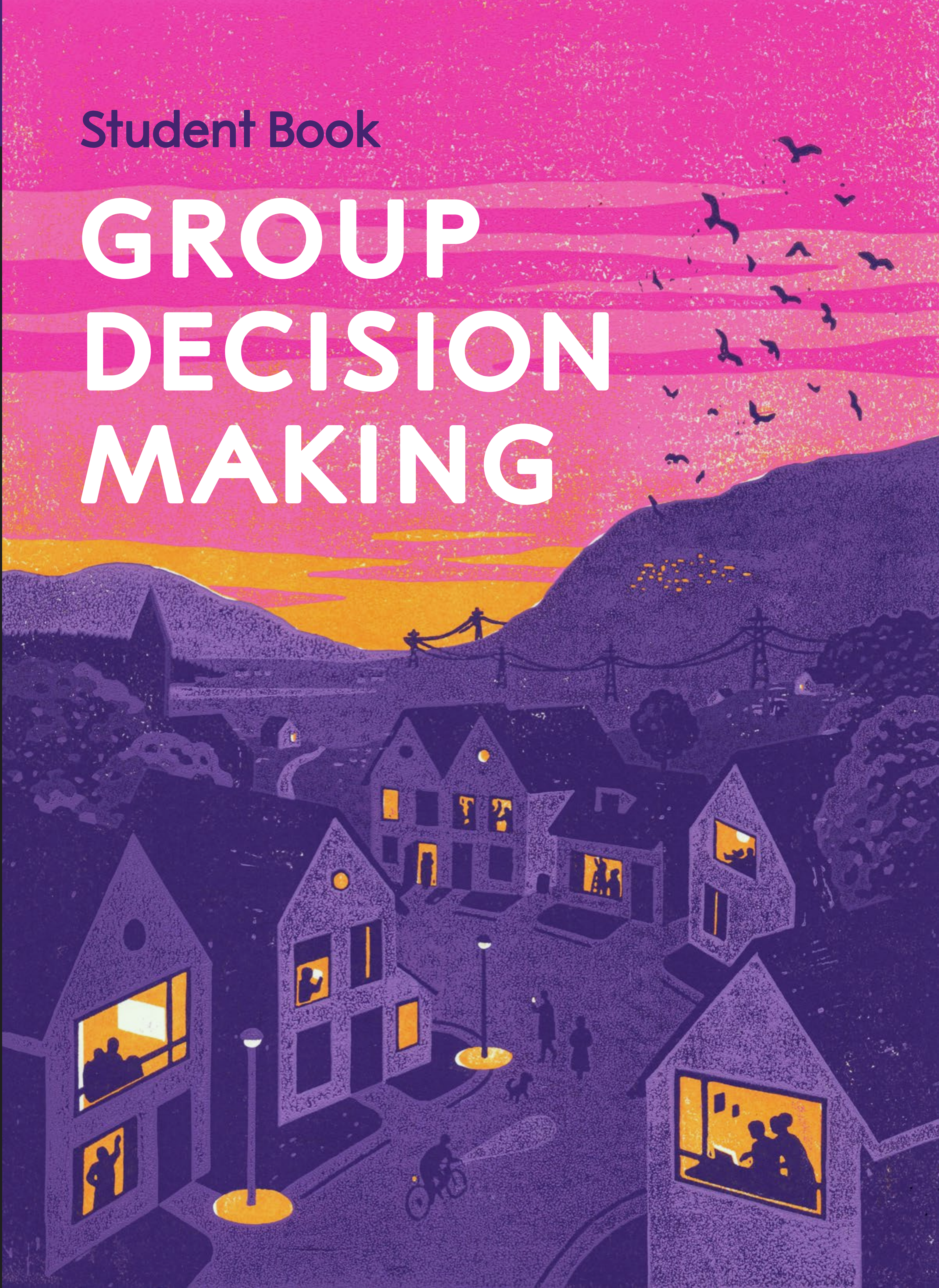
UNIT 6

v 1.0

Student Book

GROUP DECISION MAKING



SCIENTIFIC THINKING FOR ALL : A TOOLKIT

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.

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Scientific Thinking For All : A Toolkit

UNIT 6
Group Decision-Making
v1.0 MAY 2024

STUDENT BOOK

THE LAWRENCE HALL OF SCIENCE
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Berkeley, CA 94720-5200

DEAR STUDENT,

Have you ever read a news article and wondered if the information it contained was true? Or had a friend make a claim and wondered if they were right? This curriculum will equip you with ideas and techniques from science that can be applied to everyday life. Your conceptual toolkit will include strategies to help you evaluate information, reflect on your thinking, and make more informed decisions. You will use these tools to ask questions, brainstorm ideas, interpret data, manage trade-offs, and develop solutions.

Scientific tools and techniques can lead to a better understanding of how the natural world works and provide approaches to solving the problems facing individuals, communities, and the environment. Each unit will provide you with additional conceptual tools for your toolkit, and you'll practice applying them to personal and societal issues such as human health, environmental pollution, and energy use. For example, you may consider questions such as: *How much sleep do I need? Is my community's drinking water safe?*

Science offers many useful strategies for learning about the world, including:

1. working together to share observations, questions, and ideas;
2. techniques for making sense of observations and data; and
3. the iteration of ideas by modifying them as new information becomes available.

Since it's difficult for anyone to catch their own mistakes, you'll collaborate with your classmates to share your thinking and learn from one another. It is our hope that this science toolkit will empower you to think more clearly about the things you care about, to provide you with strategies for addressing problems, and to help you achieve your personal goals.

Sincerely,

Scientific Thinking for All Program Team

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Group Decision-Making

UNIT 6

GROUP DECISION-MAKING

In this unit, you will examine the role of decision-making as you examine issues related to implementing renewable energy systems. You will begin by considering a renewable energy project in a fictional community. You will explore the facts related to the values held by people affected by the city's energy project. You will learn how facts can be verified and how to seek out people's values. You will be introduced to systematic thinking tools that will help integrate both facts and values while making a group decision. You will develop factual expertise by experimenting with model wind turbines and energy storage systems. Finally, you will develop group decisions for the energy project in the fictional community. This process will require careful consideration of the community's values, understanding the relevant facts, and a willingness to compromise.

UNIT DRIVING QUESTION

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

CONCEPTUAL TOOLS

In this course, conceptual tools refer to scientific ideas and approaches that can be applied to real-world situations. Each conceptual tool is further explained in the activity in which it is introduced. The conceptual tools found in this unit are shown here and in each activity in which they appear.

Weaving Facts and Values

Credible Sources

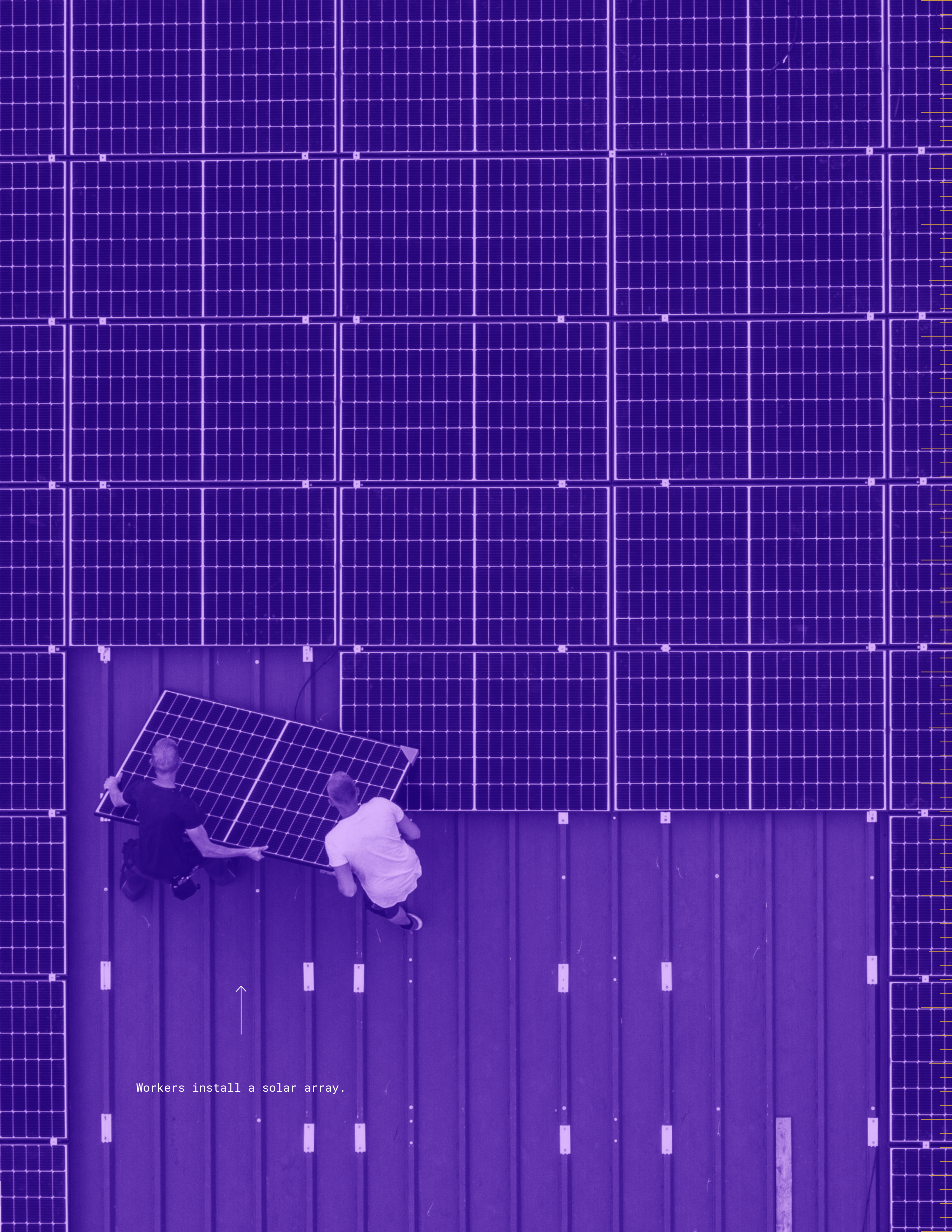
Scenario Planning

Group Decision-Making

ACTIVITY 1

Vanwick's Energy Project

CARD-BASED INVESTIGATION



Workers install a solar array.

1 : VANWICK'S ENERGY PROJECT

GUIDING QUESTION

How are facts and values connected to decision-making?

INTRODUCTION

From humans' first use of fire to the present day, people have harnessed energy to improve their lives. As human populations continue to grow and dependence on electronic devices increases, so do human energy needs. Around the world, people are making decisions about the ways they get and use energy. Some thinking tools about making energy decisions—such as considering the facts of a situation and values of a community—can inform decision-making.

In this unit, you will learn about a fictional city that is making decisions about their local energy system. Throughout the unit, you will play various roles that will allow you to participate and advise the City Council as they decide on the specifics of an energy plan for the future. The scenario throughout the unit will introduce you to important tools used in decision analysis. Decision analysis is any process of systematically considering the information that might affect a decision. Decision analysis is not a single method to analyze a problem, and all decision-analysis processes include an approach to decision-making that is intentional. As you go through the unit, you may find ways in which the scenario is similar to or different from how group decisions are made in your own community.

CONCEPTUAL TOOLS

WEAVING FACTS & VALUES IN DECISION-MAKING

PROCEDURE

PART A: VANWICK ENERGY FACTS AND VALUES

MATERIALS LIST

FOR EACH GROUP OF FOUR STUDENTS

- SET OF 13 ENERGY STATEMENT CARDS

1 With your group, read the following scenario.

Vanwick is a small city with a population of 100,000. Recently, Vanwick citizens learned that the local coal power plant that powers the city is scheduled to shut down. The Vanwick City Council recognized this as both a problem and an opportunity. The city began exploring a transition to an energy system that includes renewable energy. The city hopes to achieve its goal of reducing greenhouse gas emissions, while powering the city into the future.

After considering options, energy experts in the town identified solar and/or wind energy as possible replacements for the coal power plant. They want to take advantage of Vanwick's climate, which has sunny and windy weather conditions throughout the year. The city does not want to spend a lot of money on this, but it can get funding to build the new energy infrastructure by creating a detailed plan. They have named the plan Project Re-Energize Vanwick (REV). Project REV needs local approval, so the City Council wants to increase support by involving citizens in the decision-making process. They decided to start the process by figuring out what facts Vanwick citizens know about renewable energy and by investigating Vanwick citizens' values related to the issue.

Transmission towers help distribute electrical power from generation sites to communities.

If you need to review the concept of electrical power generation and greenhouse gas emissions, you will find a Science Review at the end of this activity.

PART A: VANWICK ENERGY FACTS AND VALUES (CONTINUED)

2 In your group of four, find the FACT and VALUE cards in the set of Energy Statement cards and place them face up on the table. Stack the remaining cards face down on the table where you can all reach them.

3 a Take turns drawing a card from the deck. Share the card with the group.

b Discuss whether the card states a fact or a value. Remember to listen to and consider the ideas of other members of your group. If you disagree with others in your group, explain why you disagree.

- If you agree, place the card next to the FACT or VALUE card.
- If you disagree, place the card face up between the two categories to show your disagreement or uncertainty.

c Continue with the remaining cards in the deck, spreading them out so all group members can see all the cards.

4 Compare your results to other students' results by repeating Step 3 as a class.

- If as a class you agree, record on the board whether it is a fact or value.
- If as a class you disagree, write the statement on the board. Then, work together to underline any part of the statement that is factual and circle any part that is a value. Use the statement on the board to help explain your position to one another.

5 Your teacher will read aloud several statements that are about facts and values. Follow your teachers' instructions to indicate if you agree, disagree, or think it depends for each statement.

