwick should use all wind turbines, incorporating most of the following, BUT one or more may be insufficiently described:** • 2–3 relevant facts (number of turbines needed to meet energy needs, how much space is available, where turbines would be built if all turbines needed are built) • stakeholder value of not wanting to see/hear renewable energy sources • meeting stakeholder value leads to the all-wind-turbine option not being possible • outcome is not enough renewable power, or additional renewable sources needed **However, additional relevant facts, values, and outcomes may be considered.**
Level 2 **On the way**	The student provides a clear and relevant decision, BUT the explanation of supporting facts and values is incomplete.	The student explains their decision about whether Vanwick should use all wind turbines, BUT the explanation of supporting facts and values is incomplete (e.g., only one fact, not including values, not stating possible outcomes).

LEVEL	GENERAL DESCRIPTION	ITEM-SPECIFIC DESCRIPTION
Level 1 **Getting started**	The student provides a clear and relevant decision BUT provides inaccurate or unrelated facts, unrelated values, and/or an illogical explanation of the decision.	The student states their decision about whether Vanwick should use all wind turbines BUT provides inaccurate or unrelated facts, unrelated values, and/or an illogical explanation of the decision.
Level 0 **Missing or off task**	The student's response is missing, illegible, or irrelevant.	
X	The student had no opportunity to respond.	

ACTIVITY 5

Scenario Planning

CARD-BASED INVESTIGATION

ACTIVITY 5

Scenario Planning

ACTIVITY SUMMARY

Students use the technique of scenario planning to consider the possible energy futures for Vanwick. Students use their imaginations to envision various futures based on factors provided on cards. The conceptual tool of scenario planning helps inform a decision by considering a variety of positive and negative possible outcomes in the future. Then students reflect on how thinking about possible futures can inform decisions made now in Vanwick.

ACTIVITY TYPE
CARD-BASED INVESTIGATION

NUMBER OF 40–50 MINUTE CLASS PERIODS
2

KEY CONCEPTS & PROCESS SKILLS

1. Making optimal decisions includes envisioning a variety of possible futures with more desirable or less desirable outcomes and identifying the choices and trade-offs needed to prepare for those futures.
2. When gathering facts, first determine whether the source is credible before looking at the information or evidence provided by the source in more depth.

NEXT GENERATION SCIENCE STANDARDS (NGSS) CONNECTION:
Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. *(Science and Engineering Practice: Constructing Explanations and Designing Solutions)*

CONCEPTUAL TOOLS

VOCABULARY DEVELOPMENT

electrification
(assumed prior knowledge)
the process of replacing technologies that include burning fossil fuels with energy generation and electrical devices that do not

factor
(assumed prior knowledge)
something that actively contributes to the production of a result

outcome
(assumed prior knowledge)
something that follows as a result or consequence

scenario planning
a technique that informs decision-making by imagining how uncertain factors might affect possible futures

trade-off
when a desirable outcome is given up to gain another desirable outcome

TEACHER BACKGROUND INFORMATION

Scenario Planning

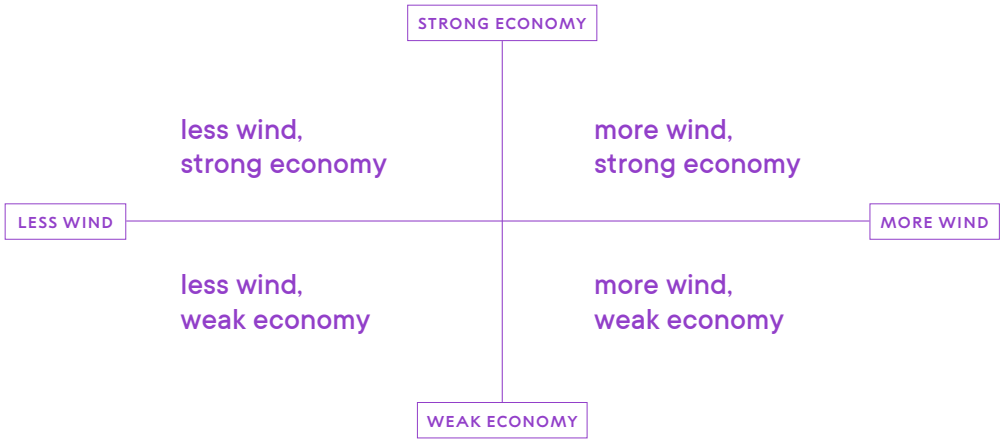
Scenario planning is a tool for informing decisions that involve considering different possible scenarios that might occur in the future, both to increase the likelihood of preferred possible futures and to prepare for multiple possible futures that we may not have power to control. Scenario planning is commonly used by businesses and governments to make more informed policy decisions and to avoid encountering completely unexpected events for which they are unprepared.

Scenario planning can also be used by individuals to prepare themselves for an uncertain future, helping them feel more confident and capable of coping with whatever happens. Individuals often imagine only one or two possible futures and are surprised and unprepared when some other unexpected future comes to pass.

There are several different ways to conduct scenario planning, but one common technique involves generating two important, uncertain, and orthogonal (uncorrelated) factors that may vary in the future. For example, in a situation of planning for renewable energy, one factor to consider is the amount of wind available for turbines, which could be high or low; another factor could be the economy in the region, which might go well or poorly.

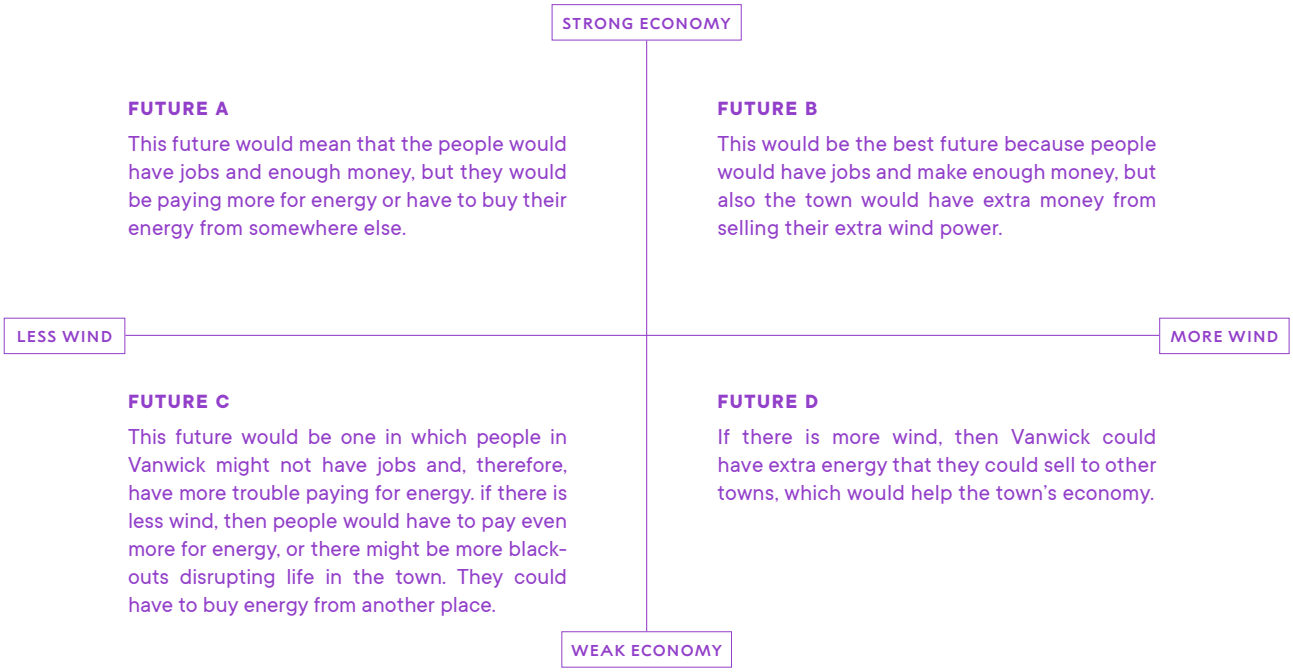
These two factors, sometimes called dimensions, are put into a graphic organizer that looks similar to a Cartesian coordinate plane. The four quadrants represent four different possible futures, as shown in Figures 5.1 and 5.2.

FIGURE 5.1
Scenario Planning Quadrants



The exercise is to envision what the reality would be for those four quadrants and describe each one, as shown in the following diagram. By systematically considering all four quadrants and what they would mean for the community, policymakers would be able to prepare for each possible future. This consideration of multiple eventualities can help minimize the damage if a more difficult possible future comes to pass.

FIGURE 5.2
Sample Quadrant Descriptions



MATERIALS & ADVANCE PREPARATION

FOR THE TEACHER

- VISUAL AID 5.1 "Possible Futures"

FOR EACH GROUP OF FOUR STUDENTS

- SET OF SCENARIO PLANNING CARDS (SETS A–D)

FOR EACH STUDENT

- STUDENT SHEET 5.1 "Scenario Planning"

Prepare the cards for students. There are 4 card sets (A–D), and each set includes 4 cards (1–4) for a total of 16 cards. Separate the cards into Sets A–D. Each group of 4 students should get cards from the same set.

TEACHING NOTES

Suggestions for **discussion questions** are highlighted in gold.

Strategies for the **equitable inclusion of diverse students** are highlighted in pink.

GETTING STARTED (10 MIN)

1 **Elicit student ideas about what life might be like in the future.**

- Ask students to generate a list of things that are uncertain about the future. This could be something small such as what the weather will be like tomorrow or something big such as what kind of job they will have as an adult. Guide students to think about societal uncertainties such as population size, climate, the economy, cost of living, education access, and job availability.
- To help students imagine different possible futures, ask them to compare the scenes shown on Visual Aid 5.1, "Possible Futures." They can compare changes in population, environment, and electricity use between the two images. Use this to spur their imagination, as opposed to providing an answer.

2 **Discuss what could change in Vanwick in the future.**

- Ask, How does uncertainty about the future make decision-making challenging? Students' responses might include not knowing what the outcomes will be later for something that is decided today or unpredictable factors changing an expected outcome. Reassure students that everyone has uncertainties in their future and that thinking about different possibilities can help make a more informed decision today.
- Ask, What do you think the future might look like in Vanwick? Ask students to describe how it might continue to change in the next 20–30 years based on the outcomes of Project REV. Have them make predictions about factors that might impact or be impacted by the renewable energy project such as:
  - electricity demand
  - environmental effects
  - changes in the landscape

  Students should pair-share to discuss their predictions. Student responses will vary and could include topics about energy, everyday life, and the environment.

3 Ask students to consider what could impact the future.

- After students read the introduction, review the term *factor* as it is used in the activity. A factor describes any number of variables that can influence the outcome in the future, such as the economy, the climate, etc.
- Clarify for students that the word *scenario* is used in two ways in this unit. First, students were introduced to a fictional scenario in the city of Vanwick. Second, in this activity, students are presented with a decision-making tool called scenario planning. The word is used in two different contexts.
- Review the scenario provided in Procedure Step 1 that presents these future ideas in the context of Vanwick. If students are surprised to read that electrification will double the consumption of electricity, review the content provided in the Science Review found in the Student Book.

PROCEDURE SUPPORT (50 MIN)

4 Students engage in scenario planning in Part A.

- Cards 1–4 in each card set (Sets A, B, C, and D) used in the procedure reflect the four quadrants of scenario planning (see Teacher Background Information). Each card identifies a possible future described in terms of two factors. These factors were chosen because they are both uncertain and important in the future. Students use these to imagine possible outcomes in the future as it relates to these factors.
- In Procedure Step 3, encourage students to be imaginative about what Vanwick might look like 50 years in the future. Allow students to use the modality they prefer to communicate what they imagine. The following shows a written news story, but accept responses that could include storytelling, drawings, video, music, or narration to describe the possible future indicated on their cards.

Sample Student Response, Procedure Step 3

SET A, CARD 1

There are lots of new technological solutions to reducing greenhouse gases. Earth has some positive recovery from climate change.

Vanwick News Outlet
December 9, 2074

Carbon Mousetrap Helps Earth Recover

The most recent advancement in reducing greenhouse gas emissions by funneling harmful molecules into the center of Earth seems to be working better than expected. The new technology, nicknamed the Carbon Mousetrap, captures greenhouse gases by pressurizing them in the atmosphere

via satellites orbiting Earth. Then, the molecules are pushed through a series of nanotubes attached to the newest international satellite docking station 100 km (60 miles) above Earth. From there, gravity pulls the molecules down to the center of Earth.

Scientist Rio Charming, one of the lead engineers from Carbon Mousetrap says, "The latest data shows that this technology has been instrumental in removing greenhouse gases from the atmosphere. It shows that the technology has helped accelerate the removal of carbon from the atmosphere." Preliminary results show that, much to the researchers' surprise, some environmental indicators related to animal and plant recovery are very positive. For example, increases in biodiversity for plant and animal life have been observed in the town of Vanwick since Carbon Mousetrap began operation. This is a change from the pattern of decreased biodiversity recorded in this area over the last 100 years. It seems that Earth has made some positive recovery from climate change.

In Vanwick, where biodiversity data has been collected for decades, the community is rejoicing in the improvements in the environment. They have begun celebrating Earth Recovery Day when people flock to the streets dressed as their favorite species recovered from extinction. With cleaner air, water, and controlled climate temperatures in Vanwick, there is a lot to celebrate.

- In Procedure Step 4, if students haven't already noticed, draw their attention to the fact that the collection of the four stories, pictures, or articles includes the four possibilities based on the two factors in their card set. In that way, each group has considered four related possible futures.
- In Procedure Step 5, if students are not able to deduce the relationship between the factors on Student Sheet 5.1, "Scenario Planning," explain how each box represents a quadrant identified by the two factors. This shows how the cards relate to one another. Students should be able to see that, for each set of factors, the upper-right (Quadrant 1) shows the best possible future, while the lower-left (Quadrant 3) shows the worst possible future.

5 In Part B, students reflect on how scenario planning informs decision-making.

- When reviewing students' stories, pictures, or articles, point out that what they imagined by using scenario planning are possible futures, as opposed to an actual outcome. Scenario planning does not predict an actual outcome—that would be a result.
- In Procedure Step 6, ask, How important is the "Likelihood It Could Happen" column (in your Possible Outcomes table) when planning for the future? Students should see that it is very important to balance the likelihood with the potential impact of that outcome. For example, if there is a catastrophic but unlikely outcome, it informs the decision you make now to address that possible future. A simple example is wearing a seatbelt. The chance of it being needed is not very high, but wearing one greatly increases having a good outcome in the infrequent but potentially catastrophic case of a crash.

Sample Student Response, Procedure Step 6

TABLE 5.1
Possible Outcomes

CARD NUMBER	TITLE	DESCRIPTION OF POSSIBLE OUTCOMES	LIKELIHOOD IT COULD HAPPEN (1 HIGH–4 LOW)
1	*Carbon Mousetrap*	*greenhouse gas is reduced; cleaner air, water, and controlled climate temperatures*	*highly unlikely: 4*
2	*Too Much, Too Late*	*greenhouse gas emissions continue despite lots of helpful technology; climate change effects of extreme weather and temperatures worsen*	*fairly likely: 2*
3	*Trouble Ahead*	*greenhouse gas emissions continue to increase, species die off, quality of life is poor everywhere*	*most likely: 1*
4	*We Got Lucky*	*greenhouse gas emissions are reduced with renewable energy; climate change impacts are reduced such as sea level rise, air quality*	*fairly unlikely: 3*

- Remind students that scenario planning is part of decision analysis because it is a tool used systematically that informs decision-making. It helps broaden what is considered before a decision is made. We cannot plan for futures that we have not imagined.

6 Introduce the concept of trade-offs and how it applies to decision-making.

- Introduce the idea that decisions about solutions to scientific and engineering problems often involve trade-offs. In Procedure Step 10, students use trade-offs when they make a decision about actions that can be taken now during Vanwick's energy transition to support a positive future. Decision-making in the context of trade-offs includes the following key ideas:
  - Decisions often involve trade-offs.
  - Identifying trade-offs involves analyzing evidence.

The concept of trade-offs is used throughout the units of this course, especially as part of the decision-making focus. Specifically, the use of trade-offs in decision-making is assessed as part of Visual Aid 4.1, "Scoring Guide: Decision-Making (DM)," although it was omitted from the Build Understanding item 1 in Activity 4 since it had yet to be introduced to students.

- A trade-off is a desirable outcome given up to gain another desirable outcome. In a decision involving trade-offs, something positive (or desirable) is given up to gain another positive (or desirable) outcome. Since many decisions involve trade-offs, students should understand that a perfect choice that maximizes all goals is often not possible. It is possible, however, to recognize and analyze the trade-offs associated with each decision.

- Provide an example of a trade-off. For example, when choosing to purchase a disposable or reusable water bottle, there are several benefits and trade-offs to consider. A consumer who chooses the disposable water bottle may want a cheap option that doesn't need to be cleaned or maintained. Disposable bottles are also easily shared with others since they are not expected to be returned. However, in choosing the disposable water bottle, the consumer is contributing to environmental problems, such as increased energy use and higher amounts of solid waste in landfills if the bottle is not recycled. A consumer choosing to purchase a reusable water bottle may do so to save money over time, to save bottles from ending up in a landfill, and—by their example—to encourage others to purchase reusable bottles. However, this option has trade-offs as well, such as the increased upfront cost of the reusable bottle and the need to clean and maintain the bottle. Neither choice is ideal, and both choices have positives and negatives. Identifying the trade-offs helps clarify the reasoning that is being applied to make a decision.

- Develop some examples of trade-offs in students' lives by brainstorming with the class a list of decisions they make every day that involve trade-offs. Choose one and talk through the associated trade-offs of deciding one way or another. This practice will familiarize students with ways to identify and consider trade-offs in this and subsequent activities.

- The idea of a trade-off is similar to *compromise,* which is a word introduced later in the unit. A trade-off is giving up a desirable outcome to get another more desirable outcome during a decision. Compromise is similar but involves multiple people with different priorities who give something up during negotiation in service of getting to an agreement that is acceptable to everyone.

- Support students, particularly emerging multilingual learners, in sensemaking and language acquisition by adding words to the word wall. For this activity, record the terms *trade-off, scenario planning,* and *electrification*. Provide additional examples for each term as needed.

SYNTHESIS OF IDEAS (20 MIN)

7 Relate scenario planning to facts verified by credible sources.

- Review Build Understanding item 2, which asks students to connect what they learned in Activity 2 with the content in this activity. Students should see that having accurate facts is critical for planning. If the facts you have are not verified, then you risk planning for an impossible outcome or one that will not achieve what you expect.
- Guide a discussion that leads to the realization that credible information helps make better predictions. For example, the amount of electricity that needs to be generated for the community of Vanwick in the future will impact the decisions made for Project REV. Knowing that twice as much electricity is likely to be needed in the future for complete electrification (true fact) instead of less electricity being needed in the future (false claim of fact) will make a significant difference during planning for electricity generation.

8 Revisit how scenario planning informs decisions in the Vanwick scenario.

- Ask students to provide some examples of how scenario planning could inform the City Council as it decides how to plan for the future. Students should respond that it would help them plan for more situations, such as the very possible outcome that better technology is developed in the future or the unlikely event that the demand for electricity decreases. The City Council might rent equipment instead of buying equipment in the case of the first example or, in the case of the second example, make a deal that they can sell the energy to another community.
- To conclude the activity, formatively evaluate if your students are able to identify the purpose of scenario planning by revisiting the Guiding Question, How can imagining the future inform current energy decisions? Look for responses that reflect the use of the scenario-planning tool that helps envision a variety of possible futures. These multiple possibilities come with more desirable or less desirable outcomes, which leads to current choices and trade-offs to prepare for a variety of possible futures.

BUILD UNDERSTANDING

① **Pick the future scenario that came up in your class discussion that you found the most interesting.**

Answers can vary. One sample response (for Set C, Card 1) is shown here.

a **Identify the two factors involved in the scenario planning and why they were interesting to you.**

This scenario had lots of financial support and lots of international cooperation. This was interesting to me because it means a quick global transition to renewable energy, which I think is a good idea.

b **Describe how Vanwick citizens would be impacted if this possible future happens.**

Things for Vanwick residents would be good because they would quickly accomplish the goals of Project REV along with the rest of the world.

c **Decide what the City Council should do to increase or decrease the likelihood that this future will happen (if anything).**

The City Council could help this by working with other communities as they start Project REV, so other communities are more likely to cooperate.

d **Decide how the City Council can best prepare for this possible future.**

Put some money in the budget for marketing the idea outside of Vanwick after the project is finished.

② **Think about Activity 2 when facts were supported with credible sources. How do you think having accurate facts could support scenario planning?**

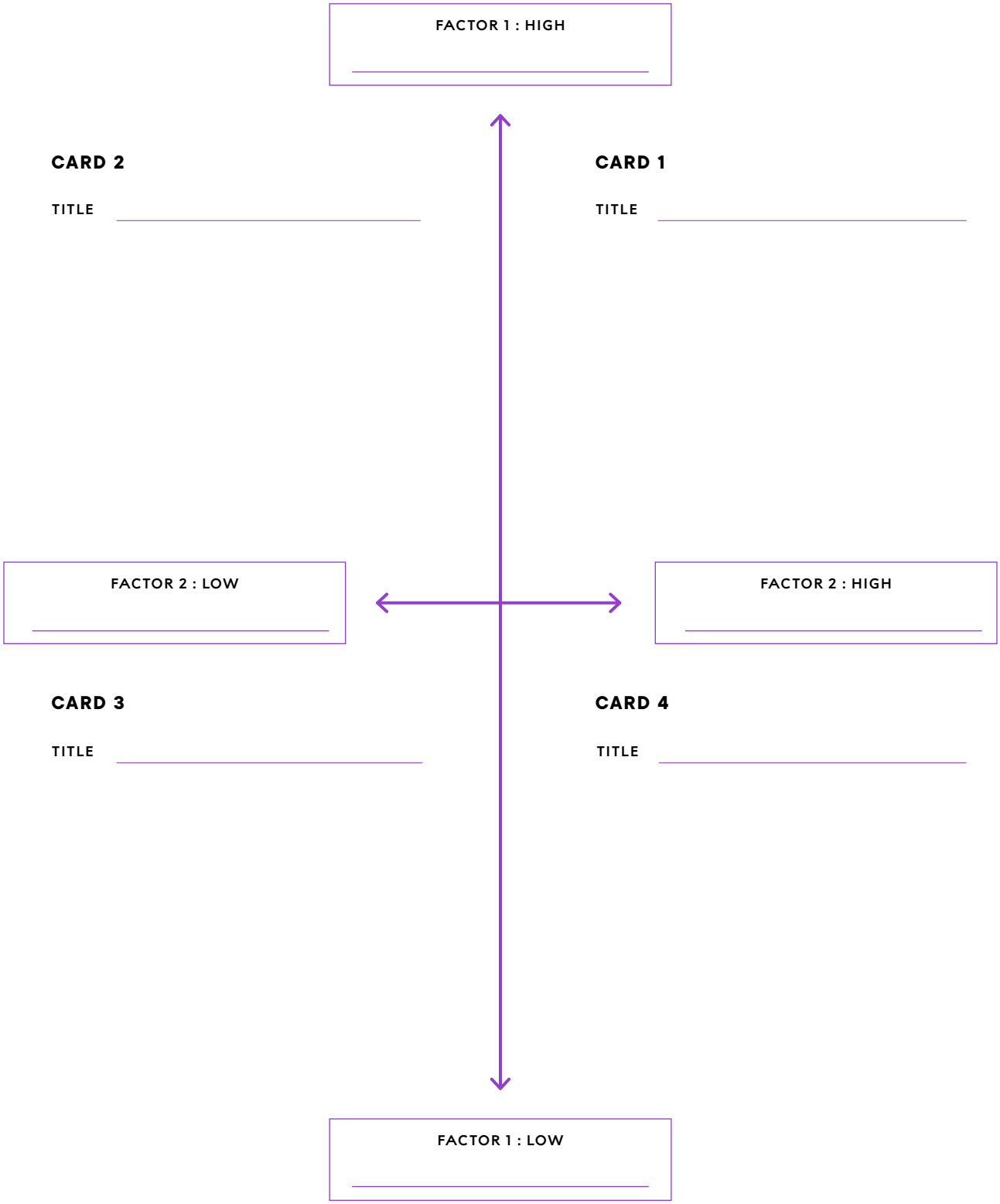
If you don't have an accurate fact, you might plan for the wrong outcome. That would result in wasted money and time. Plus, you wouldn't be ready for the outcome that actually happens.

③ **If you are planning for the future, do you think it is more important to plan for an unlikely outcome that is catastrophic or a more likely outcome that is hurtful but not catastrophic? Explain why.**

Answers can vary. One sample response is shown here.

I think it is more important to plan for the unlikely outcome that is catastrophic. This is because the catastrophic outcome is much worse and should be avoided or planned for a reduction in harm if the catastrophic outcome cannot be avoided entirely. An example of this is how engineers make their bridges stronger than they need to be so as to avoid the catastrophic outcome of a bridge collapse due to poor design and/or construction.

Card Set _____


FACTOR 1 : HIGH
CARD 2
TITLE
CARD 1
TITLE
FACTOR 2 : LOW
FACTOR 2 : HIGH
CARD 3
TITLE
CARD 4
TITLE
FACTOR 1 : LOW

Card Set A

FACTOR 1 : HIGH
lots of new technologies

CARD 2

TITLE **Too Much, Too Late**

Picture of lots of handheld gadgets that take a little greenhouse gas out of atmosphere. Houses up high on stilts, but dirty air still around. Big storm and flooding.

CARD 1

TITLE **Carbon Mousetrap**

News article about harmful molecules funneled into the center of Earth with nanotubes. Increased biodiversity. Celebrate Earth Recovery Day.

FACTOR 2 : LOW
poor Earth recovery

FACTOR 2 : HIGH
positive Earth recovery

CARD 3

TITLE **Trouble Ahead**

Science fiction story: Most plants and animals are dead, and the population is struggling to support itself. Not many computers and lights because not enough electricity to run them. People respond by meeting together and singing and dancing every day.

CARD 4

TITLE **We Got Lucky**

Picture of a town that is covered in solar panels everywhere, even on people's cars. Air is clean, lots of diverse animals, and pleasant weather.

FACTOR 1 : LOW
not many new technologies

SET A
CARD 1

What is the future for Vanwick as it relates to greenhouse gas emissions?

In this future:

- there are lots of new technological solutions to reducing greenhouse gases.
  FACTOR 1
- Earth has some positive recovery from climate change.
  FACTOR 2

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 5

SET A
CARD 2

What is the future for Vanwick as it relates to greenhouse gas emissions?

In this future:

- there are lots of new technological solutions to reducing greenhouse gases.
  FACTOR 1
- Earth does not recover well from climate change.
  FACTOR 2

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 5

SET A
CARD 3

What is the future for Vanwick as it relates to greenhouse gas emissions?

In this future:

- there are not many new technological solutions for reducing greenhouse gases.
  FACTOR 1
- Earth does not recover well from climate change.
  FACTOR 2

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 5

SET A
CARD 4

What is the future for Vanwick as it relates to greenhouse gas emissions?

In this future:

- there are not many new technological solutions to reducing greenhouse gases.
  FACTOR 1
- Earth has some positive recovery from climate change.
  FACTOR 2

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 5

SET B
CARD 1

What is the future for Vanwick as it relates to greenhouse gas emissions?

In this future:

- there is a lot of government support to reduce greenhouse gas emissions.
  FACTOR 1
- there are many more than expected negative environmental impacts from emissions.
  FACTOR 2

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 5

SET B
CARD 2

What is the future for Vanwick as it relates to greenhouse gas emissions?

In this future:

- there is a lot of government support to reduce greenhouse gas emissions.
  FACTOR 1
- there are fewer than expected negative environmental impacts from emissions.
  FACTOR 2

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 5

SET B
CARD 3

What is the future for Vanwick as it relates to greenhouse gas emissions?

In this future:

- there is little government support to reduce greenhouse gas emissions.
  FACTOR 1
- there are fewer than expected negative environmental impacts from emissions.
  FACTOR 2

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 5

SET B
CARD 4

What is the future for Vanwick as it relates to greenhouse gas emissions?

In this future:

- there is little government support to reduce greenhouse gas emissions.
  FACTOR 1
- there are many more than expected negative environmental impacts from emissions.
  FACTOR 2

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 5

SET C
CARD 1

What is the future for Vanwick as it relates to greenhouse gas emissions?

In this future:

- there is a lot of money applied to finding solutions to greenhouse gas emissions.
  FACTOR 1
- there is a lot of international cooperation in reducing greenhouse gas emissions.
  FACTOR 2

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 5

SET C
CARD 2

What is the future for Vanwick as it relates to greenhouse gas emissions?

In this future:

- there is a lot of money applied to finding solutions to greenhouse gas emissions.
  FACTOR 1
- there is a little international cooperation in reducing greenhouse gas emissions.
  FACTOR 2

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 5

SET C
CARD 3

What is the future for Vanwick as it relates to greenhouse gas emissions?

In this future:

- there is little money applied to finding solutions to greenhouse gas emissions.
  FACTOR 1
- there is little international cooperation in reducing greenhouse gas emissions.
  FACTOR 2

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 5

SET C
CARD 4

What is the future for Vanwick as it relates to greenhouse gas emissions?

In this future:

- there is little money applied to finding solutions to greenhouse gas emissions.
  FACTOR 1
- there is a lot of international cooperation in reducing greenhouse gas emissions.
  FACTOR 2

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 5

SET D
CARD 1

What is the future for Vanwick as it relates to greenhouse gas emissions?

In this future:

- there is a lot of community interest in reducing greenhouse gas emissions.
  FACTOR 1
- new technologies make renewables significantly cheaper.
  FACTOR 2

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 5

SET D
CARD 2

What is the future for Vanwick as it relates to greenhouse gas emissions?

In this future:

- there is a lot of community interest in reducing greenhouse gas emissions.
  FACTOR 1
- new technologies do not make renewables significantly cheaper.
  FACTOR 2

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 5

SET D
CARD 3

What is the future for Vanwick as it relates to greenhouse gas emissions?

In this future:

- there is little community interest in reducing greenhouse gas emissions.
  FACTOR 1
- the transition to renewables happens relatively slowly.
  FACTOR 2

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 5

SET D
CARD 4

What is the future for Vanwick as it relates to greenhouse gas emissions?

In this future:

- there is little community interest in reducing greenhouse emissions.
  FACTOR 1
- the transition to renewables happens relatively quickly.
  FACTOR 2

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 5

ACTIVITY 6

Energy Storage Model

LABORATORY

ACTIVITY 6

Energy Storage Model

ACTIVITY SUMMARY

Students model a version of energy storage with a model "gravity battery." Then they investigate the design and role of this kind of battery, and two other kinds, in the real world. Students use credible sources to consider different types of renewable energy storage options for Vanwick. The facts gathered around energy storage inform a decision about which storage is most desirable for a Vanwick stakeholder.

ACTIVITY TYPE
LABORATORY

NUMBER OF
40–50 MINUTE
CLASS PERIODS
3

KEY CONCEPTS & PROCESS SKILLS

1. Decision analysis is the process of breaking down a decision in a way that can help the decision-maker systematically consider elements related to a choice, such as facts and values.
2. Facts support informed decision-making by leading to more accurate predictions about the likely outcomes of different choices.
3. Values affect people's decisions. There can be disagreement within a community when people hold a variety of values.
4. When gathering facts, first determine whether the source is credible before looking at the information or evidence provided by the source in more depth.
5. Making optimal decisions includes envisioning a variety of possible futures with more desirable or less desirable outcomes and identifying the choices and trade-offs needed to prepare for those futures.

NEXT GENERATION SCIENCE STANDARDS (NGSS) CONNECTION:
Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations. *(Science and Engineering Practice: Constructing Explanations and Designing Solutions)*

CONCEPTUAL TOOLS

WEAVING FACTS & VALUES IN DECISION-MAKING

CREDIBLE SOURCES

SCENARIO PLANNING

VOCABULARY DEVELOPMENT

energy storage
a system or device that stores potential energy when it is abundant and releases it as electrical power when it is scarce

gravitational potential energy
(assumed prior knowledge)
energy stored due to an object's mass and height

grid sharing
when two or more organizations share or buy electricity from each other through connected transmission lines (the "grid")

potential energy
(assumed prior knowledge)
energy of position or condition

TEACHER BACKGROUND INFORMATION

Gravitational Potential Energy

Gravitational potential energy is a particular type of potential energy that is a result of an object's position above the center of Earth and is given by

$$E_{GPE} = mgh$$

where E_{GPE} is the gravitational potential energy (in joules, J),
m is the mass (in kilograms, kg),
g is the acceleration of gravity (in meters per second squared, m/s^2), and
h is the height (in meters, m).

Gravitational potential energy is dependent on the object's mass, height, and the acceleration of gravity. The higher and/or more massive an object is, the greater its gravitational potential energy. Imagine dropping a 1-kilogram mass from 1 centimeter above your toes. It will hurt, but not too much. If you drop it from 1,000 centimeters above, it will impart 1,000 times more energy and could easily break a bone. Gravitational potential energy also depends on the mass of the object. When dropped from the same heights, a 10-kg mass will impart 10 times more energy than a 1-kg mass.

Kinetic Energy

Kinetic energy is the energy an object possesses because of its motion and is given by

$$E_{KE} = \frac{1}{2}mv^2$$

where E_{KE} is the kinetic energy (in joules, J),
m is the mass (in kilograms, kg), and
v is the velocity of the object (in meters per second, m/s).

Kinetic energy is dependent on the object's mass and the square of the velocity of an object. The faster it is moving and/or more massive an object is, the greater its kinetic energy. Thus, if the mass doubles, the kinetic energy doubles. However, when the speed doubles, the kinetic energy quadruples. Kinetic energy is often confused with mechanical energy. Mechanical energy is the sum of kinetic and potential energies in a mechanical system.

