Smithsonian Science for the Classroom

HOW CAN WE PROVIDE ENERGY TO PEOPLE'S HOMES?

Grade 4 - Engineering

TRAINER GUIDE

CURRICULUM PROFESSIONAL DEVELOPMENT

Smithsonian
Science Education Center

The **Smithsonian Science Education Center** (SSEC) is an education organization within the Smithsonian Institution. The SSEC's mission is to transform K–12 *Education Through Science*™ in collaboration with communities across the globe. The SSEC promotes authentic, interactive, inquiry-based K–12 STEM teaching and learning; ensures diversity, equity, accessibility, and inclusion in K–12 STEM education; and advances STEM education for sustainable development. The SSEC achieves its goals by developing exemplary curriculum materials and digital resources; supporting the professional growth of K–12 teachers and school leaders; and conducting outreach programs through LASER (Leadership and Assistance for Science Education Reform) to help schools, school districts, state education agencies, and ministries of education throughout the world implement inquiry-based science education programs.

The **Smithsonian Institution** was created by an Act of Congress in 1846 "for the increase and diffusion of knowledge . . ." This independent federal establishment is the world's largest museum, education, and research complex and is responsible for public and scholarly activities, exhibitions, and research projects nationwide and overseas. Among the objectives of the Smithsonian is the application of its unique resources to enhance elementary and secondary education.

Acknowledgments

Lead Trainer Guide Developer

Katherine Fancher

Division Director of Professional Services

Amy D'Amico, PhD, Principal Investigator, Smithsonian Science for North and South Carolina Classrooms

Assistant Division Director of Professional Services

Katie Gainsback, Project Manager, Smithsonian Science for North and South Carolina Classrooms

Addy Allred
Jacqueline Kolb
Alexa Mogck
Layla Sastry
Katherine Blanchard
Dr. Hyunju Lee
Eva Muszynski
Ariel Waldman
Katherine Fancher
Nejra Malanovic
Shellie Pick
Sherrell Williams

Executive Director, Smithsonian Science Education Center

Dr. Carol O'Donnell, Co-PI, Smithsonian Science for North and South Carolina Classrooms

Smithsonian Science Education Center Staff

Executive Office

Kate Echevarria
Johnny F. McInerney

Advancement and Partnerships

Holly Glover, Division Director
Denise Anderson
Inola Walston

Finance and Administration

Lisa Rogers, Division Director
Allison Gamble
Jasmine Rogers

Curriculum, Digital Media, and Communications

Dr. Brian Mandell, Division Director
Sofia Elian
Heidi Gibson
Dr. Sarah J. Glassman
Carolina Gonzalez
Dr. Emily J. Harrison
Victor Lucena
Hannah Osborn
Andre Radloff
Melissa J.B. Rogers
Logan Schmidt
Dr. Mary E. Short
Khadijah Thibodeaux
Logan Werlinger
Raymond Williams, III

Thank You for Your Support

This project was supported by the US Department of Education through an early-phase Education Innovation and Research (EIR) grant (U411C190055) to the Smithsonian Science Education Center.

How Can We Provide Energy to People's Homes?

Grade 4—Engineering

Trainer Guide

INTRODUCTION

In 2019, the US Department of Education awarded the Smithsonian Science Education Center an early-phase Education Innovation and Research (EIR) grant to support the development, implementation, and initial evaluation of evidence-based innovations to improve student achievement. The project, called Smithsonian Science for North and South Carolina Classrooms (PR# U411C190055), took place between October 2019 and September 2024 in third-, fourth-, and fifth-grade classrooms in North and South Carolina.

Between 2020 and 2023, participating teachers in implementation schools received curriculum professional development tied to two Smithsonian Science for the Classroom curriculum modules and content and pedagogy professional development tied to the content of each module to implement in their classrooms. The Center for Research in Educational Policy (CREP) at the University of Memphis evaluated the impact of these modules and professional development on student achievement using standardized assessments, classroom observations, and teacher focus groups.

This guide was developed as a support for trainers leading curriculum professional development for fourth grade teachers implementing the Smithsonian Science for the Classroom Engineering module *How Can We Provide Energy to People's Homes?*

RESOURCES

- Teacher Guide (TG)
- Student Activity Guide (SAG)
- Smithsonian Science Stories Literacy Series: *Everyday Energy* (Reader)
- Carolina Science Online (CSO): Carolinascienceonline.com

HOW TO USE THIS TRAINER GUIDE

This guide shares important ideas and strategies for effectively introducing a Smithsonian Science for the Classroom (SSftC) module with educators, when used in conjunction with the corresponding Teacher Guide. The Teacher Guide contains essential details needed to implement the module in the classroom, while this Trainer Guide outlines how to conduct professional development for that module; therefore, the two guides should be used in tandem.

The professional development plan for each section is outlined in a table at the start of each session. Within each section, there is another table. The first column shows the part of the lesson being addressed, and corresponding page numbers within the Teacher Guide, Student Activity Guide, and Reader. The second column provides the trainer with additional direction in concise bullet points.

ROOM SETUP

To set up a classroom for this workshop:

1. Move tables or desks so groups of three or four participants can work together.
2. Set module materials out on side tables where they can be easily accessed.
3. Locate the nearest restrooms and evacuation routes.

WORKSHOP OVERVIEW

This trainer guide provides direction on facilitating the curriculum sessions highlighted in the table below.