6 As a class, construct definitions for *fact* and *value*.

PART B: VANWICK DECISION

7 Reread the scenario from Step 1. Make a list of the City Council's values and the facts related to Project REV. Use these facts and values to decide if you think the City Council should move ahead with Project REV.

8 With your class, use a Walking Debate to show if you agree or disagree with moving ahead with Project REV.

9 Look at the following additional facts and conduct the Walking Debate again.

- Some Vanwick residents think it is more important for the City Council to improve the school system instead of applying for renewable energy funding.
- The amount of money the City Council would be required to contribute to Project REV is equal to the amount of money it would take to build a new school.

10 After the second debate, discuss how these additional facts and values informed your decision with your small group. Then, share your ideas with the class.

BUILD UNDERSTANDING

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

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

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*.

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

> The Build Understanding and Connections to Everyday Life questions are intended to guide your understanding. Some of these questions 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.

RE-ENERGIZE VANWICK

PROJECT REV

FIGURE 1.1
Project REV

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?
   - b. Provide a fact for each value that relates to the decision and explain how it influenced your choice.
   - 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.
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?
   - b. How do these facts and values inform her decision?

KEY SCIENTIFIC TERMS

decision analysis
fact
value

SCIENCE REVIEW:
ELECTRICAL POWER GENERATION AND CLIMATE CHANGE

Where Does Electricity Come From?

Electrical power generation is the process of transforming a natural resource such as coal, natural gas, wind, or sunlight into electrical power. Often, the transformation happens at a centralized power plant. Then the electrical power (often called electricity) needs to be transmitted, often over large distances, through a web of transmission lines called the electrical grid. Then it is distributed to homes and businesses.

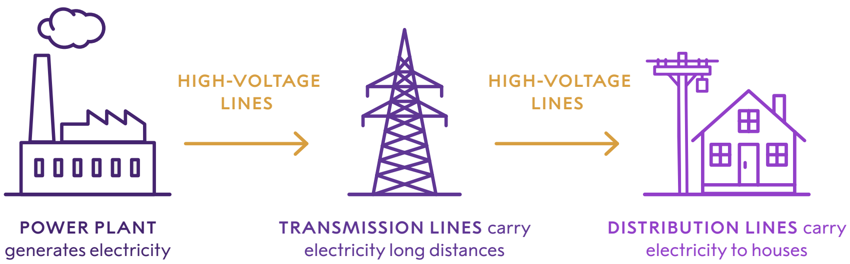


FIGURE 1.2
Traditional electricity generation, transmission, and distribution

There are many types of power plants that run on various resources, including natural gas, petroleum, wind, water, sunlight, and biomass. Most often, a generator converts mechanical energy into electrical energy. For natural gas, coal, biomass, and petroleum, the heat from burning these resources creates steam. The pressure from the steam pushes the blades of a turbine. The spinning turbine turns the shaft of a generator, producing electricity. A traditional power plant burns fuel to heat up water, which creates steam. The pressure from the steam pushes the blades of a turbine. The spinning turbine turns the shaft of a generator.

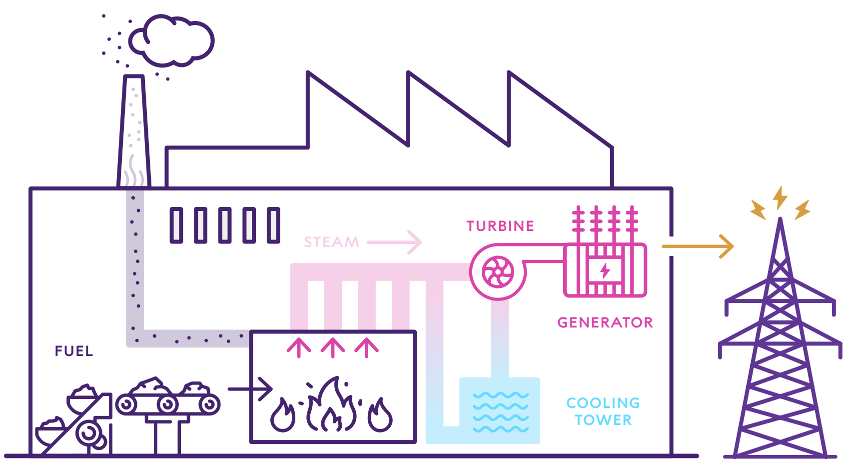


FIGURE 1.3
Coal power plant

Nuclear fission also produces heat and can generate electricity this way. Wind power and hydropower move the turbine blades directly. Solar power is generated through a different process that converts sunlight directly to electricity.

Renewable vs Nonrenewable Resources

Some of the resources used to generate electricity are renewable, and some are nonrenewable. A renewable resource is one that has a continuous supply, such as sunlight, water, wind, and biomass. To be considered renewable, a resource must be supplied faster than it is used up. A nonrenewable resource, such as coal, natural gas, and petroleum, is one that has a limited supply; once it is used up, the resource is gone.

Fossil fuels—coal, natural gas, and petroleum—are convenient in our current society because much of the world already has the infrastructure to access, process, and transport these fuels (such as railroads near coal mines, pipelines, power plants, and transmission lines). Fossil fuels have the advantage of being energy dense, meaning the amount of energy released per kilogram of fuel burned is greater than that of other kinds of energy transformation, such as burning biomass. However, burning fossil fuel produces greenhouse gases, which are driving global climate change. While there are some technological advances that can help reduce the number of pollutants released during burning, particularly at coal plants, they still produce significant amounts of greenhouse gases. As the world's energy demand increases and the effects of climate change become more significant, the need for energy sources that do not produce greenhouse gases is on the rise.

Solar, wind, tidal, hydro, and geothermal are all methods of electrical power generation that come from renewable resources that do not emit greenhouse gases during the generation process. As suggested by the name, these resources don't run out, while the world's fossil fuel supply will eventually be completely used up. The cost for some of these methods has also decreased over time as technology improves and more infrastructure has been built. Additionally, some renewable power generation can be installed on a small scale—for instance, for a single home or building—such as solar panels and wind turbines. Several renewable generation methods, including solar and wind energy, are now less expensive than fossil fuel methods. However, many of these resources depend on weather conditions and take up more space than nonrenewable generation. They are not transportable in the way that fossil fuels are, which means that more infrastructure must be built and that changes to the electric grid are often needed to utilize these methods. These needs can be expensive and, in some communities, can mean that switching from nonrenewable to renewable electricity generation is difficult or impossible.

Greenhouse Gases and Climate Change

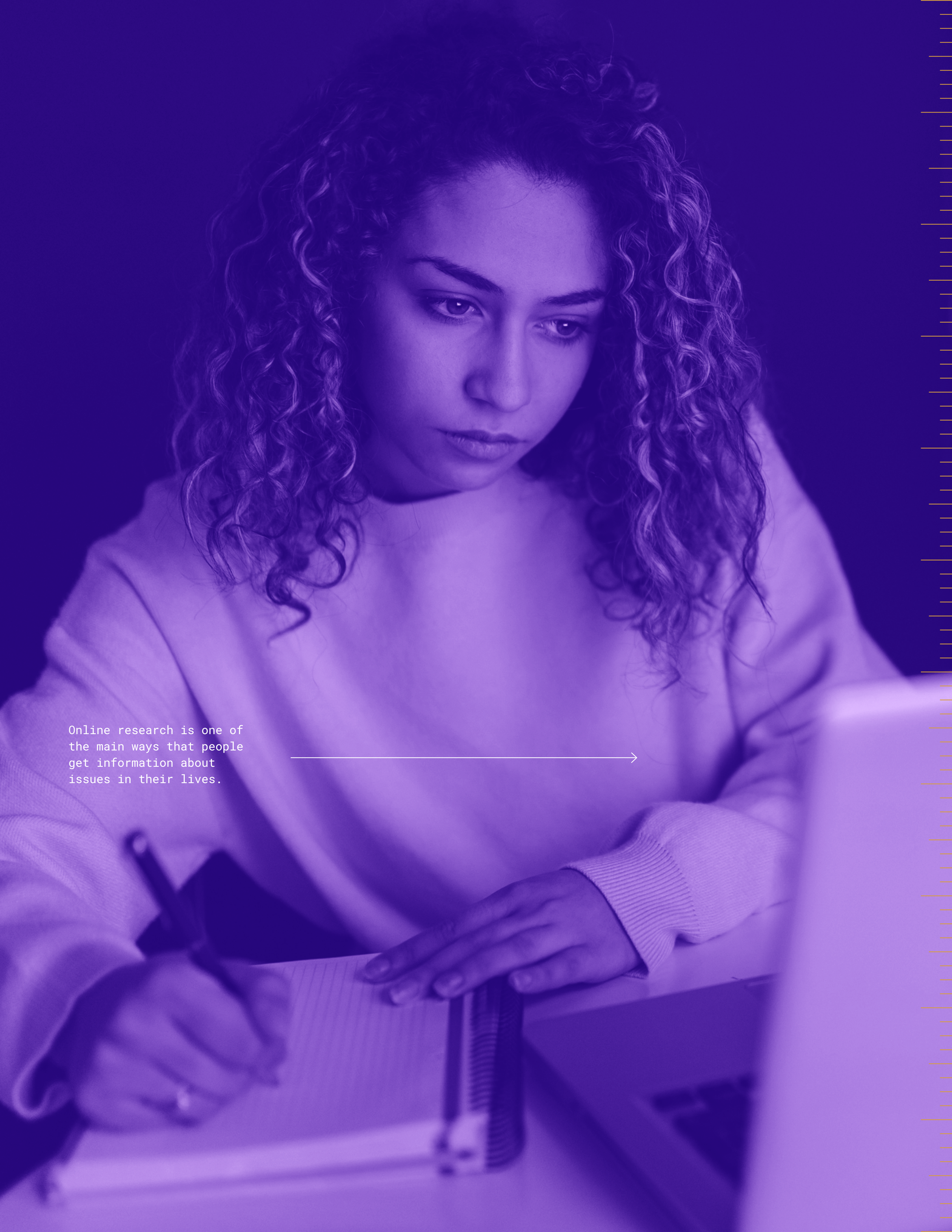
Greenhouse gases are a gas that traps thermal energy in the atmosphere, such as carbon dioxide, water vapor, and methane. They act like a blanket wrapped around our planet. As greenhouse gases increase, more heat is trapped, leading to warmer average global temperatures. This causes changes in weather patterns, including increased frequency and intensity of droughts, severity of wildfires, rising sea levels, more powerful storms, and stronger flooding. Since the 1800s, human activity has been the main driver of climate change. Many human activities produce greenhouse gases, including generating power, manufacturing and consuming goods, cutting down forests, using transportation, constructing buildings, and producing food.

An abundance of scientific evidence shows that fossil fuel use is the largest contributor to global climate change, generating over 75% of greenhouse gas emissions (including 90% of carbon dioxide emissions). The last decade (2011–2020) was the warmest decade ever recorded and, in recent years, many other records have been broken repeatedly, such as highest temperature and worst flooding. Climate change has already affected people's health, ability to grow food, the biodiversity of our planet, and many other aspects of our lives; scientific models indicate that this will intensify without significant, rapid intervention. Reducing, or eliminating, the production of greenhouse gases in electricity generation is one important way to help mitigate the effects of climate change.

ACTIVITY 2

Evaluating Energy Facts

INVESTIGATION



Online research is one of the main ways that people get information about issues in their lives.

2 : EVALUATING ENERGY FACTS

GUIDING QUESTION

How can determining a credible source help you evaluate information?

INTRODUCTION

Understanding scientific information is not always straightforward. The body of scientific knowledge is constantly changing, and sometimes new information is discovered that reveals something we thought was a fact that is not or was missing crucial information. For example, long ago, people used to think that Earth was flat. Through careful observation, many scientists over hundreds of years discovered that this is not the case. Now we have abundant evidence, from Earth measurements, astronauts, satellite images, and flights around the globe, that shows that Earth is nearly a sphere.

Sometimes people make claims of fact that are not supported by evidence. A claim of fact is a type of claim that you have not yet verified by observation or data. Claims of fact are widespread, especially on the Internet, which allows anyone to post any information about any topic, whether true or not.

One tool to evaluate claims of fact is to determine if the information comes from a credible source. A credible source is a source with relevant expertise that provides accurate information that is free from bias. It is also helpful to talk with or examine the work of an expert—a person with extensive knowledge or skill in a particular subject based on research, experience, or occupation. When you make decisions based on facts, it is important to use information from a credible source. A credible source is more likely to provide information that is accurate. In this activity, you will participate in Project REV by fact-checking some comments about the project posted online by residents of the Vanwick community.

CONCEPTUAL TOOLS

CREDIBLE SOURCES

WEAVING FACTS & VALUES IN DECISION-MAKING

PROCEDURE

1 As a class, read the following.

When the City Council unveiled the goals of Project REV, concerned residents started posting about it online. There were conflicting ideas about Project REV in the community and its impact. In response, the Vanwick City Council wants to make sure the community has accurate information that addresses citizen concerns before they proceed with the project planning.

2 As a group, read the following posts about Project REV.

VanwickForum

@VanwickCity posted today

Hello Vanwickians! Planning for Project REV is underway. The Vanwick City Council is gathering ideas from individuals in the community about the potential impact of renewable energy on the Vanwick community. WE WANT TO HEAR FROM YOU. Comment below to let us know your thoughts...

@JamieLovesHistory

Please don't decide to get wind farms. A wind farm near my home would ruin the nice view of the hills from my kitchen window! Additionally, wind turbines cast huge, flickering shadows all day long that can cause health problems for people. To preserve our views and keep our citizens healthy, we must say NO to wind turbines!

@StarshipEarth17

We live near the coal power plant, and I'm glad it is closing down. 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. The transition from the coal power plant to renewable energy sources will decrease air pollution and improve my health!