Electrical Energy Storage Systems

A drawback to renewable energy generation methods, such as wind and solar generation, is that they depend on specific conditions in order to generate electricity. With wind, that condition is having a constant wind speed above a certain threshold, which depends on the size of the turbine. For solar, there is a threshold intensity of light. Even hydroelectric power, which is usually very consistent, depends on having a minimum amount of water. Energy storage systems are essential to a successful renewable project to ensure that there is a reliable supply of energy. These installations store energy when it is abundant so it can be used when energy is not abundant. The controller systems for these generation-storage installations are more sophisticated than those traditionally used with fossil fuel generation because they need to quickly respond to supply and demand.

Batteries

Battery technology continues to evolve rapidly. Lithium-ion batteries are prevalent and used in small devices, vehicles, residential storage, and even in large-scale utility projects. Though the technology continues to improve and is being installed in more locations, there are downsides to lithium-battery systems, including the limited availability of lithium ore, environmental concerns about mining lithium, as well as the flammability of lithium-battery systems. There are many other battery technologies being developed, including iron-air and zinc-air flow battery systems. Many of these technologies are in the research and development stages but are promising developments for renewable energy.

Supplemental Information

The energy storage system that students model in the lab is based on a new rail-based energy system called GravityLine™ currently under construction in Nevada by Advanced Rail Energy System (ARES) North America.

MATERIALS & ADVANCE PREPARATION

FOR THE TEACHER

- VISUAL AID 6.1A–B "Gravity Battery: Energy Diagrams"
- VISUAL AID 6.2 "Scoring Guide: Decision-Making (DM)" (OPTIONAL)
- ITEM-SPECIFIC SCORING GUIDE: Activity 6, Build Understanding item 1
- VISUAL AID 2.2 "Evaluating Online Information" (OPTIONAL)

FOR EACH GROUP OF FOUR STUDENTS

SUGGESTED MATERIALS FOR THE MODEL:

- 1.5 V–3 V MOTOR-GENERATOR, WITH MOUNT
- TURBINE HUB, OR PULLEY, ATTACHED TO THE MOTOR-GENERATOR
- RING STAND WITH CLAMP
- RAMP WITH TRACK, ABOUT 1m (3ft)
- CART
- STRING, SLIGHTLY LONGER THAN TRACK
- RULER
- SMALL MASSES, VARIOUS
- SCALE
- 9 V BATTERY (or 1.5 V D-cell battery, depending on materials)
- VOLTMETER OR MULTIMETER
- 2 WIRES WITH ALLIGATOR CLIPS
- TAPE
- SCISSORS
- VIDEO RECORDER

FOR EACH PAIR OF STUDENTS

- COMPUTER WITH INTERNET ACCESS

FOR EACH STUDENT

- STUDENT SHEET 6.1 "Design Testing Data: Gravity Battery"
- STUDENT SHEET 1.1 "Unit Concepts and Skills" (OPTIONAL)
- STUDENT SHEET 2.2 "Lateral Reading" (OPTIONAL)
- STUDENT SHEET 6.2 "Writing Frame: Decision-Making" (OPTIONAL)
- SCORING GUIDE: Decision-Making (DM) (OPTIONAL)

Determine what materials you will use in the lab and if you need to modify the procedure based on the materials you are using. You can find instructions for how to put together a model gravity battery in Appendix 3. Modify the model setup instructions for your students as needed, based on the materials you will be providing.

A suggested option is to use commercial wind turbine kits that include the motor-generator hub used in this activity. For example, Kid Wind, distributed by Vernier Science Education, carries all the basic components to build a turbine. Essential for this activity is the motor-generator and the turbine hub.

Several of the materials in this activity are also used in Activity 6: Energy Storage Model. The materials used in both activities are:

- 1.5 V–3 V motor generator
- turbine hub
- voltmeter or multimeter
- 2 wires with alligator clips
- ring stand
- scissors
- tape
- ruler

The cart must be able to hold a variety of small masses, such as pennies or fishing weights. If you do not have access to 9 V batteries, you may opt to have students reel the carts by hand while having students consider what would provide the energy for this in a real-life situation.

Note that it is easier to get readings with a longer ramp, so make the setup as large as is reasonable in your classroom.

It is recommended that students record a video of their model tests, if possible, to aid in reading the voltmeter while the cart travels. Consider recording it in slow motion, if possible.

Consider building one model gravity battery in advance for demonstration purposes. If materials are in short supply, this model could be used to gather data for the class.

If appropriate for your students, support their research into storage methods in Part C by curating some resources for pumped hydro, gravity batteries, and chemical batteries.

TEACHING NOTES

Suggestions for **discussion questions** are highlighted in gold.

Strategies for the **equitable inclusion of diverse students** are highlighted in pink.

GETTING STARTED (20 MIN)

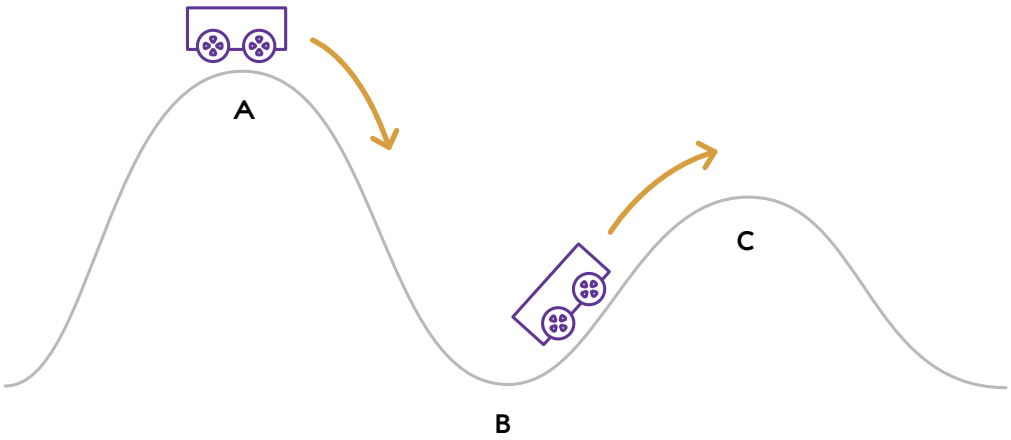
1 **Students consider the graphs in the Student Book introduction.**

- Draw students' attention to the graphs at the start of the introduction in the Student Book. Have partners make a list of possible problems of relying on wind and solar power generation methods. Ask them to compare the trends on the graphs to their typical usage of electricity in their everyday lives. Ask, What challenges do you see with relying on wind and solar electricity generation methods? Student ideas might include:
  - Peak solar generation is in the middle of the day, which doesn't match with peak usage.
  - Peak wind generation is at night, which also doesn't match with peak usage.
  - Wind and solar generation can vary greatly based on location, weather patterns, time of year.
  - If there's not enough electricity generated, there won't be enough to meet the demand, which means that some people could be without electricity.
- Relate student's ideas about the uncertainty of not having enough power when it is needed to the previous activity when they considered possible futures with scenario planning. Considering the possible future with renewable energy makes it clear that planning for the supply–demand issue will help support a favorable outcome.
- Have students read through the scenario in Procedure Step 1 and review Vanwick's options for energy storage. Of the solutions presented, emphasize that Vanwick is looking for a solution that allows them to support the goals of Project REV, which means a solution that evens out the varying generation of renewables without depending on fossil fuels.

2 **Review the science concepts of potential energy, kinetic energy, and energy transformations.**

- Like the energy transformations identified in Activity 4, the science concepts used in this activity are those of energy transformation. All energy storage relies on transforming kinetic energy into potential energy. Energy released from storage transforms energy from potential back to kinetic. In the case of electricity, the energy can be stored in various forms, such as chemical or gravitational potential energy.

- This activity assumes that students are familiar with a basic understanding of energy transfer, transformation, and the Law of Conservation of Energy. If helpful, review the concepts of gravitational potential energy and kinetic energy in the Science Review found in the Student Book. If necessary, review the Science Review content from Activity 4.
- Formatively assess students' background on the energy transformation relevant to the gravity battery by sketching the following diagram and asking, At which point on the roller coaster is the gravitational potential energy the largest? Smallest? Likewise, ask, At which point on the roller coaster is the kinetic energy the largest? Smallest?



- Students should understand that the gravitational potential energy is largest at the top of the roller coaster, Point A, and smallest at the bottom, Point B. The kinetic energy is opposite in that it is smallest at the top of the roller coaster, Point A, and largest at the bottom, Point B. Students may know that halfway up or down the hill, or at Point C, the energy is half gravitational potential energy and half kinetic energy.
- Students should know that the Law of Conservation of Energy requires that the total energy (gravitational potential plus kinetic energy) is always the same, no matter where the cart is located.

PROCEDURE SUPPORT (70 MIN)

3 Present the design challenge of the lab.

- Before students begin the procedure, remind them that they will be designing a simple battery that will store energy. Their challenge is to design the system so it releases a maximum amount of energy. As in Activity 4, students will manipulate variables and measure the output voltage. Ask, What variables do you think will impact the amount of energy that can be stored and released? Students may offer many different variables in the setup but let them know that they will be testing two important ones: the height and mass of the cart.
- Compare the two design labs: In the case of Activity 4, the energy was generated by the turning turbine blades, whereas this model releases energy that was previously stored when it moves downhill. Make the distinction between Activity 4 where energy was generated and this one where energy is being stored and released. Both instances depend on a series of energy transformations. Energy is conserved in both instances.
- Let students know that they will be able to use facts they learn about energy storage in this activity to inform a decision about what is the best storage option for Vanwick from the perspective of one of the stakeholders.

4 During the procedure, use a diagram to identify the energy transformations in the gravity battery.

- If you constructed a demonstration model, share it with students and/or review the materials and the setup diagram in Procedure Step 2. Provide any special instructions you have regarding the setup and materials.
- In Procedure Steps 4 and 6, use Visual Aid 6.1a–b, "Gravity Battery: Energy Diagrams," to identify the energy transformations with students. The blank version, Visual Aid 6.1a is provided, in addition to the labeled one, Visual Aid 6.b, so you may work together as a class to complete it. Or you can provide a copy for students who may struggle to draw the diagram.
- Consider using the *Description of diagram* prompt under each diagram to assess a student's understanding of the science concepts. Alternatively, work on this description as a class.
- When modeling how the gravity battery works, make sure students understand that the location of the cart is at the top of the ramp when the energy has been stored and that energy is being released (i.e., electricity generated) when the cart is rolling down the ramp.
- Ask students to put the model into a real-life context. Ask, If this was scaled up and used in real life, where do you think that energy to move the mass uphill would come from? Students should be able to envision a large-scale version of the model where the energy for the uphill portion of the train comes from the electric grid. This could include nearby wind turbines or solar panels.

5 Students practice recording the gravity-battery data, using the voltmeter.

- In Procedure Steps 7–9, students test the gravity-battery system and practice video recording the voltmeter. If necessary, provide instructions on how to properly set up and read the voltmeter and record it in slow motion (see Teacher Background Information). If students are not able to record the voltmeter, then designate one student in each group whose job is to specifically watch the voltmeter during the trial.

Sample Student Response, Procedure Step 8

GRAVITY-BATTERY DATA

TRIAL	MAXIMUM VOLTAGE (V)
1	*1.30 V*
2	*1.71 V*
3	*1.30 V*
average	*1.63 V*

- Once students have gathered their data and found the average maximum voltage, ask, Why is getting the average of the voltages better than using one reading? Depending on student background, answers will vary. Most students will recognize that averaging multiple trials can balance out the variability they saw over the trials. Taking an average of several trials gives a more accurate result.

TEACHER'S NOTE: If students have completed the previous unit on correlation, Evidence & Correlation, they may recognize the importance of averaging data. Connect the ideas from this activity to the one in the previous unit where averaging across more data is used to reduce random error.

6 Challenge groups to design the gravity battery to produce the highest voltage.

- In Part B of the activity, students maximize the amount of voltage produced by their models by experimenting with the cart mass and ramp height. Remind students that they did something similar in Activity 4 with investigating the variables that increased the voltage output of the model wind turbine. Review the concept of a variable and how it is important to change only one variable at a time when you are conducting an experiment. Isolating one variable at a time allows you to better see how changes in your design affect the results.

- Distribute Student Sheet 6.1, "Design Testing Data: Gravity Battery," for students to record their data and average the voltages from their trials. Provide the second page of the student sheet to those students who perform more than three design iterations. Students may find that there is more than one configuration of mass and height that gives similar results. This makes sense since gravitational potential energy is directly proportional to both mass and height. A Sample Student Response is found at the end of this activity and includes a variety of combinations.

- As with Activity 4, a negative voltage does not have meaning for this laboratory. It indicates how the voltmeter is connected. If the peak voltage change is negative, switch the two wires on the voltmeter or tell students to ignore it.
- At the end of Part B, collect and discuss the lab results as a whole class. Consider writing the class data on the board for further discussion and comparing results. Ask groups to share their max voltage, mass, and heights. Students' data should show that changing either mass or height will increase the output. Due to friction on the ramp, it is likely that they saw a bigger effect with height.
- Based on what they learned from the model, ask, What characteristics would a real-life gravity battery for Vanwick have? Students should infer that it would need a fair amount of space to build carts and tracks. It would need to have much more height and much more mass based on how little voltage their model released. The hill should not be so tall or steep that the carts roll out of control at the bottom. Since it would be hard to change the height, perhaps there would be some way that the mass could be changed.

7 Guide student research on various kinds of energy storage.

- In Part C, students investigate different battery technologies in addition to the one they experimented with in Parts A and B. Each student investigates one of the technologies and reports to the larger group. If you prefer to increase access for students during the research, use a "jigsaw" approach. Have students investigate one topic with their group and then reassemble the groups so each member goes to a different group to provide expertise on their group's research.
- In Procedure Step 16, the fourth technology shown in the table is left open for either you or students to choose. There are many types of energy storage for renewable systems to choose from. Systems that are simple to understand and explain the energy transformations include mechanical systems, such as compressed air and flywheel systems. There are also thermal batteries, hydrogen storage, and many kinds of electrochemical batteries. One interesting storage type you may want to offer is the emerging use of iron-air batteries.
- The following resources provide some examples of where the three provided methods are installed. Depending on your students' needs, it may be helpful to scaffold their research by providing the following references.

Rail-Energy Storage

- A New Kind of Renewable Energy Storage. *(YouTube)*
- Energy Storage Hits the Rails Out West. *(Scientific American)*
- The Train Goes Up, the Train Goes Down: A Simple New Way to Store Energy. *(Vox)*

Pumped Hydro Storage

- The Ludington plant features one of the "world's largest batteries." *(Detroit News)*
- Largest Pumped-Hydro Facility in World Turns on in China. *(CleanTechnica)*
- Pumped Storage Hydropower. *(United States Department of Energy)*

Large-Scale Lithium-Ion

- Creating Our Clean Energy Future—PG&E Commissions its Moss Landing Elkhorn Battery. *(Youtube)*
- Grid-Scale Battery Storage: Frequently Asked Questions. (*National Renewable Energy Laboratory)*
- Victorian Big Battery: Australia's Biggest Battery Storage System at 450MWh Is online. *(Energy Storage News)*

Other Types of Grid-Level Energy Storage

- Electricity Storage. *(United States Environmental Protection Agency)*
- Energy Storage in the UK, An Overview. *(Renewable Energy Association)*

- Remind students that they should use credible sources anytime they conduct web research. Review how to check for credible sources, using lateral reading and checking for expertise. You may wish to revisit Visual Aid 2.2, "Evaluating Online Information," with students. If you are showing the videos listed, consider using them to model the process again.
- Be clear about the expectations for the level of research for your students. This can vary depending on the abilities and interests of your students. In Build Understanding item 1, students are provided with facts about storage disadvantages in case they did not discover them during the procedure.
- Support students, particularly emerging multilingual learners, in sensemaking and language acquisition by adding terms to the word wall. For this activity, add the terms that relate to the science content such as *energy transformation, kinetic energy* and *potential energy* (if they weren't added in Activity 4), *energy storage,* and *grid sharing.* Provide additional examples for each term as needed.

SYNTHESIS (30 MIN)

8 Lead a discussion about the trade-offs of different storage options.

- Have groups share the advantages and disadvantages for each storage option discussed in their groups. When students choose a storage system on behalf of Vanwick residents in Procedure Step 17, it will help them identify the advantages and disadvantages of each choice.
- Review the concept of trade-offs introduced in the previous activity. Review the definition: when a desirable outcome is given up to gain another desired outcome.

- In Procedure Step 17, remind students of the most common values from the survey in Activity 3. Most likely these were retaining natural views, reducing greenhouse gas emissions, and maintaining jobs. Students need to make a decision based on those values and the relevant facts they found in the activity.

Sample Student Response, Procedure Step 17

Because the most common value for Vanwickians is maintaining views, my choice is the lithium-ion battery storage. This is because this storage system is the smallest one and can be put in many locations. It can be placed out of sight of the residents or easily screened by trees. The trade-off of this choice is that it gives up a low environmental impact compared to other choices. It has the disadvantage of involving a lot of mining for the natural resources for the batteries, which gives off a lot of greenhouse gases to mine and destroys the habitat.

9 Build Understanding item 1 can be assessed using the Decision-Making Scoring Guide.

- Remind students of the Decision-Making Scoring Guide. You may wish to project Visual Aid 6.1, "Scoring Guide: Decision-Making (DM)," for your students to review each level and clarify your expectations.
- Do not share the item-specific version of the Scoring Guide (Item-Specific Scoring Guide: Activity 6, Build Understanding item 1) with students as it provides specific information on how to respond to the question prompt.
- For students who need support organizing and writing their responses, you may wish to provide optional Student Sheet 6.2, "Writing Frame: Decision-Making," to compose their responses. Students could also use Student Sheet 6.2 only as a reference or as a checklist as they write their responses. A sample student response for this student sheet is shown at the end of this activity. For more information on a Writing Frame, see Appendix 1: Literacy Strategies.
- Remind students that you expect to see them demonstrate growth in their understanding and explanation of decision-making, and they may want to review their responses to the assessment in Activity 4 (Build Understanding item 1). Depending on your students, you may want to have them provide feedback on one another's work for revision prior to turning in the work to you for scoring. Alternatively, consider having students turn in a rough draft for feedback and revision.
- Sample responses for Levels 1–4 are provided in the Build Understanding section that follows. Review these responses to get an idea of what is expected for each level, alongside the Item-Specific Scoring Guide. See Appendix 2: Assessment Resource at the end of the Teacher's Guide for more guidance and information on using the Scoring Guides and assessment system with your students.

10 Relate the activity to scenario planning.

- Discuss Build Understanding item 3. Students are presented with uncertainty in the future about wind levels. Remind students that this question relates to what they did in the last activity when they imagined the future by using uncertain factors (in that case, wind levels). Ask students to apply what they learned in the last activity to the decisions they make now.
- You may wish to revisit Student Sheet 1.1, "Unit Concepts and Skills," to help students formally organize the ideas introduced in the unit so far. Students can add the headings of "Expertise" and/or "Scenario Planning" into the organizer and add examples from their classroom experiences in Activities 4–6. See the end of Activity 1 in the Teacher's Edition for a sample student response.
- Complete the activity by evaluating if your students are able to identify the essential ideas of the activity related to the key concepts and process skills. Emphasize that in this activity, the facts that students gained supported the decision-making they made from identified values.

SAMPLE STUDENT RESPONSES

BUILD UNDERSTANDING

① DM Assessment

Angelo Obrero is a resident of Vanwick. He supports Project REV because it supports one of his most important values: to preserve the natural world. When researching the storage systems, he learned that the different energy-storage systems have the following disadvantages:

- Building a pumped hydro-gravity system will flood an entire ecosystem, permanently changing it.
- Making chemical batteries takes a lot of energy and resource mining, which can cause significant environmental damage.
- A rail-energy gravity battery will take up some land that would otherwise remain in its natural state.

Review these facts and the ones you gathered in Part B about energy-storage systems and consider how they relate to Angelo's value. Based on this, which energy-storage system do you think Angelo would recommend to Vanwick's City Council to be included in Project REV? Explain your decision, including the following:

- relevant facts and stakeholder values and how they affected your decision
- predicted outcome(s) of your decision
- any trade-offs involved in your decision

Level 4 response

I think that Angelo will probably recommend the rail-energy gravity battery to the Vanwick City Council for Project REV. Even though the rail-gravity battery will take up some land, the pumped hydro-gravity system would flood an entire ecosystem and permanently change it. Making chemical batteries such as a lithium-battery system would require lots of energy and mining natural resources. Because the value of preserving the natural world is important to Angelo, I think he would choose the option that changes the natural world the least. Mining and flooding both change the environment significantly, so the rail battery is the best option, considering Angelo's value. If the City Council agrees with Angelo, the likely outcome is that they will use up some land for the rail-battery system but will be working toward fulfilling the goals of Project REV. An important trade-off is that there are not many rail-gravity systems built yet, so it's possible there will be problems with the system in the future because there might be challenges that aren't known yet. They would also be using land that would otherwise be left in its natural state.

Level 3 response

I think that Angelo will probably recommend the rail-energy gravity battery to the Vanwick City Council. Even though the rail-gravity battery will take up some land, the other systems do more damage to the land. Since Angelo values preserving the natural world, he would want to do less damage to it. If the City Council agrees with Angelo, a likely outcome will be some land use. One trade-off is that not many of these systems have been built yet.

Level 2 response

I think that Angelo will probably recommend the rail-energy gravity battery, because it doesn't damage the natural land too much. So, they would use some land, but that's a trade-off.

Level 1 response

I think that Angelo will recommend the rail-energy gravity battery. Batteries like this are always the best choice because they don't change the environment.

② **Imagine that, in the previous question, Angelo Obrero also has prioritized the value of not using a lot of land for the storage system. Does this additional value change your decision about what storage to recommend?**

These are conflicting values because taking up a small space would point to lithium storage, which conflicts with the value of preserving the environment. Would need to know priorities of the values, or the weighted values, to make a decision.

③ **Recent data has shown that wind patterns are changing in many regions on Earth, with some places experiencing "wind droughts," or periods of time with reduced wind speeds. By the year 2100, global wind speeds could fall by up to 10%. Given this possible future, what steps should Vanwick take now to ensure that it will be able to meet its power needs in the future?**

Vanwick needs to take into consideration that there is uncertainty about how much wind there will be in the future. If there is less wind in the future, as predicted, they could plan for that. They could use a different source other than wind power, or they could add extra turbines to make up for the drop in wind speed. Deciding to have extra generation and types of storage would be good planning for different possible futures.

CONNECTIONS TO EVERYDAY LIFE

④ **Your parents are deciding whether they should install solar panels at your home or buy a used electric vehicle. How would you advise them about how to make this decision?**

I need to know more about their values before deciding on what types of facts they would need to help them decide. Is cost the biggest factor? Do they care more about greenhouse gas emissions? After I know their values, I can help them compare how much emissions are saved with each option and how much each option costs to see which option fits better with their values.

⑤ **Your friend tells you that buying new clothes from a regular store uses less energy than buying used clothes from a thrift (secondhand) store. She cites that a popular environmental influencer posted online that new clothes are now made in a more energy-efficient way than they used to be.**

a **How would you find a credible source to support or refute your friend's claim?**

I would start by doing lateral reading to find out more about the environmental influencer she is citing. I could do a search and see what type of experience and education that person has, and if they have a reputation for posting biased information or untrustworthy information in the past.

b **What type of expert would you look for as a source to support or refute your friend's claim?**

I could look for experts related to sustainability or clothing production. There are probably scientists studying the environmental effects of clothing production, so I can see if they say the same things.

REFERENCES

Edrisian, A., Samani, H., Sharifan, A., & Naseh, M. (2013). The new hybrid model of compressed air for stable production of wind farms. *International Journal of Emerging Technology and Advanced Engineering*.*3*(11), 37–43. Retrieved from https://www.researchgate.net/publication/268074971_The_New_Hybrid_Model_of_Compressed_Air_for_Stable_Production_of_Wind_Farms

"GravityLine." (n.d.) ARES North America. Retrieved from https://aresnorthamerica.com/gravityline/

Robbins, J. (2022, September 13). Global 'stilling': Is climate change slowing down the wind? *Yale Environment 360*. Retrieved from https://e360.yale.edu/features/global-stilling-is-climate-change-slowing-the-worlds-wind

STUDENT SHEET 6.1 | **DESIGN TESTING DATA: GRAVITY BATTERY** | **NAME**

DESIGN ITERATION NUMBER ______

TRIAL	MASS (g), CART + LOAD	HEIGHT (cm)	VOLTAGE (V)	OBSERVATIONS
1				
2				
3				
Average				

DESIGN ITERATION NUMBER ______

TRIAL	MASS (g), CART + LOAD	HEIGHT (cm)	VOLTAGE (V)	OBSERVATIONS
1				
2				
3				
Average				

DESIGN ITERATION NUMBER ______

TRIAL	MASS (g), CART + LOAD	HEIGHT (cm)	VOLTAGE (V)	OBSERVATIONS
1				
2				
3				
Average				

STUDENT SHEET 6.1	DESIGN TESTING DATA: GRAVITY BATTERY	NAME

CONTINUED

DESIGN ITERATION NUMBER ______

TRIAL	MASS (g), CART + LOAD	HEIGHT (cm)	VOLTAGE (V)	OBSERVATIONS
1				
2				
3				
Average				

DESIGN ITERATION NUMBER ______

TRIAL	MASS (g), CART + LOAD	HEIGHT (cm)	VOLTAGE (V)	OBSERVATIONS
1				
2				
3				
Average				

DESIGN ITERATION NUMBER ______

TRIAL	MASS (g), CART + LOAD	HEIGHT (cm)	VOLTAGE (V)	OBSERVATIONS
1				
2				
3				
Average				

DESIGN ITERATION NUMBER 1

TRIAL	MASS (g), CART + LOAD	HEIGHT (cm)	VOLTAGE (V)	OBSERVATIONS
1	54	19	1.30	Cart rolls slowly downhill.
2	54	19	1.71	
3	54	19	1.87	
Average			1.63	

DESIGN ITERATION NUMBER 2

TRIAL	MASS (g), CART + LOAD	HEIGHT (cm)	VOLTAGE (V)	OBSERVATIONS
1	108	19	2.55	Cart rolls a little faster than the last design.
2	108	19	2.27	
3	108	19	2.37	
Average			2.40	

DESIGN ITERATION NUMBER 3

TRIAL	MASS (g), CART + LOAD	HEIGHT (cm)	VOLTAGE (V)	OBSERVATIONS
1	201	19	2.85	Cart rolls the fastest yet.
2	201	19	2.86	
3	201	19	2.73	
Average			2.81	

CONTINUED

DESIGN ITERATION NUMBER 4

TRIAL	MASS (g), CART + LOAD	HEIGHT (cm)	VOLTAGE (V)	OBSERVATIONS
1	54	38	3.20	Cart rolls faster compared to same weight at 15 cm height.
2	54	38	2.39	
3	54	38	2.91	
Average			2.83	

DESIGN ITERATION NUMBER 5

TRIAL	MASS (g), CART + LOAD	HEIGHT (cm)	VOLTAGE (V)	OBSERVATIONS
1	108	38	3.56	Cart rolls even faster and jolts the string when it reaches the end.
2	108	38	3.64	
3	108	38	2.90	
Average			3.37	

DESIGN ITERATION NUMBER 6

TRIAL	MASS (g), CART + LOAD	HEIGHT (cm)	VOLTAGE (V)	OBSERVATIONS
1	201	38	3.51	Cart rolls the fastest, and the weights go flying unless you stop it at the end. Voltage was > 4V once!
2	201	38	4.23	
3	201	38	3.54	
Average			3.73	

I/we/they have decided

The value(s) that I/we/they are weighting most heavily is

One fact related to the value is

A second fact related to the value is

Together, these facts and values affect the decision because

The likely outcome of this decision is

(OPTIONAL) **The trade-offs of this decision were**

(OPTIONAL) **This decision involved compromising about**

I/we/they have decided

that Vanwick should not use only wind turbines.

The value(s) that I/we/they are weighting most heavily is

that Vanwick residents don't want to see or hear the renewable energy sources.

One fact related to the value is

that they need 63 wind turbines to get enough power.

A second fact related to the value is

that they have space to build this many if they build them near homes, the school, and the park.

Together, these facts and values affect the decision because

it means that they can't build all the wind turbines they would need without building them where people would see or hear them.

The likely outcome of this decision is

that they will need another source of renewable energy.

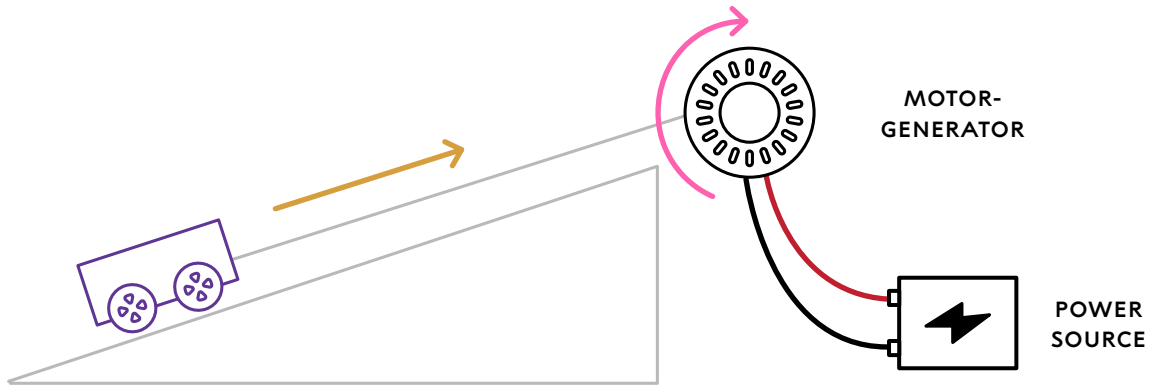
(OPTIONAL) **The trade-offs of this decision were**

N/A

(OPTIONAL) **This decision involved compromising about**

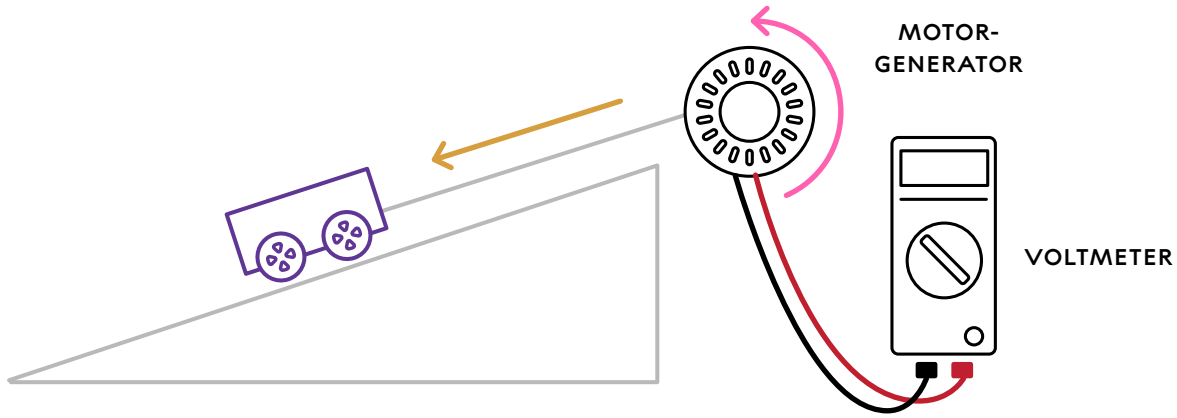
N/A

STORING ENERGY



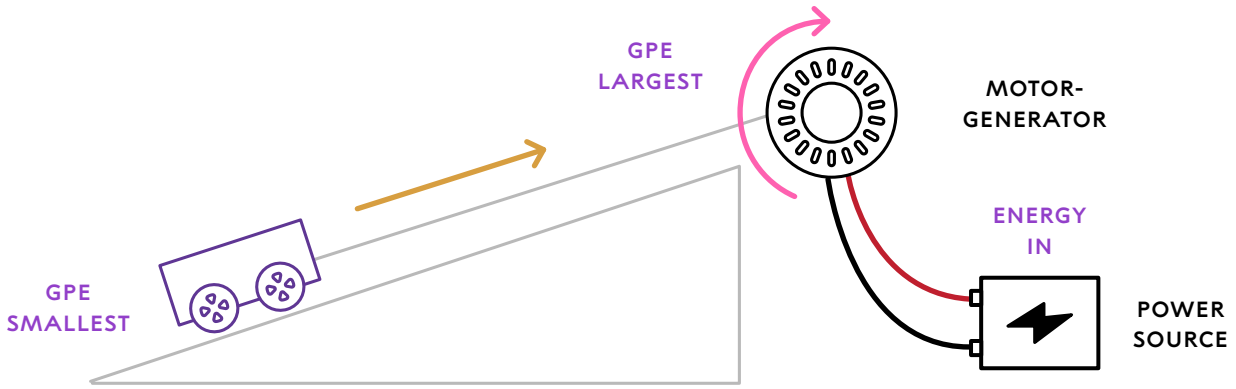
Description of Diagram

RELEASING ENERGY



Description of Diagram

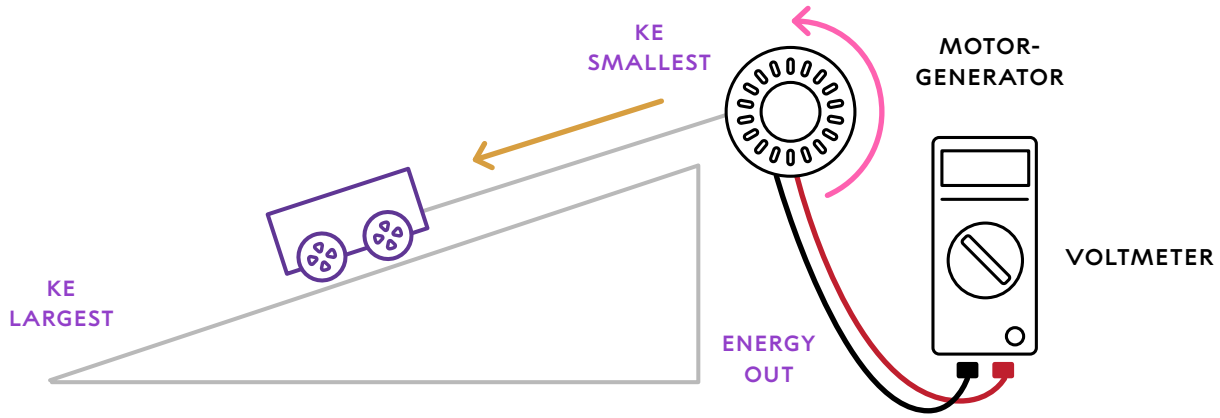
STORING ENERGY



Description of Diagram

The electrical energy from the battery transforms into kinetic energy when it turns the motor-generator hub. Lifting the cart up the hill transforms the kinetic energy into gravitational potential energy.