Day 1		Day 2	
10 a.m.	Welcome Session	**10 a.m.** Curriculum Session 3	Focus Questions 2–3 (Lessons 8–12)*
11 a.m. Curriculum Session 1	Introduction and Lesson 1	**12 p.m.**	Lunch
12 p.m.	Lunch	**12:45 p.m.** Curriculum Session 4	Focus Question 4 (Lessons 13–15)
12:45 p.m. Curriculum Session 2	Focus Questions 1–2 (Lessons 2–7)	**3 p.m.**	Closing Session
3:30 p.m.	Adjourn	**3:30 p.m.**	Adjourn

**Depending on the workshop design, this section may be led by participants if they have adequate time to prepare.*

Note: Italicized statements are intended to provide supporting information to facilitators.

SESSION 1:

Introduction and Lesson 1

In this session, the trainer leads lessons as a facilitator (wearing their "teacher hat") while teachers act as learners (wearing their "student hats").

Goal: The trainer facilitates the first lesson as an exemplar and introduces the concept storyline of the G4 Engineering module. Participants experience Lesson 1 as learners and debrief the lesson as teachers.

AGENDA AND TIMING

Sections	Minutes	Materials/Notes
Housekeeping and Introductions	10 minutes	
Lesson 1	30 minutes	Hand out Readers, make sure group roles poster is visible
SSftC Features and CSO	15 minutes	
Concept Storyline	5 minutes	

	Key Points
Housekeeping and Introductions	**Introductions** Welcome participants to your session. Remind them that this professional learning workshop is meant to orient teachers to a new Smithsonian Science for the Classroom curriculum module. At times they will be asked to wear their "student hat" and experience lessons as their students will, and at others they'll reflect on the material wearing their "teacher hat." **Icebreaker Activity** Participants introduce themselves through an icebreaker activity. next page →

	Key Points
	Housekeeping Preview the agenda. Verify the safety protocols in the classroom and locate the nearest restrooms, fire exit, tornado shelter.
	Establish the Tone for the Day Divide participants into small groups and ask them to think about what they want to achieve today. What norms do they think will encourage a positive learning environment? Introduce group norm ideas: • Be brave • Be present • Ask questions • Be respectful Have each small group discuss the suggested norms and add to the big group list of norms. Once everyone has added their ideas, ask if there are any changes, additions, or modifications that need to be made. When the discussion is finished, this will be the social contract the group abides by for the next two days.
	General Safety While the risk of injury is low, there should be clear safety guidelines and expectations. These guidelines will vary depending on the situation, but some useful examples can be found in the Stay Safe! contract included in the curriculum, chemistry lab rules, and general classroom safety expectations. Safety guidelines should be discussed before every lesson. Examples of safety guidelines: • Pull hair back • No tasting anything • Wear protective eyewear from start to finish • If something spills, report it immediately to get help cleaning it up • Listen closely to instructions • No running in the classroom

Lesson 1: Energy Around Us

Evidence of energy is all around us.

30 minutes

Students begin to explore energy as they read about and observe common household objects to find evidence of the presence of energy. They evaluate a broken object and design a possible solution to make the object usable again.

Group discussion among participants is very important for these lessons. Strategies for supporting group discussions can be found in Appendix 1. Strategies for furthering discussion through guiding thought/questioning can be found in Appendix 2.

On CSO, navigate to Lesson 1 using the numbers at the top of the screen.

Resource/Page #	Lesson 1
Overview TG: p. 77	Objectives: • Make observations of sound, light, heat, and motion to provide evidence of the presence of energy. • Develop a simple criterion for solving an engineering problem. Lesson Background Information: • Evidence of energy can include heat, light, sound, and motion. Multiple types of energy can be found in one example. Class Periods: 1 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 78–79	Materials: • Flashlight • Handwarmer • Hot pot • Kitchen timer • Spray bottles • Reader • Chart paper or whiteboard for group discussion Printed Materials: • Lesson 1 Notebook Sheet A • Lesson 1 Notebook Sheet B next page →

Resource/Page #	Lesson 1
	Digital Materials: • Energy in the Kitchen file *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.* To help participants better familiarize themselves with the lesson setup for implementation, the group will do some materials preparation during the workshop. For this lesson, the group should: • Disable one spray bottle for each group by pulling the internal hose loose. • Make sure the flashlight works. • Half fill the hot pot with water and plug it in.

Procedure: Getting Started
TG: p. 79-81
Reader: p. 1-8
	Getting Started
	• Open the Energy in the Kitchen file.
	• Have participants complete Lesson 1 Notebook Sheet A.
	• Use guiding questions to discuss what people observe.
	• Introduce the Reader *Everyday Energy*. The Reader has multiple versions. They all have the same readings, but in multiple forms:
	  • On-Grade Readers: 16 physical copies shipped with your supplies, with Lexile scores for fourth grade
	  • CSO Readers: All CSO readers can be assigned to students using the CSO system
	  1. Spanish Reader: on-grade reader in Spanish has notes and text-to-speech
	  2. Digital copy of on-grade reader with note-taking and text-to-speech
	  3. Below-grade reader: reader with the same information but simpler sentence structure to decrease the Lexile score by about 100 points
	  4. Smithsonian Science Stories: *Everyday Energy* Student Reader: e-book version of on-grade reader with annotation toolbar
	