MATERIALS LIST

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"

VanwickForum

@ShinyPearl

I think it would be horrible if Vanwick's economy would take a hit if Project REV is approved. Our local economy depends on jobs! Renewable energy projects like Project REV 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.

@JJJams

I am REVed up for this project! But I worry that solar panels are not a reliable enough source of electricity. They can only produce energy when it is sunny out, so what are we going to do for electricity at night? You can't meet the energy needs of the city at night with just solar panels. The issue of reliability is important to me because the grocery store I work at needs a constant reliable power system to keep the refrigerators running and prevent food from spoiling. People need food!

@GrannySmithJr

I think it's really important to reduce greenhouse gas emissions from Vanwick, but Project REV is missing an important piece: existing buildings. According to the US Department of Energy, buildings account for 70% of electricity usage overall. If the city wants to address greenhouse gas emissions, it would be easier to put our efforts into updating the buildings around town. Making existing buildings more energy efficient would help reduce emissions from buildings.

3. With your group, revisit each post and identify which parts of each statement are claims of fact and which are values. Record your ideas on Student Sheet 2.1, "VanwickForum Notes." After you have analyzed each statement, discuss which ones you think are credible and which ones are not.

4 Your teacher will assign your group to one claim of fact from the posts. Do a web search to find one credible source of information related to the claim of fact. Make sure your source is different from your other group members' sources.

5 Use the technique of lateral reading to check the credibility of the source you found. Lateral reading is a research technique used to evaluate a source's credibility as well as confirm the accuracy of facts. Complete Student Sheet 2.2, "Lateral Reading," to support your research.

6 When each group member has finished checking the credibility of their source, share your findings with the group. Record this information on Student Sheet 2.3, "Evaluating Claims of Fact," in the first and second columns of the table.

7 With your group, decide how confident you are about the information from the websites, based on what you found out about the authors. Rate the sources on a scale of 1 (not very credible) to 5 (extremely credible). Record this credibility ranking in the third column of the table on Student Sheet 2.3.

8 Each group member should use the source they just evaluated to look for information that can support or refute your group's claim of fact from the post. If the group decided in Step 7 that your source was not credible, find a different source that is more credible. Record notes in the last two columns of the table on Student Sheet 2.3.

9 Share your individual findings about the claim of fact with your group. Add notes about your group members' work in the table. Discuss whether your group's overall findings support or refute the claim of fact from the post and why.

10 As a class, share your work by revisiting the posts together and reviewing which claims of fact were verified. Review the posts and discuss how your research affects how you now think about them.

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.
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?
3. How can credible sources help you make decisions?

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

EXTENSION

Quiz yourself! Can you distinguish fake news from real news? Use the link provided by your teacher to take the fake news quiz. Make sure you use what you've learned about evaluating information online.

KEY SCIENTIFIC TERMS

claim of fact
credible source
expert
lateral reading

ACTIVITY 3

Gathering Residents' Values

SURVEY

3 : GATHERING RESIDENTS' VALUES

GUIDING QUESTION

How can a survey be used to gather information about community values?

INTRODUCTION

No decision can be based solely on facts. While facts can predict what may happen as a result of different choices, values are needed to decide what you want to happen. For individual decisions, values can be straightforward, but values get complicated for decisions that involve a whole group of people. A group decision includes a choice made by multiple people who consider the values of stakeholders affected by the result. Stakeholders are the set of people who will be affected by the outcome of a decision. They can be residents of a community, business owners, or government officials.

There are multiple ways to find out people's values about an issue. For example, you can talk to them, examine data gathered about their activities, or have them answer some questions. While some data might not be available and interviewing lots of people individually can be time-consuming, a survey is a tool that can gather a lot of information quickly. An effective survey will include the people that are impacted by a decision, including those that are typically underrepresented in decision-making.

In this activity, you will advise the City Council how to survey its residents. You will then switch roles to imagine how various residents might respond.

CONCEPTUAL TOOLS

WEAVING FACTS & VALUES IN DECISION-MAKING

GROUP DECISION-MAKING

PROCEDURE

PART A: DEVELOP THE SURVEY

1 With your group, read the following scenario.

The recent protests have motivated the City Council to find a way to better understand the perspectives of the residents. They realize that the values of Vanwick citizens will play a critical role in developing the details for Project REV because they want to take into account all those who will be impacted by the project. To better understand the values of the citizens around the issues brought up by Project REV, the City Council decides to survey the community.

2 With a partner, think of three survey questions that, when answered, could reveal what Vanwick residents value about a future energy system. The goal of the survey is to find out which values are most important to the residents of Vanwick.

3 Identify the kind of response you expect for each of the three survey questions—such as multiple choice, short answer, a rating scale. Consider how you will summarize and then analyze the responses. Revise any questions based on this.

4 Test the questions by swapping them with the other pair in your group. Answer the questions as though you are taking the survey. Return the questions to the other pair and make revisions based on the results of the test.

5 As a class, compile all the questions and choose 10 for the final survey. Choose a set of questions that are relevant to Project REV and will give you useful information about people's values.

A government worker gathers input about home energy needs from Tribal community members in Alaska.

MATERIALS LIST

FOR EACH GROUP OF FOUR STUDENTS

- 4 STAKEHOLDER CARDS

FOR EACH PAIR OF STUDENTS

- INTERNET ACCESS

PART B: VANWICK SURVEY

6 Get a Stakeholder card from your teacher. The card provides information about a member of the Vanwick community who you will represent. Read the card carefully and identify the values of your stakeholder.

7 Complete the final class survey as though you are the stakeholder on your card. You may need to refer back to your card as you answer the questions.

8 As a class, compile the results from all the stakeholders into a clearly presented summary.

9 With your group, use the summary to make a list of stakeholder values from the most to the least commonly held.

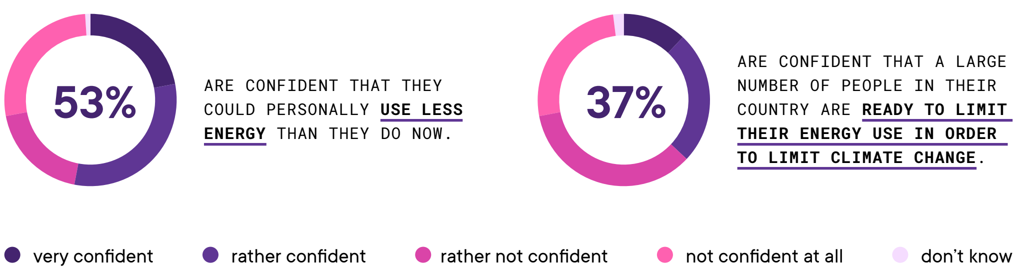
10 A weighted value is one that includes a number showing its relative importance to other weighted values. To weight the values from the previous step, distribute a total of 100 points among the values you listed in a way that shows how some values are more commonly and strongly held (greater points) or less commonly and strongly held (fewer points).

- The table on the right shows a simple example of how to distribute value points. It is someone’s distributed value points about the decision on what to have for lunch.
- Record your weighted values in your science notebook.

COST	50
TASTE	40
NUTRITION	10
TOTAL	**100**

11 Share your ideas with the class and come to an agreement on the most commonly and strongly held values in Vanwick and their relative weights. Discuss how the values might inform the planning of Project REV.

FIGURE 3.1
European Union energy survey example



The European Commission regularly surveys residents to learn about the public’s feelings and experiences on a variety of issues related to economics, the environment, community well being, jobs, etc. This example, from a survey in 2022, asked questions related to energy usage and climate change.

BUILD UNDERSTANDING

1. a What are the advantages of using surveys to gather information about stakeholder's values?

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

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?

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

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?

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

CONNECTIONS TO EVERYDAY LIFE

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

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

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

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

EXTENSION

Give the class survey to your family and friends and ask them to answer it as themselves. Compare the results to that of the Vanwick survey you completed in class.

KEY SCIENTIFIC TERMS

stakeholders
weighted value

ACTIVITY 4

Designing Model Wind Turbines

LABORATORY

Maintenance workers repel from a large wind turbine.

4 : DESIGNING MODEL WIND TURBINES

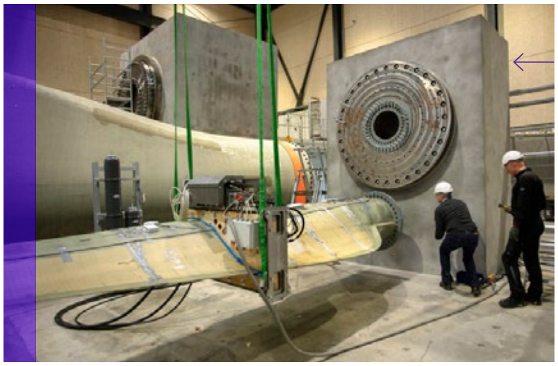
GUIDING QUESTION

How can understanding a model wind turbine help make a decision about using turbines in a community?

INTRODUCTION

There are many types of energy sources that can be used to generate electricity. Common sources include fossil fuels (such as coal and natural gas), hydroelectric, thermal, nuclear, and tidal. Generating electricity from any of these sources relies on energy transformations. An energy transformation is the change of energy from one type to another, such as from chemical to thermal energy.

In this activity, you will investigate how to design a model wind turbine to generate more power during its energy transformation. You will play the role of engineers developing expertise in energy transformations and wind turbine technology. As you design your model wind turbine, you will consider how people with firsthand experience with experimentation in a particular subject are more likely to know facts about that subject than other people. Then, you will have the opportunity to put your expertise into the context of a decision for Vanwick.



Engineers inspect a wind turbine blade at a testing facility in Denmark. Photo courtesy of Moog.

If you need to review the concept of energy transformations, you will find a Science Review at the end of this activity.

CONCEPTUAL TOOLS

WEAVING FACTS & VALUES IN DECISION-MAKING

MATERIALS LIST

FOR THE CLASS

- FAN STATION

FOR EACH GROUP OF FOUR STUDENTS

COMPONENTS NEEDED TO BUILD A MODEL WIND TURBINE:

- 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”
- SURVEY RESULTS FROM ACTIVITY 3

PROCEDURE

PART A: DESIGNING A WIND TURBINE

1 In your group, discuss reasons why one wind turbine might generate more power than another. Record your ideas in your science notebook. You may want to draw a diagram or picture to illustrate your ideas.

2 Your teacher will provide your group with one variable to test in your wind turbine design. A variable is a feature, factor, or result that can change or vary. Record your variable in your science notebook and discuss how you might test that variable.

3 In your group, design a wind turbine model to maximize the voltage produced by changing only your assigned variable. Your model should have a similar setup to the following diagram. Follow your teacher’s instructions for building the model.

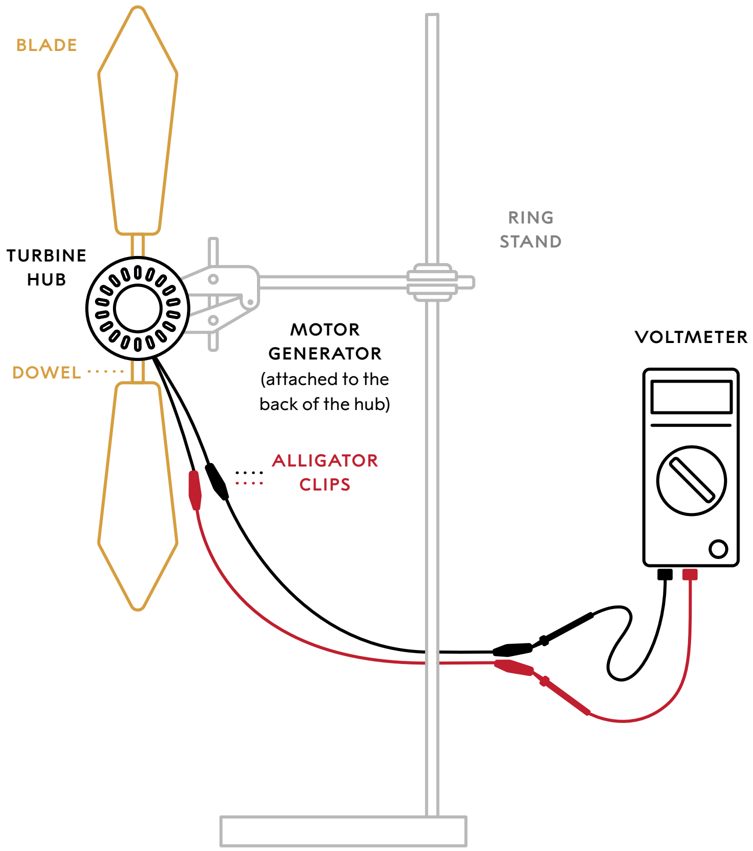


FIGURE 4.1
Wind turbine model setup

4 Before testing your model, consider your reasoning for the design. Record your ideas in the first row of Student Sheet 4.1, "Wind Turbine Design Testing."

5 Test your first design at the classroom fan station. For every test, make sure that
- the turbine is at the same distance from the fan.
- the fan is on the same speed setting.
- the turbine faces directly into the fan.

Record the peak voltage on your student sheet. It is not important if the voltage reads "+" or "–"; just record the number.

6 With your group, discuss possible changes to the design in order to maximize the amount of electrical power (measured by the voltage) your model wind turbine can produce.

7 Revise your model wind turbine design based on your test results two or three more times. Each time, complete a row of the table on Student Sheet 4.1.

8 Follow your teacher's instructions to meet with another pair from another group who experimented with the same variable. Share your findings about the variable you were testing and the designs that led to the best results. Discuss similarities and differences in your designs and how those led to similar or different voltage readings.

9 Follow your teacher's instructions to meet in a group in which each member experimented with a different variable. Share your findings about the variable you were testing and the designs that led to the best results. Discuss which aspects of each group's design might be combined for a better model wind turbine.

10 With this new group, redesign the model wind turbine to incorporate the expertise from each member. Build and test this version. Record your work on Student Sheet 4.1.