RELEASING ENERGY



Description of Diagram

The gravitational potential energy of the cart at the top of the hill is transformed into kinetic energy when it rolls downhill. The motor-generator hub transforms that energy of motion into electrical energy.

VISUAL AID 6.2 | SCORING GUIDE: DECISION-MAKING (DM)

WHEN TO USE THIS SCORING GUIDE:

This Scoring Guide is used when students are explaining a decision (sometimes in the form of a recommendation) that incorporates relevant facts and values and predicts possible outcomes.

WHAT TO LOOK FOR:

- Response incorporates and explains the effects of relevant facts and stakeholder values on the decision.
- Response identifies trade-offs (if appropriate).
- Response describes any compromises made (if appropriate).

LEVEL	GENERAL DESCRIPTION
Level 4 **Complete and correct**	The student explains a decision made from two or more options that incorporates: • one or more relevant stakeholder values. • the facts associated with those values. • how the facts and values affected the decision. • predicted outcome(s) supported by the relevant facts. • any trade-offs made as a result of weighing the relevant facts and values (if appropriate). • any compromise made by stakeholders (if appropriate).
Level 3 **Almost there**	The student explains a decision made from two or more options that incorporates most of the following, BUT one or more may be insufficiently described: • one or more relevant stakeholder values • the facts associated with those values • how the facts and values affected the decision • predicted outcome(s) supported by the relevant facts • any trade-offs made as a result of weighing the relevant facts and values (if appropriate) • any compromise made by stakeholders (if appropriate)

LEVEL	GENERAL DESCRIPTION
Level 2 **On the way**	The student provides a clear and relevant decision, BUT the explanation of supporting facts and values is incomplete.
Level 1 **Getting started**	The student provides a clear and relevant decision BUT provides inaccurate or unrelated facts, unrelated values, and/or an illogical explanation of the decision.
Level 0 **Missing or off task**	Student response is missing, illegible, or irrelevant.
X	The student had no opportunity to respond.

ITEM-SPECIFIC SCORING GUIDE | ACTIVITY 6, BUILD UNDERSTANDING ITEM 1

WHEN TO USE THIS SCORING GUIDE:

This Scoring Guide is used when students are explaining a decision (sometimes in the form of a recommendation) that incorporates relevant facts and values and predicts possible outcomes.

WHAT TO LOOK FOR:

- Response incorporates and explains the effects of relevant facts and stakeholder values on the decision.
- Response identifies trade-offs (if appropriate).
- Response describes any compromises made (if appropriate).

LEVEL	GENERAL DESCRIPTION	ITEM-SPECIFIC DESCRIPTION
Level 4 **Complete and correct**	The student explains a decision made from two or more options that incorporates: • one or more relevant stakeholder values. • the facts associated with those values. • how the facts and values affected the decision. • predicted outcome(s) supported by the relevant facts. • any trade-offs made as a result of weighing the relevant facts and values (if appropriate). • any compromise made by stakeholders (if appropriate).	**The student identifies which storage system would be recommended and explains their decision, incorporating the following:** • 2–3 relevant facts (gravity battery takes land, pumped hydro floods/permanently changes ecosystem, chemical batteries use energy/require mined resources) • stakeholder value of not wanting to change the natural world • why/how the chosen option addresses stakeholder values • 1–2 trade-off(s) based on chosen storage system • 1–2 outcome(s) based on chosen storage system **However, additional relevant facts, values, and outcomes may be considered.**

LEVEL	GENERAL DESCRIPTION	ITEM-SPECIFIC DESCRIPTION
Level 3 **Almost there**	The student explains a decision made from two or more options that incorporates most of the following, BUT one or more may be insufficiently described: • one or more relevant stakeholder values • the facts associated with those values • how the facts and values affected the decision • predicted outcome(s) supported by the relevant facts • any trade-offs made as a result of weighing the relevant facts and values (if appropriate) • any compromise made by stakeholders (if appropriate)	**The student identifies which storage system would be recommended and explains their decision, incorporating most of the following, BUT one or more may be insufficiently described:** • 2–3 relevant facts (gravity battery takes land, pumped hydro floods/permanently changes ecosystem, chemical batteries use energy/require mined resources) • stakeholder value of not wanting to change the natural world • why/how the chosen option addresses stakeholder values based on relevant facts • 1–2 trade-off(s) based on chosen storage system • 1–2 outcome(s) based on chosen storage system **However, additional relevant facts, values, outcomes, and trade-offs may be considered.**

LEVEL	GENERAL DESCRIPTION	ITEM-SPECIFIC DESCRIPTION
Level 2 **On the way**	The student provides a clear and relevant decision, BUT the explanation of supporting facts and values is incomplete.	The student identifies which storage system would be recommended, BUT the explanation of supporting facts and values is incomplete (e.g., only one fact, not including values, not stating possible outcomes).
Level 1 **Getting started**	The student provides a clear and relevant decision BUT provides inaccurate or unrelated facts, unrelated values, and/or an illogical explanation of the decision.	The student identifies which storage system would be recommended BUT provides inaccurate or unrelated facts, unrelated values, and/or an illogical explanation of the decision.
Level 0 **Missing or off task**	Student response is missing, illegible, or irrelevant.	
X	The student had no opportunity to respond.	

ACTIVITY 7

Building Initiative

COMPUTER APP

ACTIVITY 7

Building Initiative

ACTIVITY SUMMARY

Students make a recommendation about which initiative related to buildings should be adopted in Vanwick. The decision supports the efforts of Project REV by reducing greenhouse gas emissions. Students make the decision based on weighing facts and values with a computer app. They evaluate three different proposals to evaluate how well each option fulfills the values of the City Council and then make a recommendation.

ACTIVITY TYPE
COMPUTER APP

NUMBER OF
40–50 MINUTE
CLASS PERIODS
1–2

KEY CONCEPTS & PROCESS SKILLS

1. Facts support informed decision-making by leading to more accurate predictions about the likely outcomes of different choices.
2. Values affect people's behaviors, opinions, and decisions. There can be disagreement within a community when people hold a variety of values.
3. Decision analysis is the process of breaking down a decision in a way that can help the decision-maker systematically consider elements related to a choice, such as facts and values.
4. Community decisions are more likely to be accepted if the values of all stakeholders, especially those who are underrepresented, are considered in the decision-making process.

NEXT GENERATION SCIENCE STANDARDS (NGSS) CONNECTION:
Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations. *(Science and Engineering Practice: Constructing Explanations and Designing Solutions)*

CONCEPTUAL TOOLS

WEAVING FACTS & VALUES IN DECISION-MAKING

GROUP DECISION-MAKING

VOCABULARY DEVELOPMENT

decision-analysis tool
a tool that systematically breaks down a decision by mathematically weighing the facts and values related to the decision

MATERIALS & ADVANCE PREPARATION

FOR THE TEACHER

- VISUAL AID, 7.1 "Read, Think, and Take Note Guidelines" (OPTIONAL)
- VISUAL AID 7.2 "Scoring Guide: Decision-Making (DM)" (OPTIONAL)
- ITEM-SPECIFIC SCORING GUIDE: Activity 6, Build Understanding item 1

FOR THE CLASS

- SURVEY RESULTS FROM ACTIVITY 3

FOR EACH GROUP OF FOUR STUDENTS

- BUILDING INITIATIVE FACT SHEETS (A–D)

FOR EACH PAIR OF STUDENTS

- COMPUTER WITH INTERNET ACCESS

FOR EACH STUDENT

- STUDENT SHEET 7.1 "Building Initiative Information"
- STUDENT SHEET 7.2 "Writing Frame: Decision-Making" (OPTIONAL)
- STUDENT SHEET 7.3 "Decision-Analysis Tool: Manual Calculation" (OPTIONAL)
- SCORING GUIDE: Decision-Making (DM) (OPTIONAL)

If you do not have computer accessibility, you can create a printed version of this activity by printing the optional Student Sheet 7.3, "Decision-Analysis Tool: Manual Calculation." Read through the student and teacher instructions to further determine how to modify the activity for use offline with your students.

TEACHING NOTES

Suggestions for **discussion questions** are highlighted in gold.

Strategies for the **equitable inclusion of diverse students** are highlighted in pink.

GETTING STARTED (10 MIN)

1 **Brainstorm day-to-day experiences that are related to greenhouse gas emissions.**

- Before students open their Student Books to the activity, revisit the primary goals of Project REV with the class: *reduce harmful greenhouse gas emissions.* Until now, students have been focused on electricity generation and distribution as a major solution to the problem. Ask, What other activities contribute to greenhouse gases other than electrical energy generation? Expect students to identify transportation and energy to make products.

- Have students read the introduction and review the other areas of significant greenhouse gas emissions identified in the first paragraph. Together, brainstorm examples of how they are part of everyday life.
  - Goods and services: everything bought and used in the built world, includes industrial processes to make those goods
  - Transportation: cars, trucks, trains, buses, planes
  - Buildings and construction: original construction (related to goods and services) and running the building with lights, heat, devices, etc.
  - Agricultural practices: deforestation, cattle farming, monocultures, etc.

- With students, compare their responses to the Global Greenhouse Gas Emissions by Sector diagram in the Student Book. Help students translate the sectors into their everyday experiences and activities. Students may notice that the building emissions quoted in the introduction are higher than in the "Energy use in buildings" section of the diagram. Challenge them to figure out why that is the case. It is because the estimate in the introduction includes large portions of other sectors, such as unallocated fuel combustion, iron and steel production, cement, transportation, petrochemical manufacturing, etc.

  TEACHER'S NOTE: For a detailed description of each sector, see References for the webpage where the chart appears.

- Ask, What does the diagram say about the role of energy in greenhouse gas emissions? Students should be able to see that energy-related activities make up almost three-fourths of all greenhouse gas emissions.

- Recall that the stakeholder @GrannySmithJr in Activity 2 posted about how greenhouse gas emissions from buildings were very high (which was subsequently found to be credible in the activity). @GrannySmithJr wanted to address that problem before developing renewable energy generation. Point out that with enough money to do both, these initiatives could work together.
- Let students know that in this activity, they will make a decision from the perspective of the City Council. They will make a recommendation on the City Council's behalf.

PROCEDURE SUPPORT (40 MIN)

2 Introduce the scenario for the building initiatives.

- As students read the scenario in their Student Books, let them know that this activity does not deal with generation as in the previous activities; however, it explores another way to reduce greenhouse gas emissions. This is only one of several approaches that can support Project REV. Others could include grid upgrades, reusing discarded materials, or reducing greenhouse gas emissions in transportation. This activity exemplifies that greenhouse gas emission reductions can be reduced in many ways. These reductions can be implemented concurrently with the development of renewable energy generation.
- Distribute the Building Initiative Fact Sheets A–D. Provide each group with all four sheets. Have students read all four initiatives and answer any questions related to the initiatives.
- Support students' reading comprehension as they read the Building Initiative Fact Sheets with the literacy strategy of Read, Think, and Take Note. This provides an opportunity for students to record their thoughts, reactions, and questions on sticky notes as they read. The notes serve to make concrete the thoughts arising in their minds and then serve as prompts to generate conversation or write explanations. You can use Visual Aid 7.1, "Read, Think, and Take Note Guidelines," to review this literacy strategy. If your students are unfamiliar with the strategy, it can be helpful to demonstrate with a short passage of simple text, such as the introduction to the activity. For more information about the Read, Think and Take Note strategy, see Appendix 1: Literacy Strategies.

3 Familiarize students with using the Decision-Analysis Tool computer app.

- Before beginning the procedure, introduce the online Decision-Analysis Tool as a thinking tool that can help to weigh facts and values related to a decision when choosing between options. Emphasize that this digital app is a concrete tool that supports decision analysis.
- Review the concept of weighted values introduced earlier in this unit (in Activity 3). Recall how students used points to prioritize a list of values. Students will have to weight values numerically to use the app.

- Introduce the idea of using a fact to evaluate an option, which is done in the bottom part of the app. To illustrate this, provide a simple example: Imagine someone deciding on a snack who has the value of eating nutritious food. The nutritional facts of each snack option shows that a bowl of vegetable chili fulfills the value of nutrition better than the cake. In the app, there is a scale of 0 (the value is not fulfilled at all) to 4 (the value is completely fulfilled). If the app was used to inform the decision for the snack, the cake option might have a rating of 0, and the vegetable chili option a rating of 4.

- Model how to work the app with a simple example to illustrate the principles of weighting the facts and values:

  - Imagine your school club is trying to decide what kind of food to sell at your club's end-of-year fundraiser. You are choosing between candy, muffins, or sandwiches.

  - First, you send out a survey to members of the club (stakeholders) and gather their values. You learn that 40% think that cost is the most important, 35% said the food's popularity was most important, and 25% said ease of transporting was the most important.

  - After putting this information into the app, you need to find out some facts about these three options. These facts can be summarized as follows:

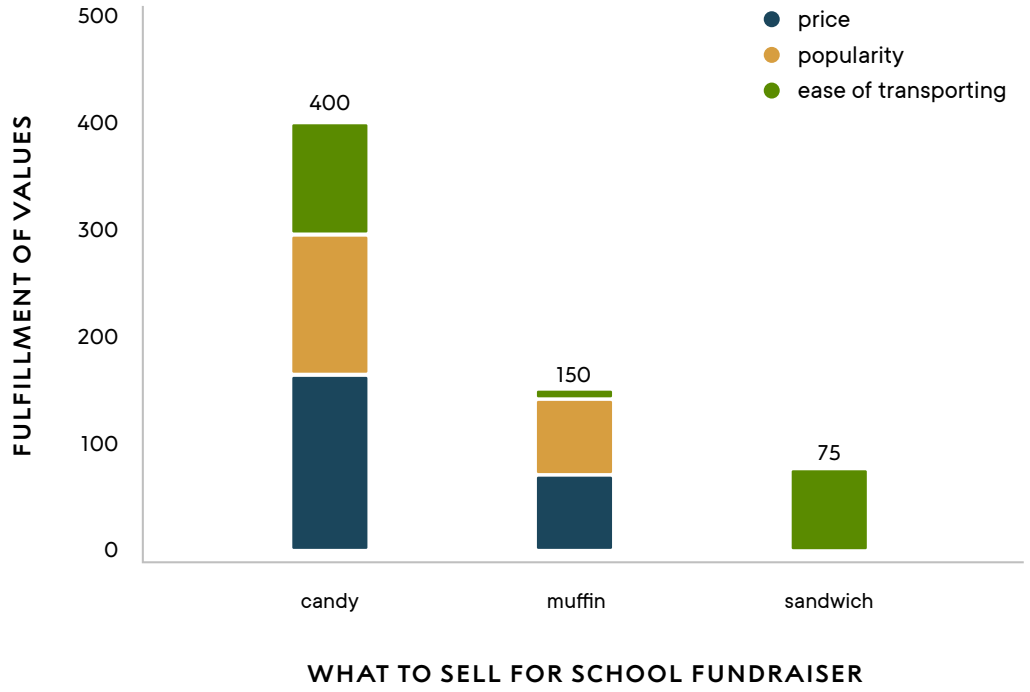
    OPTION 1
    Candy is the least expensive, the most popular, and the easiest to transport.

    OPTION 2
    Muffins are in between the other two in price and popularity, and it is the least easy to transport due to its squishability.

    OPTION 3
    Sandwiches are the most expensive, the least popular, and in between the other two for ease of transporting.

  - Entering these facts and values together in the app shows that the candy is the best choice according to the app, as shown in Figure 7.1 on the following page.

FIGURE 7.1
Decision-Analysis Tool Screenshot



- Discuss with students how the answer would change if the values were different—for example, if nutrition was one of the top values.
- It is important to remind students that the app provides advice but does not make the decision. If students were running the fundraiser, it would be okay to realize that perhaps there were other values not accounted for. They could either run the app again after adjusting the values or reflect on how the app informs the decision.
- Ask, How does the Decision-Analysis Tool integrate the facts and values? If students can't quite figure it out, let them know that it integrates the facts and values by assessing how well each option fulfills a given value based on the facts related to that option. The app takes into account the value weights and option ratings for each option, adds up all (value weight x option rating) for each option, and then displays it on the graph. This allows for a direct comparison of all options.

4 Support students as they use the Decision-Analysis Tool to decide on a building initiative.

- As students begin the procedure, distribute Student Sheet 7.1, "Building Initiative Information." Filling in the tables will help students understand the information they need to input into the app.
- If students do not have individual Internet access and are calculating the results from the Decision-Analysis Tool manually, explain how to use the following formulas. This calculation is supported by optional Student Sheet 7.3, "Decision-Analysis Tool: Manual Calculation."

Value 1 Decision Score = (Value 1 weight x option rating 1)
+ (Value 1 weight x option rating 2)
+ (Value 1 weight x option rating 3)
+... continue

Likewise, the Decision Scores for the other values are:

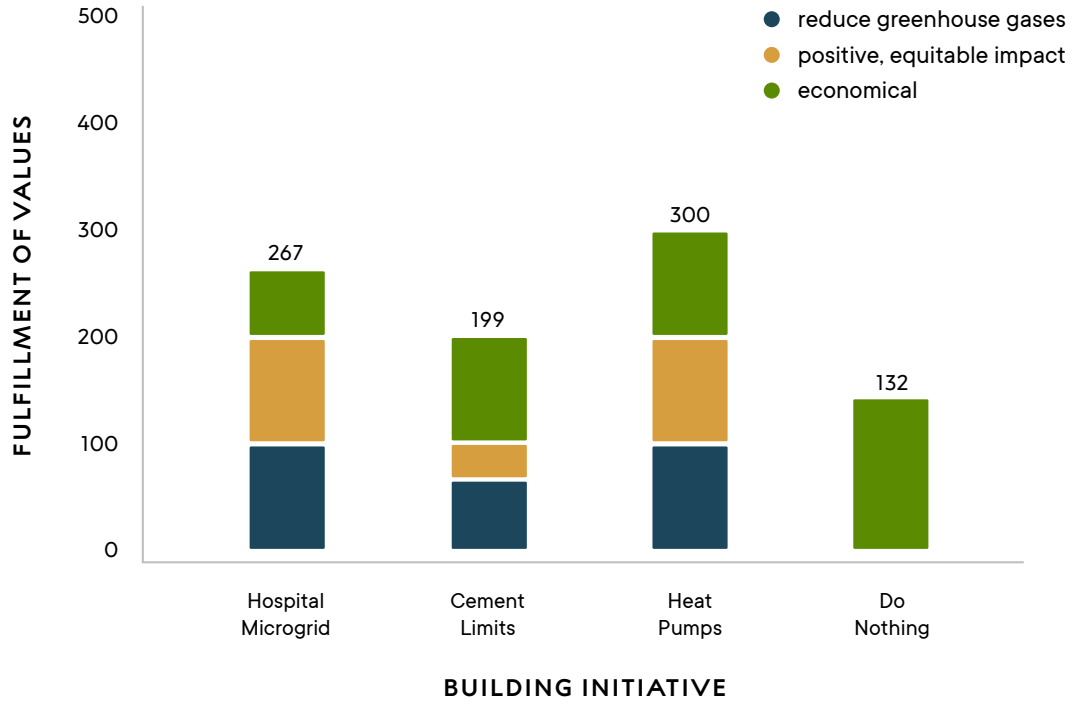
Value 2 Decision Score = (Value 2 weight x option rating 1)
+ (Value 2 weight x option rating 2)
+ (Value 2 weight x option rating 3)
+... continue

and

Value 3 Decision Score = (Value 3 weight x option rating 4)
+ (Value 3 weight x option rating 5)
+ (Value 3 weight x option rating 3)
+... continue

- When students run the Decision-Analysis Tool, they will get a variety of responses based on how they rate the facts. Initiative A: Microgrids and Initiative C: Heat Pumps usually come out with the highest values in the app. Figure 7.2 on the following page shows one sample response.

FIGURE 7.2
Sample Student Response, Procedure Step 6



- In Procedure Step 9, encourage students to be clear in their one-sentence recommendations. Responses will vary. The following shows one sample response.

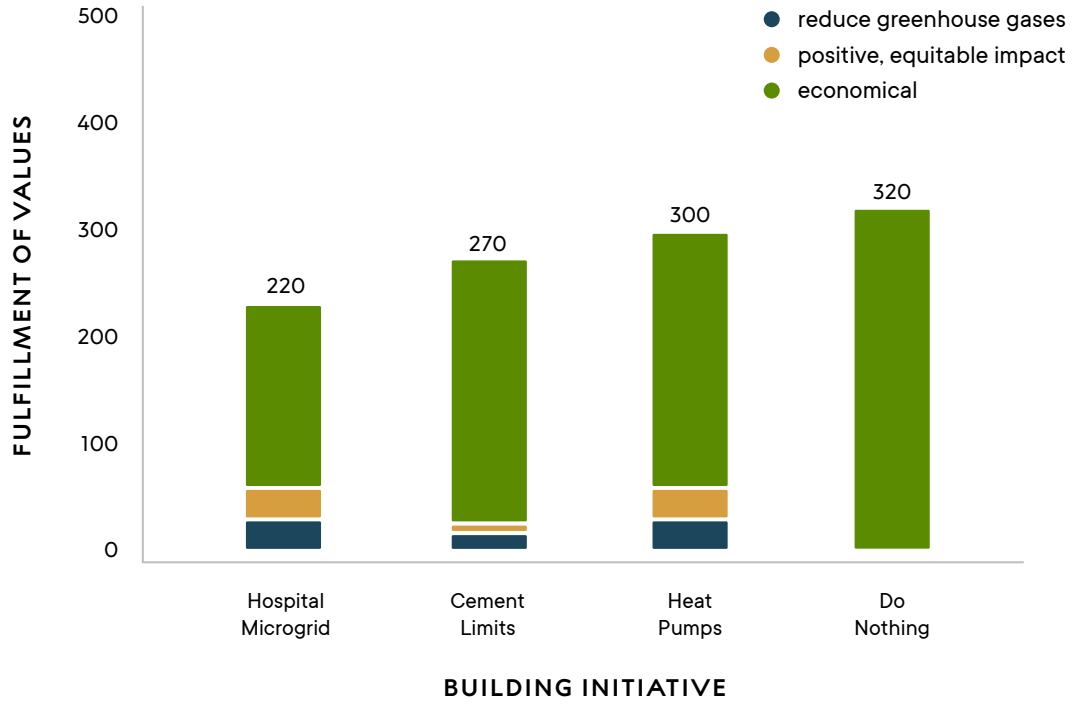
Sample Student Response, Procedure Step 9

The Vanwick City Council announces that it supports Building Initiative C: Heat Pumps! This program will help reduce greenhouse gases, positively impact lots of people in the city, and will be cost-effective compared to other plans.

5 Support students in seeing how values impact decisions.

- In Procedure Steps 11–12, students should first predict and then find that the heavily weighted economic value changes the decision. App responses will vary, but most often the numbers favor Initiative D: Do Nothing, as shown in Figure 7.3 on the following page.

FIGURE 7.3
Sample Student Response, Procedure Steps 11-12



- Through this exercise, students should see clearly that different decisions can be made using the same facts, even when the values are different. One option would help accomplish the Project REV goal of reducing emissions, and the other would not. This also reinforces the role of weighted values introduced in Activity 3.
- If time allows, let students move the three value sliders to show different weights and compare the results.

SYNTHESIS OF IDEAS (20 MIN)

6 Reflect on the process of group decision-making.

- Elicit student ideas about what kind of decisions the Decision-Analysis Tool would be most helpful for and where it has limitations. Students should see, through their experiences, that complicated decisions with multiple choices benefit the most from being broken down into components. Likewise, the app does not capture all the complexities of a decision. There could be missing facts or ideas that are not quantitative that are overlooked. Emphasize again that the tool is for informed consideration, and the highest score from the app does not mandate that decision.
- When finishing the activity, discuss whose ideas were left out of the decision and why they were overlooked. If the values were not weighted highly enough to show up on the survey summary, their values were not included in the app. Ask, If you know some people's values are overlooked, what could you do about it? Responses will vary but some ideas may include adding more values to the app, seeking out what the overlooked values are, giving another survey, or using the app as only part of the decision-making process. Use this discussion to emphasize the important role of values in a complex group decision.

7 Use the Decision-Making Scoring Guide to assess responses to Build Understanding item 1.

- Remind students of the Decision-Making Scoring Guide. You may wish to project a copy of Scoring Guide: Decision-Making (DM) for your students to review each level and clarify your expectations.
- Do not share Item-Specific Scoring Guide: Activity 7, Build Understanding item 1 with students as it provides specific information on how to respond to the question prompt.
- For students who need support organizing and writing their responses, you may wish to provide optional Student Sheet 7.2, "Writing Frame: Decision-Making" to compose their response. Students could also use Student Sheet 7.2 only as a reference or as a checklist as they write their responses. A sample student response for this student sheet is shown at the end of this activity. For more information on a Writing Frame, see Appendix 1: Literacy Strategies.

- Remind students that you expect to see them demonstrate growth in their understanding and explanation of decision-making, and they may want to review their responses to the assessment in Activity 4 (Build Understanding item 1) and/or Activity 6 (Build Understanding item 1). You may also want to let students know that they will have one more opportunity in the unit to be assessed (Activity 10, Build Understanding item 1).
- Depending on your students, you may want to have them provide feedback on one another's work for revision prior to turning in the work to you for scoring. Alternatively, consider having students turn in a rough draft to you for feedback and revision.
- Sample responses for Levels 1–4 are provided in the Build Understanding section that follows. Review these responses to get an idea of what is expected for each level, alongside the Item-Specific Scoring Guide. See Appendix 2: Assessment Resource for more guidance and information on using the Scoring Guides and assessment system with your students.
- Conclude the activity by revisiting the Guiding Question, How can a decision-analysis tool help make group decisions? Use student responses to evaluate if your students are able to identify the essential ideas of the activity.

EXTENSION (10 MIN)

8 **Use the Extension as an opportunity for advanced learning.**

Students can connect the scenario to the issues being decided in their own community. If they are not familiar with an energy decision the town is facing—such as things related to development projects, redistricting, or what to cut when facing a budget deficit—have them speak with their parents or look at a government-sponsored website for information. In most cases, the app could be helpful to bring people together to look for a solution that would satisfy the greatest number of people.

SAMPLE STUDENT RESPONSES

BUILD UNDERSTANDING

① DM Scoring Guide

Consider the initiatives proposed in this activity. If you were a resident of Vanwick making a recommendation for the City Council on Initiatives A–D, which initiative would you recommend? Explain your decision and include the following:

- the relevant facts and stakeholder values and how they affected your decision
- the predicted outcome(s) of your decision
- any trade-offs involved in your decision

The sample responses that follow recommend Initiative C: Heat Pumps, but this does not indicate that C is the correct choice. The response should be assessed based on the student's support of their recommendation with relevant facts and values, predicted outcomes, and inclusion of trade-offs.

Level 4 response

If I were a resident of Vanwick, I would recommend the Vanwick Heat Pump initiative (Initiative C) because I think it is the best choice when all the facts, values, and trade-offs are considered. Heat pumps do not produce greenhouse gases as long as they are run off of electricity from renewable energy sources. They are more efficient than older heating and cooling systems, so they use less energy. These facts support the stakeholder values of reducing overall greenhouse gas emissions and being cost-effective. There is the trade-off of producing some greenhouse gases in making and installing the heat pumps, but long term, there will be an overall reduction of greenhouse gases. Also, city buildings—including elementary schools, the library, and the firehouse—will have air conditioning, and there will be a cooling center at the library for people to use during future heat waves. Overall, this initiative works well with stakeholder values and is the best choice for Vanwick.

Level 3 response

If I were a resident of Vanwick, I would recommend the Heat Pump initiative. Heat pumps do not produce greenhouse gases and are more efficient than older heating systems. These facts support the stakeholder value of reducing greenhouse gas emissions. Installing heat pumps will mean more efficient use of energy and provide air conditioning in some buildings and a cooling center. The trade-off is that there are some emissions produced in making the heat pumps.

Level 2 response

If I were a resident of Vanwick, I would recommend the Heat Pump initiative. They don't produce greenhouse gases, and that's a stakeholder value. There will also be cooling centers.

Level 1 response

I would recommend the Heat Pump initiative because it is the best choice. It will be expensive and still produce some greenhouse gases. It also might be difficult for builders.

② **What factors might lead you to make a group decision that is different from the numerical result from the Decision-Analysis Tool?**

Answers can vary. One sample response is shown here.

Using the number is really helpful, but the app is supposed to inform the decision and not necessarily make the decision. For example, there could be a situation where an important population in Vanwick was not included in the survey. They might hold a minority value that was not represented in the app, but an important one, so that should be considered in the final decision.

CONNECTIONS TO EVERYDAY LIFE

③ **Think about a significant decision that you must make in the near future. Use the Decision-Analysis Tool to evaluate your choices. Did the results of the Decision-Analysis Tool help you make the decision? Explain why or why not.**

The Decision-Analysis Tool said I should definitely get a job at a coffee shop. It helped me because it was not the same decision I arrived at when I was breaking it down in my head. It was good to think about it more before deciding.

REFERENCES

2022 Global Status Report for Buildings and Construction. (November 9, 2022). United Nations Environment Programme. Retrieved from https://www.unep.org/resources/publication/2022-global-status-report-buildings-and-construction

Ritchie, H. (2020). Sector by sector: Where do global greenhouse gas emissions come from? Our World in Data. Retrieved from: https://ourworldindata.org/ghg-emissions-by-sector

STUDENT SHEET 7.1	BUILDING INITIATIVE INFORMATION	NAME

TABLE 1: VALUES

STAKEHOLDER VALUE	DESCRIPTION	WEIGHT
1		
2		
3		
TOTAL		

TABLE 2: EVALUATING FACTS

OPTIONS	VALUE 1		VALUE 2		VALUE 3	
	FACTS	RATING	FACTS	RATING	FACTS	RATING
A: Hospital Microgrid						
B: Cement Limits						
C: Heat Pumps						
D: Do Nothing						

TABLE 1: VALUES

STAKEHOLDER VALUE	DESCRIPTION	WEIGHT
1	*reduce greenhouse gas emissions*	*33*
2	*positive, equitable impact on residents*	*34*
3	*cost-effective*	*33*
TOTAL		*100*

TABLE 2: EVALUATING FACTS

OPTIONS	VALUE 1		VALUE 2		VALUE 3	
	FACTS	RATING	FACTS	RATING	FACTS	RATING
A: Hospital Microgrid	*good, except for building*	*3*	*supports vulnerable, but not everyone*	*3*	*most expensive, but eventually bills are $0*	*2*
B: Cement Limits	*most are elsewhere, small amount*	*2*	*difficult for builders*	*1*	*relatively low cost*	*3*
C: Heat Pumps	*makes a difference*	*3*	*city-only buildings*	*3*	*2nd most expensive, have to keep paying for electricity*	*3*
D: Do Nothing	*emissions keep increasing*	*0*	*doesn't help anyone*	*0*	*no cost*	*4*

I/we/they have decided

The value(s) that I/we/they are weighting most heavily is

One fact related to the value is

A second fact related to the value is

Together, these facts and values affect the decision because

The likely outcome of this decision is

(OPTIONAL) **The trade-offs of this decision were**

(OPTIONAL) **This decision involved compromising about**

I/we/they have decided

that Vanwick should choose the Vanwick Heat Pump Initiative.

The value(s) that I/we/they are weighting most heavily is

of reducing overall greenhouse gas emissions and being cost-effective.

One fact related to the value is

that heat pumps do not produce greenhouse gases if they are powered by renewable energy.

A second fact related to the value is

that they cost less to run because they are more efficient than older heating and cooling systems.

Together, these facts and values affect the decision because

it means that the choice of the Heat Pump Iniative can fulfill both of the city's values.

The likely outcome of this decision is

that the energy costs will be reduced and the city buildings will have air conditioning. There will be a cooling center at the library for people to use during a heat wave.

(OPTIONAL) **The trade-offs of this decision were**

that greenhouse gases are produced when making and installing the heat pumps, so the emissions savings are not immediate.