	next page →

Resource/Page #	Lesson 1
	• Ask participants to open the Reader to reading 1, "Energy at Home." • Introduce evidence as careful observations that come from reading, firsthand experiences, or other trusted sources. • Have participants identify the categories of evidence of energy: heat, light, sound, and motion. **Reading Summary** Energy is used in many ways around the house. It can be used to make lights come on, make things like fans move, play music, or provide heat. Things that use or convert energy are described as devices and devices are made by engineers.
Procedure: Activity TG: p. 81-83	***Activity*** • Groups will observe demonstrations (a boiling hot pot, flashlight, handwarmer, kitchen timer) to identify evidence of energy. • Record class observations in a table on chart paper or a whiteboard. • Divide the class into groups and assign the roles of Organizer, Speaker, and two Questioners. • Hand out Lesson 1 Notebook Sheet B and the non-working spray bottles. • Have the small groups work on the Notebook Sheet. • Make sure groups focus on creating a criterion rather than focusing on what is wrong with the bottle or how they will fix it.
Procedure: Bringing It All Together TG: p. 83	***Bringing It All Together*** • Ask groups to share their criterion for knowing whether a solution worked. • Have groups discuss ways to solve the problem.

Resource/Page #	Lesson 1
Assessment, Enrichment & Extension TG: p. 84-86	Briefly review, as time allows: • Assessment Rubrics: Pre-Assessment • Extension: Energy Inventory (Community and Home), Write a Journal Entry (Social Studies, Literacy)
Reflection	After experiencing the lesson, ask participants with their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Smithsonian Science for the Classroom Features and Carolina Science Online

15 minutes

	Key Points
TG	Hand out TGs. Briefly review the physical items that accompany a module: • Teacher Guide (1) • Student Activity Guide (8) • Smithsonian Science Stories (16) • Materials (for 32 students)
CSO	Carolina Science Online (CSO) is the virtual platform that hosts the teacher guide, digital copies of the student readers, digital readers in Spanish, and other digital resources for the module. next page →

	Key Points
	Set Up a Carolina Science Online Account Before training, you should receive an email directing you to create your teacher login on CSO (www.carolinascienceonline.com). On the main page, hover over the "Teacher login" button. "Create a Teacher account" will appear as an option. Enter the required information. Make sure you choose a password you can remember. Return to the main page and log in. At the top of the page, click "redeem code." Enter the code that was emailed to you. The account is now ready to use. On the main page, all the titles available to you will be in bright colors. Click on the module you need. The module will open in the "Module Overview" tab. The "Home" button in the top left of the screen will take you back to the main screen with all of the available titles. "Bookmarks" will open your bookmarks folder. You can bookmark any of the digital resources on CSO by clicking on the star underneath the resource. "Assignments" shows all assignments you have created using CSO digital resources. You can add a digital resource to assignments by clicking "add to assignment" on any CSO digital resource.
TG and CSO TG: p. 1–17	Navigate to the "Curriculum Overview" section in the TG, which is also found under the "Module Overview" tab in CSO. This section provides an introduction to the curriculum and the research-based methods integrated into Smithsonian Science for the Classroom.
TG: p. 20–21	**Concepts and Practices Storyline** Modules are broken down into areas that revolve around a single focus question. The focus questions build a storyline that provides a coherent experience that builds toward solving a problem. The storylines are carefully integrated with the 5E model and each lesson is identified as to where it fits in the model. next page →

	Key Points
	This module has four focus questions, with the final focus question being the Engineering Design Challenge.
TG: p. 22-24	**Prerequisite Concepts and Practices** The listed items are the skills and knowledge students will lean on to incorporate new skills and content learning. Each set of concepts and practices identifies where the prerequisites should have been taught.
TG: p. 25-28	**Module Background Information** This section provides background information for the teacher. It covers content that is not directly discussed in the module but may prove useful in understanding where content or practices are headed. It also provides information that is a fundamental building block for content and practices used in the module.
TG: p. 29-31	**Common Misconceptions** Students may express misconceptions throughout the lesson. This section provides a list of common misconceptions identified in research for both content and practices, an explanation of the misconception, and a possible example of how it may come up. The number after the misconception refers to which reference the misconception is described in. Throughout the module, misconception callouts will be highlighted using the Good Thinking! bubble. Good Thinking! is a YouTube video series created by the Smithsonian Science Education Center focused on misconceptions and learning. next page →

	Key Points
TG: p. 31-37	**Materials Management and Safety** This section provides information on materials that will be provided with the module kit, needed but not supplied materials, safety concerns, and a safety contract for students. Under the "Materials Lists" section you will need to click on the hyperlink to download the materials lists. These lists show you everything that will be included in the module kit and items teachers will need to supply. The lists also show how much of each material is needed and in which lesson. In the "Safety" section, there are callouts for specific concerns for this module and a link to a Stay Safe! contract. The contract lists expectations for students to keep themselves and others safe during science investigations. It has lines for both students and guardians to sign.
TG: p. 40-41	Navigate to the "NGSS Alignment and Planner" tab in CSO. **Module Alignment to NGSS** These modules are aligned to the Next Generation Science Standards, which teachers can use as an additional tool to identify student objectives and goals for learning.
TG: p. 42-71	**Lesson Planners** The lesson planners highlight everything that will happen in a lesson, such as: • Focus Question • Step of 5E model • Number of class periods needed • Vocabulary that will be introduced • Student objectives • Misconceptions: more information can be found in the "Module Overview" tab or TG p. 28-31 • Disciplinary core ideas: content focus • Science and engineering practices • Crosscutting concepts: ideas that are multidisciplinary next page →