11 Use the test results from the previous step to make a final design. Build and test this version. Record your design, voltage readings, and observations on Student Sheet 4.1.

12 As a class, compare the similarities and differences in the designs. Summarize the variables that did or did not contribute to increasing the measured voltage. Discuss how the design could be changed further to possibly improve results.

PART B: CALCULATING POWER

13 Use the highest voltage reading from your designs to calculate the power output of the turbine. The power of a device is the rate at which energy is transformed. It is calculated using the formula:

> **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).

For the model turbine, the estimated current coming out of the turbine is 0.1 A. Conduct your calculation in your science notebook and check your answer with your group members.

14 A typical laptop needs a power source of about 60 W. Calculate the approximate number of your model turbines that would be needed to power a laptop. Record this information in your science notebook. Check your estimate with your group members.

15 Look at the data (in the following table) about small and large wind turbine technologies. Calculate the number of units that would be required to meet Vanwick's power needs for each kind of turbine. Compare this to Vanwick's current electrical generation of 500 megawatts (MW) to the area. Record your calculations in your science notebook.

TABLE 4.1
Power Generation of Wind Turbines

SOURCE	TYPICAL LOCATION	APPROXIMATE MAX POWER (MW)	NUMBER OF POSSIBLE TURBINES IN VANWICK
SMALL TURBINE	RESIDENTIAL, SMALL FARM, RANCH, CITY LAND	0.010 MW	5
LARGE TURBINE	UTILITY COMPANIES	8 MW	52

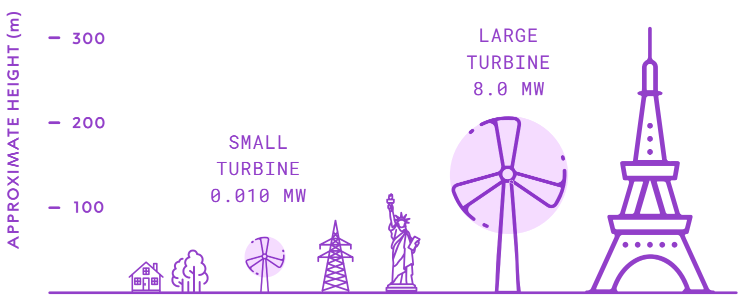


FIGURE 4.2
Scale of small and large wind turbines

16 Discuss what your calculations mean for Project REV. Specifically, how do wind turbines support, or not support, Project's REVs goal of reducing greenhouse gas emissions.

BUILD UNDERSTANDING

1. 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.

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% of the maximum.
   - **a** Make a list of variables that can affect the amount of power produced by wind turbines.
   - **b** How would these variables affect the number of turbines needed to meet Vanwick's power needs?

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

EXTENSION

Wind farms kill an estimated 140,000 to 328,000 birds every year in North America. Birds can fly into the wind turbine's spinning blades and die instantly. Design a solution to this problem. You may consider making a diagram, writing a description of your solution, or building a model to add to your model wind turbine from this activity. Share your ideas with someone. Then, investigate how engineers are trying to solve this problem and compare your idea with theirs.

KEY SCIENTIFIC TERMS

energy transformation
power
variable

SCIENCE REVIEW

Energy Transformation

Energy can cause objects to change, move, or do work and appears in many forms. From our everyday experiences, energy seems like it is something that people use up or consume. Although it often appears that energy is used up, it has not gone away. Instead, it has been transferred to another part of the system or transformed into another type of energy. For example, when chemical energy stored in the food we eat gets released, it enables our bodies to perform the processes that allow us to survive and grow. Or when the chemical energy in wood is released by burning the wood, it is transferred to the environment as thermal energy and light.

These forms of energy are grouped into two types—kinetic and potential. Potential energy is stored energy that has not yet been used, such as energy stored in the oil in a furnace, a buildup of electric charge on your clothes, or a rubber band that is fully stretched. Kinetic energy is associated with movement, such as when a roller coaster travels down its tracks or when a ball is thrown in the air. There are many forms of potential and kinetic energy, such as chemical, electrical, thermal, sound, light, and nuclear. The table that follows provides a short description of different types of energy. The unit for energy in the International System of Units (SI) is the joule (J), which is used for all kinds of energy types.

While we cannot observe energy directly, we can detect when it is transformed from one form to another. For example, when an object falls, its gravitational potential energy is transformed into kinetic energy of motion. When hot water is mixed with cold water, thermal energy is transferred into the cold water. We can observe that the cold water warms up, and the hot water cools down. Whenever energy is transformed or transferred, the total amount of energy beforehand must be equal to the amount afterward, regardless of the process or energy types involved. This is known as the Law of Conservation of Energy.

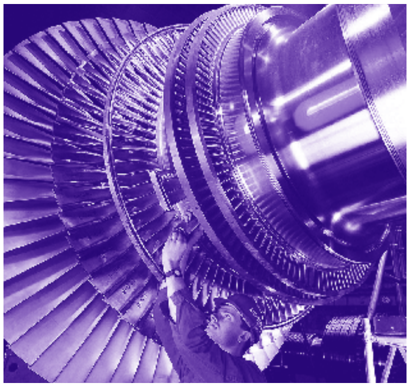
TABLE 4.2
A summary of energy types

ENERGY TYPE	NAME	DEPENDS ON	DESCRIPTION	EXAMPLE
Potential energy	Chemical	Type of substance	Energy stored in the bonds of atoms	Energy stored in fossil fuels and food
	Elastic	Springiness of object	Energy stored by stretching or compressing	Energy stored in a stretched rubber band or compressed foam
	Electric (static)	Electric charge buildup	Energy stored by the buildup of charges (electrons or ions)	Charge building up on a person walking on a rug or combing fine hair
	Gravitational	Height and mass	Energy stored due to an object's mass and position	Energy stored due to the mass and position of a train on the top of a roller coaster or water at the top of a waterfall
	Nuclear	Atomic structure	Energy stored in the nucleus of atoms	Energy stored in uranium-238 atoms, or energy stored in the nucleus of hydrogen atoms in the center of the Sun
Kinetic energy	Electric (current)	Charge, conductivity	Movement of charge and energy from one place to another	Lightning, or electricity through wires
	Light	Intensity and frequency	Energy transferred by the rapid movement of electromagnetic fields	Sunlight or X-rays
	Motion (kinetic)	Mass, speed	Movement of an object from one place to another	Wind or a moving train
	Sound	Loudness	Energy transferred by the vibration of an object	Music in air or voices under water
	Thermal	Mass, material, and temperature	Energy transferred in transit from a hot to a cold object	Hot plate heating up water, or hot water cooling to room temperature

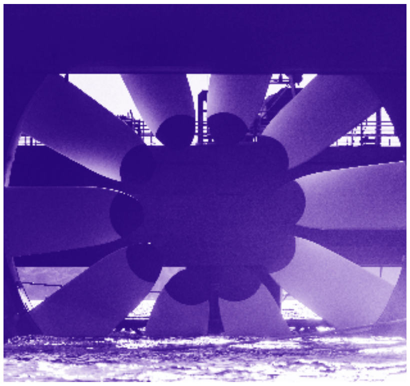
Motors and Generators

A generator converts mechanical energy into electrical energy; a motor does the opposite and converts electrical energy into mechanical energy. In a simple generator, a coil of wire spins inside a magnetic field. This produces an electromotive force (known as voltage) that results in an electrical current when connected to devices. A motor is similar to an electric generator but in this case, an electric current makes a coil move in a magnetic field. Often, a motor can also be used as a generator, provided there is some way to make the coil spin.

The most common way of making the coil spin in a generator is by pushing a gas at high velocity through the blades of a turbine that is connected to the generator. The most common gas for this is steam, which is produced by the boiling of water. The heat needed to boil the water may come from a variety of sources, such as burning fossil fuels or nuclear power. Some turbines are rotated by other moving fluids, such as water and air. Hydroelectric and tidal power stations harness the movement of water, while wind turbines harness the movement of air.



Steam turbine



Hydro turbine

Wind turbine

The word *generate*, while used by experts and laymen alike, is a misnomer. The electrical energy that comes out of a generator is not made, or generated, from nothing. It is a result of an energy transformation, so no energy was created or destroyed in the process.

Electrical Power

When generators provide electrical energy, the amount of generation is measured by the rate that the device can provide energy. Power is the rate that energy is moved or used. While the SI unit for energy is joules (J), power is measured in joules/second (J/s), which is equivalent to watts (W). Electrical devices are also rated by the amount of power they need to run properly, either in watts or kilowatts (kW).

ACTIVITY 5

Scenario Planning

CARD-BASED INVESTIGATION

Imagination can jump-start planning for the future.

5 : SCENARIO PLANNING

GUIDING QUESTION

How does imagining the future inform current energy decisions?

INTRODUCTION

Making decisions about things that will impact the future can be challenging because of uncertainty. There are often factors with many possible outcomes, such as how much money you will have or how healthy you will be. Imagining and considering a range of possibilities in the future is an important tool to inform the decisions we make today.

In this activity, you will imagine possible futures by considering specific uncertainties and using that information to help make a decision. This process is called scenario planning, a technique that informs decision-making by imagining how uncertain factors might affect possible futures. Your class will play the role of a team of consultants invited to make a recommendation to the Vanwick City Council on what possible future outcomes they should consider as they plan.

CONCEPTUAL TOOLS

SCENARIO PLANNING

CREDIBLE SOURCES

PROCEDURE

PART A: IMAGINING THE FUTURE

1 With your group, read the following scenario.

Part of developing a detailed energy plan for the future of Vanwick includes thinking about what might happen in the future. For example, it's likely the demand for electricity will increase with electrification because more things will be running off of electricity, such as heating systems. By imagining what could happen and how likely those possible scenarios might happen, the City Council hopes to make better decisions for the future.

2 Your teacher will provide your group with a set of 4 cards, 1 card per person. Read your card, which describes possibilities for two factors in the future.

3 Using the information on the cards, imagine what life would be like in Vanwick 50 years in the future if the two factors on the card happen as described. Choose one of the following activities to creatively communicate what you imagine this possible future would be like for a typical Vanwick citizen.

- Write a fictional story about the future.
- Draw a picture or label a diagram.
- Write a future news article.

Make sure to add a title to your story, picture, or article.

4 In your group, share your story, picture, or article from the future of Vanwick. In the boxes on Student Sheet 5.1, "Scenario Planning," record notes that summarize each of the four possible futures.

5 Use completed Student Sheet 5.1 to compare the four stories. Discuss how the two factors are related to the boxes and how they inform the stories that were made in Step 3.

If you need an introduction to the concept of electrification, you will find a Science Review at the end of this activity.

MATERIALS LIST

FOR EACH GROUP OF FOUR STUDENTS

- SET OF 4 SCENARIO PLANNING CARDS

FOR EACH STUDENT

- STUDENT SHEET 5.1 "Scenario Planning"

PART B: CONSIDERING THE OUTCOMES

6 In your group, describe the outcomes that could possibly result from the futures you envisioned in Part A. Then, evaluate how likely it is that such an outcome will happen. Make a table such as the one that follows. Complete the table together as you discuss one another's ideas.

TABLE 5.1
Possible outcomes

CARD #	TITLE	POSSIBLE OUTCOME(S)	LIKELIHOOD IT COULD HAPPEN (1 high—4 low)
1			
2			
3			
4			

7 Select the best-case possible outcomes and the worst-case possible outcomes from the table.

8 In your group, think of ways the City Council could prepare for best and worst possible futures. Your recommendation should include:

- how they could avoid the worst possible future,
- how they could make the best possible future more likely to happen, and
- how they could prepare for the possibility that the worst possible future will come about, since our limited control makes the future uncertain.

9 With the class, share your story, picture, or article about a possible future and your recommendations for preparing for the best and worst possible outcomes. Discuss how those recommendations may be similar or different to those from another group.

10 As a class, decide what you—a group of consultants—recommend to the City Council. Your recommendation(s) to the Vanwick City Council on behalf of these possible futures should include:

- decisions or actions that can be taken now during Vanwick's energy transition to support a positive future, despite the uncertainty of it.
- The trade-offs that will need to be made to follow your recommendation. A trade-off is when a desirable outcome is given up to gain another desirable outcome.

BUILD UNDERSTANDING

1. Pick the future scenario that came up in your class discussion that you found the most interesting.
   - a. Identify the two factors involved in the scenario planning and why they were interesting to you.
   - b. Describe how Vanwick citizens would be impacted if this possible future happens.
   - c. Decide what the City Council should do to increase or decrease the likelihood that this future will happen (if anything).
   - d. Decide how the City Council can best prepare for this possible future.
2. Think about Activity 2 when facts were supported with credible sources. How do you think having accurate facts could support scenario planning?
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.

KEY SCIENTIFIC TERMS

scenario planning
trade-off

SCIENCE REVIEW

Electrification

When envisioning the future of energy with fewer greenhouse gas emissions, one possibility is an increase in electrification. Electrification is the process of replacing technologies that include burning fossil fuels with energy generation and electrical devices that do not. An example of this is an electric car's battery charged at a home that gets its electricity from a local natural gas plant. That electricity was generated at the plant by burning fossil fuels, transmitted, and then distributed to the end user who plugged in their car. While the electric car in this example does reduce the amount of greenhouse gas emissions compared to a combustion-engine vehicle, the system is not free of greenhouse gas emissions. Electrification, in this example, would mean that the electric car gets its electrical power from another generation method that does not release greenhouse gases, such as solar panels. Electrification means replacing parts of the system to eliminate fossil fuel burning, whether that be the generation, the end–user device, or both. This and another everyday example follow.