(OPTIONAL) **This decision involved compromising about**

N/A

DECISION-ANALYSIS TOOL: MANUAL CALCULATION

NAME

Add Option | Subtract Option | Add Value | Subtract Value

What are you deciding?	OPTION 1	OPTION 2	OPTION 3	OPTION 4
Building Initiative	Hospital Microgrid	Cement Limits	Heat Pumps	Do Nothing

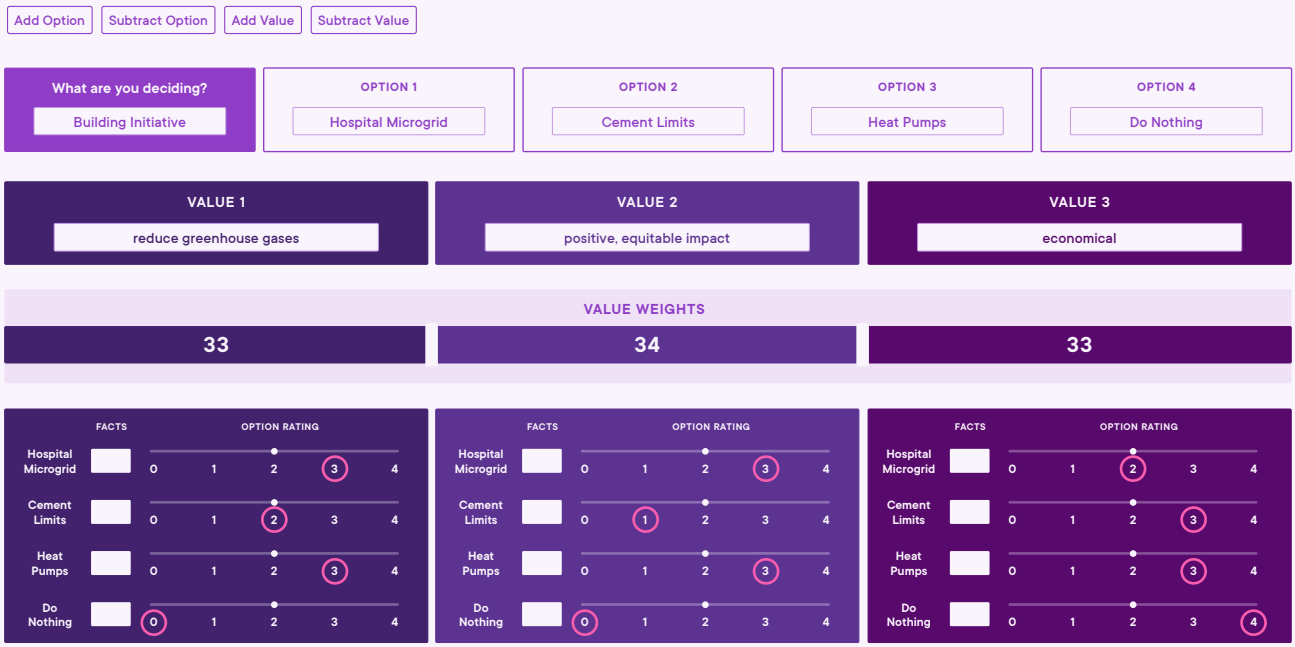
VALUE 1	VALUE 2	VALUE 3
reduce greenhouse gases	positive, equitable impact	economical

VALUE WEIGHTS

33	34	33

FACTS	OPTION RATING	FACTS	OPTION RATING	FACTS	OPTION RATING
Hospital Microgrid	0 1 2 3 4	Hospital Microgrid	0 1 2 3 4	Hospital Microgrid	0 1 2 3 4
Cement Limits	0 1 2 3 4	Cement Limits	0 1 2 3 4	Cement Limits	0 1 2 3 4
Heat Pumps	0 1 2 3 4	Heat Pumps	0 1 2 3 4	Heat Pumps	0 1 2 3 4
Do Nothing	0 1 2 3 4	Do Nothing	0 1 2 3 4	Do Nothing	0 1 2 3 4

	WEIGHT x OPTION RATING			
	VALUE 1	VALUE 2	VALUE 3	
OPTION	_____ _____	_____ _____	_____ _____	TOTAL
1				
2				
3				
4				



OPTION	WEIGHT x OPTION RATING			TOTAL
	VALUE 1 *reduce greenhouse gases*	VALUE 2 *positive, equitable impact*	VALUE 3 *cost-effective*	
1	*33 x 3 = 99*	*34 x 3 = 102*	*33 x 2 = 66*	*267*
2	*33 x 2 = 66*	*34 x 1 = 34*	*33 x 3 = 99*	*199*
3	*33 x 3 = 99*	*34 x 3 = 102*	*33 x 3 = 99*	*300*
4	*33 x 0 = 0*	*34 x 0 = 0*	*33 x 4 = 132*	*132*

Read, Think, and Take Note Guidelines

Stop at least three times during each section of the reading to mark on a sticky note your thoughts or questions about the reading.

As you read, use a sticky note from time to time to:

- explain a thought or reaction to something you read.
- note something in the reading that is confusing or unfamiliar.
- list a word from the reading that you do not know.
- describe a connection to something you've learned or read previously.
- make a statement about the reading.
- pose a question about the reading.
- draw a diagram or picture of an idea or connection.

After writing a thought or question on a sticky note, place it next to the word, phrase, sentence, diagram, drawing, or paragraph in the reading that prompted your note.

After reading, discuss with your partner the thoughts and questions you had while reading.

VISUAL AID 7.2 | SCORING GUIDE: DECISION-MAKING (DM)

WHEN TO USE THIS SCORING GUIDE:

This Scoring Guide is used when students are explaining a decision (sometimes in the form of a recommendation) that incorporates relevant facts and values and predicts possible outcomes.

WHAT TO LOOK FOR:

- Response incorporates and explains the effects of relevant facts and stakeholder values on the decision.
- Response identifies trade-offs (if appropriate).
- Response describes any compromises made (if appropriate).

LEVEL	GENERAL DESCRIPTION
Level 4 **Complete and correct**	The student explains a decision made from two or more options that incorporates: • one or more relevant stakeholder values. • the facts associated with those values. • how the facts and values affected the decision. • predicted outcome(s) supported by the relevant facts. • pny trade-offs made as a result of weighing the relevant facts and values (if appropriate). • any compromise made by stakeholders (if appropriate).
Level 3 **Almost there**	The student explains a decision made from two or more options that incorporates most of the following, BUT one or more may be insufficiently described: • one or more relevant stakeholder values • the facts associated with those values • how the facts and values affected the decision • predicted outcome(s) supported by the relevant facts • any trade-offs made as a result of weighing the relevant facts and values (if appropriate) • any compromise made by stakeholders (if appropriate)

LEVEL	GENERAL DESCRIPTION
Level 2 **On the way**	The student provides a clear and relevant decision, BUT the explanation of supporting facts and values is incomplete.
Level 1 **Getting started**	The student provides a clear and relevant decision BUT provides inaccurate or unrelated facts, unrelated values, and/or an illogical explanation of the decision.
Level 0 **Missing or off task**	Student response is missing, illegible, or irrelevant.
X	The student had no opportunity to respond.

WHEN TO USE THIS SCORING GUIDE:

This Scoring Guide is used when students are explaining a decision (sometimes in the form of a recommendation) that incorporates relevant facts and values and predicts possible outcomes.

WHAT TO LOOK FOR:

- Response incorporates and explains the effects of relevant facts and stakeholder values on the decision.
- Response identifies trade-offs (if appropriate).
- Response describes any compromises made (if appropriate).

LEVEL	GENERAL DESCRIPTION	ITEM-SPECIFIC DESCRIPTION
Level 4 **Complete and correct**	The student explains a decision made from two or more options that incorporates: • one or more relevant stakeholder values. • the facts associated with those values. • how the facts and values affected the decision. • predicted outcome(s) supported by the relevant facts. • any trade-offs made as a result of weighing the relevant facts and values (if appropriate). • any compromise made by stakeholders (if appropriate).	**The student explains which initiative they would recommend to the City Council, incorporating the following:** • 2–3 relevant facts • relevant stakeholder values (such as reduce emissions, positive equitable access, cost-effective) • how facts support particular options • predicted outcomes • clear description of trade-off(s) **However, specific facts, values, outcomes, and trade-offs will vary depending on the initiative being recommended. There is no correct initiative choice.**

LEVEL	GENERAL DESCRIPTION	ITEM-SPECIFIC DESCRIPTION
Level 3 **Almost there**	The student explains a decision made from two or more options that incorporates most of the following, BUT one or more may be insufficiently described: • one or more relevant stakeholder values • the facts associated with those values • how the facts and values affected the decision • predicted outcome(s) supported by the relevant facts • any trade-offs made as a result of weighing the relevant facts and values (if appropriate) • any compromise made by stakeholders (if appropriate)	**The student explains which initiative they would recommend to the City Council, incorporating the following, BUT one or more may be insufficiently described:** • 2–3 relevant facts • relevant stakeholder values (such as reduce emissions, positive equitable access, cost-effective) • how facts support particular options • predicted outcomes • clear description of trade-off(s) **However, specific facts, values, outcomes, and trade-offs will vary depending on the initiative being recommended. There is no correct initiative choice.**

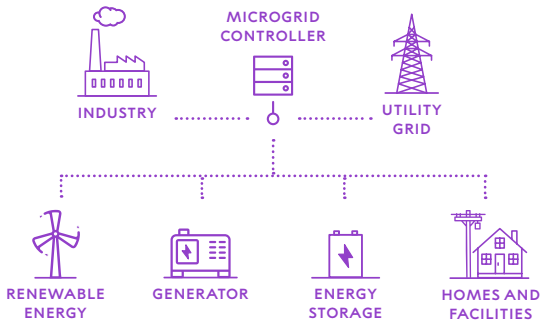
LEVEL	GENERAL DESCRIPTION	ITEM-SPECIFIC DESCRIPTION
Level 2 **On the way**	The student provides a clear and relevant decision, BUT the explanation of supporting facts and values is incomplete.	The student explains which initiative they would recommend to the City Council, but the explanation of supporting facts and values is incomplete (e.g., only one fact, not including values, not stating possible outcomes) and/or is missing trade-offs relevant to their plan.
Level 1 **Getting started**	The student provides a clear and relevant decision BUT provides inaccurate or unrelated facts, unrelated values, and/or an illogical explanation of the decision.	The student explains which initiative they would recommend to the City Council BUT provides inaccurate or unrelated facts, unrelated values, and/or an illogical explanation of the decision.
Level 0 **Missing or off task**	Student response is missing, illegible, or irrelevant.	
X	The student had no opportunity to respond.	

INITIATIVE A

VANWICK COMMUNITY HOSPITAL MICROGRID

BACKGROUND

A microgrid includes one or more energy sources (and a distribution system) located near the end user. It includes the energy generation, a smart grid-controlling system, energy storage, and connected electrical devices. Microgrids work primarily as an independent energy system, but some microgrids are still connected to the local grid so it can draw from it when more power is needed. If the microgrid has excess power, it can give it back to the grid for others to use.



DESCRIPTION

The Vanwick Community Hospital Microgrid Initiative plans to cut down greenhouse gas emissions by building a microgrid at the regional hospital campus. It will provide all the power for all the heating, cooling, lights, and medical devices that are needed for the hospital campus of 10 large buildings. It will depend on renewable generation through solar panels placed on the building roofs and parking garages and in a large field on campus. Less energy will be needed overall due to a complex control system that will respond to the changes in the electricity demand in the buildings and the supply coming in from the solar panels. While the microgrid will stay connected to the grid, a second backup in the form of a diesel generator will be included. This is for the very unlikely, but possible, future scenario in which electricity is completely cut off and medical services become critical.

BENEFITS

- Estimates are that the buildings will rarely need to draw power from the Vanwick grid, thereby reducing, over time, the electricity costs to zero for the hospital.
- Since the power does not have to be transmitted over distances, the typical loss of 5% of the power will be eliminated. This is equal to about 50 MW less generation needed per year.
- Not having to transmit the electricity over long-distance transmission wires also reduces the risk of fire in wildfire-prone areas, such as Vanwick.
- The microgrid does not emit greenhouse gas emissions while in operation. There will be greenhouse gas emissions released while making and installing it.

WHO IT IMPACTS

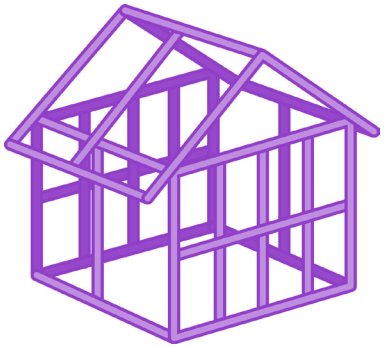
- Everyone working or staying at the hospital buildings.
- Cost: $5 million.
- This option is the most expensive of the initiatives with an initial cost of $5 million. It will take 10 years to recover the costs in savings, and after that, the electricity will be free; the only cost will be for maintenance.

INITIATIVE B

VANWICK CEMENT LIMITATIONS

BACKGROUND

Although the cement industry uses less than 1% of US energy, it is the most energy-intensive of all manufacturing industries. Cement is unique in its heavy reliance on coal and petroleum. Cement is mostly used as a binder in concrete, which is a basic material for all types of construction—including buildings, roads, dams, and ports—and applications such as walls, foundations, patios, and even sculptures.



DESCRIPTION

This proposed initiative aims to place strict limitations on using cement in building projects, both new buildings and renovations in existing buildings. This initiative would place a ban on new cement for buildings in Vanwick, both city-owned and privately owned. As a result, no new concrete building foundations can be built. This initiative requires removal of concrete in asphalt in the building of new roads, driveways, and sidewalks. New construction projects will switch to wheelchair accessible porous materials that take less energy to build and are friendlier to the environment overall. New construction would need to repurpose old buildings instead of building ones with new concrete foundations. In the event that non-concrete materials won't work, there is an exception to the limitations for essential buildings, such as schools and hospitals. This initiative would provide money for contractors that use renewable local timber materials and repurposed building materials. Grants will also be given to universities and companies to support research on energy-friendly alternative cements.

BENEFITS

- This initiative will reduce the amount of greenhouse gases that are emitted in the production of the cement used in Vanwick.
- It will not have a significant impact on the power needs or electric bills in Vanwick, as cement is made outside the city.
- Vanwick could help reduce greenhouse gas emissions to zero by leading significant change in building approaches.

WHO IT IMPACTS

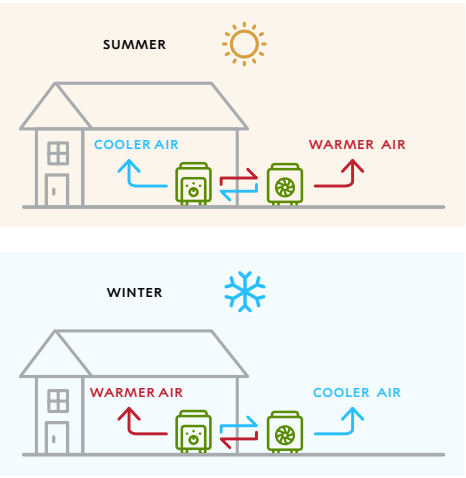
- This new rule will impact those who are building houses now or in the future.
- Cost: $1 million.
- This initiative is relatively low cost because it is made up of new rules and incentives.

INITIATIVE C

VANWICK HEAT PUMPS

BACKGROUND

A heat pump is a single electric device that works as both air conditioning and heating. Unlike conventional systems, heat pumps don't generate heat or cool air; instead, heat pumps transfer heat energy. In warmer months, it pulls heat out of indoor air and transfers it outdoors to cool your home, like air conditioning. In cooler months, a heat pump pulls heat from the cold outdoor air and transfers it indoors. Heat pumps move heat around more efficiently than traditional systems and use one-third the energy of conventional heating systems. Heat pumps have been used in homes since the 1960s, but it is only more recently that the technology has evolved to make them work better. In very cold climates, however, heat pumps may need additional heating technology or a backup furnace. Heat pumps support electrification because they run on electricity and not fossil fuels, as conventional furnaces do.



DESCRIPTION

This initiative would replace all the heating and cooling systems in Vanwick's city-owned buildings with heat pumps. In Vanwick, the winters are not severe, so the heat pumps would rarely use any backup furnaces; natural gas furnaces would be kept for emergencies. In addition to installing the new systems, there will need to be some ductwork improvements in some older buildings. Some of the older city buildings—such as the library, elementary schools, and the firehouse—will now have air conditioning installed where they previously did not. This initiative will also provide money to establish a cooling center at the library for heat waves.

BENEFITS

- In most buildings, about half the energy use is for heating and cooling. This initiative will decrease the total amount of energy used by buildings because the new system will be more efficient than the old systems.
- While the amount of fossil fuels needed will decrease, the amount of electrical energy used will increase since the heating system will now run off electricity.
- The heat pump does not emit greenhouse gas emissions while in operation. (Note: There will be greenhouse gas emissions released while making and installing heat pumps.)
- Vanwick could also consider possible future initiatives that require heat pumps in private buildings, thereby significantly increasing the savings.

WHO IT IMPACTS

- The city won't have to pay as much to heat and cool its buildings. The initiative will benefit those working in the buildings and those who would benefit from being in a cooling center during the next heat wave.
- Cost: $2.5 million.
- While the cost of installing a heat pump is more than a traditional heating and cooling system, the savings on energy expenses will recover the extra cost from installation in 5 years.

INITIATIVE D

DO NOTHING

BACKGROUND

When groups can't decide which course of action to take, sometimes no decision becomes the decision.

DESCRIPTION

No action is to be taken. The status quo of emitting greenhouse gases from buildings would continue into the future.

BENEFITS

- There is no effort or investment.
- Cost: $0
- No jobs would be created or lost as a result of this initiative.

WHO IT IMPACTS

- Greenhouse gas emissions will continue to increase and affect people, animals, and the entire planet.

ACTIVITY 8

Stakeholder Recommendation

INVESTIGATION

ACTIVITY 8

Stakeholder Recommendation

ACTIVITY SUMMARY

Students make a recommendation about the land-use requirements for different types of solar and wind generation for Project REV, from the perspective of a stakeholder. To make the recommendation, they weave facts and values about the land-use requirements for different types of solar and wind generation and incorporate their stakeholders' values.

ACTIVITY TYPE
INVESTIGATION

NUMBER OF
40–50 MINUTE
CLASS PERIODS
2-3

KEY CONCEPTS & PROCESS SKILLS

1. Facts support informed decision-making by leading to more accurate predictions about the likely outcomes of different choices.
2. Values affect people's decisions. There can be disagreement within a community when people hold a variety of values.
3. Community decisions are more likely to be accepted if the values of all stakeholders, especially those who are underrepresented, are considered in the decision-making process.
4. Decision analysis is the process of breaking down a decision in a way that can help the decision-maker consider both the facts and values related to a choice.

NEXT GENERATION SCIENCE STANDARDS (NGSS) CONNECTION:
Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations. (*Science and Engineering Practice: Constructing Explanations and Designing Solutions*)

CONCEPTUAL TOOLS

WEAVING FACTS & VALUES IN DECISION-MAKING

GROUP DECISION-MAKING

TEACHER BACKGROUND INFORMATION

Generation Capacity

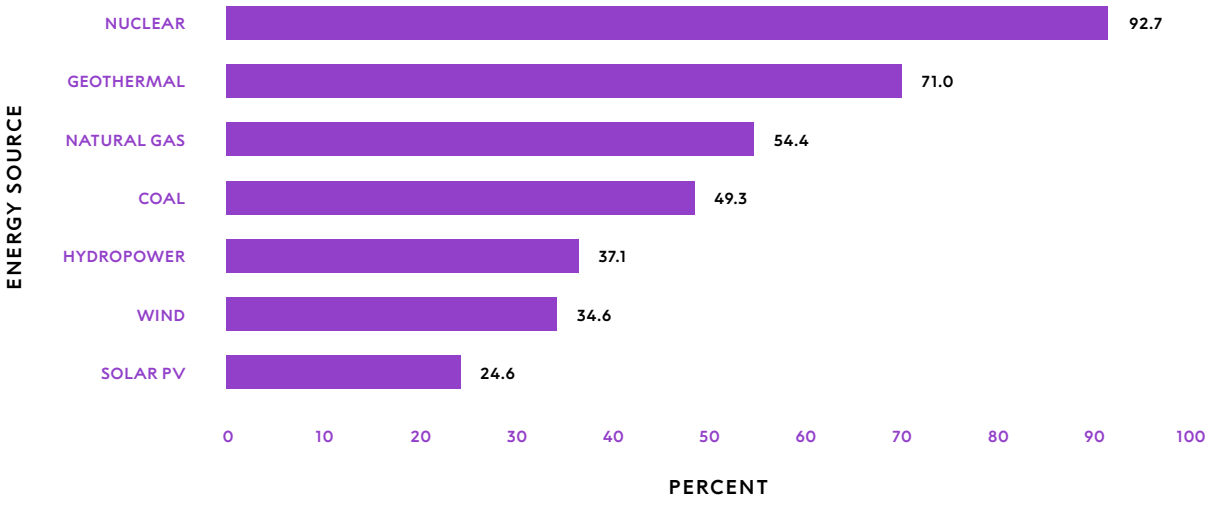
Capacity is the maximum electric output a generator can produce. Power plants are rated by maximum capacity. This means a 500–megawatt plant is capable of producing 500 megawatts (MW) operating at continuous full power. This rating is used for all power plants, regardless of the resource used to run the plant.

However, most generators do not operate at their maximum capacity all the time. A power plant's level of generation is based on many factors, including maintenance issues, weather conditions, time of day, fuel costs, or conditions on the grid. For example, it is not unusual for a wind-turbine plant that has a maximum capacity of 1,000 MW to typically produce an average of 300 MW.

Capacity Factor

The capacity factor of a power plant is the ratio between a generator's actual generation divided by the maximum output over a given time period. Capacity factor varies by fuel types. Utility-scale wind or solar facilities are significantly less than fossil fuel plants. Nuclear plants have the highest capacity factor, followed by fossil fuel plants. This is because nuclear, coal, natural gas, and hydro can operate continuously, unlike variable resources such as wind and solar. This means that a 50–megawatt wind farm is not equivalent to a 500–megawatt nuclear power plant because of the significant differences in their capacity factors. This key difference between maximum generation capacity and actual power produced is an important distinction when considering different generation resources. Figure 8.1 shows the differences between capacity factors for different generation methods.

FIGURE 8.1
Capacity Factor by Energy Source, 2021



MATERIALS & ADVANCE PREPARATION

FOR THE TEACHER

- VISUAL AID 8.1 "City of Vanwick"

FOR EACH GROUP OF FOUR STUDENTS

- SITE SURVEY CARDS (9)
- STAKEHOLDER CARD (FROM SET OF 8)

FOR EACH PAIR OF STUDENTS

- COMPUTER WITH INTERNET ACCESS

FOR EACH STUDENT

- STUDENT SHEET 8.1 "Vanwick Site Map: Stakeholder"
- STUDENT SHEET 8.2 "Vanwick Planning: Facts and Values" (OPTIONAL)
- STUDENT SHEET 8.3 "Anticipation Guide: Solar and Wind" (OPTIONAL)

Students need to use the Decision-Analysis Tool independently in this activity. If they do not have experience using the app, complete Activity 7: Building Initiatives with students before beginning this activity.

The Stakeholder cards provided in this activity are similar to those from Activity 3 but have been modified to provide the information that students need to use the Decision-Analysis Tool.

TEACHING NOTES

Suggestions for **discussion questions** are highlighted in gold.

Strategies for the **equitable inclusion of diverse students** are highlighted in pink.

GETTING STARTED (10 MIN)

1 **Review the key decision-making content of the unit that will be applied in the activity.**

- This activity does not introduce any new content, but allows students to apply what they have learned, including how to integrate the Decision-Analysis Tool from Activity 7 to a complicated decision.
- To formatively assess that students have a grasp of the key decision-making content they need to apply in the activity, provide students with the following lists of words and conduct a word sort. For more information on a word sort, see Appendix 1: Literacy Strategies.

LIST 1	LIST 2
group decision-making	option rating
value	options
scenario planning	value
underrepresented stakeholder	decision analysis
fact	claim of fact

- In each list, look for a relationship among a list of four or five words or phrases related to a topic.
- Cross out the one word or phrase that does not belong.
- Highlight any word or phrase that includes all the other words.
- Explain how the highlighted word or phrase is related to all the other words or phrases in the list. (There may be more than one correct answer to a single word sort.)

Sample Student Response

LIST 1	
group decision-making	*In group decision-making, the values of underrepresented stakeholders should be sought out so the facts can be evaluated against those values.*
value	
~~scenario planning~~	
underrepresented stakeholder	
fact	

LIST 2

option rating
options
value
decision analysis
~~claim of fact~~

When a stakeholder completes a decision analysis using the app, fact ratings evaluate how well the fact fulfills the values of that option.

PROCEDURE SUPPORT (80 MIN)

2 **Introduce the scenario and information about the generation sites in Vanwick.**

- Review the introduction and the scenario. Students will get to decide the kind and location of renewable generation in Vanwick. Remind students that their group recommendation in this activity is from the perspective of one of the stakeholders that was introduced in Activity 3. In Activity 10, students (as their respective stakeholders) will get together with other stakeholders and come to a final decision.
- Use the optional Anticipation Guide to elicit students' initial ideas about solar and wind generation. Student Sheet 8.3, "Anticipation Guide: Solar and Wind," provides a preview of science concepts in this activity. An Anticipation Guide gives students an opportunity to explore their initial ideas and revisit and modify them at the end of the activity. Be sure students understand that they should complete only the "Before" column for the statements at this time; they will have a chance to revisit these statements after the reading to see whether their ideas have changed. For more information on an Anticipation Guide, see Appendix 1: Literacy Strategies.
- While an Anticipation Guide supports sensemaking, it requires additional reading and interpretation and may need to be modified for some student populations, such as emerging multilingual learners. You may wish to complete Student Sheet 8.3 as a class, use it at the end of the activity to summarize key ideas, or use it as a formative assessment of students' learning.
- In Procedure Step 2, draw students' attention to the types of solar and wind that are identified in the infographic in the Student Book. Point out that not all types of generation are appropriate for all locations, both because of the suitability of the location and because of residents' values related to those locations.
- If students live near a coastal community, they may be familiar with offshore wind. Offshore towers are similar to the large utility turbines but are even larger with blades that are 80 meters (260 ft) wide and a maximum capacity of over 10 MW. These are not included in the infographic in the Student Book because Vanwick is not a coastal city in the scenario, but it may be worth mentioning depending on your location.

- If students are using the optional Anticipation Guide, direct them to complete the "After" column on Student Sheet 8.3. after completing the background information in the beginning of the activity. Review student responses as a class to ensure that all students understood the important ideas they need to know in order to complete the activity. A sample student response is shown at the end of this activity.

3 Provide stakeholder roles for each group of students.

- This activity assumes students hold the perspective for the entirety of the procedure. The Stakeholder cards provided are the same as in Activity 3 but have been modified to provide the information that students need to use the Decision-Analysis Tool. The two or three weighted values on this version of the cards are consistent with the cards in Activity 3, but they have a narrower focus on values related to this activity.

- In Procedure Step 3, assign each group of four students to one stakeholder role and provide them with the corresponding stakeholder card from this activity. You may want to create groups based on the Stakeholder roles students used in Activity 3, or have students consider a new perspective with a new role. Either way, students need to be organized into same-stakeholder groups.

- Students' task is to find sites that fulfill the values of the stakeholders, using the facts provided. This is easier for some stakeholder perspectives than others, and variation is expected. There are some obvious sites for some stakeholders, and others they will have to consider more closely. During the activity, encourage students to identify the trade-offs they are making when selecting locations.

- In this activity, there is no requirement for the total amount of generation students need to recommend. This allows students to focus on evaluating the options based on the facts and stakeholders' values related to those options. In Activity 10, students will revisit the locations with other stakeholders and make a group decision with a singular recommendation. In that activity, they will have the additional challenge of needing to meet a 1,000 MW generation requirement.

4 Have students gather facts about the generation options from the Site Survey cards.

- In Procedure Step 2, distribute a set of 9 Site Survey cards to each group of 4 students. Students should read the Site Survey cards and identify the locations on the map on Student Sheet 8.1, "Vanwick Site Map: Stakeholder." Answer any questions students have about the information. Use Visual Aid 8.1, "City of Vanwick," to help orient students to the locations on the cards.

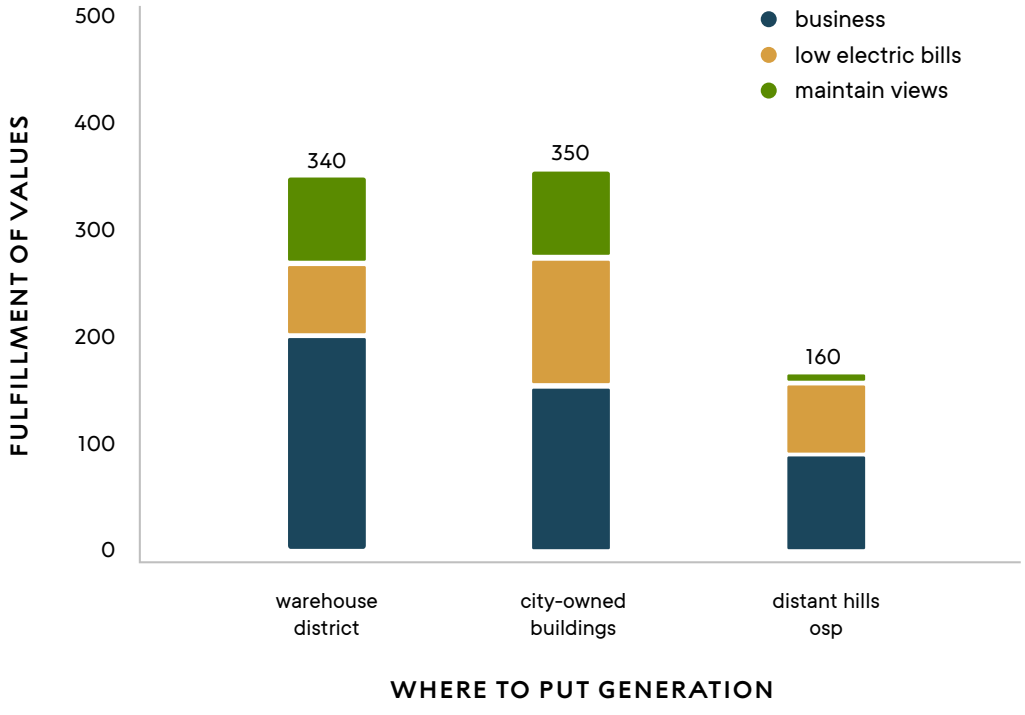
- For students who need more support reading the cards, have students divide into pairs and preread the cards. They can describe each location by using whatever modality is most comfortable, such as verbal (story) or visual (drawing). If there is time, students could find a generic picture on the Internet that matches each description.

- In this activity and in Activity 10, students choose the maximum generation capacity identified from each site. Since the activity is from the perspective of renewable generation, it does not focus on how much energy in kilowatt-hours is consumed by the end user, (For that information, see Teacher Background Information in Activity 4.) This type of analysis is beyond the scope of what is needed for this activity.

5 Students use the facts given to use the Decision-Making Tool for their stakeholder.

- Students' approach to using the app to inform their decisions will vary depending on their comfort with the app. Since the app provides space for up to five options, students will have to think about how to use the tool for the nine locations. Two suggested procedures are provided here.
  - After testing three locations, students can substitute the location with the lowest score and keep comparing until they find the top three scores.
  - Students can initially knock out the locations they know do not fit with their stakeholder values at all and focus on the trickier ones.
- When inputting data into the app, remind students to decide how well each generation site fulfills their stakeholder values on a scale of 1 (not at all) to 5 (completely). This process is similar to the process from the previous activity.
- In Procedure Step 6, if students need support using the app, you may wish to provide optional "Student Sheet 8.2, "Vanwick Planning: Facts and Values." Have students review the values and priorities on their Stakeholder cards and record them in the top row of the table, as they did in Activity 7. A sample student response for Student Sheet 8.2 is found at the end of this activity.
- Make sure students record their work, as instructed in Procedure Step 7. They may need the justification for their sites when they bring their recommendations to the larger group in Activity 10.
- Student responses using the app will vary depending on what sites they choose. Figure 8.2 on the following page is a sample student response that includes a comparison for Amber Wogan who is considering the Warehouse District, the City-Owned Buildings, and the Distant Hills Open Space Preserve.

FIGURE 8.2
Sample Student Response, Procedure Step 6



6 Support students as they choose generation sites based on the facts and values.

- In Procedure Step 8, students should complete Student Sheet 8.1 to select the locations, type of electrical generation, and amount of generation for their stakeholders. Student responses will vary, but one student response is completed at the end of this activity. Following is a table showing the reasonable prioritized selections for each stakeholder.

TABLE 8.1
Priority Locations for Each Stakeholder

NAME	VALUES		PRIORITY LOCATIONS
Amber Wogan	• *supporting businesses* • *low electric bills* • *maintaining beautiful views"*	*50* *30* *20*	• *Warehouse District* • *City-Owned Buildings* • *Commercial Farm* • *Family Farm*
Jackson Moore	• *lots of renewable generation* • *creating jobs*	*80* *20*	• *Old Mining Site* • *Distant Hills Open Space Preserve* • *Commercial Farm*
Flora Salazar	• *keeping noise down* • *maintaining jobs*	*60* *40*	• *Old Mining Site* • *Family Farm*
Miguel Ortiz	• *lots of renewable generation* • *keeping noise down*	*50* *50*	• *Distant Hills Open Space Preserve* • *Old Mining Site* • *Commercial Farm*
Roman Kozlov	• *wind turbines* • *lots of generation* • *his location's contribution*	*50* *30* *20*	• *Distant Hills Open Space Preserve* • *Family Farm* • *City Park* • *Warehouse District, turbine* • *Nature Forest, turbine*
Olivette Allard	• *increasing jobs* • *reducing transmission* • *maintaining beautiful forests*	*70* *20* *10*	• *Gentle Hills Open Space Preserve* • *Old Mining Site*
Thomas Cho	• *lots of renewable generation* • *maintaining beautiful views* • *creating jobs*	*50* *40* *10*	• *Old Mining Site* • *Commercial Farm*
Diya Khan	• *maintaining beautiful views* • *no land changes*	*80* *20*	• *City-Owned Buildings* • *Warehouse District*

7 **Instruct students to record and keep their work from this activity.**

- Do not allow groups to share their selections and reasoning with other students at this time. The information from this activity will be carried forward into Activity 10, so make sure students keep a copy of their work for the upcoming activity. Likewise, they should hold onto their notes from Procedure Step 7 and/or optional Student Sheet 8.2.