	Key Points
	• ELA and math connections: numbers reference the Common Core Standards • Extensions: additional lessons that are not necessary to move forward in the module
TG: p. 74-75	In the TG, review the callout icons itemized in the Guide to Module Investigations: • NGSS • Common Core • Misconceptions • Digital Resource • ELL Strategy • Teacher Tips and Tech Tips • Guiding Questions • Safety Notes • Class Period Break
Readers and CSO	All the written materials (Readers, Student Activity Guides, Notebook Sheets) are available digitally on CSO. Navigate to the student readers under the "Digital Resources" tab in CSO. There are multiple versions. The on-grade reader cover has a matchstick with the round end pointing up. The below-grade reader cover has a matchstick with the round end pointing down. The Spanish reader is only available on grade. The on-grade reader exists in two forms on CSO. One is an interactive book and the other is an e-book. The other readers are only available in the e-book format. Both formats have tools for students. In the interactive book, students can highlight and make notes using the tools in the toolbar. In the e-book format, students can use the text-to-talk feature by highlighting the text and selecting the speaking icon.

	Key Points
Support and CSO	Carolina Science Online provides a number of supports to teachers, including: • Teacher Resource videos: These videos provide an overview of the focus questions and show any lessons with a potentially tricky setup. They're available under the "Digital Resources" tab. • Tutorial videos: For help using CSO's features, choose "Support" from the vertical toolbar on the left side of the homepage. • Get Ready! Professional Learning: These short videos offer information on-demand and teacher tips about the program. They can be found at https://www.smithsonianstc.com/ssftc-get-ready-campaign-172N7-44857Z.html

Concept Storyline

Grade 4 Engineering: *How Can We Provide Energy to People's Homes?*

5 minutes

CSO /TG	Concept Storyline
TG and CSO TG: p. 20-21	**Concepts and Practices Storyline** Return to the "Concepts and Practices Storyline" tab and walk through the module's structure. This module has four focus questions, with the final focus question being the Engineering Design Challenge. Explain each focus question with its objectives, as below: FQ#1: How does energy move and change (Lessons 1-4) *Students observe phenomena—motion, light, sound, and heat—that provide evidence of the presence of energy, and track how energy moves and changes in systems. They then observe that electrical energy moves via electric current and can be changed into other forms of energy.* next page →

CSO /TG	Concept Storyline
	FQ#2: What are the advantages and disadvantages of the different energy resources used to generate electricity? (Lessons 5–9) *Students obtain and combine information about the advantages and disadvantages of using various natural resources to generate electricity. Students apply what they learn to identify the best energy resource solution for four real-world locations, based on criteria and constraints.* FQ#3: How does electricity power our devices? (Lessons 10–12) *Students obtain information about how energy gets from power plants to homes, and explore simple electric circuits. They apply what they learn to design and build electric devices that serve specific purposes.* FQ#4: How can you design a house that runs on renewable energy? (Lessons 13–15) *Students engage in a two-part summative assessment. In the written assessment, students use information about a fictional family to demonstrate their understanding of energy movement and the advantages and disadvantages of renewable and nonrenewable resources. Students are then challenged to apply what they have learned about electrical systems to solve an engineering problem: to design, build, test, and optimize a solar-powered doorbell system for a model house.*

Assessment	There are four types of assessment throughout the module.
	• Pre-Assessment (Lesson 1)
	• Formative Assessment (Lessons 2–12)
	• Summative Assessment (Lessons 13–15)
	  • Written Summative Assessment
	  • Performance Summative Assessment
	• Self-Assessment (SAG): Stop & Check

SESSION 2:

Lessons 2–7

The trainer introduces Lessons 2-4 (Focus Question 1) and Lessons 5-7 (Focus Question 2).

Goal: The trainer facilitates Lessons 2-7 with participants experiencing the lessons as learners and debriefing each focus question as teachers.

At various points in the training, there may be differing ideas presented by participants, especially when introducing claims and evidence. For strategies on handling differing opinions, please see Appendix 4.

AGENDA AND TIMING

Sections	Minutes	Materials/Notes
Group Roles	5 minutes	Make sure Group Roles poster is visible
Lesson 2	25 minutes	Set up energy stations
Lesson 3	20 minutes	Set up energy stations
Short break	10 minutes	
Lesson 4	25 minutes	Set up energy stations
Lesson 5	20 minutes	
Short break	10 minutes	
Lesson 6	25 minutes	
Lesson 7	25 minutes	Group presentations

Many of the lessons use group roles to assign specific jobs. For strategies on using group roles effectively, please see Appendix 3.

Group Roles

5 minutes

Starting in Lesson 1, students will be assigned group roles. The assignments and a possible rotation system can be found in Appendix 3. Group roles are a common tool to build teamwork skills such as turn taking, communication, and responsibility for individual and group needs. Additionally, having a specific role can increase student involvement and confidence by ensuring they know what is expected of them in a given situation. You can learn more about collaborative groups and group roles in the Zero Barriers in STEM Education Accessibility and Inclusion Workbook found at https://ssec.si.edu/zero-barriers.

Lesson 2: Energy in Action

Energy can change and can move from place to place.

25 minutes

Students observe various phenomena for evidence that energy can move from place to place and change into other forms of energy. They develop models to document energy in the systems they investigate.

On CSO, navigate to Lesson 2 using the numbers at the top of the screen.