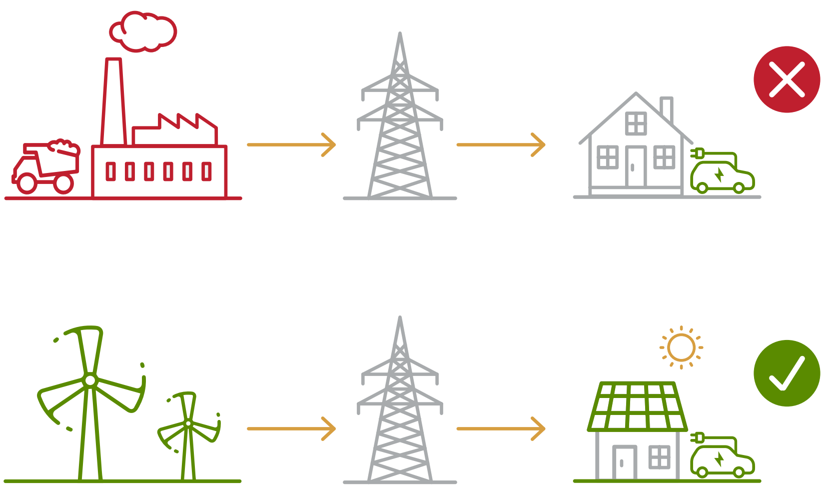


FIGURE 5.1

EV setup (not electrified)
fossil fuels
electric vehicle

EV setup (electrified)
wind energy
solar panels
electric vehicle

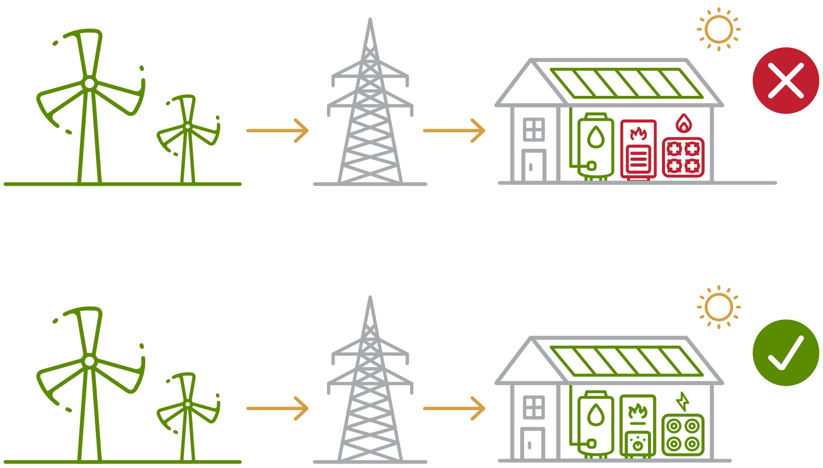


FIGURE 5.2

House (not electrified)
wind energy
solar panels
electric water heater
furnace
natural gas stove

House (electrified)
wind energy
solar panels
electric water heater
heat pump
electric stove

Electrification has an important outcome to consider for the future. Even if the overall demand for energy stays the same, electrification will cause electrical energy consumption overall to increase. This is because more devices—such as cars, stoves, and heaters that traditionally run on fossil fuels—will need to draw electrical power instead. For electrification to work, more electrical power needs to be generated, along with a more robust grid infrastructure to transmit and distribute it. Current estimations for the possible future where everything is electrified is that most communities will need twice as much electrical power than they are currently generating. However, the total amount of energy that communities will use, if demand doesn't change, will fall by about 20% because there are fewer energy losses. This is due to more efficient energy transformations in a renewable system and not needing to put energy into capturing the resources.

ACTIVITY 6

Energy Storage Model

LABORATORY

The upper reservoir of the Markersbach pumped hydro storage in Saxony, Germany.

6: ENERGY STORAGE MODEL

GUIDING QUESTION

How can understanding an energy storage model help make a decision about using energy storage in a community?

INTRODUCTION

One of the challenges of some renewable electrical power generation methods is that there are times when the sources cannot meet the demand. For example, solar panels only work when the Sun is shining, and wind turbines only spin when there is wind. For these electrical power generation methods, there needs to be a supplementary source of electrical power when generation is lower than demand or not available. One solution is to remain connected to fossil fuel systems for as long as fossil fuels are available. A second solution is to share electrical power among communities. This approach is called grid sharing, which is when two or more organizations share or buy electricity from each other through connected transmission lines (the "grid"). This solution is common, but it is not perfect because up to 5% of energy is lost during transmission. A third solution is to invest in an energy storage system. Energy storage is a system or device that stores potential energy when it is abundant and releases it as electrical power when it is scarce. There are various options for storing energy, such as battery systems, pumped water systems, or mechanical systems. Like electrical generation, energy storage depends on energy transformations.

In this activity, you'll model one renewable method of energy storage. Then you'll learn about real-world energy storage systems and gather facts to help with decision analysis for Vanwick's decision about the energy storage systems.

CONCEPTUAL TOOLS

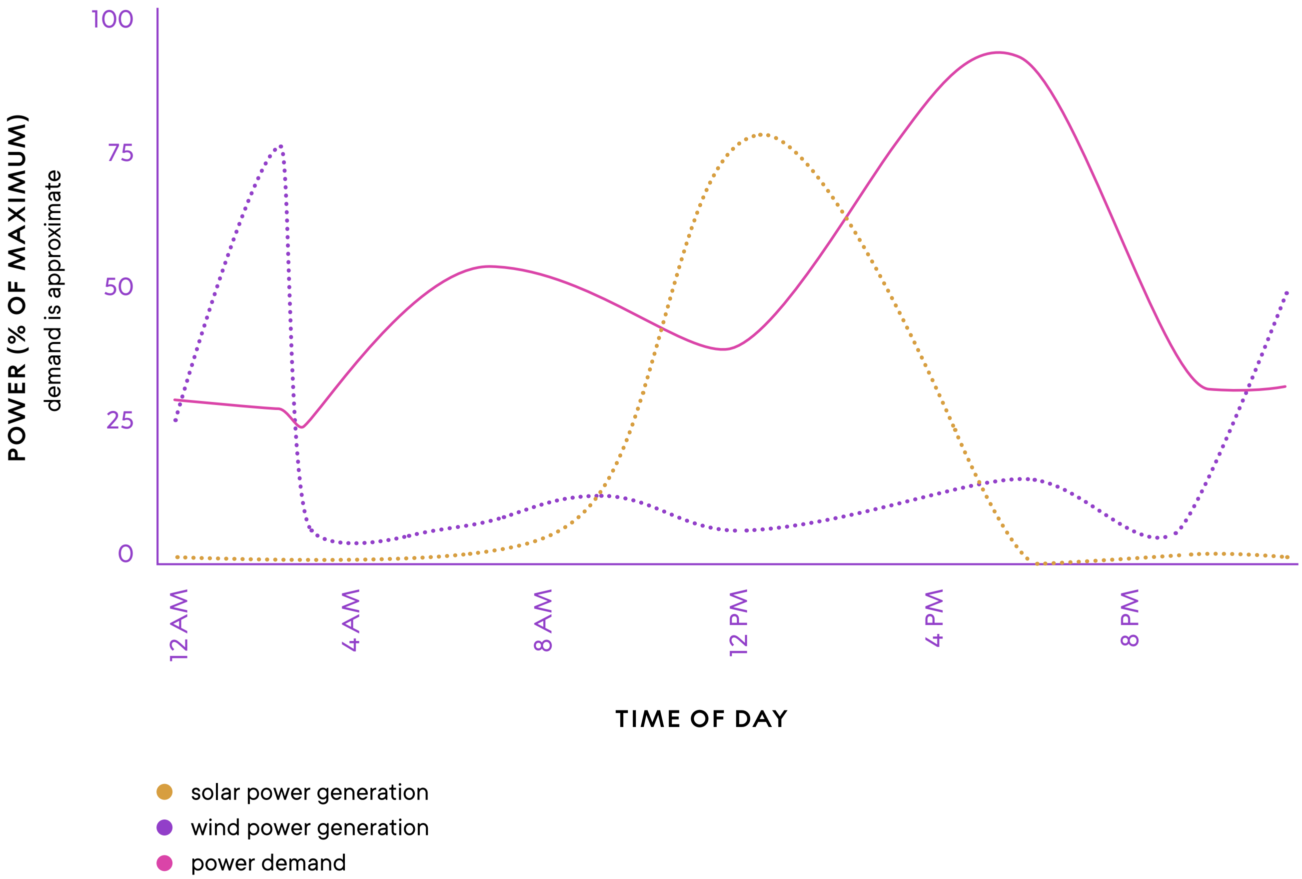
WEAVING FACTS & VALUES IN DECISION-MAKING

CREDIBLE SOURCES

SCENARIO PLANNING

FIGURE 6.1
Patterns of renewable generation and power demand

The graph shows an example of typical power-generation patterns from solar and wind, along with power demand.



MATERIALS LIST

FOR EACH GROUP OF FOUR STUDENTS

Components needed to build a model energy storage system:

- 1.5V–3V MOTOR-GENERATOR WITH MOUNT
- TURBINE HUB OR PULLEY
- RING STAND WITH CLAMP
- RAMP WITH TRACK, about 1 m (3 ft)
- CART
- STRING, slightly longer than track
- RULER
- SMALL MASSES
- SCALE
- 9V OR 1.5V BATTERY
- VOLTMETER
- 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”

PROCEDURE

PART A: MODELING A GRAVITY BATTERY

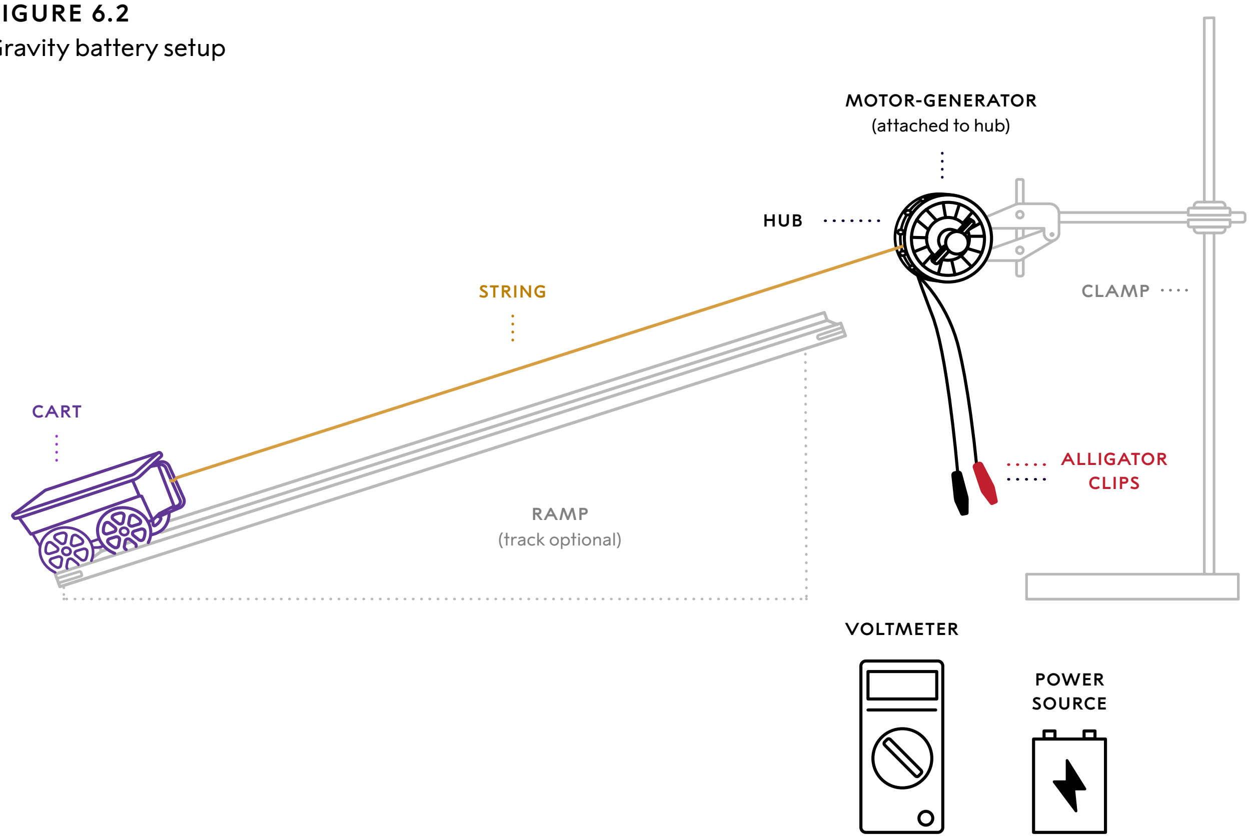
1. With your group, read the following scenario.

   Because Vanwick lacks robust transmission lines to other communities, it is not in a position to buy electricity from another location or grid share when demand increases. Even if they could, the town prefers not to buy electricity from neighboring communities as the generation would be dependent on fossil fuels. Instead, Vanwick is looking at ways to store energy for use at a later time. A local company has submitted a proposal to build an energy storage system that has a low environmental impact. Instead of using mineral-intense chemical batteries, the storage system will use some land around Vanwick to build “gravity batteries,” train-like devices that are moved by energy and gravity.

2. Follow your teacher’s instructions to set up the model gravity battery as shown in Figure 6.2. Make sure your ramp is tall enough (inclined) so the cart can roll down on its own. Your setup may vary from the one shown, depending on the materials your teacher provides.

> If you need to review the concept of energy transformations, you will find a Science Review at the end of this activity.