SYNTHESIS OF IDEAS (10 MIN)

8 **Reflect on the process of making stakeholder recommendations.**

- Ask, What would happen if the generation locations were limited and did not match your stakeholder's values? Students should say that this would be a big problem because then they couldn't really make a recommendation. Point out how challenging that could be to move forward with the group decision if there is a stakeholder for whom there are no good options. Use this to foreshadow the introduction of the concept of compromise in group decisions in the upcoming activities.
- Point out that there are multiple recommendations developed, but that Vanwick can only implement one plan. Ask, Do you think your decision from your stakeholder perspective represents what the larger Vanwick community wants? Responses will vary but should indicate that students can see the potential of conflict between stakeholders. Let students know that in Activity 10, they will have to narrow down their choices to one recommendation.
- Evaluate if your students are able to identify the essential ideas of the activity by revisiting the Guiding Question, How can facts and values inform planning for the future? Formatively assess if students are able to use relevant facts to fulfill values during decision-making.

SAMPLE STUDENT RESPONSES

BUILD UNDERSTANDING

① **How did creating the plan to meet the values of your stakeholder, instead of for yourself, impact the plan you made?**

The plan for the stakeholder was different than what I would have done myself. My stakeholder valued supporting businesses, so we chose all the sites that had any businesses on them. I would have chosen the sites that had a lot of generation, like the Distant Hills Open Space Preserve and Gentle Hills Open Space Preserve, because my top value is to generate the most electricity possible.

② **What trade-offs did you make in choosing the locations for your recommendation?**

Answers will vary. One sample response is shown here.

The trade-off of the sites Amber Wogan chose is that the sites selected, compared to those I did not choose, do not generate a lot of electricity. The sites I didn't select can generate 734 MW, compared to just over 300 MW for the business sites.

③ **Imagine that two different stakeholder groups decided to join together to make a single group decision. What are some ways they could go about it?**

Answers will vary. One sample response is shown here.

The two groups could start by comparing their values and looking for ones that are common. Those ones could be the prioritized values for the new group. If they couldn't do that, maybe they could use some of the tools in the unit, like scenario planning or the Decision-Analysis Tool, to inform their decision.

CONNECTIONS TO EVERYDAY LIFE

④ **Describe a situation in which you and someone else had the same facts about a situation but had different values about it. Explain how facts and values resulted in different decisions and outcomes.**

I know someone who thinks it is cool to take as many easy classes as possible. We agree on which classes are easy, so our facts are the same. But I think having a transcript with all easy classes is kind of a waste of time because it doesn't show how smart you are. My friend, however, values not ever having to do any homework. They think differently than me about the facts because their top value is reducing effort, and my top value is to get into a decent college.

REFERENCES

Gross, S. (2020, January). Research: Renewables, land use, and local opposition in the United States. *Brookings*. Retrieved from https://www.brookings.edu/articles/renewables-land-use-and-local-opposition-in-the-united-states/#:~:text=Wind%20and%20solar%20generation%20require,and%20transport%20the%20fossil%20fuels

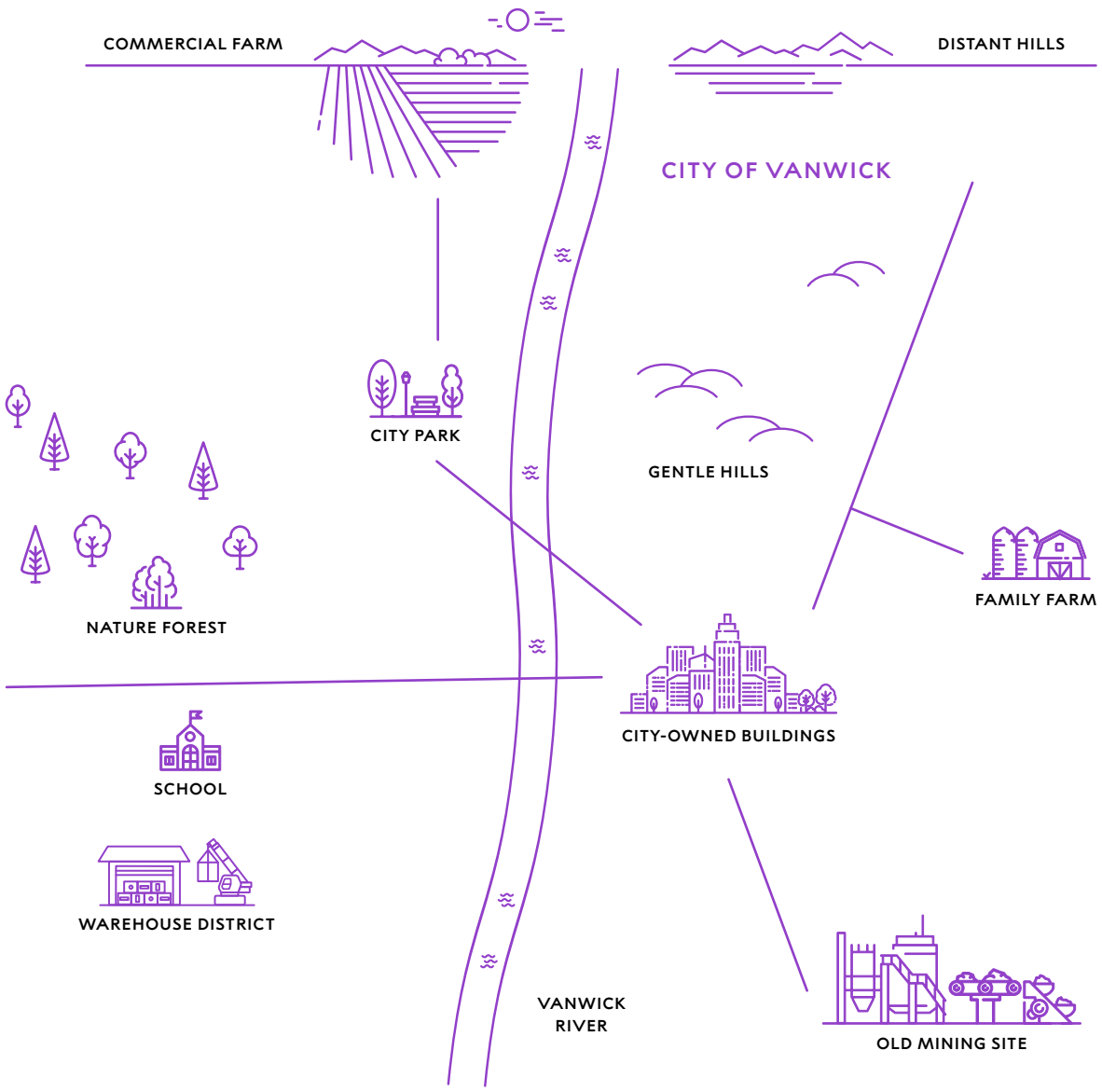
Lawhorn, W. (2021, February 26). Solar and wind generation occupations: A look at the next decade. Beyond the Numbers, *10*(4). U.S. Bureau of Labor Statistics. Retrieved from https://www.bls.gov/opub/btn/volume-10/solar-and-wind-generation-occupations-a-look-at-the-next-decade.htm

Sullivan, R., Kirchler, L., Lahti, T., Roché, S., Beckman, K., Cantwell, B.,Richmond, P. (2012, May). Wind turbine visibility and visual impact threshold distances in western landscapes. Argonne National Laboratory, U.S. Department of Energy. Retrieved from https://blmwyomingvisual.anl.gov/docs/WindVITD.pdf

US Department of Energy. (2020, May 1). What is generation capacity? Office of Nuclear Energy. Retrieved from https://www.energy.gov/ne/articles/what-generation-capacity

STUDENT SHEET 8.1	VANWICK SITE MAP : STAKEHOLDER	NAME

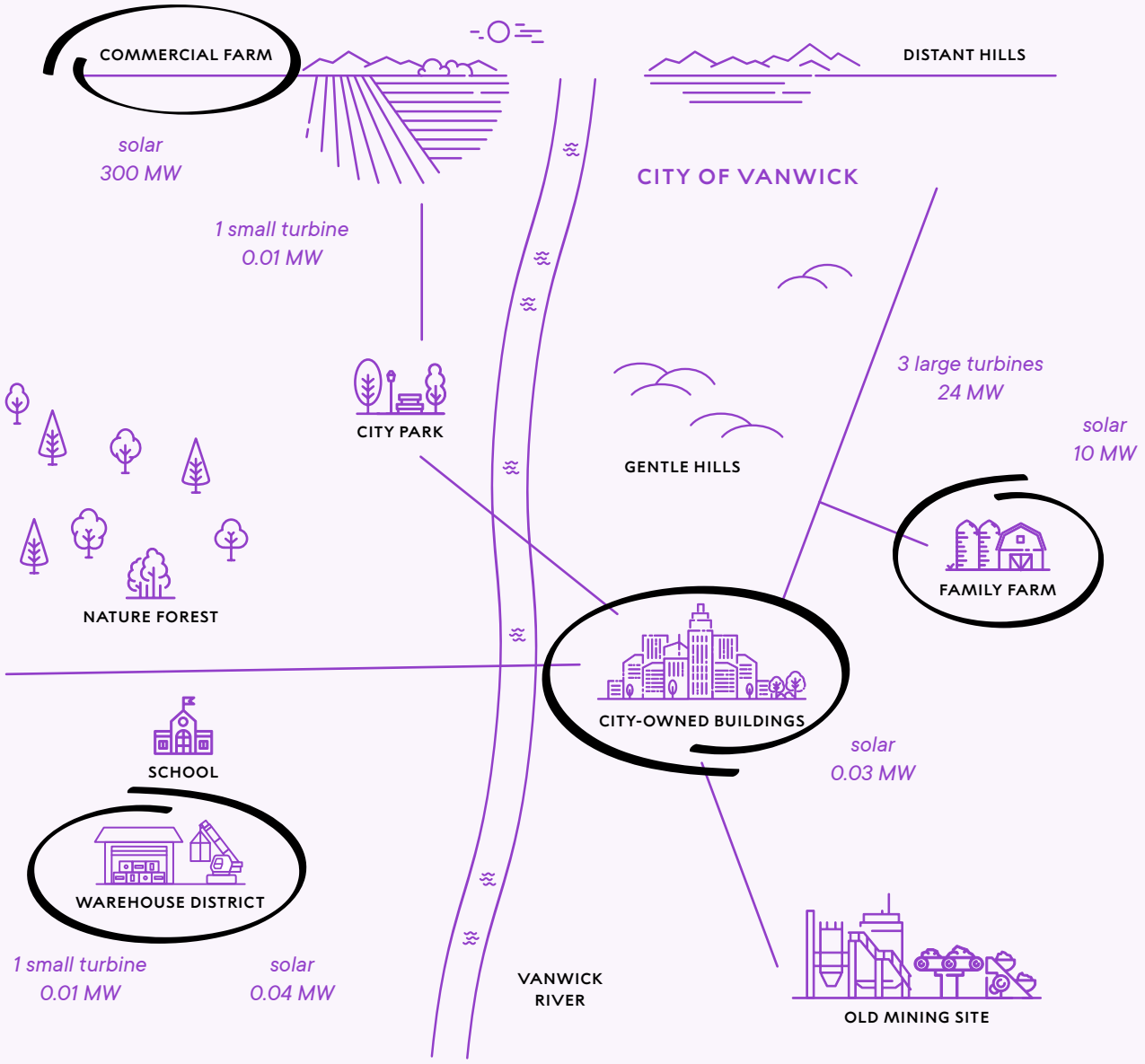
Stakeholder: _____



Reasoning:

STUDENT SHEET 8.1	VANWICK SITE MAP : STAKEHOLDER	NAME SAMPLE STUDENT RESPONSE

Stakeholder: *Amber Wogan*



Reasoning:

Since Amber's highest weighted value was supporting businesses, I selected all the sites that included businesses. That is the Warehouse District, City-Owned Buildings, the Commercial Farm, and the Family Farm. Amber's second value of low electric bills did not influence my choices much because the costs for all the choices in Vanwick are predicted to be the same, except for the City-Owned Buildings, which I already chose. I did not select the places that might have a bad impact on tourism in Vanwick, which was also one of Amber's values. So I didn't choose anywhere that might have a natural view, which is Nature Forest, City Park, and Gentle Hills Open Space Preserve.

STUDENT SHEET 8.2	VANWICK PLANNING: FACTS AND VALUES	NAME

Stakeholder perspective: _____

TABLE 1: VALUES

STAKEHOLDER VALUE	DESCRIPTION	WEIGHT
1		
2		
3		
TOTAL		

CONTINUED

TABLE 2: EVALUATING FACTS

OPTIONS	VALUE 1 _____		VALUE 2 _____		VALUE 3 _____	
	FACTS	RATING	FACTS	RATING	FACTS	RATING

STUDENT SHEET 8.2	VANWICK PLANNING: FACTS AND VALUES	NAME SAMPLE STUDENT RESPONSE

Stakeholder perspective: *Amber Wogan*

TABLE 1: VALUES

STAKEHOLDER VALUE	DESCRIPTION	WEIGHT
1	*supporting businesses*	*50*
2	*not increasing electric bills*	*30*
3	*maintaining beautiful views*	*20*
TOTAL		*100*

CONTINUED

TABLE 2: EVALUATING FACTS

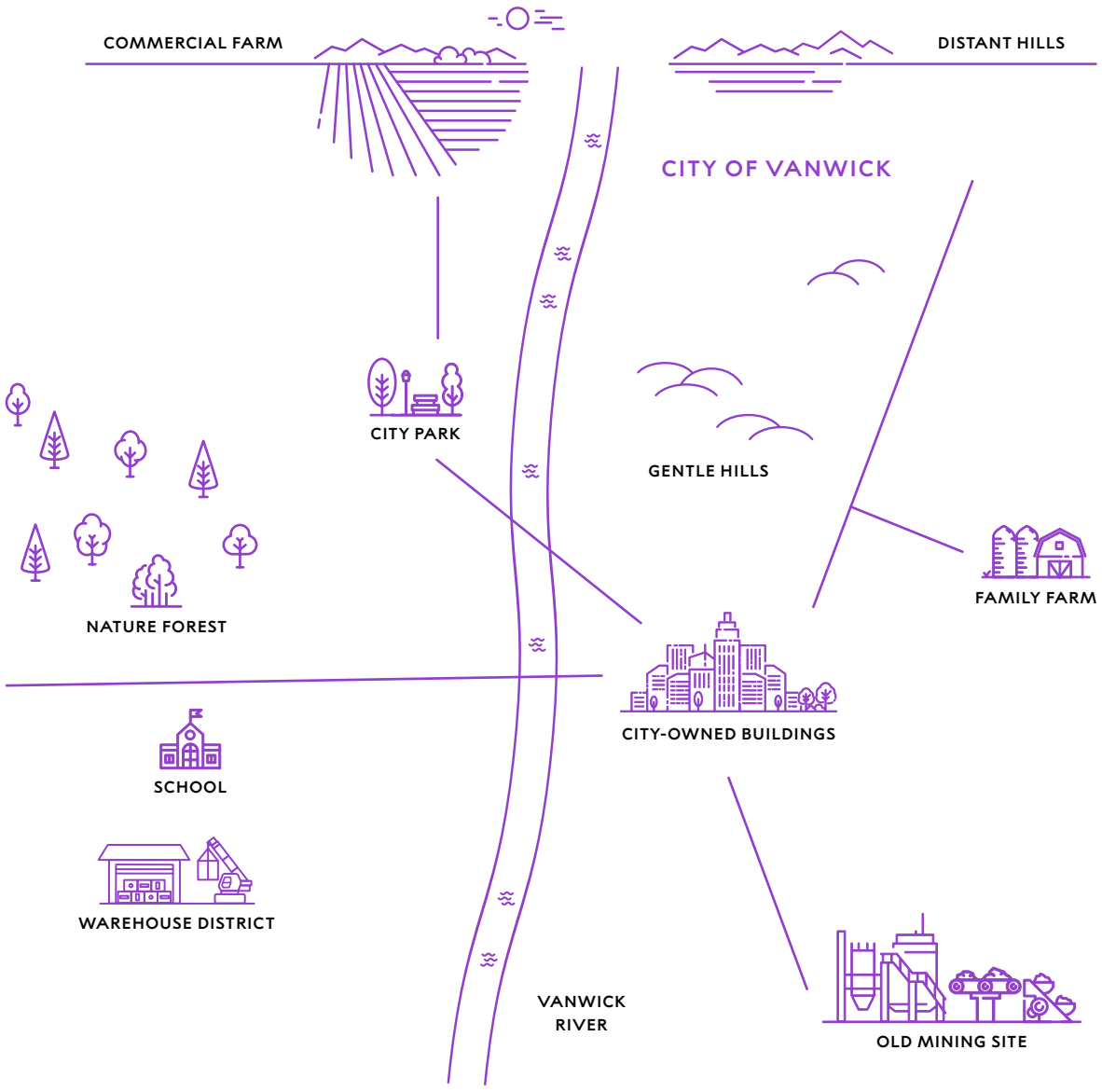
OPTIONS	VALUE 1 *business*		VALUE 2 *electric bills*		VALUE 3 *views*	
	FACTS	RATING	FACTS	RATING	FACTS	RATING
Warehouse District	*business owners would collect rent*	*4*	*costs are predicted to stay about the same*	*2*	*would not impact views*	*4*
City-Owned Buildings	*run by the city, which supports jobs and businesses*	*3*	*costs over 5 years would go down because city owns the panel*	*4*	*would not impact view*	*4*
Commercial Farm	*run by company, business owners would collect rent*	*4*	*costs are predicted to stay about the same*	*2*	*would impact views but tourists unlikely to be on farm*	*2*
Family Farm	*small business, business owners would collect rent*	*4*	*costs are predicted to stay about the same*	*2*	*would impact views but not a huge installation*	*1*
Gentle Hills Open Space Preserve	*supports business through tourism*	*2*	*costs are predicted to stay about the same*	*2*	*would negatively impact views*	*0*
Old Mining Site	*does not directly support businesses*	*0*	*costs are predicted to stay about the same*	*2*	*can be seen but would not impact views since tourists don't go to that site*	*3*
Distant Hills Open Space Preserve	*supports business through tourism*	*2*	*costs are predicted to stay about the same*	*2*	*would negatively impact views*	*0*
City Park	*does not directly support businesses*	*0*	*costs are predicted to stay about the same*	*2*	*might deter walkers*	*1*
Nature Forest	*supports business through tourism*	*2*	*costs are predicted to stay about the same*	*2*	*would negatively impact views*	*0*

In the "Before" column, mark whether you agree (+) or disagree (–) with each of the following statements. Then complete the reading. In the "After" column, mark whether you agree (+) or disagree (–) with the statements. Under each statement you agree with, explain how the activity gave evidence to support or change your ideas. Under each statement you disagree with, write and explain a corrected statement.

BEFORE	AFTER	
		1 Solar does not release greenhouse gases during operation.
		2 Solar panels do not require a lot of workers to install.
		3 Solar panels work well in locations that are open and flat.
		4 Paying off solar panels with savings from electricity bills takes about 20 years.
		5 Fossil fuels are typically used to build wind turbines.
		6 A single large wind turbine can generate 100 MW of power.
		7 Wind turbines need more maintenance than solar panels.
		8 Space can be saved by putting wind turbines close together.

In the "Before" column, mark whether you agree (+) or disagree (–) with each of the following statements. Then complete the reading. In the "After" column, mark whether you agree (+) or disagree (–) with the statements. Under each statement you agree with, explain how the activity gave evidence to support or change your ideas. Under each statement you disagree with, write and explain a corrected statement.

BEFORE	AFTER	
+	+	1 Solar does not release greenhouse gases during operation. *The energy transformation in solar panels does not include burning fossil fuels, so no greenhouse gases are released during operation.*
+	–	2 Solar panels do not require a lot of workers to install. *Solar panels take a lot of people to install, but not as many to maintain once they are built.*
+	+	3 Solar panels work well in locations that are open and flat. *Solar panels need a direct line to the Sun as it travels across the sky, so location needs to be open for panels.*
+	–	4 Paying off solar panels with savings from electricity bills takes about 20 years. *Paying off solar panels with savings from electricity bills takes about 5 years.*
–	+	5 Fossil fuels are typically used to build wind turbines. *Energy is required to get materials and to build the turbines, most of which is supported by traditional energy fossil fuels sources.*
+	–	6 A single large wind turbine can generate 100 MW of power. *A turbine generates about 8 MW. Offshore turbines generate more, closer to over 10 MW each.*
+	+	7 Wind turbines need more maintenance than solar panels. *There are moving parts in turbines, unlike in solar panels, so they need to be worked on and maintained.*
+	–	8 Space can be saved by putting wind turbines close together. *Large wind turbines are spread apart by half a mile so they do not disturb the wind traveling through each one.*


COMMERCIAL FARM
DISTANT HILLS
CITY OF VANWICK
CITY PARK
GENTLE HILLS
NATURE FOREST
FAMILY FARM
CITY-OWNED BUILDINGS
SCHOOL
WAREHOUSE DISTRICT
VANWICK RIVER
OLD MINING SITE

CITY PARK

This area has a mix of flat and hilly areas. There are a few hiking trails, picnic areas, activity fields, and a small community amphitheater. There is one steep hill called City View Hill with a popular hiking trail. The top of City View Hill has a lookout area that overlooks the Vanwick River and the Gentle Hills Open Space Preserve area. The trail is steep and often windy at the top.

- 1 small turbine
  10 kW = 0.01 MW

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 8

FAMILY FARM

This small farm grows organic hay and wheat. The farm is relatively close to town, so there is a section of it used for a community garden that is visited by those who live in the city. There are no livestock on the farm. The farm is located at the base of the Gentle Hills, which is windy enough to support a mile of large wind turbines. There are a few open sunny areas that are not used for crops and that could be used for solar panels. The farmer has indicated that they support renting their land for wind turbines in order to help meet the goals of Project REV.

- 3 large turbines
  24 MW and/or
- solar panels
  10 MW

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 8

DISTANT HILLS OPEN SPACE PRESERVE

This is a beautiful natural area full of plants and animals. The preserve is the farthest point away from downtown and the largest in the area. It has a mix of trees near the river and grassy areas higher up on the hills. The hills, which are the highest in the area, include tall ridges that have high winds for a large portion of the day and night. There is also a flat sunny area at the foothills of the ridge that is a total of 10 km^2.

- 25 large turbines
  200 MW and/or
- solar panels
  10 MW

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 8

COMMERCIAL FARM

This is a large farm run by a company that grows wheat, much of which is sent out of the area. They also raise some livestock. The area lies flat and low next to the Vanwick River and is not windy. The landowner has agreed to lease land for Project REV, but it means that he will switch his business to be entirely cattle, which will give off much more greenhouse gas emissions than his current farm.

- solar panels
  300 MW

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 8

GENTLE HILLS OPEN SPACE PRESERVE

This area is filled with wild grass on gentle rolling hills. Like the Distant Hills Open Space Preserve, this area is known for its great natural beauty and wildlife. There is no development in the area, although the Community Farm is nearby, which is closer to downtown than this Open Space Preserve. There is a diversity of plants and animals in the area. About 50% of the area is open and sunny and very windy in the evening.

- solar panels
  200 MW and/or
- 20 large wind turbines
  160 W

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 8

CITY-OWNED BUILDINGS

This area includes all the city recreation, school, and office buildings in downtown Vanwick. While the roofs mostly have a clear view of the Sun, the wind does not meet minimum requirements for small turbines on most days. The city would get the electricity direct from these panels.

- rooftop solar panels
  0.030 MW

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 8

NATURE FOREST

Although close to neighborhoods, this area is mostly forested and has never been developed. The low-lying area has trees that block the light and wind. There is a hill with a small, exposed ridge. Recently, a nonprofit started bird-watching programs and hiking programs in the forest for the community. A local timber company wants to cut the trees for building lumber, which would clear space for solar panels.

- 4 large wind turbines
  32 MW (on hill) and/or
- solar panels
  100 MW (after cutting timbered area)

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 8

OLD MINING SITE

There is an abandoned mine that includes a big pit; water that has accumulated in it; and a large, cleared area around it. The water in the lake is considered contaminated, and there have been some discussions about cleaning it up. The rest of the area is not currently utilized. The land is flat, rocky, and has few dry shaded areas.

- solar plant
  600 MW

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 8

WAREHOUSE DISTRICT

There are five privately owned warehouses near the Vanwick Elementary School, with a total of a 200 m^2 roof area. The warehouses are currently in use and maintained by a group of business owners who will rent their roofs to Project REV. The roofs just meet the daily requirement of sunlight for solar panels and wind for small turbines.

- rooftop solar panels
  0.040 MW and/or
- 1 smaller turbine
  10 kW = 0.01 MW

AMBER WOGAN

SMALL BUSINESS OWNER

I own a restaurant in downtown Vanwick that has been in my family for three generations. As someone who has lived and worked in Vanwick my whole life, I hope that Project REV is good for all the small businesses in town. My biggest concern about Project REV is if there will be an increase in the cost of electricity for consumers due to the change in electrical systems. I am not sure my business could afford to pay more for electricity that runs the restaurant. We already pay a lot to keep the lights, heat, stoves, and ovens running. I hope that Project REV doesn't stop tourists from visiting the town to enjoy the Nature Forest, City Park, and Gentle Hills because they are full of unattractive solar panels and wind turbines.

WEIGHTED VALUES

•supporting businesses	50
•low electric bills	30
•maintaining beautiful views	20

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 8

JACKSON MOORE

HIGH SCHOOL STUDENT

I'm a student at Vanwick High School. I really care about what happens to our environment in the future, and I completely support Project REV. It is about time we worked together to address this issue! It has been difficult knowing that the biggest challenge of our time is lowering our greenhouse gas emissions, but as an individual, I am only able to do small things toward this goal. My mom works at the power plant that is closing down, so I am worried that she won't be able to get another job. If she can't find permanent work after the plant closes, I may have to work a lot more at my after-school job. However, I am grateful that she will no longer be subjected to the poor air quality near the plant.

WEIGHTED VALUES

•lots of renewable generation	80
•creating jobs	20

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 8

FLORA SALAZAR

VANWICK CITY LIBRARIAN

I am excited that Project REV will bring money into our city, but I am most concerned about installing wind turbines. I know someone who knows someone who says that wind turbines can be very noisy. I want to make sure there aren't any devices such as wind turbines or electrical substations where I live near City Park. They could disrupt me at home. Getting solar panels instead of wind turbines sounds better to me, but how can they be reliable if they don't work at night? I don't want to close the library early when it gets dark! I have lived and worked in Vanwick for a long time, and I just love the community of readers that are here. I hope this gets worked out because I don't want friends to lose their jobs in Vanwick.

WEIGHTED VALUES

•keeping noise down	60
•maintaining jobs	40

MIGUEL ORTIZ

HOSPITAL WORKER

I'm a medical worker at Vanwick General Hospital. I am very happy that we are considering replacing the coal plant with renewable energy options. I have worried for a long time about the greenhouse gas emissions that coal plants put into the atmosphere. At my job, I see a lot of people with health effects from the coal plant, such as asthma, that can be triggered by the air pollution. Something else that's really important to me is to make sure the new infrastructure for energy generation is quiet. The hospital setting is sometimes very hectic, and I really value quiet time at my home in Vanwick to keep a balanced lifestyle.

WEIGHTED VALUES

•lots of renewable generation	50
•keeping noise down	50

ROMAN KOZLOV

FARMER

I run a small farm, and I was born and raised in Vanwick. As someone who works on the land, I want to help take care of it. My family and I love this place and want to help move it into a good future. I have started lowering our greenhouse gas emissions on the farm in other ways, so I support Project REV. I'd be willing to have renewables installed on my land, especially wind turbines installed in my fields. I think wind turbines are the coolest, and I wonder if we could run the whole city off of them! I'm looking forward to someday replacing my diesel-powered tractors with electric versions. If I could get the electricity for the electric tractors from renewable energy, that would really help bring down the greenhouse gas emissions from my farm. Plus, I think it will support my business because the changes I'm willing to make for Project REV will reduce my overall energy costs for the farm to help keep expenses down.

WEIGHTED VALUES

•wind turbines	50
•lots of generation	30
•his location's contribution	20

OLIVETTE ALLARD

CONTRACTOR

As a contractor, I do electrical work frequently, so I know how important electricity is to our everyday lives. I think Project REV is a great way to increase job opportunities for electrical workers in the area. Transitioning to renewable energy generation will mean the whole system will need to be upgraded. There will be jobs that help increase the capacity of the system as well as jobs to upgrade the electrical power transmission lines and improve distribution. At the same time, I am worried that Project REV is going to put this new infrastructure, along with the solar panels and wind turbines, in an area that will disrupt our beautiful landscape. We have ruined so much forest already by running transmission lines to faraway places. Furthermore, ruining the natural world surrounding Vanwick might make this a less desirable place to live. I'm worried this change to Vanwick might decrease my home's property value, and I could lose money.

WEIGHTED VALUES

•increasing jobs	70
•reducing transmission	20
•maintaining beautiful forests	10

THOMAS CHO

OFFICE WORKER

At the office, I see the energy bill for our building when it comes in. I know how much natural gas we burn in the furnaces all winter just to keep our large building heated. When I think about all the buildings in the area that all emit a lot of fossil fuels with our heating systems, it feels like we are just burning up our future! Project REV can change that, so I am thrilled it is happening. My high-rise building has a beautiful view of the Distant Hills Open Space Preserve, so I don't want to disrupt that because I see it every day. I feel lucky because I have friends who will need new jobs when the coal plant is closed. I hope Project REV will give them at least short-term work helping build everything for the new energy system.

WEIGHTED VALUES

•lots of renewable generation	50
•maintaining beautiful views	40
•creating jobs	10

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 8

DIYA KHAN

VANWICK HISTORICAL SOCIETY MEMBER

I go hiking every week in the Gentle Hills area, and I heard that they are thinking of installing wind turbines or solar panels for Project REV there. What a horrible idea! Solar panels will take up so much room in that area that the hiking trails could be ruined. I am not so sure I want to hike the trails anyway if I am just looking at a sea of black panels. I think it is important to not have any changes to the land so we can preserve our history and way of life in Vanwick. Plus, I've heard from a family member that solar panels and wind turbines only work when the weather is sunny and windy. We might use all our resources to install these huge devices, and they may not even work when the weather conditions aren't right. I don't understand why Project REV wants to replace a reliable energy source with one that doesn't work all the time. This Project REV is not the answer!

WEIGHTED VALUES

•maintaining beautiful views	80
•no land changes	20

SCIENTIFIC THINKING FOR ALL: A TOOLKIT
UNIT 6: Group Decision-Making, Activity 8

ACTIVITY 9

Real-World Energy Decisions

READING

ACTIVITY 9

Real-World Energy Decisions

ACTIVITY SUMMARY

Students read about two contrasting group decisions about renewable energy. In one case, the group decision-making process went well; in the other, it did not. The cases exemplify how real-world group decision-making takes into account the values of multiple stakeholders. Students analyze the case studies for shared or conflicting values between stakeholders and identify how conflict can be overcome through compromise.

ACTIVITY TYPE
READING

NUMBER OF 40–50 MINUTE CLASS PERIODS
1–2

KEY CONCEPTS & PROCESS SKILLS

1. Values affect people's behaviors, opinions, and decisions. There can be disagreement within a community when people hold a variety of values.
2. Community decisions are more likely to be accepted if the values of all stakeholders, especially those who are underrepresented, are considered in the decision-making process.
3. When making a group decision where there are conflicting values, a compromise is sometimes necessary.

CONCEPTUAL TOOLS

WEAVING FACTS & VALUES IN DECISION-MAKING

GROUP DECISION-MAKING

VOCABULARY DEVELOPMENT

compromise
when each side gives up something they want in order to reach an agreement

utility company
(assumed prior knowledge)
a business that provides services to customers, such as electricity, water, sewage services, and natural gas

TEACHER BACKGROUND INFORMATION

Causes of Disagreement in Group Decision-Making

Group decision-making can be challenging when people disagree about either the values, the facts, or both related to a decision. For example, one set of stakeholders may be against installing new wind turbines because they rank bird safety as the most important value to consider, while another group may support the decision because they value reduced greenhouse gas emissions as the most important value. In this case, these conflicting values could prevent agreement on a decision. An example of disagreement about the facts related to the values could be that the first group believes that wind turbines harm 10,000 birds a year, while the other group may think it is only 10 birds a year. In the case of facts, but not values, such disagreements can often be resolved by collecting more evidence.

Reaching a Group Decision

Researching information using credible sources and incorporating expert judgements can help groups reconcile disagreements over facts. Differences in values can sometimes be more difficult to address. Compromise is sometimes necessary to resolve conflicting values. By changing parts of the proposed decision, both parties in a disagreement may give up something to be able to agree on a decision. For example, both groups may agree on choosing a model of wind turbine that causes less harm to birds but does not reduce emissions as much as the other model. Successful group decisions often produce outcomes that are desirable by multiple stakeholders. This is most likely to happen when the values of various groups are considered throughout the decision-making process, including those that are underrepresented.

Hydroelectric Power

Hydroelectricity works on the science principle of transforming the gravitational potential energy of water into kinetic energy as it moves and then into electricity by a generator. Rivers and streams naturally flowing from a higher to a lower elevation are used to produce small amounts of electricity, while large hydroelectric plants require the construction of a large dam. Hoover Dam, a large dam on the Colorado River, created a waterfall of 122 meters (400 feet), which is more than twice as high as Niagara Falls. Hydroelectric power is a renewable resource because the water cycle continually supplies water to streams and rivers. Building hydroelectric dams also creates lakes and reservoirs that increase the

local water supply. This kind of power does not produce any pollution or waste outside of making the dam. Although building a dam is very expensive, once the dam is built, the cost of power is very low. The energy transformation of running water turning turbines is over 90%, which is the highest transformation efficiency of generation methods.