Resource/Page #	Lesson 2
Overview TG: p. 87	Objectives: • Make observations to provide evidence that sound, light, heat, and motion can move from place to place and can be converted into other forms of energy. • Use an energy model to represent how energy moves and/or changes in a system. • Construct an explanation that uses evidence to support the claim that energy can move and change. Lesson Background Information: • Energy can be moved from place to place. • Energy can be changed into other forms of energy. Class Periods: 1 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 88-90	Materials: • Hand boiler energy station • Crank light energy station • Lamp and foam energy station • Butter energy station • Tuning fork and salt energy station • Marbles energy station • SAG • Soft toy or ball • Chart paper or whiteboard for group discussion next page →

Resource/Page #	Lesson 2
	Printed Materials: • Lesson 2 Notebook Sheet A • Lesson 2 Notebook Sheet B • Lesson 2 Notebook Sheet C • Lesson 2 Notebook Sheet D Digital Materials: • N/A *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.* To help participants better familiarize themselves with the lesson setup for implementation, the group will do some materials preparation during the workshop. For this lesson, the group should: • Gather materials and set up the six energy stations.
Procedure: Getting Started TG: p. 90–92	***Getting Started*** • Toss a toy to someone. Ask the group what is happening to the energy. Introduce the energy model on page 91 of the TG. • Discuss what a model is, using the definition on page 92 of the TG: A model is something that can be used to predict or explain how the parts of a system work.
Procedure: Activity TG: p. 92–95 SAG: p. 1–2	***Activity*** • Hand out Notebook Sheets A, B, C, and D and the SAG. • Demonstrate how the hand boiler works. As a whole group, complete the hand boiler energy model on Lesson 2 Notebook Sheet C. • Divide into groups and assign group roles: Organizer, Speaker, and two Questioners. • Have each group follow Steps 1–3 in the SAG to complete at least three of the other energy stations and the associated sections of Lesson 2 Notebook Sheets A, B, C, D.

Resource/Page #	Lesson 2
Procedure: Bringing It All Together TG: p. 95-96	***Bringing It All Together*** • Create a group explanation for the question, Can energy move and change?, by collecting data in a chart, as shown in the TG, p. 96.
Assessment, Enrichment & Extension TG: p. 96-98	Briefly review, as time allows: • Assessment Rubrics: Formative Assessment • Extension: Energy in Instruments (Music)
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Lesson 3: It's Electric!

Energy can move via electric currents.

20 minutes

Students observe evidence of electrical energy in a variety of systems. They create models of the systems and analyze patterns to infer that energy moves and changes.

On CSO, navigate to Lesson 3 using the numbers at the top of the screen.

Resource/Page #	Lesson 3
Overview TG: p. 99	Objectives: • Carry out investigations to provide evidence that electrical energy can be converted into motion, sound, light, or heat. • Analyze data to find patterns in how electrical systems move and change energy. • Use evidence from observations to support the claim that electrical currents provide a way to delivery energy to people's homes. Lesson Background Information: • Electric energy is a form of energy that can be transferred or converted. • Electric energy is the movement of electrons. Class Periods: 1 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 100-103	Materials: • Handheld Fan Station • Grain-of-Wheat Lamp Station • Electric Bell Station • Clock Station • 1 wire cutter • 1 clamp lamp • 1 light bulb, 72-watt • SAG Printed Materials: • Lesson 3 Notebook Sheet A • Lesson 3 Notebook Sheet B • Lesson 3 Notebook Sheet C • Lesson 3 Notebook Sheet D next page →

Resource/Page #	Lesson 3
	Digital Materials: • N/A *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.* To help participants better familiarize themselves with the lesson setup for implementation, the group will do some materials preparation during the workshop. For this lesson, the group should: • Set up the 4 electricity energy stations.
Procedure: Getting Started TG: p. 103–104	***Getting Started*** • Observe an unplugged clamp lamp and discuss what is needed to make the lamp work. • As a whole group, create an energy model for the clamp lamp.
Procedure: Activity TG: p. 105–107 SAG: p. 3–4	***Activity*** • Hand out the SAGs and Lesson 3 Notebook Sheets A, B, C, and D. • Most of the stations will run on batteries, which are stored energy that can change into electrical energy. • Divide into groups and assign group roles: Organizer, Speaker, and two Questioners. • Have groups explore the energy stations. As groups complete stations they should record observations on Lesson 3 Notebook Sheets A and B and complete the models on Lesson 3 Notebook Sheets C and D.
Procedure: Bringing It All Together TG: p. 108–109	***Bringing It All Together*** • Review the evidence the group has gathered that electrical energy can change into other forms of energy. • Explain that electrical energy moves through wires, introducing the term “electric current.” • Ask groups to consider evidence for or against the claim, Electric current is a good way to provide energy to people’s homes.

Resource/Page #	Lesson 3
Assessment, Enrichment & Extension TG: p. 109-111	Briefly review, as time allows: • Assessment Rubrics: Formative Assessment • Extension: The History of Electricity (Literacy, Social Studies)
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Lesson 4: Generate!

Motion, light, and stored energy can be converted to electrical energy.

25 minutes

Students investigate systems for evidence that motion, light, and stored energy can be changed into electrical energy. They plan a fair test of possible ways to increase the output of an electrical system.

On CSO, navigate to Lesson 4 using the numbers at the top of the screen.