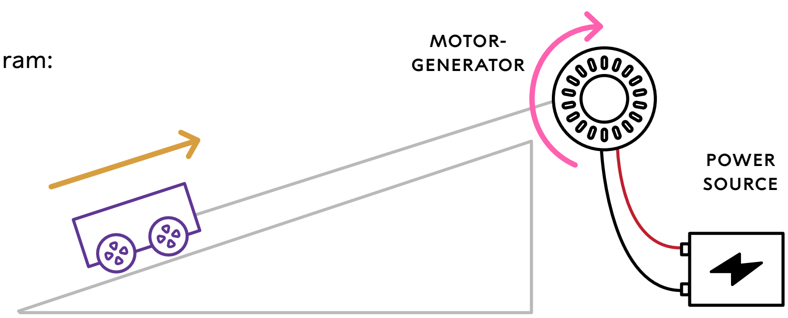
FIGURE 6.2
Gravity battery setup



3 Connect the power source to the motor-generator wires to model the charging phase of the model gravity battery. In this phase, the cart moves up the ramp to store energy. Check that the hub is aligned straight over the ramp so the string will wind smoothly during the test.

4 With the class, work together to identify, in Figure 6.3, all the energy transformations from Step 3. Discuss how the cart waiting at the top of the hill is similar to a charged battery. Copy the diagram into your science notebook, label it, and record a sentence that explains what happened in Step 3 in terms of energy transformations.

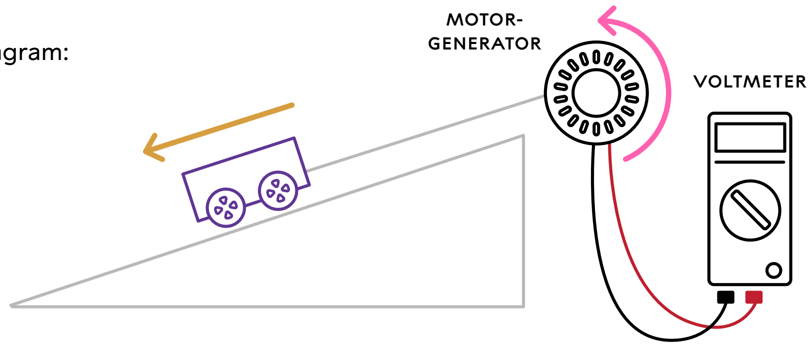
FIGURE 6.3
Gravity battery diagram:
Storing energy



5 Follow your teacher's instructions to set up the discharge phase of the model gravity battery. In this phase, the cart rolls downhill to release energy.

6 With the class, work together to identify, in Figure 6.4, all the energy transformations from Step 5. Discuss how the cart rolling to the bottom of the hill is generating power. Record a sentence in your science notebook that explains what happened in Step 5 in terms of energy transformations.

FIGURE 6.4
Gravity battery diagram: Releasing energy



7 Connect the voltmeter to the motor-generator wires, using the alligator clips, to measure the voltage produced as the cart rolls downhill. Check that the hub is aligned straight over the ramp so the string will unwind smoothly during the test. It is not important if the voltage reads "+" or" –"; just record the number.

8 Charge the battery so the cart sits at the top of the hill. Then test the set-up by video recording the voltmeter display as it rolls down the ramp. Review the video and find the maximum voltage released. Copy a table similar to the Gravity-Battery Data table that follows and record your data as Trial 1. It is not important if the voltage reads "+" or "–"; just record the number.

9 Repeat the charging and discharging of the gravity-battery model at least two more times (Trials 2 and 3) and then average your results.

HINT: To save energy and time, you may want to switch to winding up the cart by hand.

TABLE 6.1
Gravity-battery data

TRIAL	MAXIUMUM VOLTAGE (V)
1	
2	
3	
AVERAGE	

PART B: MAXIMIZING THE DESIGN

10 In your group, come up with a plan to improve the model gravity battery by changing the height of the hub or the mass in the cart so it discharges a higher voltage. Make sure you plan to change only one variable at a time in the design.

11 Test your new design with the same procedure as in Part A. Use Student Sheet 6.1, "Design Testing Data: Gravity Battery," to record your data.

12 With your group, consider the results of the first design iteration. Repeat Steps 10–11 to improve the design for Design Iteration 2.

13 Continue iterating on the design until you are confident you have a design that changes one variable to maximize the voltage as the cart rolls down the hill.

14 Share your designs and test results with the class and discuss how to maximize storing energy in the gravity battery. If a gravity-battery system like this were to be built in the real world, describe the kind of location and the mass in the cart that would be best.

PART C: OTHER TYPES OF ENERGY STORAGE

15 In your group, research facts about the energy systems listed in the table. Investigate how they work, their advantages, and their disadvantages. Make sure to use credible sources in your research. Make a table in your science notebook like the one that follows and record your information in it.

TABLE 6.2
Energy storage system research

STORAGE SYSTEM	DESCRIPTION	ADVANTAGES	DISADVANTAGES	CREDIBLE SOURCE
Rail-energy gravity battery				
Pumped-hydro gravity battery				
Chemical lithium batteries				

16 In your group, take turns sharing your research with your other group members. Explain why the sources you chose for your research were credible. Discuss the advantages and disadvantages of each storage type.

17 Review the most common values from Activity 3 for the city of Vanwick. Identify the facts from this activity that relate to those values. Based on this, choose a storage system that you think is best for Vanwick's Project REV. Identify the trade-offs of the decision.

Chemical battery facility
Flevopolder, The Netherlands

BUILD UNDERSTANDING

1. 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, and
   - any trade-offs involved in your decision.

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?

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?

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?

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?

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

KEY SCIENTIFIC TERMS

energy storage system
grid sharing

SCIENCE REVIEW

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. It depends on mass, height, and the acceleration of gravity. Specifically:

Gravitational Potential Energy (GPE) = mgh

where **m** is mass of the object (in kilograms),
g is acceleration of gravity (in m/s^2), and
h is the height from the ground (in meters).

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. It is dependent on the mass and velocity of an object. Specifically:

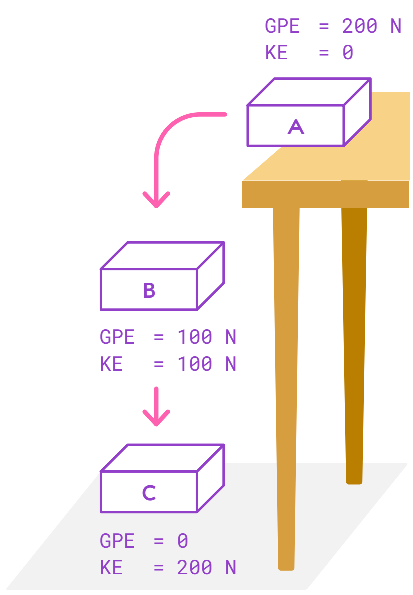
Kinetic energy (KE) = 1/2 mv^2

where **m** is mass of the object (in kilograms), and
v is the velocity of the object (in m/s).

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.

When an object is dropped from some height, it begins to lose this potential energy. It simultaneously loses gravitational potential energy while it gains kinetic energy. The total energy stays the same, as shown in Figure 6.5.

FIGURE 6.5
Example of a GPE to KE transformation



ACTIVITY 7

Building Initiative

COMPUTER APP

BedZED in Hackbridge, London, England, is a large-scale zero-carbon emissions community.

7: BUILDING INITIATIVE

GUIDING QUESTION

How can a decision-analysis tool help make group decisions?

INTRODUCTION

Energy generation from renewable resources instead of fossil fuels is crucial to reducing greenhouse gas emissions. Yet, there are other significant sources of greenhouse gas emissions, such as those from burning fossil fuels when making goods and services and those from transportation such as cars, trucks, and airplanes. Another big contributor to greenhouse gas emissions that is often overlooked are homes and buildings. About 37% of greenhouse gas emissions come from buildings, with 28% coming from building operations and 9% released during construction.

There are many different ways that energy consumption in buildings can be reduced. Effective strategies include reducing the amount of energy needed and installing a heating system that does not depend on fossil fuels. In this activity, you will act in the role of the Vanwick City Council who has decided to try to reduce greenhouse gas emissions from buildings in support of Project REV. To do this, you will use a tool in the form of an online app to inform your decision. This decision-analysis tool systematically breaks down a decision by mathematically weighing the facts and values related to the decision.

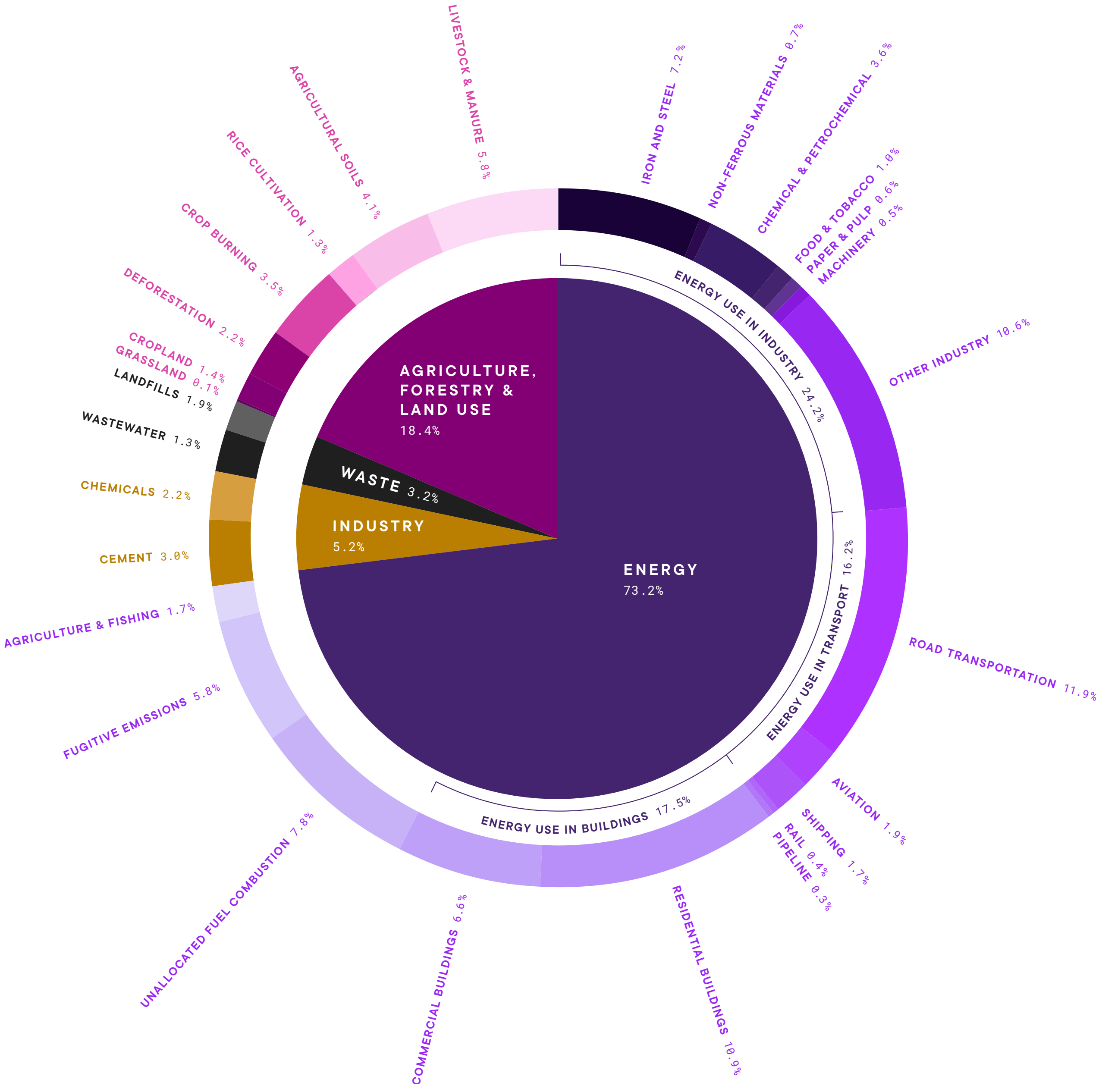
CONCEPTUAL TOOLS

WEAVING FACTS & VALUES IN DECISION-MAKING

GROUP DECISION-MAKING

FIGURE 7.1
Global greenhouse gas emissions by sector
Our World in Data (2020)

This graph shows the percentage of greenhouse gas emissions released from running residential and commercial buildings. Additional emissions related to buildings are included in unallocated fuel combustion, iron and steel production, cement, transportation, and petrochemical manufacturing.



PROCEDURE

1 With your group, read the following scenario.

When the City Council asked for feedback about Project REV from its citizens, they discovered that many people realized that there is more to reducing greenhouse gas emissions than using renewable sources to generate electricity. They decided to support the Project REV efforts to reduce emissions by creating a concurrent plan to improve the energy efficiency of existing buildings and future construction in Vanwick. They came up with a final list of solutions but need to decide which one they should fund. As they consider their options, city leaders are looking for solutions that will prioritize the following values:

- *reduce greenhouse gas emissions,*
- *have a positive, equitable impact on all residents, and*
- *be cost-effective.*

2 Read the information on the Building Initiative Fact Sheets (A–D) provided by your teacher. As a class, review the information and discuss any clarifying questions.

3 Assume that the City Council weighs the three values given in the scenario equally. Record the values, assign weights to the values, and record them in Table 1 of Student Sheet 7.1, "Building Initiative Information."

4 Reread each initiative and identify the facts for each option that relate to each value. Record them in Table 2 of Student Sheet 7.1. Then, use the facts to evaluate how well each option fulfills that value. Assign a rating with a scale from 0 (doesn't fulfill this value at all) to 4 (fulfills this value perfectly). If there is more than one fact that relates to an option, just record the same value again in the left-hand column.