Dams do have significant negative environmental effects, such as a loss of fish and other aquatic species in the area when the natural environment is changed. Building a large dam floods the area upstream, in some cases drowning out forests and forcing whole towns to move away. Downstream, the amount and quality of water may also change because the dam will have changed the flow of the water.

MATERIALS & ADVANCE PREPARATION

FOR EACH STUDENT

- STUDENT SHEET 9.1 "Group Decisions Based on Stakeholder Values"
- STUDENT SHEET 1.1 "Unit Concepts and Skills" (OPTIONAL)
- STUDENT SHEET 2.2 "Lateral Reading" (OPTIONAL)

If students are going to conduct the Extension, review the task and choose one of the three research pathways, depending on the scaffolding needs of your students.

TEACHING NOTES

Suggestions for **discussion questions** are highlighted in gold.

Strategies for the **equitable inclusion of diverse students** are highlighted in pink.

GETTING STARTED (20 MIN)

1 **Introduce the activity with a Walking Debate about an energy conflict.**

- Begin the activity by presenting an imaginary energy conflict and conducting a Walking Debate. For more information on a Walking Debate, see Appendix 1: Literacy Strategies. Divide the class in half and tell each side to imagine that they live in an apartment building.
  - One half of the class represents those who rent an apartment in the building.
  - One half of the class represents those who own the apartment building.

  The Owners Association plans to upgrade the building to be more energy efficient by adding solar panels to run a heat-pump system. After the renovations, it will reduce greenhouse gas emissions from the building by 30%. They expect that electricity bills will be about the same, but that renters will no longer need to pay a heating or air conditioning bill. To pay for all the upgrades, the building owners plan to increase the monthly rent for all renters by 20%. This would be the largest increase in the history of the building.
- Depending on your student population, you may consider changing the context of the situation and the corresponding questions to better connect to the life experiences of your students.
- With students, make a list of the facts and values from the scenario and record them on the board before conducting the Walking Debate.
- Begin the debate by asking, Considering your role (renter or building owner), do you agree with the plan to reduce greenhouse gas emissions from the apartment building? Identify one side of the classroom for those who agree and another for those who don't agree. Expect student arguments to include concerns related to the lack of affordability of the rent hike, the importance of reducing greenhouse gases because of climate change, and the possible outcomes that would result.
- When the debate is over, identify the conflict in the scenario and ask, Do you think the disagreement between both sides is caused by differences in facts or values? Accept all responses because the idea that conflicting values, not facts, tend to cause disagreements will be developed throughout this activity.
- Let students know that in this activity, they will be reading about some similar real-world energy conflicts by communities making energy-related group decisions.

PROCEDURE SUPPORT (35 MIN)

2 Students read about two real-world communities making energy-related group decisions.

- To support reading comprehension, students engage in the Read, Think, and Take Note strategy. Review student questions that are generated by the strategy.
- To help synthesize the information in the reading, have students work in pairs to complete a Directed Activity Related to Text (DART) on Student Sheet 9.1, "Group Decisions Based on Stakeholder Values." For more information on a Directed Activity Related to Text (DART), see Appendix 1: Literacy Strategies. Students will need two copies of the student sheet, one for each case study. Sample student responses to Student Sheet 9.1 can be found at the end of this activity.
- For students who need more reading support, consider having students share the reading responsibilities within a group of four. One pair completes one of the case studies and shares the information with the other pair who has completed the other case study. Then the group of four works together to complete Student Sheet 9.1.

3 Discuss the main takeaways from the readings with students.

- Have a discussion about stakeholders related to the reading. First, review which stakeholders were similar in each scenario as identified on Student Sheet 9.1. Students may suggest the residents, politicians, government, and energy companies were present in both cases. Then ask, Which stakeholders in the energy situations are often underrepresented? Students may suggest Indigenous Peoples, those with little access to renewable technology due to money or education, and those not able to vote—such as people under 18, plants and animals, and the environment. Ask students to come up with ways that those stakeholders could have been a bigger part of the decision-making process. Accept all responses; students may circle back to some of the ideas from Activity 3 and suggest surveying them.
- Emphasize that the lack of success in Williamsport was not because the renewable project did not pass in the end. The community could have successfully made a group decision to turn down the renewable project. What made it unsuccessful was how the process broke down, the anger between stakeholders, and the ruined relationships between friends as a result of the group decision-making.

4 Lead a discussion about the role of compromise in group decision-making.

- Have students look at their completed Student Sheet 9.1 and compare the compromises made, or not, in each case. Students should have seen that in Uruguay, the group was able to successfully reach a compromise, whereas they were not in Williamsport. Ask, What made the compromise successful in Uruguay when compared to the attempt in Williamsport? Students should see that in Uruguay, there were concessions made by multiple parties. Both the government and the utility companies gave up something to make the plan acceptable to other stakeholders. This is

in contrast to Williamsport where one side made an offer that the other side rejected. This suggests that a successful compromise involves people from both sides considering one another's viewpoints carefully.

- If it comes up, clarify the difference between common values and shared values. Common values refer to those values that are most prevalent in the community and are the most popular for everyone. Shared values are values that are the same between two or more stakeholders. Shared values can be important in finding a compromise by bringing different stakeholders together to understand their common goals.
- Support students, particularly emerging multilingual learners, in sensemaking and language acquisition by adding a final word for the unit to the word wall. Record the word *compromise* and provide an example as needed.

SYNTHESIS OF IDEAS (20 MIN)

5 Have students reflect on how the reading informs the situation in Vanwick.

- Ask, How do the real-world situations in the readings relate to the situation in Vanwick? Students may see parallels between Vanwick and Williamsport, Ohio, because they are the same size communities and because solar farms are being considered as part of the Vanwick energy plan. The case study in Uruguay showed that group decision-making can happen, even in complicated situations such as energy generation. This implies that Vanwick can make a change for a better future. The readings also showed that successful group decisions need good leadership, persistence, and a commitment to invest in stakeholders' values.
- Apply the lessons learned in the activity to the global energy situation. Ask, How does the reading inform the global energy situation? Students should recognize that the Uruguay case study provides a perspective on the global community. Uruguay, albeit a small country, offers a model to the world of an energy system that is self-reliant and low emissions. Their experience shows other countries that they, too, can engage in group decision-making in a way that can accomplish global energy goals.
- Remind students that in Activity 8, they made a land-use decision from the perspective of a stakeholder. In this activity, they investigated some similar group decisions. In the next activity, they will combine what they learned when they will make a group decision.

6 Have students consider the scenario from the beginning of the activity.

- Revisit the scenario from the Getting Started section about the renters and owners of a building. Brainstorm with students some ideas about how the scenario could be resolved with a compromise. Responses will vary but expect students to propose ways to compromise such as staging the renovation over time to spread out the cost or getting the money elsewhere to keep rents affordable.

- You may wish to revisit Student Sheet 1.1, "Unit Concepts and Skills," to help students formally organize the ideas introduced in the unit so far. Students can add the headings "Decision Analysis" and "Group Decision-Making" into the organizer and add examples from their classroom experiences in Activities 7–9. This is the last time students will revisit this sheet so, when completed, it should reflect the majority of the unit content. See the end of Activity 1 in the Teacher's Edition for a sample student response.
- To conclude the activity, evaluate if your students are able to answer the Guiding Question, What can support successful group decision-making? Use this as a chance to revisit and summarize the key concepts and process skills of the activity in preparation for the final activity.

EXTENSION (90 MIN)

7 Use the Extension as an opportunity for advanced learning.

- Have students investigate the energy situations in other countries. Students are often interested in learning about other countries and their energy situations. Of importance is how the decision-making process can be different in these countries compared to their own country. Some countries to suggest are:
  - Australia
  - China
  - Nigeria
  - Pakistan
  - Saudi Arabia
  - United Kingdom
  - USA
- Depending on the scaffolding needs of your students, you may want to provide more curated or less curated resources for students. You may also want to provide students with Student Sheet 2.2, "Lateral Reading," from Activity 2 as a guide to exploring websites.

SAMPLE STUDENT RESPONSES

BUILD UNDERSTANDING

① **For each of the two communities you studied, which values were conflicting? Explain why it made it more difficult to agree on a decision.**

a Williamsport, Ohio

Many residents in Williamsport did not want to change the views of the countryside and wanted to keep it as farmland. Some also had worries that the solar panels would lower home prices and be a danger to the health of the environment, people, and animals. This prevented agreement between a small group of farmers who valued more income by leasing their land and the mayor and electrical union who valued more money and jobs from the solar farm being built.

b Uruguay

The government liked the plan because they valued not having to buy energy from other countries. A lot of residents on the coast also liked it because they valued lower emissions. But many people opposed it because of worries about how much it would raise the cost of electricity if the companies owned the utility. The private companies were also worried that it would cost them too much money to build all the wind turbines at the very beginning if they couldn't make money by owning the electrical grid.

② **Which of the two communities—Williamsport or Uruguay—had a more successful group decision-making process? Describe why.**

Answers may vary. One sample response follows.

I think Uruguay had a more successful decision-making process because the people who had a large influence on the decision (such as the president, private companies, and other government officials) were more open to the viewpoints of others and were more willing to compromise. The solar company in Williamsport offered a few ideas to compromise, such as walls to hide the view and help with the noise, but they did not really address the other side's values enough to really change most people's minds. In Williamsport, some people did not use verified facts about the safety of solar panels and seemed to make judgements based only on what they valued. Some people ended up really unhappy in the town afterward. In Uruguay, I feel like the different stakeholders listened to each other more and were more willing to compromise.

③ **Stakeholders can fail to reach a decision because of disagreement over values, claims of fact, or both. Describe an example from the first reading in which different stakeholders disagreed about a claim of fact.**

Some of the residents in Williamsport thought that the solar panels would leak dangerous cadmium that could harm plants and animals and people. But one of the farmers said he did research that showed that the levels of the element are too low to cause any health or environmental problems. Also, the company had agreed to clean up the solar panels after the lease, so it was not a fact that should have mattered.

④ **How are the real-world situations in the readings similar to:**

a the energy situation in Vanwick?

There are a lot of similarities between Vanwick and Williamsport because they are the same size community. They both considered solar farms as part of their energy plans. The conflicts over the size of the solar panels and their locations were also the same issues that came up in Vanwick.

b the energy situation around the world?

The Uruguay case study is an international situation, so it provides a little perspective on the global community. It is a small country, but it is a good model for the world about how to create a self-reliant system with low emissions. Uruguay's experience shows other countries that it can be done.

⑤ **In the Uruguay case, part of the success of the decision-making process included addressing the values of those who were previously underrepresented. Think about decisions in your school or community. Who are other stakeholders that may be underrepresented when group decisions are being made?**

Responses will vary. One sample response follows.

Students who have to travel a long distance to our school are underrepresented because they are not able to stay after school and contribute to the school council clubs. When the school administration makes decisions, they talk to students in the clubs, and those clubs don't have any members who live across town. The bus leaves right after school, and the late bus is unreliable. So those students' values are not well represented when students get to make decisions with the administrators.

CONNECTIONS TO EVERYDAY LIFE

⑥ **Think about a time you disagreed about what to do with someone at school or at home. It could have been a friend or someone related to you. How did you cope with this conflict between the values of pleasing the other person and your own values? Describe the situation and how a compromise might have resolved it (or did resolve it).**

My parents wanted me to finish my homework, but I wanted to go out with my friends to a movie. They valued me finishing my schoolwork to learn and help me in the future, but I was feeling stressed out and really wanted to have some fun. I got angry, but I think a compromise could have been reached if they agreed to let me do my homework with my friends. I would have gotten to spend time with friends and get my work done at the same time.

REFERENCES

Beras, E. (2023, October 6). How did Uruguay cut carbon emissions? The answer is blowing in the wind. National Public Radio. Retrieved from www.npr.org/2023/10/06/1197954251/uruguay-green-energy-carbon-emissions-climate-change

Gallagher Shannon, N. (2022, October 5). What does sustainable living look like? Maybe like Uruguay. *The New York Times*. Retrieved from www.nytimes.com/2022/10/05/magazine/uruguay-renewable-energy.html

Garcia-Navarro, L. (2014, May 12). Meet Uruguay's pot-legalizing, VW-driving, sandal-wearing president. National Public Radio. Retrieved from www.npr.org/sections/parallels/2014/05/12/311846447/meet-uruguays-pot-legalizing-vw-driving-sandal-wearing-president

Gearino, D. (2022, July 29). The energy transition runs into a ditch in rural Ohio. *Inside Climate News*. Retrieved from insideclimatenews.org/news/29072022/williamsport-ohio-solar/

Gearino, D. (2022, August 14). Outnumbered in rural Ohio: Two supporters of solar power step into a roomful of opposition. *Inside Climate News*. Retrieved from insideclimatenews.org/news/14082022/ohio-solar-outnumbered/

Gearino, D. (2022, September 30). The choice for rural officials: Oppose solar power or face revolt. *Inside Climate News*. Retrieved from insideclimatenews.org/news/30092022/solar-power-williamsport-ohio-rural-leaders/

Gearino, D. (2022, December 22). In the end, solar power opponents prevail in Williamsport, Ohio. *Inside Climate News*. Retrieved from insideclimatenews.org/news/22122022/solar-ohio-culture-wars-oppositionin/

Ritchie, H. Rosado, P., and Roser, M. (2023). Energy. Retrieved from: https://ourworldindata.org/energy

Community: _____

What was the energy problem and the group decision that needed to be made?

Reading Notes

WHO WERE THE STAKEHOLDERS?	WHAT VALUES WERE MOST IMPORTANT TO THEM?

Describe any compromises made to address the values of the stakeholders and the community's final decision.

Community: *The town of Williamsport, Ohio*

What was the energy problem and the group decision that needed to be made?

Many utility companies want to reduce emissions and lower costs by switching to more energy production by wind and solar. Generating electricity from solar panels or wind turbines can be cheaper than using coal or natural gas and help the state reach lower emission goals. The town of Williamsport, Ohio, needed to decide if a company called EDF Renewables would be allowed to build a new solar farm there.

Reading Notes

WHO WERE THE STAKEHOLDERS?	WHAT VALUES WERE MOST IMPORTANT TO THEM?
the solar company and the utility company	*lower costs to generate electricity, lower carbon dioxide emissions, making money for their companies*
farmers who want to lease their land to the solar company	*a stable source of money from leasing*
the mayor and other members of the community	*more money and jobs for the town by taxing the solar company*
the city of Columbus and the state of Ohio	*lower emissions for their climate-change goals of switching to more electricity from renewables*
other farmers and community members	*unchanged views and use of their countryside for farming, home values, health of animals and people*

Describe any compromises made to address the values of the stakeholders and the community's final decision.

The solar company offered to put up fences to hide some of the solar panels and work with farmers to prevent underground pipes from being broken. But in the end, most of the residents decided that they did not want the solar farm to be built in their town.

Community: *The nation of Uruguay*

What was the energy problem and the group decision that needed to be made?

Uruguay was not getting enough electricity from its hydroelectric dam and had to start buying energy from other counties. Electricity was getting expensive and was unreliable. Uruguay needed to decide on a new energy plan that would build wind turbines all around the country to generate electricity.

Reading Notes

WHO WERE THE STAKEHOLDERS?	WHAT VALUES WERE MOST IMPORTANT TO THEM?
residents who live on the coast	*lower greenhouse gas emissions to deal with climate change and prevent flooding of where they live*
members of government	*not having to depend on other countries for energy, lower costs of energy, a more stable source of energy*
labor unions	*reliable electricity, job stability*
residents who had been previously overcharged for electricity	*cost of electricity if the companies owned the energy grid*
private companies	*cost to build the wind turbines at the beginning of the plan*

Describe any compromises made to address the values of the stakeholders and the community's final decision.

The government offered to train the electrical workers and upgrade the hydroelectric dam to help the labor union agree to the energy plan. They also changed the plan so the electrical grid would be owned by the government, and the private companies would generate the electricity instead. The companies only agreed to this after the government agreed to buy all the energy for the next 20 years. In the end, the nation adopted the energy plan.

ACTIVITY 10

Group Decision for Vanwick

DISCUSSION

ACTIVITY 10

Group Decision for Vanwick

ACTIVITY SUMMARY

In this culminating activity, students participate in a group decision about Vanwick's energy future. Students review the location recommendations of different stakeholders from Activity 8 and bring those recommendations, and the stakeholder roles, into a final recommendation for the City Council. They draw from the unit's key concepts and process skills to work together to make a decision that is acceptable to all stakeholders.

ACTIVITY TYPE
DISCUSSION

NUMBER OF
40–50 MINUTE
CLASS PERIODS
3

KEY CONCEPTS & PROCESS SKILLS

1. Values affect people's decisions. There can be disagreement within a community when people hold a variety of values.
2. Community decisions are more likely to be accepted if the values of all stakeholders, especially those who are underrepresented, are considered in the decision-making process.
3. When making a group decision where there are conflicting values, a compromise is sometimes necessary.

NEXT GENERATION SCIENCE STANDARDS (NGSS) CONNECTION:
Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations. *(Science and Engineering Practice: Constructing Explanations and Designing Solutions)*

CONCEPTUAL TOOLS

WEAVING FACTS & VALUES IN DECISION-MAKING

GROUP DECISION-MAKING

MATERIALS & ADVANCE PREPARATION

FOR THE TEACHER

- VISUAL AID 10.1 "Scoring Guide: Decision-Making (DM)" (OPTIONAL)
- ITEM-SPECIFIC SCORING GUIDE: Activity 10, Build Understanding item 1

FOR THE CLASS

- SURVEY RESULTS FROM ACTIVITY 3 (OPTIONAL)

EACH GROUP OF FOUR STUDENTS

- POSTER BOARD OR SLIDE PRESENTATION

FOR EACH STUDENT

- STUDENT SHEET 8.1 "Vanwick Site Map: Stakeholder" (COMPLETED)
- STUDENT SHEET 10.1 "Vanwick Site Map: Group Decision"
- STUDENT SHEET 10.2 "Writing Frame: Decision-Making" (OPTIONAL)
- SCORING GUIDE: DECISION-MAKING (DM) (OPTIONAL)
- STAKEHOLDER CARD FROM ACTIVITY 8 (OPTIONAL)

Plan on how you'd like to have groups share their plans with the class. Options to present to the class could be a poster, gallery walk, video, or slideshow. If your students will not do well in a large group of eight students during the procedure, plan an alternate way for students to work on their recommendation (see Procedure Support Step 2). Lastly, decide how you would like the class to make a final recommendation, or not, for Vanwick after the presentations (see Procedure Support Step 3).

TEACHING NOTES

Suggestions for **discussion questions** are highlighted in gold.

Strategies for the **equitable inclusion of diverse students** are highlighted in pink.

GETTING STARTED (10 MIN)

1 **Revisit the stakeholder recommendations from Activity 8.**

- Ask students to locate their recommendations from Activity 8. They should have their completed recommendations in the form of Student Sheet 8.1, "Vanwick Site Map: Stakeholder." Remind students that each group made a recommendation, in the role of a stakeholder, about which generation sites they prefer. Review the map and the potential sites. Optionally, provide student groups with their stakeholder cards from Activity 8. Let students know that in this activity, they will start in the same groups they were in for Activity 8, using the same stakeholder perspective.
- Read the scenario and answer any questions students might have about it. In particular, revisit the concept of electrification as introduced in the Science Review in Activity 5. Make sure students understand why the demand for electricity in the future is predicted to grow significantly, while the overall consumption of energy in most developed countries is not. The predicted doubling of electricity in Vanwick reflects the real-world credible scientific predictions for the transitioning to renewable energy.
- Let students know that in this activity, they will have an opportunity to apply what they've learned in the unit to a final decision about where the renewable generation will be located.

PROCEDURE SUPPORT (75 MIN)

2 **Divide students into mixed-stakeholder groups for the decision-making process.**

- In Procedure Step 2, consider distributing the Stakeholder cards from Activity 8 so students can reference their role from the last activity. After groups review their stakeholder recommendations from that activity, reorganize students into mixed-stakeholder groups for Procedure Step 3. Each mixed-stakeholder group should include one representative from each of the eight stakeholder groups—to emphasize that the situation will truly be a group decision.

- If a group of eight is not manageable in your classroom, consider altering the procedure. One suggestion is to divide students into groups of four, instead of groups of eight. After each group comes to a consensus for the stakeholders in their group, they can present those plans to the class, or they can meet with another group of four to renegotiate a recommendation for the class.

3 **Support students as they make a group decision about the location of the renewable generation in Vanwick.**

- Students may ask about using the survey results from Activity 3 to guide their decision-making. Since the stakeholder perspectives provided in this activity are the same as in previous activities (Activity 3 and Activity 8), the most commonly held values are represented. However, you may want to remind students of the three most weighted values from the survey in Activity 3 as information they can use in their deliberations. Encourage groups to come up with decisions that are consistent with all stakeholder values so the group decision has a higher chance of being approved by the Vanwick community.

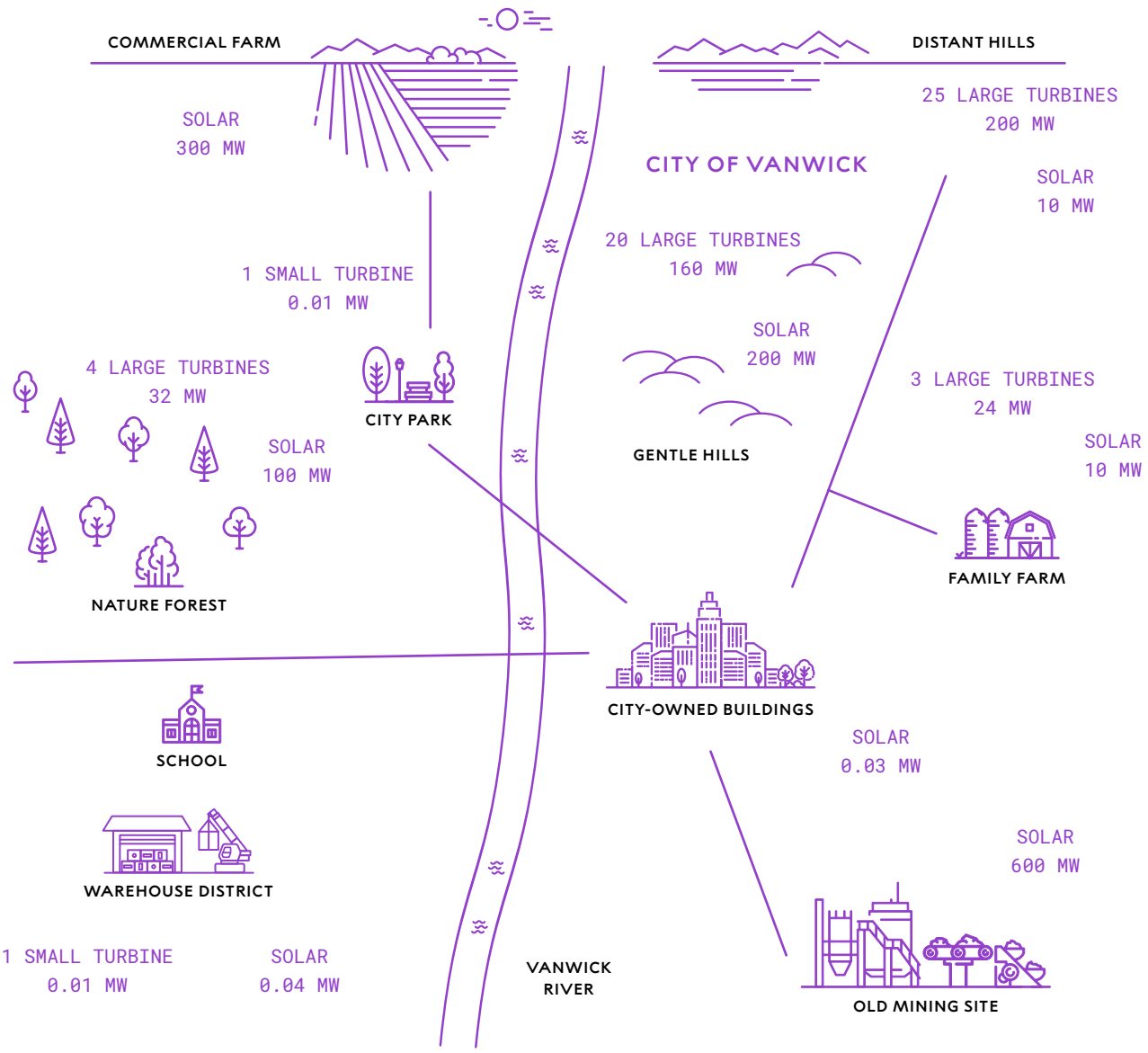
- Students should find that many of the recommendations from Activity 8 do not meet the 1,000 MW generation minimum. This means that students are not only forced to compromise with one another, but they must navigate the trade-offs needed to meet the generation needs. This reflects the challenging real-world situation many communities are facing. Often, the value of wanting renewable energy conflicts with people's values about land use.

- Students may also notice that there is an easy consensus around some sites. Examples are agreement to select the Old Mining Site and to not select the Nature Forest. Other sites have consensus but don't provide a lot of generation, such as the rooftop installations at the City-Owned Buildings, City Park, or the Warehouse District. Much conversation may be centered around the facts and values of a few critical sites—the Distant Hills Open Space Preserve, the two farms, and the Gentle Hills Open Space Preserve.

- As students work in their groups, circulate around the room to support their interactions. Remind students of the tool of compromise that was illustrated in the last activity. Suggest possible ways forward if students are struggling to find an acceptable compromise.

- While the Site Survey cards show the possible power generation quantities for each site, Figure 10.1 shows all the quantities together as a reference.

FIGURE 10.1
Possible Power Generation Quantities



4 Students present their recommendations to the class.

- Students should complete Student Sheet 10.1, "Vanwick Site Map: Group Decision," as they work in their groups to make a decision. Student responses for the student sheet will vary. One sample student response is shown at the end of this activity.
- Make sure students record their reasoning in their science notebooks so they can respond to the Build Understanding items. Consider having students preread the questions, particularly Build Understanding item 1, to provide guidance on what they need to record. The following is a sample of student notes, based on the sample student response to Student Sheet 10.1.

Sample Student Response, Procedure Step 5

Old Mining Site	*Everyone agrees on this. It is out of sight in an area that is already disturbed and has lots of generation.*
Business Farm	*The trade-off for this is that livestock creates more greenhouse gas emissions, which is not helpful, but those who valued natural views were willing to make that trade-off.*
Gentle Hills, solar	*It was a compromise because the other two sites don't have enough power. Those who valued views were willing to use solar panels if they were low and screened by greenery. Those who valued generation were willing to not put up the wind turbines at Gentle Hills Open Space Preserve to get more generation there.*
Warehouse District, solar	*Why not? Even though it is a small amount, it supported everyone's values. Aligned with businesspeople's values.*
City-Owned Buildings	*Why not? Even though it is a small amount, it aligned with everyone's values.*

Our big compromise happened because those who wanted lots of jobs also wanted wind, but we did not choose any wind. The compromise was that we picked an amount that went over 1,000 MW minimum so as to add some jobs.

- Provide the expectations for each group's presentation. Some choices are as follows:
  - completing a written proposal
  - designing a poster for a poster session and/or gallery walk
  - creating a slideshow to present to the class

- After all groups present their ideas, decide how students will make a final decision. Students can take a simple vote by a show of hands, using a ballot box, or taking an online survey. Alternatively, students could work together as a class to incorporate compromises and create a single plan based on consensus. Students will have an opportunity after the group decision to reflect on how the decision differs from their own choices.
- Complete the final class decision. Combine it with the previous decisions about energy storage and the Building Initiative. Put it all together with students and display it prominently in the classroom.

SYNTHESIS OF IDEAS (40 MIN)

5 **Responses to Build Understanding item 1 can be assessed using the Decision-Making Scoring Guide.**

- Remind students of the Decision-Making Scoring Guide. You may wish to project Visual Aid 10.1, "Scoring Guide: Decision-Making (DM)," for your students to review each level and clarify your expectations.
- Do not share Item-Specific Scoring Guide: Activity 6, Build Understanding item 1 with students, as it provides specific information on how to respond to the question prompt.
- For students who need support organizing and writing their responses, you may wish to provide the Writing Frame on optional Student Sheet 10.2, "Writing Frame: Decision-Making," to help them compose their responses. Students could also use the student sheet only as a reference or as a checklist as they write their responses. A sample student response for this student sheet is shown at the end of this activity. For more information on a Writing Frame, see Appendix 1: Literacy Strategies.
- Remind students that you are looking for demonstrated growth in their understanding and explanation of decision-making, and they may want to review their responses to the assessment in Activities 4 (Build Understanding item 1), 6 (Build Understanding item 1), and/or 7 (Build Understanding item 1). Note that this is the last opportunity in the unit to formally assess students, using the decision-making scoring guide.
- Depending on your students, you may want to have them provide feedback on one another's work for revision prior to turning in the work to you for scoring. Alternatively, consider having students turn in a rough draft to you for feedback and revision.
- Sample responses for Levels 1–4 are provided in the Build Understanding section that follows. Review these responses to get an idea of what is expected for each level, alongside the item-specific scoring guide. See Appendix 2: Assessment Resource for more guidance and information on using the scoring guides and assessment system with your students.

6 **Lead a class discussion to allow students to reflect on the decision-making process.**

- Ask, What were some of the conflicting (or different) values in your mixed-stakeholder group? Answers will vary but one of the big conflicts that students should recognize is that those who heavily weighted the value of maintaining natural views were at odds with those who valued the reduction of greenhouse gas emissions by generating as much renewable energy as possible. These values conflict because attempting to satisfy one of the values results in a solution that goes against the other value.

- Discuss how the decisions that students made as stakeholders compared to what their personal decisions would have been. Students often find it challenging to act on someone else's behalf, and this activity tested that skill. Students, like all people, will often insert their own values into a situation. Support the ideas that having to consider someone else's perspective builds empathy and supports decision-making.

- Elicit student ideas about how this process of decision-making compares to those from other cultures with which they are familiar. They may have group experiences that differ considerably from what was modeled in the activity. Some cultures are more authoritarian or less authoritarian and range from top-down to consensual leadership. Regardless of the leadership style, every culture has big decisions that involve multiple people's input, and its success depends on the consideration of facts and values.

- Conclude the activity by revisiting the Guiding Question, What should be considered while making a group decision about Vanwick's Project REV? The response to the question serves as a summary of the unit and should include key concepts and process skills related to decision analysis such as facts, values, weighted values, scenario planning, and compromise.

- Wrap up the unit by asking students to reflect on what was most impactful about their growth in group decision-making during the unit. Ask, How can the tools you learned about decision-making in this unit affect how you make decisions in your own life in the future? Accept all responses and connect students' ideas to their everyday decisions, especially important ones. Remind students that although the scenario in this unit was related to renewable energy—which they also learned about—the point of the unit was gaining the thinking tools related to decision-making concepts.

SAMPLE STUDENT RESPONSES

BUILD UNDERSTANDING

① DM Scoring Guide

Explain how your group decided on what to include in your plan to recommend to the Vanwick City Council. Be sure your explanation includes the following:

- the relevant facts and stakeholder values and how they affected your decision,
- the predicted outcome(s) of your decision,
- any trade-offs involved in your decision, and
- any part of the decision where there was a compromise.

Level 4 response

Our group decided to recommend solar panels only, built on a combination of locations at the Old Mining Site, Commercial Farm, Gentle Hills Open Space Preserve, Warehouse District, and City-Owned Buildings. We discussed all the stakeholder values, the facts related to each possible generation location, and how they all fit together to come up with a plan that would address as many stakeholder values as possible and still generate at least the minimum amount of electricity (1,000 MW) needed for the community. We considered a range of facts, such as how much power could be generated at each site (to meet ProjectREV goals) and if there would be a change of land use or an obstruction of views (to support stakeholder values). We predict that our recommended plan will generate more than the 1,000 MW needed for Vanwick, while supporting most of the stakeholders' common values.

Overall, meeting the ProjectREV goals supports the common stakeholder value of reduction of greenhouse gases. This means that by generating enough power with renewable resources, our plan will line up with that value. There was one area where there was a trade-off—choosing the Commercial Farm site means that the farmer will have to switch to just raising cattle, which will give off more greenhouse gas emissions than his current farm. But we think the trade-off for the solar panels is worth it in the end since that location can hold enough solar panels to produce 300 MW. The common stakeholder value of not obstructing views meant that we had to be careful about choosing locations, but we were able to do that and still have enough sites. However, another common stakeholder value was increasing the number and security of jobs, and we had to compromise on that because putting in solar panels does not create as many jobs. But we tried to address that, at least partially, by choosing sites that together generate more than the 1,000 MW minimum needed and that will still create some jobs.

Level 3 response

Our group decided to recommend solar panels only, built on a combination of locations at the Old Mining Site, Business Farm, Gentle Hills Open Space Preserve, Warehouse District, and City-Owned Buildings. We discussed all the stakeholder values, the facts related to each possible generation location, and how they all fit together. We considered a range of facts, such as how much power could be generated at each site and if it would obstruct views. We predict that our recommended plan will generate more than the 1,000 MW needed for Vanwick.

There was one trade-off—choosing the Commercial Farm site means more greenhouse gas emissions. One common stakeholder value was increasing number and security of jobs, and we had to compromise on that because putting in solar panels does not create as many jobs.

Level 2 response

Our group decided to recommend solar panels at several locations. We made sure that, together, the sites would generate enough MW for Vanwick's needs. We also made sure that there were fewer greenhouse gases emitted, based on our plan. We had to compromise a little because we chose the Commercial Farm as one location and that means the farmer will have more cattle, and cattle produce greenhouse gases.

Level 1 response

Our group decided to recommend solar panels at several locations. We didn't want too many greenhouse gases, and we thought that jobs were important but not the most important thing. We didn't want any wind power generation because the stakeholders might not value that.

② **How do you think your stakeholder would have responded to the final recommendation?**

Responses will vary. One sample response is shown here.