Resource/Page #	Lesson 4
Overview TG: p. 113	Objectives: • Carry out investigations to observe that motion, light, and stored energy can be used to generate electrical energy. • Design a solution to a simple problem by changing a system to generate more electrical energy. • Design a fair test of the proposed solution. Lesson Background Information: • Stored energy can be transformed into electrical energy and light can be transformed into electrical energy. • More energy must be added into a system to change the amount of light or sound created. Class Periods: 1 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 114–118	Materials: • Hand-Crank Generator with Bulb Station • Hand-Crank Generator with Bell Station • Photovoltaic Cells with Fan Station • Photovoltaic Cells with Buzzer Station • Battery and Bulb Station • SAG Printed Materials: • Lesson 4 Notebook Sheet A • Lesson 4 Notebook Sheet B next page →

Resource/Page #	Lesson 4
	Digital Materials: • N/A *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.* To help participants better familiarize themselves with the lesson setup for implementation, the group will do some materials preparation during the workshop. For this lesson, the group should: • Set up the 5 generation stations.
Procedure: Getting Started TG: p. 119	***Getting Started*** • Collect ideas from the group about potential sources of energy other than a power station.
Procedure: Activity TG: p. 119–122 SAG: p. 5–6	***Activity*** • Hand out the SAGs. • Divide into groups and assign group roles: Organizer, Speaker, Tester and Questioner. • Have groups explore the energy stations by following the directions in the SAG and create energy models for each station. • Discuss whether motion, light, and stored energy can be changed into electrical current.

Procedure: Bringing It All Together
TG: p. 122–126
	Bringing It All Together
	• Hand out Lesson 4 Notebook Sheets A and B.
	• Explain that each group will design and test a solution to answer the question, How can you increase the amount of electrical energy generated by a system?
	• Choose one of the following systems to use:
	  • Hand crank generator with bulb
	  • PV cells with buzzer
	  • Battery and bulb
	• Have each group choose their system, develop criteria for a solution, and then develop a solution using the prompts on Lesson 4 Notebook Sheets A and B.
	• Define a fair test using examples.
	• Test the group solutions.

Resource/Page #	Lesson 4
Assessment, Enrichment & Extension TG: p. 126-128	Briefly review, as time allows: • Assessment Rubrics: Formative Assessment • Extension: Power Outage Plan (Community and Home)
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Lesson 5: Power to the People

Motion, light, and stored energy can be converted to electrical energy on a large scale.

20 minutes

Groups obtain information from text to compare and contrast two kinds of power plants. They use models to explain that the motion of a turbine within power plants results in the generation of electrical energy.

On CSO, navigate to Lesson 5 using the numbers at the top of the screen.

Resource/Page #	Lesson 5
Overview TG: p. 129	Objectives: • Obtain information from text and images and compare and contrast two kinds of power plants used to generate electricity. • Use models to explain and communicate that coal-burning power plants and hydroelectric plants involve energy moving and changing. Lesson Background Information: • Most electrical energy in the United States is generated by steam turning turbines. • The turbines turn magnets that create an electron stream we call electricity. Class Periods: 1 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 130	Materials: • Hot pot • Pinwheel • Reader • Chart paper or whiteboard for group discussion Printed Materials: • N/A Digital Materials: • Black Marble file *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.* next page →

Resource/Page #	Lesson 5
	To help participants better familiarize themselves with the lesson setup for implementation, the group will do some materials preparation during the workshop. For this lesson, the group should: • Set up the hot pot and turn it on. • Test the placement of the pinwheel to make sure it turns.
Procedure: Getting Started TG: p. 131–132	***Getting Started*** • Show the Black Marble file, which is an image of Earth at night with light shining from the cities. • Ask what people think is going on and how the energy for the lights is created. • Explain that the next few lessons will focus on large- scale electricity generation.
Procedure: Activity TG: p. 132–134 Reader: p. 9–10	***Activity*** • Use the steam from the hot pot to move the pinwheel. Discuss what is happening and how the pinwheel might move faster. • Make an energy model on chart paper or a whiteboard to clarify what is happening in this demonstration. • Have groups read reading 2, "Inside a Power Plant" in the Reader and focus on identifying cause-and-effect relationships. • After the reading, have pairs of participants create an energy model for the power plants in the reading. **Reading Summary** A power plant is where electricity is generated using a natural resource. In one kind of plant, coal is burned to create steam to turn a turbine. In another, moving water is used to turn a turbine and create hydroelectric energy.
Procedure: Bringing It All Together TG: p. 135–136	***Bringing It All Together*** • Have students share their energy models and then compare and contrast them. • Discuss what type of energy generation is most like the pinwheel example.

Resource/Page #	Lesson 5
Assessment, Enrichment & Extension TG: p. 136-138	Briefly review, as time allows: • Assessment Rubrics: Formative Assessment • Extension: Harnessing the Wind in Malawi (Social Studies)
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Lesson 6: Energy Resources

Obtaining and using energy resources can impact the environment.

25 minutes

Students create common goals for communicating their research findings. They then work collaboratively to obtain and combine information about renewable and nonrenewable energy resources and identify how using these resources to generate electricity causes environmental impacts.

On CSO, navigate to Lesson 6 using the numbers at the top of the screen.