MATERIALS LIST

FOR EACH GROUP OF FOUR STUDENTS

- BUILDING INITIATIVE FACT SHEETS (A–D)

FOR EACH PAIR OF STUDENTS

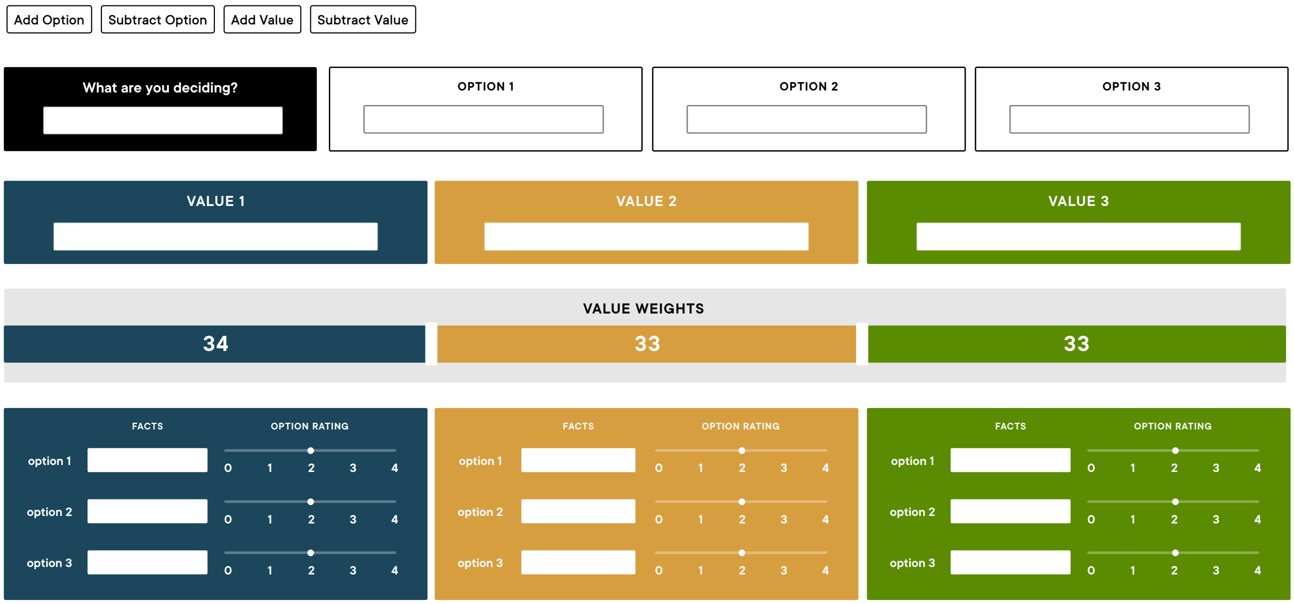
- COMPUTER WITH INTERNET ACCESS

FOR EACH STUDENT

- STUDENT SHEET 7.1 "Building Initiative Information"

FIGURE 7.2

Portion of the Decision-Analysis Tool screen



5 Go to the Decision-Analysis Tool and fill out the information from Student Sheet 7.1 into the app.

HINT: Choose "Add an Option" at the top of the screen before beginning.

6 Look at the points in the graph for each Initiative. Record the results from the app on your student sheet.

7 In your group, write a one-sentence decision together on behalf of the City Council to be posted on Vanwick's social media account. Use the information you gained from the Decision-Analysis Tool to explain your reasoning.

8 Share your posts with your class.

9 Now imagine that the City Council prioritized one of the values over the other two. In your group, predict how the outcome will be different if the value weights are the following:

- cost-effective 80
- reducing greenhouse gases 10
- positive, equitable impact 10

Record your prediction in your science notebook.

10 Change the value weights in the Decision-Analysis Tool to correspond with Step 9. Record your results in your science notebook.

11 As a class, compare the decision with the values being evenly weighted to values made with different weights. Discuss how decisions are shaped by values even when relying on the same facts.

BUILD UNDERSTANDING

1. 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.

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

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.

EXTENSION

Find out about an energy decision your town is considering. Do you think the app you used in this activity would be helpful in making that decision? Explain why or why not.

KEY SCIENTIFIC TERMS

decision-analysis tool

ACTIVITY 8

Stakeholder Recommendation

INVESTIGATION

Land-use decisions impact many
stakeholders, including farmers.

8: STAKEHOLDER RECOMMENDATION

GUIDING QUESTION

How can facts and values inform planning for the future?

INTRODUCTION

When considering a new renewable energy system, an important factor in planning can be how the land in the area will be used for power generation. Every electrical power generation site takes up space, but renewable energy can be especially land intensive. For the same amount of energy, wind and solar electricity generation requires 10 times as much land as a fossil fuel power plant. Plus, wind and solar generation must be located where the resource availability is best, unlike fossil fuels that can be transported from a more convenient place after it has been extracted from the land. On the other hand, fossil fuel extraction can devastate the land from which it is drawn and requires energy to do so. An important part of planning a renewable energy project such as Project REV is taking into consideration how stakeholders feel about where electrical power generation sites are located.

In this activity, you will get information about solar and wind power, along with the possible locations for generation in Vanwick. Your role is to identify the generation sites that will help accomplish the goals of Project REV, using the tools you have learned. This will include taking into account your stakeholders' perspectives and balancing the trade-offs of the choices.

CONCEPTUAL TOOLS

WEAVING FACTS & VALUES IN DECISION-MAKING

GROUP DECISION-MAKING

PROCEDURE

1 Read the following scenario.

Project REV has identified nine locations in Vanwick that are possible sites for solar and wind generation. In order to generate enough power, multiple sites will need to be used. Now, the City Council is soliciting feedback from its residents about the type and location of the generation to include in their final plan.

The city of Vanwick is looking for places to add electrical power generation.

MATERIALS LIST

FOR EACH GROUP OF FOUR STUDENTS

- SITE SURVEY CARDS (9)
- STAKEHOLDER CARD

FOR EACH PAIR OF STUDENTS

- COMPUTER WITH INTERNET ACCESS

FOR EACH STUDENT

- STUDENT SHEET 8.1 "Vanwick Site Map: Stakeholder"

2 Read the following background information about solar and wind power generation.

SOLAR POWER

Rooftop solar power systems usually provide around 5 kW for a typical household. A rooftop solar system on a large commercial building, which has more area than a typical household rooftop, can generate over 100 kW–1 MW.

Solar Plants typically provide around 10–500 MW (the largest single plant in the world is over 1,000 MW).

Greenhouse gases

Since light is transformed directly into electrical power, greenhouse gases are not released during operation.

Location

- For large solar plants, the area needs to be big, open, and flat. There needs to be additional space between the panel rows.
- Rooftop solar systems work best with uncomplicated rooflines and panels that face south to capture sunlight.

Impacts

- Solar panels have no moving parts, so they are silent. Other activities can be used with panels so the land can be used for multiple purposes, such as animal grazing, rotating crops, sheltering parking garages, and more.
- There are natural resources and energy, usually supplied by fossil fuels, that are required to build the panels. There are some electronics in the panel, so disposal is important, and there are currently limited recycling options.

Jobs

Solar power systems require a lot of workers to install the site, but since there are no moving parts, it does not need as many permanent workers as wind power.

Electricity costs

- For private small solar installations, there are minimal electric bills because power is generated on site. The initial cost of rooftop solar is usually recovered in about 5 years by savings on electric bills.
- For large-scale solar plants, the cost to the consumer depends on the utility company in charge of service. For Vanwick, costs are predicted to stay about the same.

WIND POWER

Small wind turbines, sometimes called microturbines, range in size but typically provide around 10–100 kW.

Large utility-size wind turbines can generate up to 8 MW.

Greenhouse gases

Since wind turbines directly turn the shaft of a generator, no greenhouse gases are released during operation.

Location

- Large wind turbines are placed on top of hills with towers up to 150 m (490 ft) and are 90 m (295 ft) wide. They are placed about 0.8 km (½ mile) apart. They are often visible over 20 km (12 miles) away.
- Small wind turbines need to be mounted on secure towers, either on roofs or in fields that are 9 m (30 ft) above objects and people.

Impacts

- Wind turbines make a "swishing" noise as they turn that can be heard up to a mile away.
- There are natural resources and energy, usually supplied by fossil fuels, that are used to build the wind turbines. The towers are made mostly of metal, which is easily recyclable. The blades are made of fiberglass, which currently has some reuses but has limited recyclability.

Jobs

A lot of workers are needed to install wind turbines. Since there are custom pieces and moving parts, turbine installation requires some educated and highly paid workers compared to solar. The maintenance of wind turbines is ongoing because parts wear out, so that provides more permanent jobs than solar.

Electricity costs

- For private small wind turbines, there are minimal electric bills because power is generated on site. The initial cost of a small turbine is usually recovered in about 5–10 years by savings on electric bills.
- For large-scale wind turbines, the cost to the consumer depends on the utility company that is in charge of service. For Vanwick, costs are predicted to stay about the same.

3 Your teacher will provide your group with a stakeholder card. Review the values and their weights on the card that relate to choosing a generation site.

4 With your group, review the 9 Site Survey cards and match the descriptions to their locations on Student Sheet 8.1, "Vanwick Site Map: Stakeholder."

5 Compare the values and their weights of your stakeholder to the possible generation at each location.

6 Use the Decision-Analysis Tool to analyze the locations that your stakeholder will support. Use the values on the Stakeholder card and choose up to five sites as options. Use the facts about solar and wind and the description of each site to evaluate the values with a rating.

HINT: You may want to use the tool more than once or swap in locations to analyze more than five sites.

7 In your science notebook, record your results from the Decision-Analysis Tool.

8 With your group, use Student Sheet 8.1 to select the locations, type of electrical generation, and amount of generation your stakeholder supports. Circle or highlight the locations on the student sheet. Record your reasoning at the bottom of the student sheet. Remember, this recommendation is based on the perspective of your stakeholder.

BUILD UNDERSTANDING

① How did creating the plan to meet the values of your stakeholder, instead of for yourself, impact the plan you made?

② What trade-offs did you make in choosing the locations for your recommendation?

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?

CONNECTIONS TO EVERYDAY LIFE

④ Describe an experience 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.

ACTIVITY 9

Real-World Energy Decisions

READING

9: REAL-WORLD ENERGY DECISIONS

GUIDING QUESTION

What can support successful group decision-making?

INTRODUCTION

Making a plan that satisfies all members of a community, whether it is a renewable energy plan or something else, can be difficult. Making a group decision for the future may involve a compromise. A compromise is when each side gives up something they want in order to reach an agreement. A compromise is an important tool to reconcile the values held by different stakeholders. In this activity, you will read about groups making real-life decisions about renewable projects that depended on working out tension between stakeholders.

CONCEPTUAL TOOLS

WEAVING FACTS & VALUES IN DECISION-MAKING

GROUP DECISION-MAKING

PROCEDURE

1 Read about two communities on the following pages. Use the Read, Think, and Take Note strategy as you read.

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.

2 After you complete the reading, work with a partner to complete Student Sheet 9.1, "Group Decisions Based on Stakeholder Values," for each community.

3 Compare and discuss your findings with the rest of your group. Be ready to share your thoughts with the class about what can make group decision-making more successful.

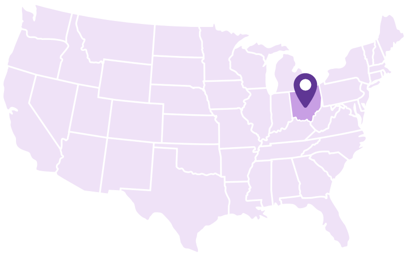
MATERIALS LIST

FOR EACH STUDENT

2 STUDENT SHEET 9.1 "Group Decisions Based on Stakeholder Values"

READING

COMMUNITY 1 THE TOWN OF WILLIAMSPORT



In late 2022, a state committee rejected a plan to build a new solar farm in the small town of Williamsport, Ohio. The decision was difficult for Mark Shein. He was a landowner who had agreed to have part of the solar farm on his land. "I'm disappointed, and there are a couple people here in the community I don't think I'll speak to for the rest of my life," he said, speaking about neighbors who worked to stop the project.

The plan for the project had been presented to the community of Williamsport the year before. A solar company called EDF Renewables wanted to build the Chipmunk Solar Farm in different parts of the town. The farm was going to generate 400 MW of renewable electricity and send power to over 75,000 homes in other parts of the state. After 30 years, the company would remove the panels, and the land could be used for farming again. Four other similar solar farms had recently been approved or were under construction in nearby areas.

Mark Shein supported the project because he wanted to financially support his family. He signed an agreement with EDF Renewables to rent out his land for solar panels. The payments he would get from the solar farm were five times what he could make from renting out

Farmer Mark Schein stands in front of his field in Pickaway County, Ohio.

the land for farming. About a dozen landowners had also agreed to lease their land to the solar company. This included Mark Shein's friend Doug Steck who wanted a more stable source of income and to reduce his dependence on farming.

Other stakeholders also supported the project. The mayor and some citizens approved of the plan because it would generate money for the town. Taxes paid by the solar company and utilities would make $100 million that could be used to fund schools, build a new firehouse, and upgrade the town's sewer system. The electricians' union supported the plan because it would create 600 jobs during construction and 8 full-time jobs afterward. Other groups endorsed the project because it would help their state meet their goals of reducing greenhouse gases. Electricity from the Chipmunk Solar Farm could provide energy to the large city of Columbus, Ohio, where residents had voted to get 100% of their electricity from wind or solar. The new project would also help utility companies follow a state law that required them to generate at least 8.5% of their energy from renewables.

But this was all before Mark Shein's neighbors heard more about the project.

One of those neighbors was Chris Weaver, a local carpenter. "I'm here to ask you to resign," he said to the mayor at a Williamsport town meeting. He was upset that the mayor was supporting the Chipmunk Solar Farm project. Weaver worried that a new electrical facility built next to his house would give off noise. Other local families were concerned with how the project would change the look and use of the countryside. They wanted to keep the land for farming and wildlife.

Signs opposing the solar project could be found throughout Williamsport, Ohio.