My stakeholder would not have been happy with the recommendation because it included 10 wind turbines up on the Distant Hills Opens Space Preserve. His top values included not having any obstructed views or turbines, so he would have been upset about the decision.

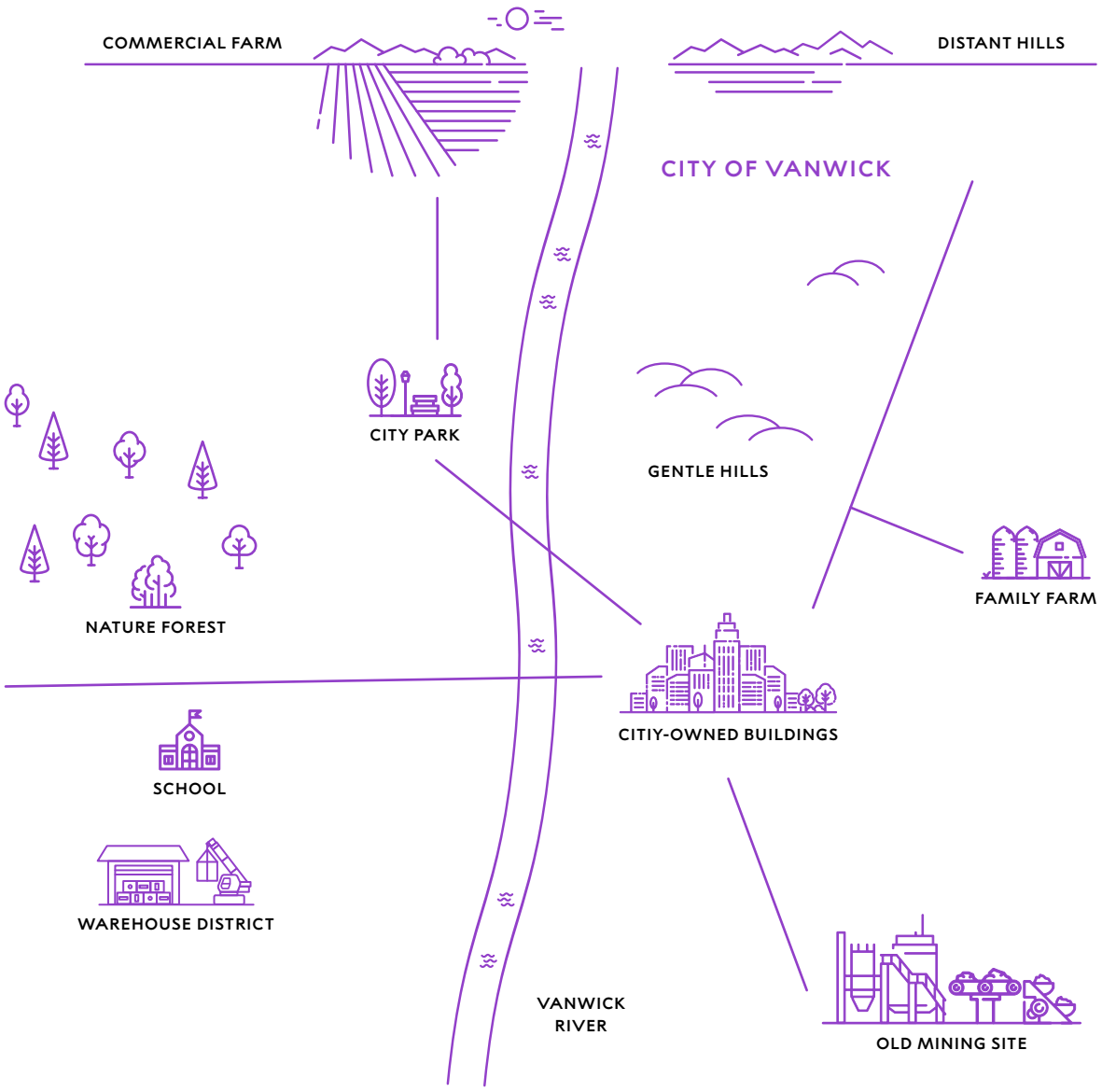
③ **Think back on your experience trying to find compromises with your group.**

a What was most difficult about the process of group decision-making?

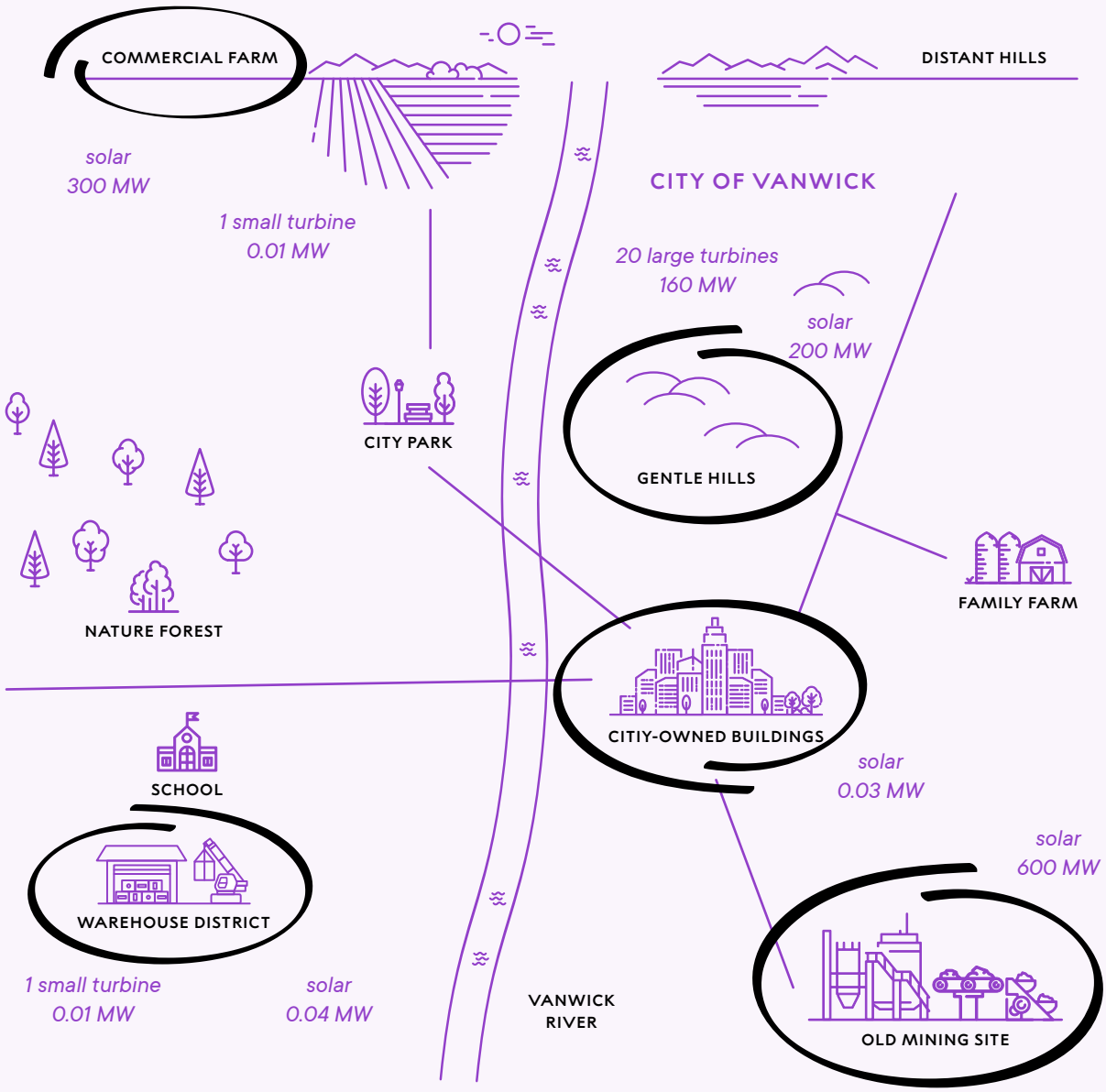
The most difficult thing was making compromises because everyone in my group was really into their roles and would not give up anything. In the end, we agreed on something that not everyone was happy about.

b What are some advantages and disadvantages of compromising during group decision-making?

The advantage is that you can make a decision and move on. Making a decision that everyone can live with is better than not being able to make a decision, but the disadvantage is that no one gets what they want! Sometimes, the compromise leads to mixed-up ideas and solutions that don't make enough sense.



Possible Power Generation	TOTAL	MW



Possible Power Generation	TOTAL	1,100.07 MW

I/we/they have decided

The value(s) that I/we/they are weighting most heavily is

One fact related to the value is

A second fact related to the value is

Together, these facts and values affect the decision because

The likely outcome of this decision is

(OPTIONAL) **The trade-offs of this decision were**

(OPTIONAL) **This decision involved compromising about**

I/we/they have decided

that Vanwick should use solar panels only at commercial locations.

The value(s) that I/we/they are weighting most heavily is

the reduction of greenhouse gases and not obstructing views.

One fact related to the value is

wind turbines obstruct views more than solar panels.

A second fact related to the value is

that some of the bigger commercial locations (Old Mining Site, Commercial Farm) provide a large amount of electrical power through solar.

Together, these facts and values affect the decision because

it means we could reach our goal of 1,000 MW without having to compromise our most important values.

The likely outcome of this decision is

that we will generate over the minimum amount of electricity (1,000 MW) needed for the community with low emissions and without obstructing views with turbines.

(OPTIONAL) **The trade-offs of this decision were**

choosing the Commercial Farm site means that the farmer will have to switch to just raising cattle, which will give off more greenhouse gas emissions than his current farm. The trade-off for the solar panels is worth it in the end since that location can produce 300 MW without generating greenhouse gases.

(OPTIONAL) **This decision involved compromising about**

the common stakeholder value of increasing the number and security of jobs. We had to compromise on that because putting in solar panels does not create as many jobs as wind turbines. But we tried to address that, at least partially, by choosing sites that together generate more than the 1,000 MW minimum needed and that will still create some extra jobs.

VISUAL AID 10.1 | SCORING GUIDE: DECISION-MAKING (DM)

WHEN TO USE THIS SCORING GUIDE:

This _ is used when students are explaining a decision (sometimes in the form of a recommendation) that incorporates relevant facts and values and predicts possible outcomes.

WHAT TO LOOK FOR:

- Response incorporates and explains the effects of relevant facts and stakeholder values on the decision.
- Response identifies trade-offs (if appropriate).
- Response describes any compromises made (if appropriate).

LEVEL	GENERAL DESCRIPTION
Level 4 **Complete and correct**	The student explains a decision made from two or more options that incorporates: • one or more relevant stakeholder values. • the facts associated with those values. • how the facts and values affected the decision. • predicted outcome(s) supported by the relevant facts. • any trade-offs made as a result of weighing the relevant facts and values (if appropriate). • any compromise made by stakeholders (if appropriate).
Level 3 **Almost there**	The student explains a decision made from two or more options that incorporates most of the following, BUT one or more may be insufficiently described: • one or more relevant stakeholder values • the facts associated with those values • how the facts and values affected the decision • predicted outcome(s) supported by the relevant facts • any trade-offs made as a result of weighing the relevant facts and values (if appropriate) • any compromise made by stakeholders (if appropriate)

LEVEL	GENERAL DESCRIPTION
Level 2 **On the way**	The student provides a clear and relevant decision, BUT the explanation of supporting facts and values is incomplete.
Level 1 **Getting started**	The student provides a clear and relevant decision BUT provides inaccurate or unrelated facts, unrelated values, and/or an illogical explanation of the decision.
Level 0 **Missing or off task**	Student response is missing, illegible, or irrelevant.
X	The student had no opportunity to respond.

WHEN TO USE THIS SCORING GUIDE:

This Scoring Guide is used when students are explaining a decision (sometimes in the form of a recommendation) that incorporates relevant facts and values and predicts possible outcomes.

WHAT TO LOOK FOR:

- Response incorporates and explains the effects of relevant facts and stakeholder values on the decision.
- Response identifies trade-offs (if appropriate).
- Response describes any compromises made (if appropriate).

LEVEL	GENERAL DESCRIPTION	ITEM-SPECIFIC DESCRIPTION
Level 4 **Complete and correct**	The student explains a decision made from two or more options that incorporates: • one or more relevant stakeholder values. • the facts associated with those values. • how the facts and values affected the decision. • predicted outcome(s) supported by the relevant facts. • any trade-offs made as a result of weighing the relevant facts and values (if appropriate). • any compromise made by stakeholders (if appropriate).	**The student explains their group's decision on what to recommend to the City Council, incorporating the following:** • 2–3 relevant facts OR overall summary of pertinent facts • common stakeholder values (such as reduce emissions, no view obstruction, more jobs) • how facts and values were woven together (general or specific description) • predicted outcomes (may vary, depending on plan) • clear description of trade-off(s) • clear description of compromise(s) **However, specific points may vary, depending on the group's recommendation.**

LEVEL	GENERAL DESCRIPTION	ITEM-SPECIFIC DESCRIPTION
Level 3 **Almost there**	The student explains a decision made from two or more options that incorporates most of the following, BUT one or more may be insufficiently described: • one or more relevant stakeholder values • the facts associated with those values • how the facts and values affected the decision • predicted outcome(s) supported by the relevant facts • any trade-offs made as a result of weighing the relevant facts and values (if appropriate) • any compromise made by stakeholders (if appropriate)	**The student explains their group's decision on what to recommend to the City Council, incorporating the following, BUT one or more may be insufficiently described:** • 2–3 relevant facts OR overall summary of pertinent facts • common stakeholder values (such as reduce emissions, no view obstruction, more jobs) • how facts and values were woven together (general or specific description) • predicted outcomes (may vary depending on plan) • clear description of trade-off(s) • clear description of compromise(s) **However, specific points may vary, depending on the group's recommendation.**

LEVEL	GENERAL DESCRIPTION	ITEM-SPECIFIC DESCRIPTION
Level 2 **On the way**	The student provides a clear and relevant decision, BUT the explanation of supporting facts and values is incomplete.	The student explains their group's decision on what to recommend to the City Council, BUT the explanation of supporting facts and values is incomplete (e.g., only one fact, not including values, not stating possible outcomes) or is missing compromises or trade-offs relevant to their plan.
Level 1 **Getting started**	The student provides a clear and relevant decision BUT provides inaccurate or unrelated facts, unrelated values, and/or an illogical explanation of the decision.	The student explains their group's decision on what to recommend to the City Council BUT provides inaccurate or unrelated facts, unrelated values, and/or an illogical explanation of the decision.
Level 0 **Missing or off task**	Student response is missing, illegible, or irrelevant.	
X	The student had no opportunity to respond.	

APPENDIX 1

LITERACY STRATEGIES

Teaching ***Scientific Thinking for All: A Toolkit*** provides constant opportunities for students to improve their English language skills. For example, students are expected to read informational text and procedures, write clearly to respond to assessment items, and use oral language skills during discussions. Research-based support strategies are embedded throughout the activities to help students process new content, develop analytical skills, connect concepts, become more proficient readers, and express their knowledge.

The literacy strategies offered in the curriculum depend on the instructional needs of the activity in which they are embedded. Because a full explanation of each research-based strategy is not practical to provide in the Teaching Notes of the Teacher Edition, a more detailed description for each goal is described below.

Eliciting Prior Knowledge

Concept Map
Anticipation Guide

Processing Information

Frayer Model
Venn Diagram
Word Sort

Reading Comprehension

Read, Think, and Take Note
DART (Directed Activity Related to Text)

Oral Discussion and Debate

Walking Debate
Developing Communication Skills

Writing Support

Writing Frame
Science Notebook

CONCEPT MAP

What It Is

A concept map is a visual representation of the relationship between ideas and concepts. Concept maps ask students to make and describe relationships between main ideas and subtopics and among the subtopics themselves.

Why Use It?

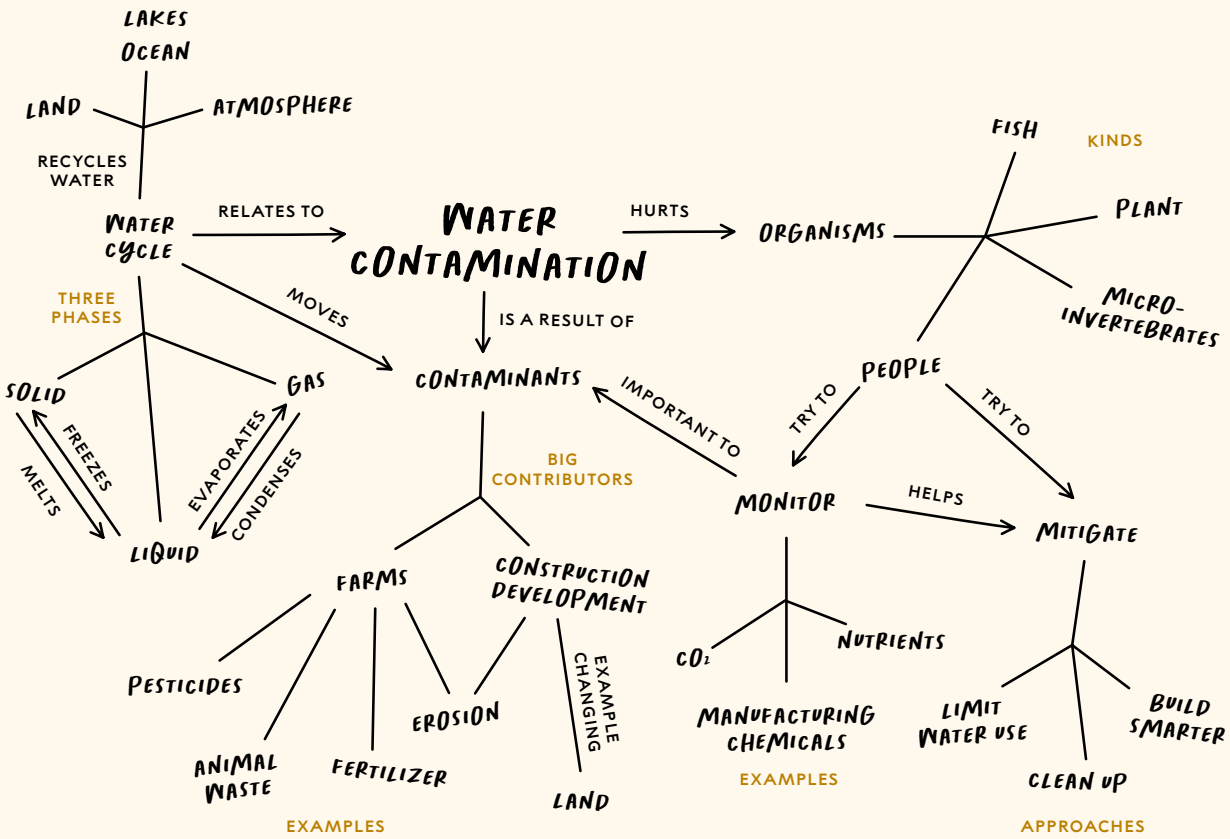
Concept maps demonstrate students' understanding of the connections between topics in a spatial manner. They also allow students to expand their knowledge related to a topic.

How To Use It

The main concept is written in the center of a page (or on the board), and students place subtopics around it, connecting lines between each subtopic and the main concept. On or near each line they've drawn, students add a brief description of the relationship between the two words.

The following example is from a prompt in a unit where students are asked to draw a concept map about water contamination.

Initially, students may find it helpful to have a list of words that must be included in the map or an incomplete concept map to fill in. Later, students might brainstorm words that should be included and make a list before beginning their concept maps. It may also be helpful to write each subtopic on an index card or sticky note so students can physically manipulate them and lay out the map.



If your students are unfamiliar with concept maps, model the process by using a familiar central idea, such as school. Write "school" on the board and with the class, brainstorm subtopics to place around it (i.e., What are words and ideas associated with school?). Off to the side, organize these subtopics in a hierarchy, listing the more general ideas first and the more specific ones toward the bottom. Arrange the ideas spatially on the map, with the more general ideas closer to the central topic and the more specific ideas radiating out from the general ideas. Link the general ideas to the central concept with ideas, words, or short sentences defining the connection between the concepts. Then add links explaining the connection between the general and more specific ideas.

Where It Is

Concept maps are most often part of the Teaching Notes in the Teacher Edition; they may also be Build Understanding items in the Student Book. Instructions for constructing a concept map can be found in the Teacher Edition.

ANTICIPATION GUIDE

What It Is

An Anticipation Guide is a pre-reading exercise to help students activate their background knowledge about a topic and generate curiosity about the material they will learn. Students answer a set of prompts before reading; after reading, students discuss how their predictions compare with the information in the reading.

Why Use It?

The value of an Anticipation Guide is in the discussion that occurs before and after the reading. Before reading, students discuss their predictions and the reasons for them. During this discussion, the teacher gleans information about the depth of students' existing knowledge and their misconceptions about a topic. The post-reading discussion on how students' answers have changed allows teachers to formatively assess what students gained from the reading.

How To Use It

Students begin by individually responding to a series of statements related to the text they will read. They state whether they agree or disagree with a statement by marking it with a + (agree) or a – (disagree). The statements give students a sense of the key ideas in the reading and elicit their current ideas about and knowledge of the material. Students then discuss their predictions as a class. After completing the reading and participating in another discussion, students revisit the statements and record whether they now agree or disagree with each one. Their final task is to cite information from the reading to explain how the text either supported or changed their initial ideas.

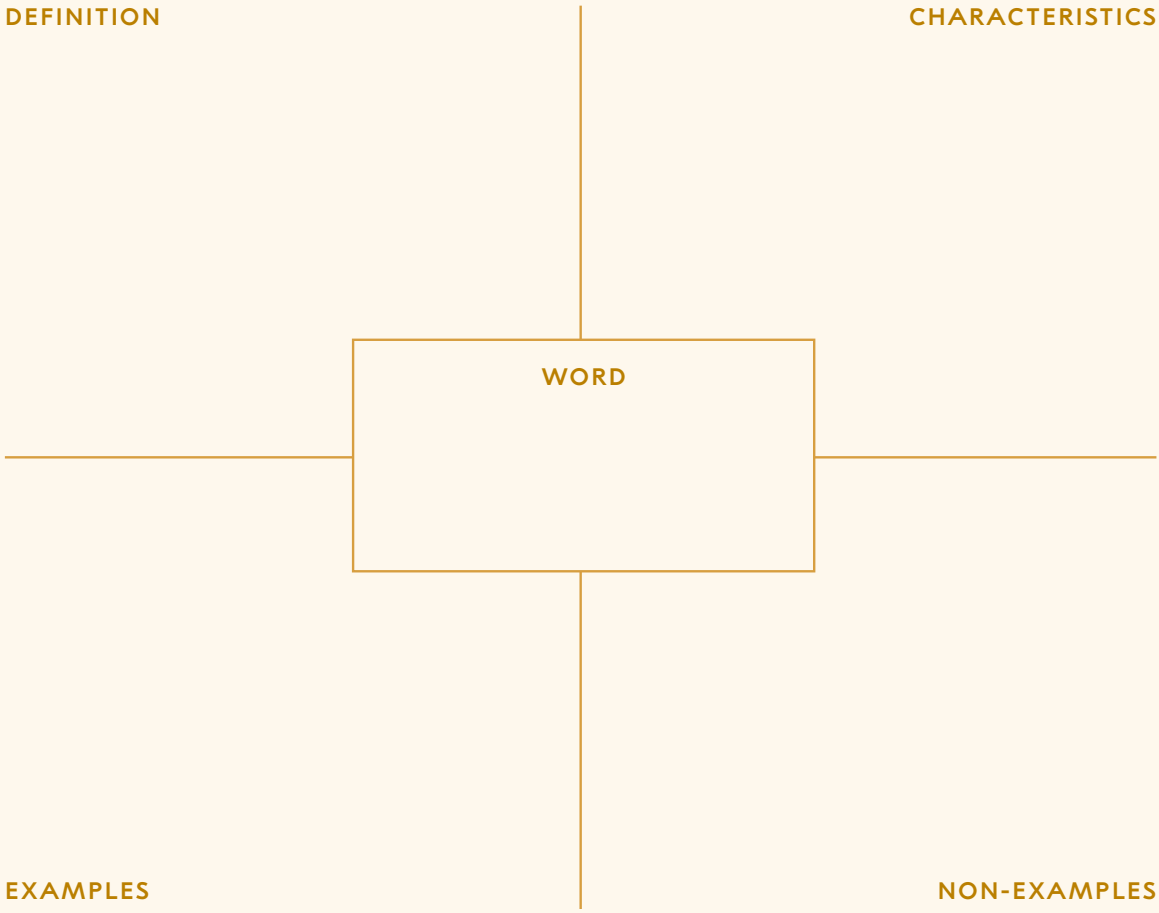
Where It Is

The Anticipation Guide student sheet can be found in the Teacher Edition for the activities in which it is used. Sample student responses are also located in the Teacher Edition.

FRAYER MODEL

What It Is

The Frayer Model is a graphic organizer used in direct instruction of discipline-specific vocabulary. In a Frayer Model, students define a word and examine its characteristics and then offer examples and non-examples to build a deep conceptual understanding of the word.



Why Use It?

The Frayer Model offers support as students examine the conceptual meaning of discipline-specific vocabulary. The Frayer Model supports the conceptual development of terms and concepts as they are introduced. Students can return to the Frayer Model as they continue to use the word throughout a course of learning to revise the model, based on their deepening understanding of the word.

Where It Is

Frayer Models can be found as Build Understanding items in the Student Book and in the Teaching Notes in the Teacher Edition.

VENN DIAGRAM

What It Is

A Venn diagram is a strategy for comparing the relationship between two ideas or concepts in a simple visual format. Students visually map the characteristics that are unique to a set of ideas or concepts and the characteristics that are shared.

Why Use It?

By placing words on a page in relation to each other and then explaining their placement, students show that they understand the meaning of each word and the relationship between them. A Venn diagram can be used as a focus for a discussion or for a writing assignment that asks students to compare and contrast ideas. It can also be used as a formative assessment that probes students' understanding of a set of concepts. The simplicity and flexibility of setting up a Venn diagram makes it easily adaptable to many classroom situations.

How To Use It

A Venn diagram involves drawing two to four overlapping circles, each labeled according to the subject being compared. In the outer part of each circle, students write the information that is unique to the subject of the circle. In the overlapping spaces, they write the elements common to all subjects. Students may complete Venn diagrams as a class, in groups, or individually.

Where It Is

Venn diagrams can be found as Build Understanding items in the Student Book and in the Teaching Notes in the Teacher Edition.

WORD SORT

What It Is

A word sort is a categorization activity that helps students synthesize science concepts and vocabulary. Students classify words and phrases into categories based on the relationship between them.

Why Use It?

Word sorts encourage students to accurately draw on what they've learned and to use logic to determine how different words and phrases are related. Teachers can use students' explanations as a formative assessment of how well they understand the overall concepts.

How To Use It

Students are first asked to look for a relationship among a list of four or five words or phrases related to a topic and to cross out the one word or phrase that does not belong. Next, they are asked to circle or highlight any word or phrase that includes all the other words. (There may be more than one correct answer to a single word sort.) Finally, students must explain how the circled word or phrase is related to all the other words or phrases in the list.

Where It Is

Word sorts can appear as Build Understanding items in the Student Book and in the Teaching Notes in the Teacher Edition.

READ, THINK, AND TAKE NOTE

What It Is

Read, Think, and Take Note is a strategy that helps students externalize their thinking by recording their thoughts, reactions, or questions on sticky notes as they read. The notes serve to make concrete the thoughts arising in students' minds and then serve as prompts to generate conversation or write explanations.

Why Use It?

Asking students to record thoughts on sticky notes as they read helps with literacy development by providing a structure for students to record the thinking process. Students may later return to that record to clarify misconceptions or to add depth to their thoughts. The notes also provide a way for the teacher to see how students think as they read, enabling the teacher to select appropriate supports. For example, a student who is unsure of the meaning of a word benefits from the teacher's suggestion to look up the definition. Or, if a student has noted how a reading reminds them of an event from their own life, the teacher can note how making those connections helps with comprehension.

How To Use It

Teachers can explain to students that as they follow this strategy, they are learning some ways that proficient readers think while reading. After reviewing the "Read, Think, and Take Note Reading Strategy" in the Student Book, teachers can then model the strategy, using a section of text from the Student Book. There are many ways to respond to text, and each student will create a unique set of comments. Teachers should emphasize that everyone is learning and has questions and that they should all be respectful of one another's ideas. One option is to conduct small-group discussions or a class discussion during which students can clarify any points of confusion, and the teacher can see how students are interpreting the reading.

Where It Is

The Read, Think, and Take Note directions can be found in the Student Book.

DIRECTED ACTIVITY RELATED TO TEXT

What It Is

A Directed Activity Related to Text (DART) supports reading comprehension and critical thinking by having students interact with and manipulate the information they are reading. Examples of DARTs are matching and labeling exercises, sequencing, grouping, predicting, and completing a diagram or table. DARTs that require higher-order processing include extracting information and placing it in tables and flowcharts.

How To Use It

A DART must be prepared before students begin so that it can be tailored to a particular text. Students usually complete the DART after they finish the reading. To help students further engage with the content, they may discuss the DART in groups before completing it or complete it as a group.

Where It Is

DARTs are usually found as Build Understanding items or as student sheets in the Teacher Edition for the activity in which they are used.

WALKING DEBATE

What It Is

A Walking Debate allows students to practice oral argumentation. The teacher designates specific locations around the classroom that represent differing perspectives on an issue. Students stand in the location that best represents their opinion regarding the issue. In turns, students argue for the merits of their perspectives and support their arguments with evidence. As they hear others' arguments and evidence, students can opt to change their opinions and physically move to the area of the room that best represents what they now believe.

Why Use It?

Walking Debates require students to physically engage in oral discourse in the classroom. By committing to a position, both literally and figuratively, Walking Debates support oral discourse that uses claims, evidence, and reasoning. Students' engagement in scientific argumentation is motivated by seeing the distribution of perspectives among their classmates. Research also suggests that the inclusion of movement in the activity provides sensory input to the brain that enhances learning.

How To Use It

Begin by identifying the question or issue to be debated and designate different parts of the classroom as representing certain points of view. For example, for the question *Which vehicle do you think is safer, Vehicle 1 or Vehicle 2?*, one corner of the room could be designated as Vehicle 1 and a different corner designated as Vehicle 2.

Students walk to the corner that best represents their point of view and then talk within that group to come up with a convincing argument to bring people from the other area(s) to their own area. It is helpful to have students keep a record of the evidence they will consider for the Walking Debate, especially when they are new to the strategy. Teachers might also have students work in pairs to generate the evidence.

Each group makes its presentation, and students from the other group(s) may ask questions. When all groups have presented, students who change their minds move to the area that represents their final position.

Where It Is

Walking Debates are usually identified in the Procedure steps in the Student Book. The corresponding Teacher Edition provides instructions on how to run the specific debate.

DEVELOPING COMMUNICATION SKILLS

COMMUNICATION	SENTENCE STARTERS
to better understand	One point that was not clear to me was . . . Are you saying that . . . ? Can you please clarify . . . ?
to share an idea	Another idea is to . . . What if we tried . . . ? I have an idea—we could try . . .
to disagree	I see your point, but what about . . . ? Another way of looking at it is . . . I'm still not convinced that . . .
to challenge	How did you reach the conclusion that . . . ? Why do you think that . . . ? How does it explain . . . ?
to look for feedback	What would help me improve is . . . Does it make sense, what I said about . . . ?
to provide positive feedback	One strength of your idea is . . . Your idea is good because . . .
to provide constructive feedback	The argument would be stronger if . . . Another way to do it would be . . . What if you said it like this . . . ?
to discuss information presented in text and graphics	I'm not sure I completely understand this, but I think it may mean . . . I know something about this from . . . A question I have about this is . . . If we look at the graphic, it shows . . .

DEVELOPING COMMUNICATION SKILLS

What It Is

The Developing Communication Skills visual aid is a tool to help students effectively participate in class discussions. It promotes positive classroom discourse by suggesting how students might appropriately express disagreement, seek clarification, or build on one another's ideas.

How To Use It

Suggestions are presented in the form of sentence starters that students can use to initiate a conversation and express their ideas. Teachers can gradually incorporate this strategy into group work by introducing one sentence starter at a time to elicit students' ideas.

Where It Is

The Developing Communication Skills visual aid, as shown on the previous page, can be found in the Teacher Edition for the activities in which it is used, in Appendix E: Group Interactions in the Student Book, and under the Embedded Student Support Sheets tab of these Teacher Resources.

WRITING FRAME

What It Is

A Writing Frame creates an outline to guide student composition. It can be geared to a particular type of explanatory writing, such as arguments that depend on evidence. Through prompts that students briefly respond to in writing, the Writing Frame leads students to develop headings, sentences, and main content points.

Why Use It?

Writing Frames are an excellent strategy to help students develop and organize their ideas prior to writing extended responses or completing a writing assignment. Writing Frames also support assessment of student work.

How To Use It

Teachers first provide direct instruction on the appropriate type of Writing Frame and the components it includes. When introducing the Writing Frame, teachers instruct students on the components essential to the structure of the essay, including an opening sentence that states the decision or conclusion each student has come to, evidence that supports the decision or conclusion, and a discussion of the trade-offs associated with their conclusion.

Where It Is

The Writing Frame student sheet can be found in the Teacher Edition for the activities in which it is used. Sample student responses are also located in the Teacher Edition.

SCIENCE NOTEBOOK

What It Is

The science notebook is an informal place for students to record their ideas and develop new constructs that aid in their sensemaking. In their notebooks, students bring together their ideas as they make sense of the unit issue and key concepts.

Why Use It?

A science notebook allows students to authentically engage in the practices of science. It supports students' efforts to process ideas, ask questions, keep track of data during investigations, and build their scientific-observation and writing skills. Students can also use the science notebook to keep complete records of their data and investigations.