Resource/Page #	Lesson 6
Overview TG: p. 139	Objectives: • As a group, use a variety of reliable sources to obtain information about one energy resource and its advantages and disadvantages. Lesson Background Information: • All forms of electricity generation have advantages and disadvantages. Class Periods: 1 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 140–141	Materials: • Chart paper • Markers • Reader Printed Materials: • N/A Digital Materials: • Research Questions file *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.* To help participants better familiarize themselves with the lesson setup for implementation, the group will do some materials preparation during the workshop. For this lesson, the group should: • Write resources on slips of paper to assign groups resources to study.

Resource/Page #	Lesson 6
Procedure: Getting Started TG: p. 141	***Getting Started*** • Restate the focus question: What are the advantages and disadvantages of the different energy resources used to generate electricity?
Procedure: Activity TG: p. 141-143 Reader: p. 11-22	***Activity*** • As a whole group, read about coal in reading 3, "Remarkable Resources" in the Reader. • Identify the advantages and disadvantages of using coal to generate energy. • Divide into groups and assign group roles: Artist, Organizer, Speaker, Questioner • Assign each group to read and research one of the energy resources listed in the reading. • Display the Research Questions file to help groups understand what to look for in their research. **Reading Summary** Natural resources are used to generate electricity. Some resources, such as coal, petroleum (oil), natural gas, and uranium, must be mined and refined before they can be sent to power plants. Other power plants must be set up where the resources are, such as hydroelectric, solar, wind turbines, and underground heat. Biomass is material that would otherwise go to waste, but can be burned to generate electricity.
Procedure: Bringing It All Together TG: p. 144	***Bringing It All Together*** • Ask groups to share what resource they researched and how the research went. Was it easy or hard? Did the different research sources agree? • Explain that groups will share advantages and disadvantages in the next lesson.
Assessment, Enrichment & Extension TG: p. 144-146	Briefly review, as time allows: • Assessment Rubrics: Formative Assessment • Extension: Joking Around About Energy (Literacy)

Resource/Page #	Lesson 6
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Lesson 7: Energy Experts

Obtaining and using energy resources can impact the environment.

25 minutes

Students use their research to prepare and deliver presentations that communicate the effects of using various energy resources to generate electricity. They look for patterns in the compiled information, leading to definitions of renewable and nonrenewable resources.

On CSO, navigate to Lesson 7 using the numbers at the top of the screen.

Resource/Page #	Lesson 7
Overview TG: p. 147	Objectives: • Communicate information about a natural resource used to generate electricity. • Obtain information from classmates about other natural resources used to generate electricity. • Organize information so it can be analyzed and used to compare the advantages and disadvantages of each energy resource. Lesson Background Information: • Students share the pros and cons of energy resources. Class Periods: 2 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 148	Materials: • Group presentation materials (e.g., PowerPoint, posters, etc.) • Chart paper or whiteboard for group discussion Printed Materials: • N/A Digital Materials: • N/A *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.* This lesson does not require any additional setup.

Resource/Page #	Lesson 7
Procedure: Getting Started TG: p. 148–149	***Getting Started*** • Explain that groups will share the information they have collected.
Procedure: Activity TG: p. 149–151	***Activity*** • With the class, develop presentation criteria. • Divide into the same groups as in Lesson 6 and assign group roles: Artist, Organizer, Speaker, and Questioner. • Have groups create their presentations to meet the criteria. • Before each group presents, decide as a class how the advantages and disadvantages of each resource will be tracked. • Have groups present, while the class tracks the advantages and disadvantages of each resource on chart paper or a whiteboard.
Procedure: Bringing It All Together TG: p. 152–153	***Bringing It All Together*** • Introduce the terms "renewable" and "nonrenewable" as categories. • Ask groups to identify patterns in the advantages and disadvantages they tracked. • Explain that in the next lesson, we will explore where these resources are being used.
Assessment, Enrichment & Extension TG: p. 154–156	Briefly review, as time allows: • Assessment Rubrics: Formative Assessment • Extension: Energy Advertisements (Art)
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

SESSION 3:

Lessons 8–12

The trainer introduces Lessons 8-12 (Focus Questions 2 and 3).

Goal: The trainer facilitates Lessons 8-12, with participants experiencing the lessons as learners and debriefing each focus question as teachers.

At various points in the training, there may be differing ideas presented by participants, especially when introducing claims and evidence. For strategies on handling differing opinions, please see Appendix 4.

AGENDA AND TIMING

Sections	Minutes	Materials/Notes
Lesson 8	20 minutes	
Lesson 9	25 minutes	
Short break	10 minutes	
Lesson 10	25 minutes	Hand out Readers
Lesson 11	20 minutes	Make a circuit kit for each group
Lesson 12	20 minutes	Assemble and set out the fan components

Lesson 8: Energy Resources in Use

Some energy resources are renewable and others are not, but all impact the environment in some way.

20 minutes

Students analyze mathematical representations of data about the mix of renewable and nonrenewable resources that are currently being used in the US to generate electricity, and look for patterns to support an argument about how the energy mix could be improved.

On CSO, navigate to Lesson 8 using the numbers at the top of the screen.