Doug Steck could understand why some of his neighbors might feel this way. They valued keeping their backyard views free of solar panels, and the project would cover the size of almost 2,700 football fields. However, Steck worried about other claims of fact that were being used as arguments against the plan. Some stated that the project would harm animals, people, or the land. For example, one claim of fact said that some of the elements in the solar panels, such as cadmium, would leak into the ground and water. Others said that the solar panels would lower real-estate values of their homes.

"I'm a firm believer in property owners being able to do what they want with their property. I really am," Chris Weaver said, "until it defaces my property [and] quite possibly destroys my health."

Doug Steck looked for credible sources and found out that some of these claims of fact were not accurate. Researchers had shown that solar panels don't contain enough cadmium to cause health and environmental problems. Other studies found that real-estate values are unlikely to decrease from being located near solar panels. Steck hoped to bring this information to the next town meeting. He also wanted to share how the project would help him and other farmers who wanted to rent their land to the project. However, there were so many people already against the project that Mark Shein and Doug Steck felt others were not open to hearing their views.

The solar company offered compromises to try to win support for the plan. They agreed to put up fences and to plant trees in "visually sensitive locations" around the project. They also offered to work with farmers to avoid breaking underground water pipes. To address the safety of the panels, the company planned to carefully remove the solar panels after the lease period was over. But it was too little, too late. Some stakeholders did not trust the company. They were upset that their concerns were not considered earlier in the process, and they formed an opposition group. Posts against the project grew on social media and anti-solar signs were printed and put up around town. Some residents started accusing Mark Shein of being greedy or stupid for supporting the solar project.

In the end, the compromises were not enough. Some groups thought the other side was unwilling to consider their values. The project did not have enough support from a variety of stakeholders to be approved. Shein realized that it was difficult to stay friends with other families that were against the project. Without a decision-making process that was open to all the stakeholders from the beginning, the community felt divided long after the final decision was made.

COMMUNITY 2 THE NATION OF URUGUAY

In 2007, Uruguay was facing a major energy problem. As a small country in South America, Uruguay did not have its own supply of oil, coal, or natural gas. The country relied on a large hydroelectric dam for over 80% of its electricity. However, droughts over the past 10 years had reduced the amount of electricity the dam could produce. Without enough electricity, Uruguay had to limit the amount of power that people could use, and prices for energy increased.

"It was difficult for us to cope," resident Ramón Méndez Galain remembers. "It was difficult to get electricity. For some time, we were beginning to have blackouts."

To deal with the problem, Uruguay started to buy fossil fuels from nearby countries to generate more electricity. A new pipeline was built to bring in natural gas from nearby Argentina. But importing more fossil fuels into the country had its own problems. This made Uruguay dependent on other countries for energy. It also made them vulnerable to higher prices or sudden stops in the supply of energy.

Méndez Galain was a scientist from Uruguay who began looking for a different solution. Although he was trained to study the physics of atoms, he wanted to learn more about energy systems. He talked with energy experts around the world and researched different options. Then he designed a national plan to provide energy to the entire country by adding wind and solar farms.

Uruguay President Jose Mujica (2010-2015) sits outside his home.

"When you are trained as a scientist," he said, "you are trained to see an unsolved problem and [to try] to find an explanation and a solution. So, I used, if you wish, my scientific skills I had developed in order to face this difficulty with the same strategy."

To make the plan work, Méndez Galain needed the help of a new leader named Jose Mujica. Mujica was elected as the president of Uruguay in 2009 and was not a typical politician. He has been described as "the world's humblest head of state" because of his simple lifestyle and his ability to relate to ordinary citizens. As president, he donated 90% of his salary to charities and lived on a small farm instead of in the presidential palace.

President Mujica thought that Mendez Galain's plan was a better way to transform the nation's energy system. For the plan to be accepted and successful, he needed to address the values of many different stakeholders in the country.

Some stakeholder groups did not support the plan from the beginning. Some members of the labor unions were concerned about the risk of losing jobs to a new industry. They and others were also worried that wind power would be too unreliable from day to day. To resolve these concerns, a compromise was proposed and accepted. The aging hydroelectric dam could be upgraded to serve as a backup for the wind turbines. Also, workers would be trained on how to install and service the wind-turbine technology. Both compromises would allow a smoother transition to the new renewable energy system.

Green technology and livestock share a field in Maldonado, Uruguay.

Another challenge came from citizens who were worried about the cost of electricity. They feared that if a private company owned the distribution network, the electricity would become too expensive—especially for those that are least able to afford it. Since these stakeholders are often left out of group decisions, Méndez Galain adjusted the plan so ownership was shared. The private companies would own and run the wind turbines to make electricity, but the utility, which is owned by the government, would run the electrical grid. However, this idea worried the private power companies. They needed to recover the cost to build and set up the wind turbines. The businesses and lawmakers worked together to find yet another compromise. The government utility agreed to buy all the energy from the wind turbine companies for the next 20 years.

After these compromises were made, the national energy plan was adopted in 2010. Mujica and others had worked to get the support of many stakeholders, including the opposing political party. Within 10 years, Uruguay made a dramatic shift to renewable energy. The country is now generating 98% of its electricity from renewables, and it is one of the world leaders in wind-power production. Uruguay is also proud to be selling its excess electricity back to Argentina, the country it used to depend on for oil imports.

Three important factors made this group decision possible. The stakeholders used information from experts, were involved early in the process, and were willing to find a compromise. In the end, a majority of stakeholders not only accepted the plan but wanted to work together to make it a reality.

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
   - b Uruguay
2. Which of the two communities—Williamsport or Uruguay—had a more successful group decision-making process? Describe why.
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.
4. How are the real-world situations in the readings similar to:
   - a the energy situation in Vanwick?
   - b the energy situation around the world?
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?

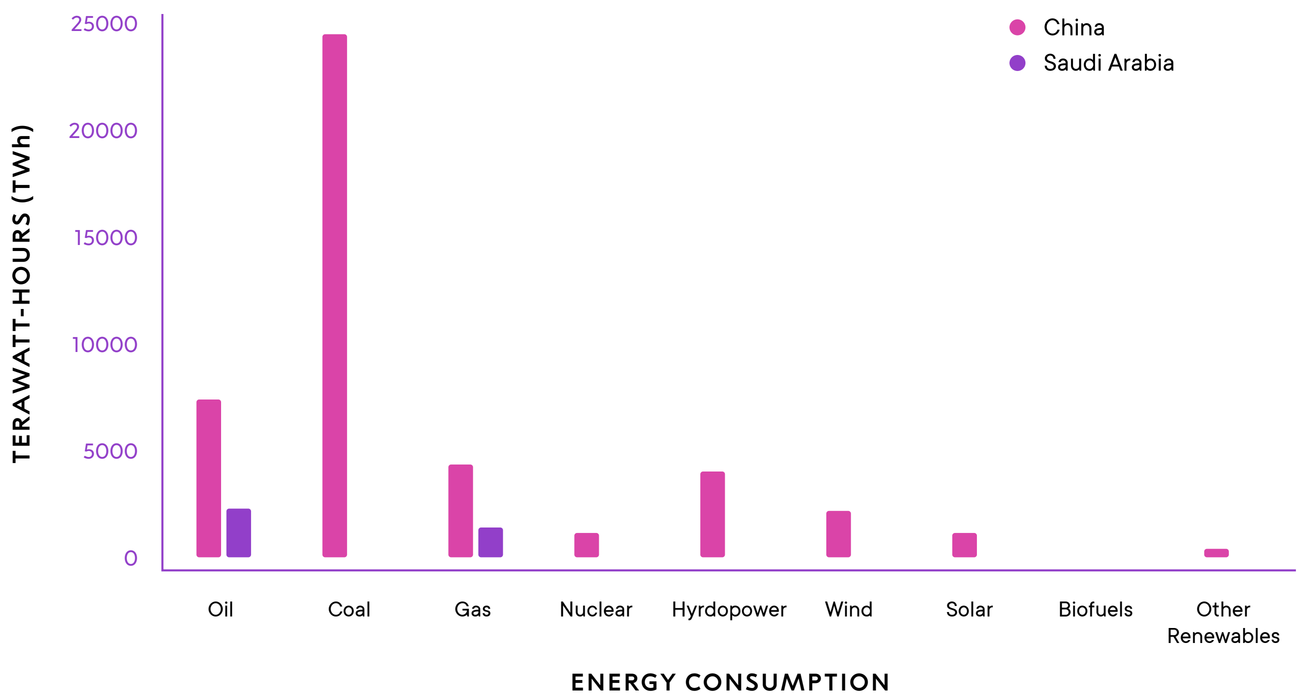
CONNECTIONS TO EVERYDAY LIFE

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).

EXTENSION

Investigate another country's energy-infrastructure system to understand its energy problems and possible solutions. Use credible sources to investigate the key stakeholders for that country, facts and values related to the energy situation, and what compromises might be possible. Share your findings with the class.

FIGURE 9.1
Energy consumption of China and Saudi Arabia in 2022



KEY SCIENTIFIC TERMS

compromise

ACTIVITY 10

Group Decision for Vanwick

DISCUSSION

Group decision-making is supported by clear communication and active listening.

10: GROUP DECISION FOR VANWICK

GUIDING QUESTION

What should be considered while making a group decision about Vanwick's Project REV?

INTRODUCTION

In a previous activity, you considered Vanwicks' future power needs by investigating renewable power generation. In this activity, you will play the role of a participant who is making a group decision about renewable power generation for Project REV. Previously, while different ideas were developed by various stakeholders, here you will use decision-making tools to develop a single recommendation. This recommendation should incorporate the values of Vanwick stakeholders so it will be more likely to be approved by residents.

Tribal leaders identify suitable renewable energy sources and locations for potential renewable energy projects in their communities.

CONCEPTUAL TOOLS

WEAVING FACTS & VALUES IN DECISION-MAKING

GROUP DECISION-MAKING

PROCEDURE

1 With your group, read the following scenario.

It is time for the City Council to decide on the Project REV energy plan. After having planned for energy storage and deciding on a Building Initiative, the City Council now needs to decide on the generation sites. The stakeholders have gathered to generate the final recommendation.

The Project REV generation sites need to meet the electrical power needs of the area, which is currently 500 MW maximum capacity. With the possibility of full electrification in the future, Vanwick's demand for electricity would increase. This is because devices such as home heating and cars will run on electricity instead of fossil fuels. The amount of electric power Vanwick needs to provide is expected to double to 1,000 MW in the future. The stakeholders have to come up with an agreed-upon plan that meets that requirement if they want to get the funding for Project REV.

2 Review the site recommendations that you made with your stakeholder group in Activity 8. Recall the facts, values, and trade-offs that led to the recommendation. Be able to explain why this plan should be accepted by fellow citizens of Vanwick.

3 Follow your teacher's instructions to switch to a mixed-stakeholder group with a representative for each stakeholder. You represent your stakeholder from Activity 8. Give a brief summary of your recommendation to your group and explain why the City Council should choose your stakeholder's sites.

4 With your group, come up with a single plan that meets the 1,000 MW requirement that is agreed on by all stakeholders. The recommendation can be a new plan, a combination of previous recommendations, or one of the existing stakeholder recommendations. Remember to listen to and consider the ideas of other group members. If you disagree with other group members, explain why you disagree.

5 Record the group's single recommendation by completing Student Sheet 10.1, "Vanwick Site Map: Group Decision." Record the reasoning for choosing each site in your science notebook.

6 Create a presentation to share your decision with the class. Present your plan and explain how your group decided on it.

MATERIALS LIST

FOR 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"

BUILD UNDERSTANDING

1. 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.

2. How do you think your stakeholder would have responded to the final recommendation?

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?
   - **b** What are some advantages and disadvantages of compromising during group decision-making?

STUDENT GLOSSARY

battery
a device that transforms chemical energy into electrical energy

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

climate change
the effects that increasing temperatures caused by global warming have on Earth's systems

compromise
when each side gives up something they want in order to reach an agreement

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

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

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

disinformation
false information that is intended to mislead the audience or reader

electrical energy (current)
energy associated with the flow of charge

electrical power generation
the process of transforming a natural resource such as coal, natural gas, wind, or sunlight into electrical power

electrification
the process of replacing technologies that include burning fossil fuels with energy generation and electrical devices that do not

energy
the ability to cause objects to change, move, or work

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

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

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

fact
information that has been verified by observation or data

factor
something that actively contributes to the production of a result

fossil fuel
a fuel produced by living plant materials that have been buried and changed by heat and pressure under layers within the earth over millions of years; natural gas, petroleum, and coal are examples of fossil fuels

generator
a machine that converts mechanical energy into electrical energy

gravitational potential energy
energy stored due to an object's mass and height

gravity battery
a device that transforms gravitational potential energy into electrical energy

greenhouse gas
a gas that traps thermal energy in the atmosphere such as carbon dioxide, water vapor, and methane

greenhouse gas emissions
greenhouse gases that are released through human activities, such as burning fossil fuels for heat and transportation

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

group decision-making
a process for making a choice by multiple people who consider the values of stakeholders affected by the result

heat pump
a single electric device that works as both air conditioning and heating

kinetic energy
the energy an object has because of its motion

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

microgrid
a small local energy system that includes one or more energy sources located near the end user, a smart grid-controlling system, and interconnected electrical devices drawing from that source

misinformation
false or incorrect information

nonrenewable resource
a natural resource that cannot be replaced faster than it is used up by human populations

opinion
views that an individual or group form about something that may not be based on facts

outcome
something that follows as a result or consequence

potential energy
energy of position or condition

power
the rate at which energy is transformed

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

renewable resource
a natural resource that can be replaced or replenished faster than it is used up by human populations

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

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

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

turbine
a type of machine through which liquid or gas flows, thereby spinning blades that then produce power

utility company
a business that provides services to customers, such as electricity, water, sewage services, and natural gas

value
what an individual or group considers important

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

voltage
the difference in electric potential between two points

watt
the unit of power that is one joule per second

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

CREDITS

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