How To Use It

When introducing science notebooks, model how students should record information. The Keeping a Science Notebook visual aid has guidelines for how to keep good records—including the purpose, background, hypothesis, experimental design, data, and conclusion for an investigation.

Where It Is

The Student Book regularly prompts students to use their science notebooks, particularly during Procedures. The Keeping a Science Notebook visual aid is included in the Teacher Edition to support the use of a notebook in class.

APPENDIX 2

ASSESSMENT RESOURCE

The assessments provided in *Scientific Thinking for All: A Toolkit* are designed to be used as formative and summative assessment of students' progress. Assessments support classroom instruction while ensuring that students are provided with adequate opportunities to demonstrate their developing understanding of the content and receive feedback to further this learning process. Teachers can use this research-based approach for interpreting students' work to monitor and facilitate their progress. The assessment approach for the course shifts the assessment of knowledge from **what students know to how they are able to apply what they know**. As such, students engage in the key concepts and process skills of the course as they analyze evidence and make decisions related to everyday issues.

Assessment tasks are embedded in the curriculum and are an integral part of the learning activities. Teachers can use these assessments to inform future instruction, with the aim of helping to enhance students' learning. This is done through the use of purposefully designed assessment variables, assessment items, and Scoring Guides, as shown in the following diagram and description of each component.

ASSESSMENT VARIABLES concepts and practices		ASSESSMENT ITEMS		SCORING GUIDES general and item-specific rubrics
Evidence & Trade-Offs (E&T) Developing and Using Models (MOD) Analyzing and Interpreting Data (AID) Decision-Making (DM)	→	embedded in activities for each variable	→	describe competency levels for each variable

ASSESSMENT VARIABLES

The assessment variables listed in the second column of the diagram are the key areas across which students are expected to progress throughout a unit or sequence of units. Each unit focuses on one of these variables as shown in the following table:

UNIT	ASSESSMENT VARIABLE	DESCRIPTION
1 **Scientific Tools & Evidence**	Evidence & Trade-Offs	This Scoring Guide is used when students are making a choice or developing an argument about a socioscientific issue where arguments may include judgments based on nonscientific factors.
2 **Scientific Modeling**	Developing and Using Models	This Scoring Guide is used when students develop their own models or use established models to describe relationships and/or make predictions about scientific phenomena.
3 **Systematic Scientific Investigations**	Analyzing Data	This Scoring Guide is used when students analyze and interpret data that they have collected or that has been provided to them.
4 **Evaluating Data**	Analyzing Data	This Scoring Guide is used when students analyze and interpret data that they have collected or that has been provided to them.
5 **Human Bias in Science**	Argumentation	This Scoring Guide is used when students are developing arguments about alternative explanations of scientific phenomena.
6 **Group Decision-Making**	Decision-Making	This Scoring Guide is used when students are making a decision by integrating evidence, facts, and values.

Within each unit, the focus should be on progress, and each student's goal should be to improve with each subsequent assessment in a unit. Across the units, the variables build upon one another as the course progresses. Over time, the progression of variables supports students' increasing sophistication in using the conceptual thinking tools of the course for decision-making in their everyday lives. For example, in Unit 6, students are assessed on their ability to use evidence to make a decision and identify simple trade-offs based on that decision. By Unit 5, students' understanding of how evidence is used in claims has increased, and they are expected to articulate their decision using more complex claims, evidence, and reasoning.

ASSESSMENT ITEMS

Assessment items are questions, tasks, or prompts related to the assessment variables, which are designed to gather evidence about students' progress. Assessment items may take the form of a procedural step, a Build Understanding item or an Everyday Connection prompt that asks students to communicate about a new idea, analyze data from an experiment, model concepts and relationships, transfer their understanding to a novel context, or make predictions. For example, in Unit 6, students make a recommendation for a fictional community's energy generation system. After their group collectively comes up with a recommendation, each student is assessed on their individual response to a Build Understanding item that prompts students to describe in detail how they used facts and values to make a decision.

SCORING GUIDES

Scientific Thinking for All: A Toolkit Scoring Guides directly correspond with each assessment variable and are used to interpret students' responses. Scoring Guides allow teachers and students to monitor students' growth and encourage their progression from novice to expert on each variable. The general Scoring Guides are formatted as holistic scoring guides. Additionally, all items designated as assessments within the curriculum also have detailed Item-Specific Scoring Guides with criteria specific to each assessment item. These Item-Specific Scoring Guides can be found in the Teacher Edition for the activity in which a summative assessment appears.

Students' responses are categorized into five competency levels:

Level 4	**Complete and correct**
Level 3	**Almost there**
Level 2	**On the way**
Level 1	**Getting started**
Level 0	**Missing or off task**

To achieve a particular assessment level, a student's response must fulfill all the requirements of that level. A Level 4 response indicates that the student has mastered the practice or concept. The Teacher Edition includes Level 1–4 student exemplar responses in the Teaching Notes or sample responses for each designated assessment item.

Note that while the Scoring Guides involve assigning numerical values from 0 to 4 to student work, these scores are not equivalent to a grading system. Rather, scores on assessment items are indicative of the level of performance demonstrated by the student on a specific task, evaluated through a clearly defined lens.They are meant to reflect levels of performance on individual tasks, whereas a grading system inevitably reflects the goals and desired outcomes of a district, school, and/or teacher.

USING A SCORING GUIDE

Initially, it is not reasonable to expect students to perform at Levels 3 and 4. The targets for an assessment level may vary over the course of a unit and a school year. Likewise, it is not always useful to use students' work to set the standards for each assessment level. For example, the best student response should not automatically be given a score of 4. The important thing is that both teacher and student understand what each level represents and that it can identify growth over multiple uses of the Scoring Guide. For most students, achieving consistent improvement of one level or more in an assessment variable over the course of a unit is an indicator of academic progress.

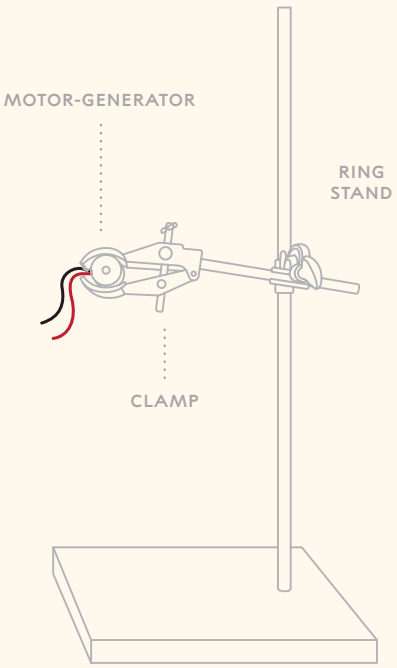
Before using a Scoring Guide, teachers must make sure that the criteria for each scoring level are clear to themselves and their students and that everyone understands the distinctions between levels. While the Item-Specific Scoring Guide is provided only for teacher use, as it can reveal an appropriate response, students should be provided the general Scoring Guide in advance of an assessment item. They should be encouraged to refer to the Scoring Guide as they develop their responses. This helps them develop the ability to evaluate their own work and take on more ownership of their learning.

APPENDIX 3

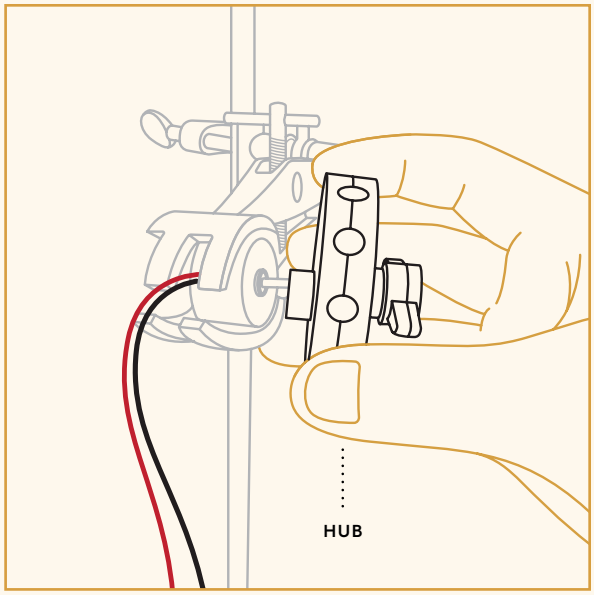
LABORATORY SETUP INSTRUCTIONS

ACTIVITY 4 LAB SETUP INSTRUCTIONS

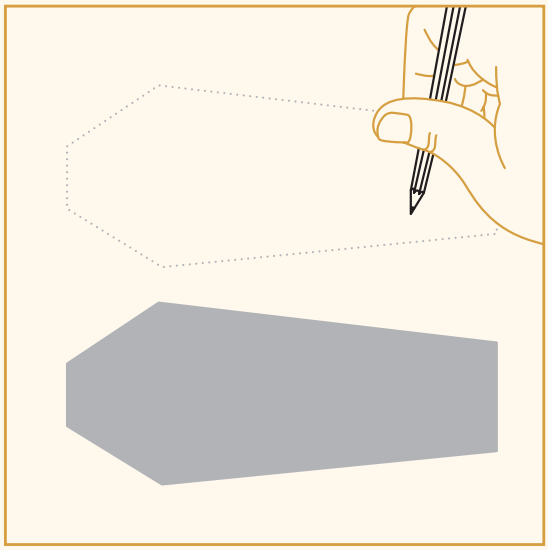
① **Attach the motor-generator to a ring stand, using a clamp.**



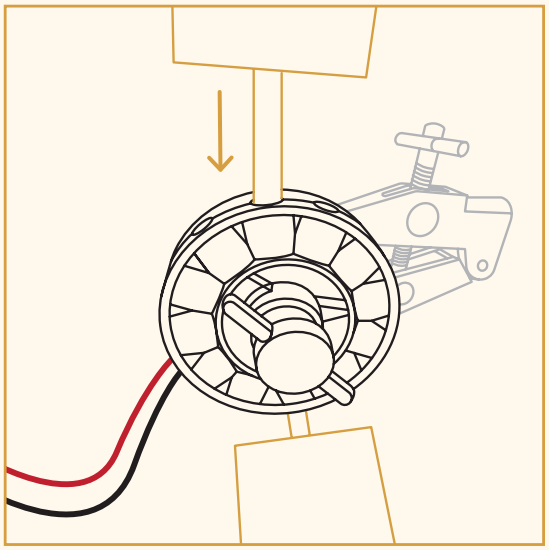
② **Attach the hub onto the shaft of the motor. Test to make sure the hub spins unhindered.**



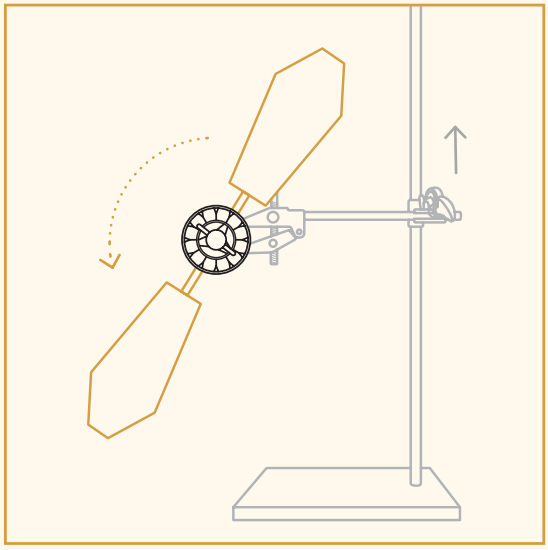
③ **Draw blades onto a sheet of cardstock or thin cardboard. Cut them out and tape a dowel onto the blade.**



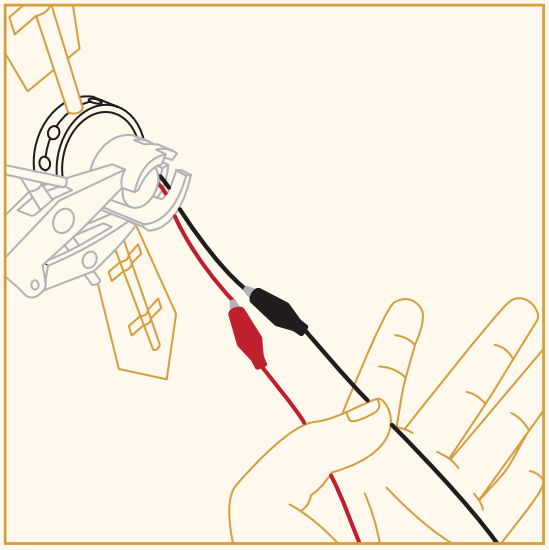
④ **Loosen the hub slightly by turning the knob on the front. Insert the dowels at the desired locations of the hub. Tighten the hub.**



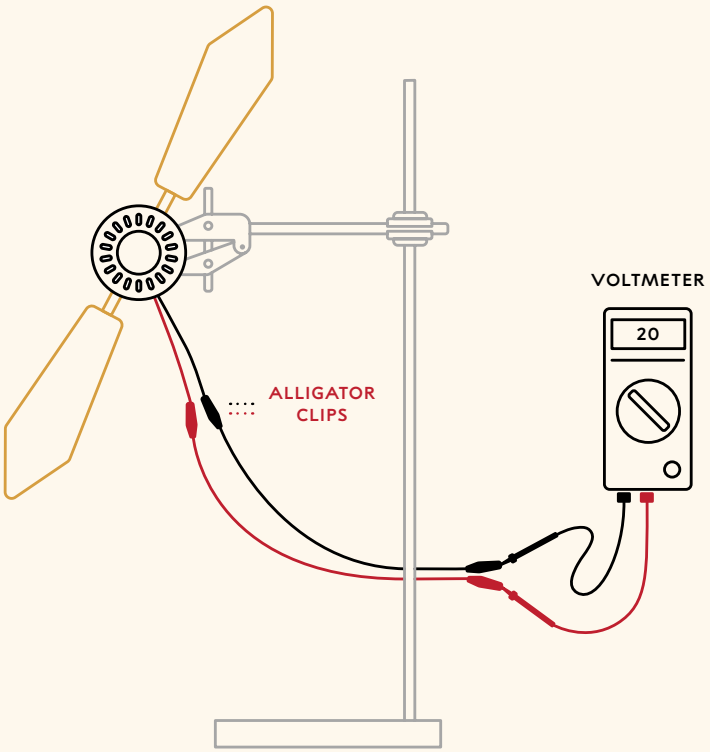
⑤ **Spin the rotor to make sure the blades can spin unhindered. Adjust the position of the clamp as needed.**



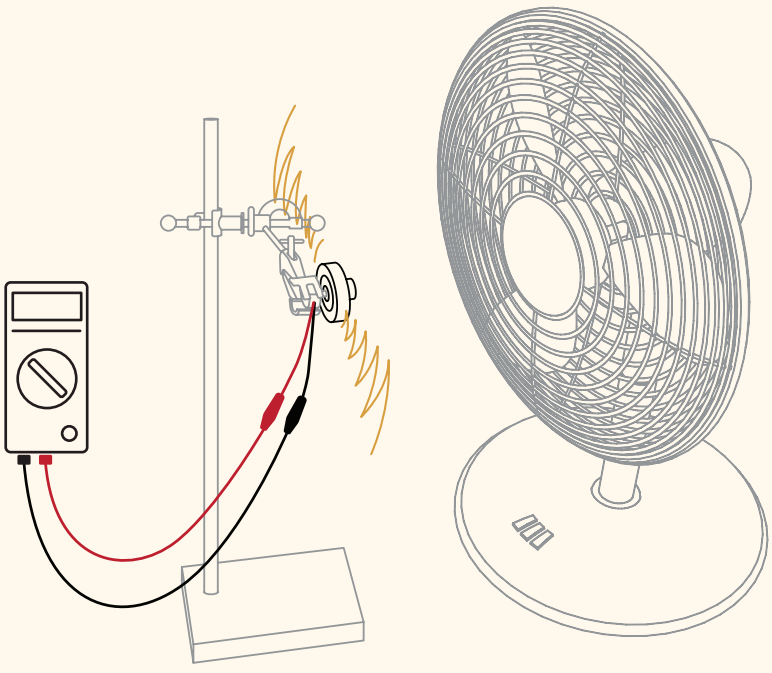
⑥ **Attach the alligator clips to the wires of the motor-generator. The lead wires may need to be stripped in order to be long enough to attach the clips.**



⑦ **Attach the voltmeter to the alligator clips. Turn on the voltmeter to the 20 mA volt setting.**

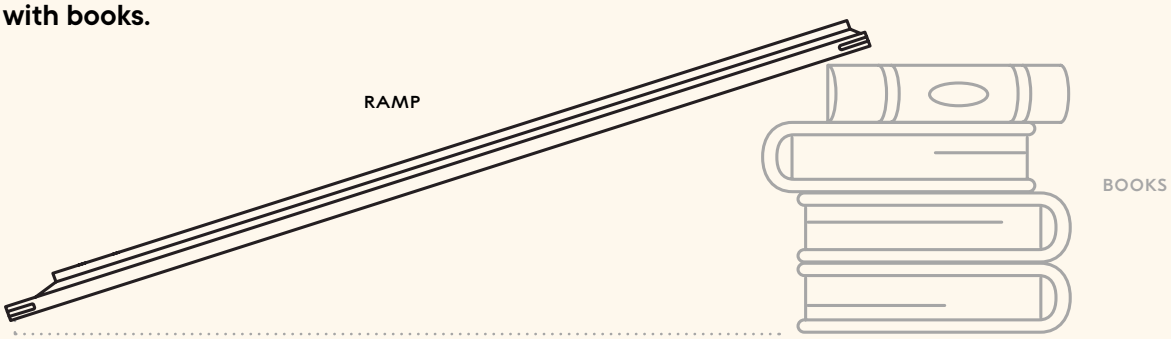


⑧ **Place the model in front of the fan station. Let the model run for a few moments until the voltage reading stabilizes.**

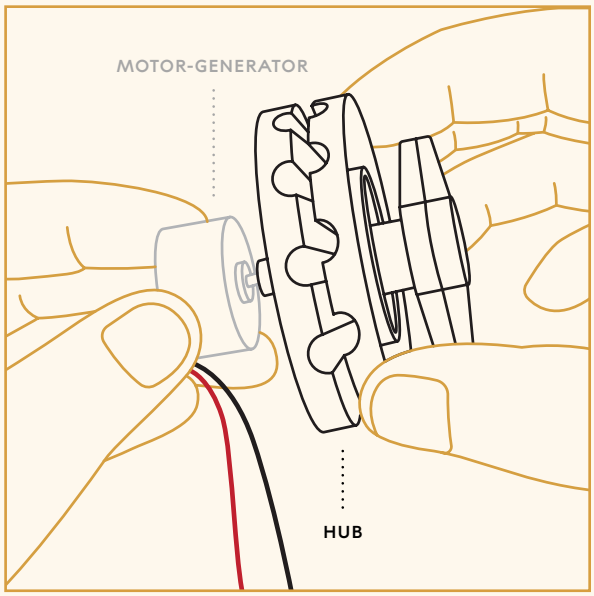


ACTIVITY 6 LAB SETUP INSTRUCTIONS

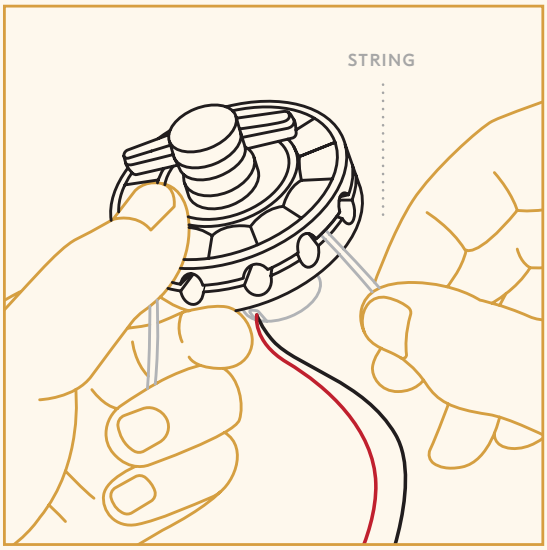
① **Build the ramp, using a track meant for testing physics experiments placed on a flat length of cardboard. If the track is not stiff enough, place a meterstick under the cardboard for stiffness. Elevate one end with books.**



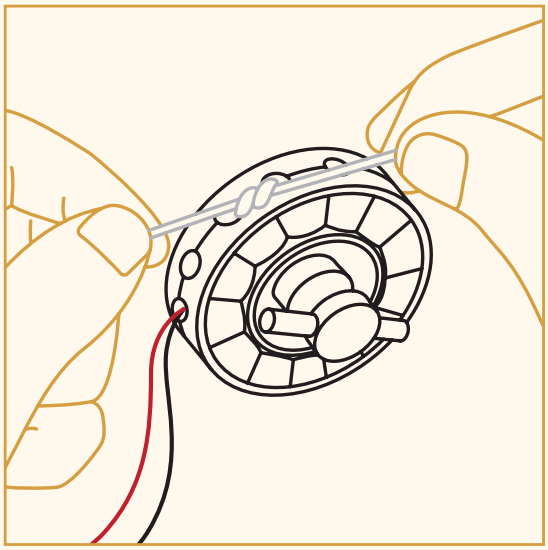
② **Remove the motor-generator from the clamp. Turn the dial to open the hub slightly and remove the dowels. Leave the hub attached to the motor shaft and open slightly.**



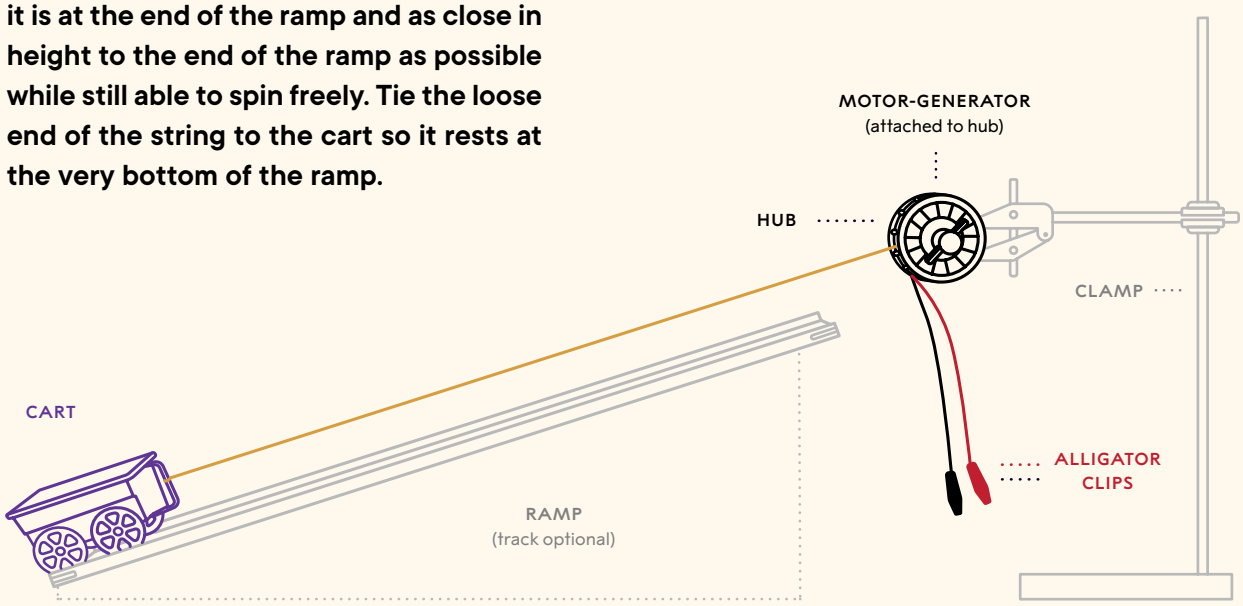
③ **Measure a length of string slightly longer than the ramp. Wind the string around the hub and through the center open slot.**



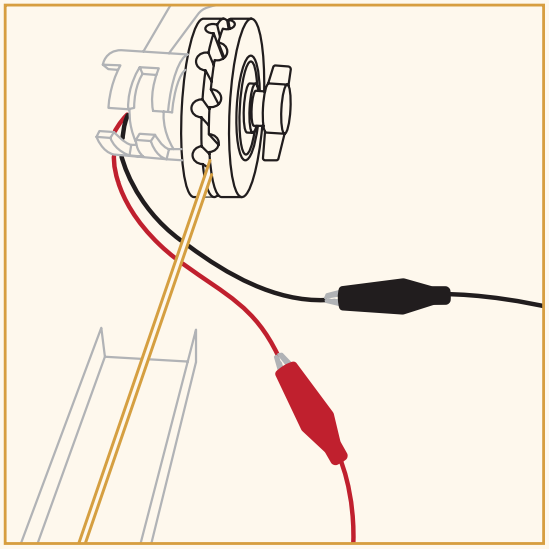
④ **Knot the string around the hub.**



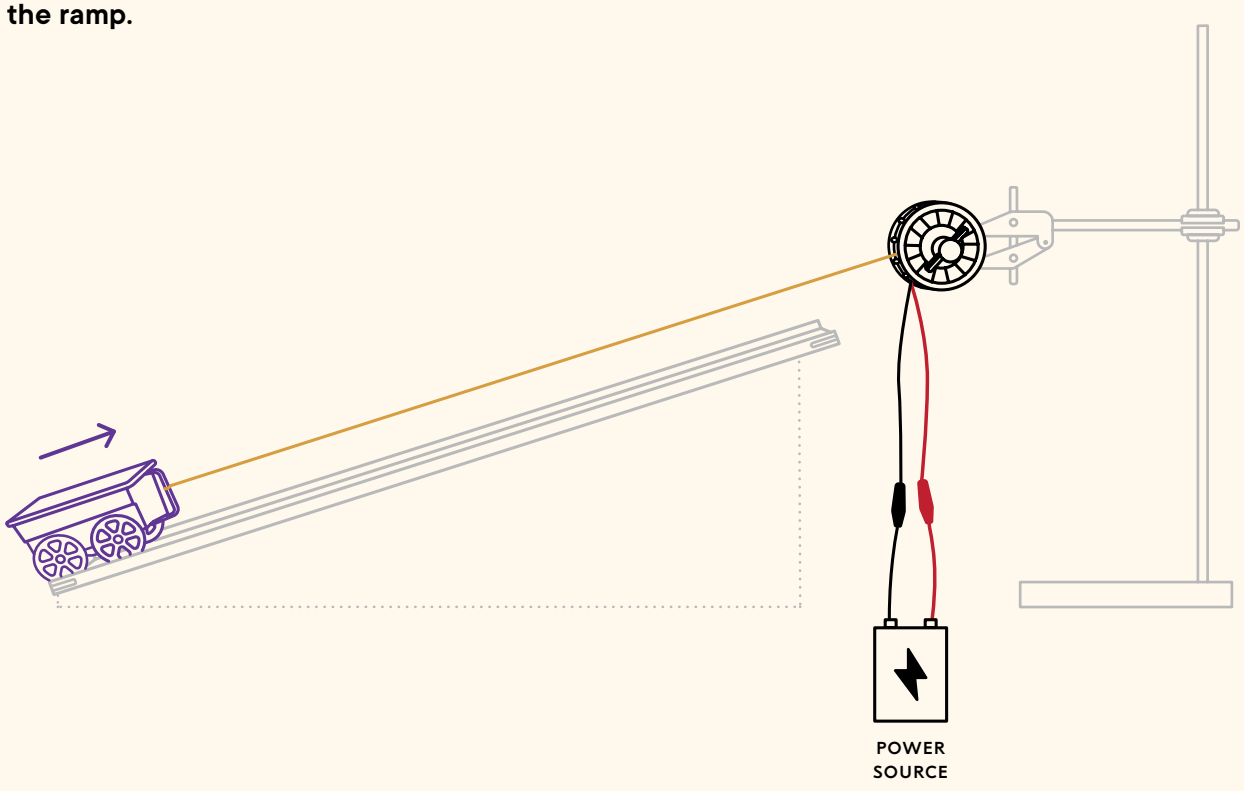
⑤ **Reattach the motor-generator hub assembly to the ring stand with the clamp. Adjust the placement and height of the motor-generator hub assembly so it is at the end of the ramp and as close in height to the end of the ramp as possible while still able to spin freely. Tie the loose end of the string to the cart so it rests at the very bottom of the ramp.**



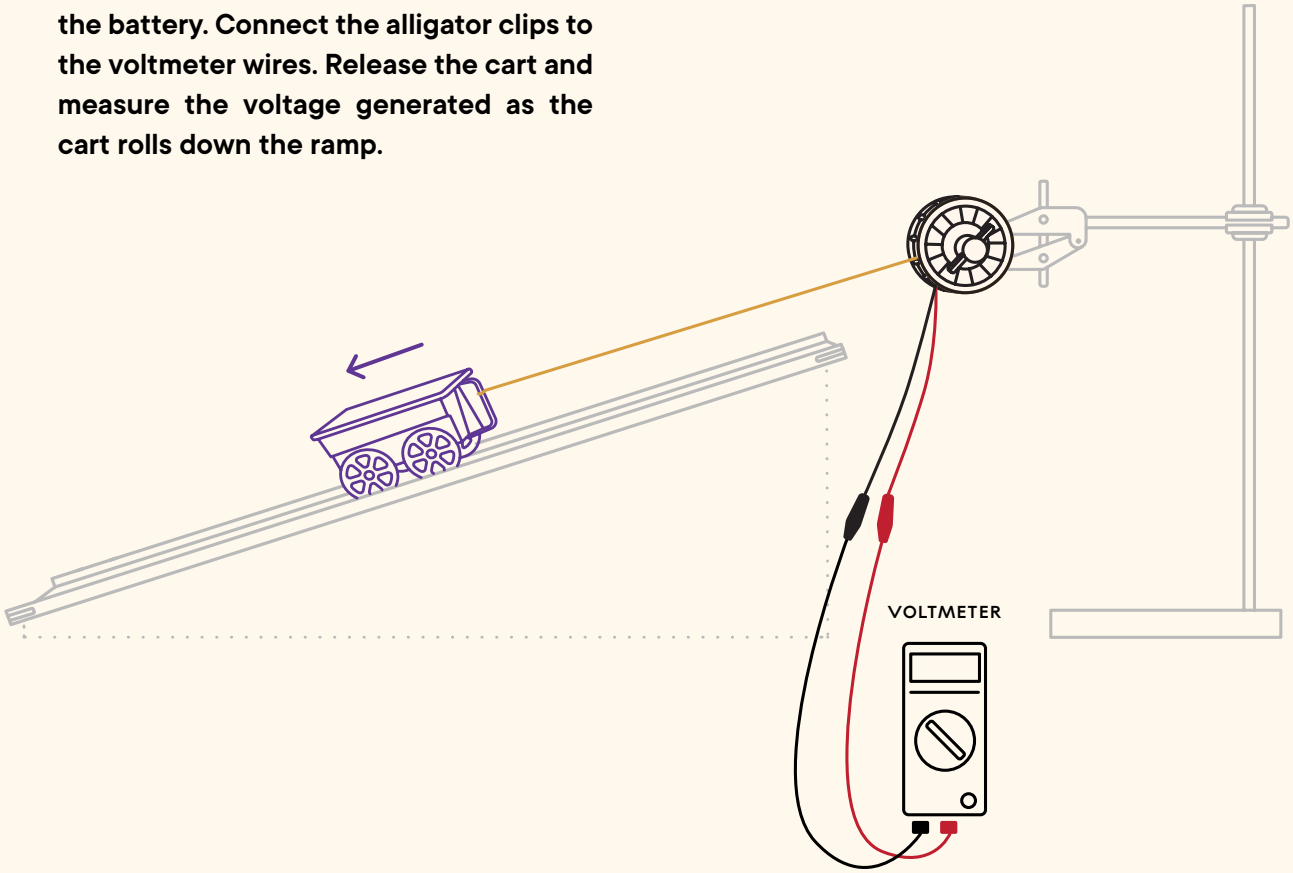
⑥ **Attach the alligator clips to the wires of the motor-generator.**



⑦ **Touch the alligator clips to the terminals of the 9 V battery to move the cart up the ramp.**



⑧ **Disconnect the battery when the cart comes to a rest at the top of the ramp. Hold the cart in place at the top of the ramp until you are ready to discharge the battery. Connect the alligator clips to the voltmeter wires. Release the cart and measure the voltage generated as the cart rolls down the ramp.**



CREDITS

Cover Merijn Jansen;
28 (row 1 left) Chimpinski/iStock, 2011;
28 (row 1 center) Roman Valiev/iStock, 2019;
28 (row 1 right) nndanko/iStock, 2020;
28 (row 2) urfinguss/iStock, 2016;
28 (row 2 far right) Trifonov_Evgeniy/iStock, 2016;
28 (row 3 left) Nordroden/iStock, 2016;
28 (row 3 center) kynny/iStock, 2022;
28 (row 3 right) PhonlamaiPhoto/iStock, 2016;
28 (row 4) sorrapong/iStock, 2020;
51 (top) generated using Midjourney, 2024;
51 (bottom) generated using Midjourney, 2024;
69 (top) generated using Midjourney, 2024;
69 (bottom) generated using Midjourney, 2024;
70 (top) generated using Midjourney, 2024;
70 (bottom) generated using Midjourney, 2024;
71 (top) generated using Midjourney, 2024;
71 (bottom) generated using Midjourney, 2024;
72 (top) generated using Midjourney, 2024;
72 (bottom) generated using Midjourney, 2024;
114 (top) generated using Midjourney, 2024;
114 (bottom) generated using Midjourney, 2024;
205 (top) generated using Midjourney, 2024;
205 (bottom) generated using Midjourney, 2024;
206 (top) generated using Midjourney, 2024;
206 (bottom) generated using Midjourney, 2024;
207 (top) generated using Midjourney, 2024;
207 (bottom) generated using Midjourney, 2024;
208 (top) generated using Midjourney, 2024;
208 (bottom) generated using Midjourney, 2024.