Resource/Page #	Lesson 8
Overview TG: p. 157-158	Objectives: • Use real-world data to compare the mix of renewable and nonrenewable sources used to generate electricity in different parts of the United States. • Use evidence to support a claim that the environmental impact of electricity generation could be reduced in your state. Lesson Background Information: • In 2016, 60 percent of electricity was generated by burning fossil fuels. • Nuclear energy provided 20 percent of electricity. • Renewables supplied 15 percent, mostly through hydroelectric power. Class Periods: 1 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 158-159	Materials: • Green pencil • Protractor • SAG Printed Materials: • Lesson 8 Notebook Sheet A • Lesson 8 Notebook Sheet B next page →

Resource/Page #	Lesson 8
	Digital Materials: • State Profiles and Energy Estimates (https://www.eia.gov/state/?sid=US) *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.* To help participants better familiarize themselves with the lesson setup for implementation, the group will do some materials preparation during the workshop. For this lesson, the group should: • Gather state energy data for states that will be looked at in the lesson.
Procedure: Getting Started TG: p. 159	***Getting Started*** • Discuss with the whole group how weather and other considerations today could affect the electricity needs in their area. • How could the weather also affect electricity production? • Have groups predict what are the top three resources used to generate electricity in the United States and in their state.
Procedure: Activity TG: p. 159–160 SAG: p. 7–8	***Activity*** • Divide into groups and assign group roles: Organizer, Speaker, Tester and Questioner. • Distribute the SAGs. Have groups follow step 1 and Lesson 8 Notebook Sheet B to determine which resources are used the most in the United States. • Groups will then use websites or precollected data to determine which resources are most commonly used in their state and others. This data will be recorded on Lesson 8 Notebook Sheet B.
Procedure: Bringing It All Together TG: p. 161–162	***Bringing It All Together*** • Have the Speakers share what patterns their group noticed in their research. • Ask groups how the resources used impact the environment. • Ask whether they think the impact of electricity production in their state could be reduced.

Resource/Page #	Lesson 8
Assessment, Enrichment & Extension TG: p. 163-164	Briefly review, as time allows: • Assessment Rubrics: Formative Assessment • Extension: Understanding Units of Electricity (Math)
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Lesson 9: Energy—The Big Picture

Solutions to problems consider criteria and constraints and are based on research.

25 minutes

Students use the information they gathered on the effects of energy resource use to develop an argument about which energy resource solution is best in four real-world locations.

On CSO, navigate to Lesson 9 using the numbers at the top of the screen.

Resource/Page #	Lesson 9
Overview TG: p. 165	Objectives: • Develop an argument to support the use of a specific energy resource in a location, considering criteria, constraints, and trade-offs. Lesson Background Information: • Groups will use what they learned in the previous lessons to draw conclusions about the most viable energy resource for four areas. Class Periods: 1 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 166	Materials: • Energy Around the World card sets Printed Materials: • Lesson 9 Notebook Sheet A • Lesson 9 Notebook Sheet B Digital Materials: • N/A *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.*
Procedure: Getting Started TG: p. 167	***Getting Started*** • Ask groups to share their claim from Lesson 8 about whether the environmental impact of electricity generation in their state could be reduced. • Introduce the idea of trade-offs: that there may be a downside to a good thing or a thing you want.

Resource/Page #	Lesson 9
Procedure: Activity TG: p. 167–169	***Activity*** • Assign group roles: Organizer, Recorder, Speaker, and Questioner. • Distribute one Energy Around the World card set to each group. • Review the information on the cards and the criteria and constraints. • For each location, individuals should choose the best energy option and then share their ideas with their group to create a team choice. Choices and reasoning should be recorded on Lesson 9 Notebook Sheets A and B.
Procedure: Bringing It All Together TG: p. 169–170	***Bringing It All Together*** • Speakers will share what their team decided would be the best option. • Lead a whole-class discussion for each location, making sure that evidence is used to support each decision.
Assessment, Enrichment & Extension TG: p. 170–172	Briefly review, as time allows: • Assessment Rubrics: Formative Assessment • Extension: Culture Quest (Social Studies)
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Lesson 10: Electricity on a Budget

Solutions to problems consider criteria and constraints and are based on research.

25 minutes

Students obtain information about electricity transmission and home use through text, data, and visual formats. They use the information to design a solution to cause a decrease in a family's home electricity use.

On CSO, navigate to Lesson 10 using the numbers at the top of the screen.

Resource/Page #	Lesson 10
Overview TG: p. 173	Objectives: • Interpret authentic data to determine possible solutions to help a family meet an energy budget constraint. • Explain how engineers use models to design and optimize effective new ways to provide energy to people's homes. Lesson Background Information: • Groups learn about the energy grid. • The National Institute of Standards and Technology has a house that uses robots to simulate a family, to measure energy requirements, which are then met by the house's own energy generation. Class Periods: 1 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 174	Materials: • SAG • Reader Printed Materials: • N/A Digital Materials: • Electricity Transmission Diagram • US Electric Grid site • NIST Net-Zero House video • Sample Home Electricity Bill • Solar Energy Potential Map website *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.* This lesson does not require any additional setup.

Resource/Page #	Lesson 10
Procedure: Getting Started TG: p. 174–175	***Getting Started*** • Ask participants to consider how electricity is distributed to homes and how it is used when it is in their home. • Have participants predict which uses require the most energy and explain why they believe that.
Procedure: Activity TG: p. 176–179 SAG: p. 9–10 Reader: p. 23–26	***Activity*** • Introduce the concept of electricity transmission using the Electricity Transmission Diagram and the US Electric Grid site. • Divide into groups and assign group roles: Organizer, Recorder, Speaker, and Questioner. • Groups complete steps 1–6 in the SAG to review how energy is used in the United States, what types of energy are used, and what a sample home electricity bill looks like. • Read reading 4, "At Home with Robots" in the Reader. • Groups discuss ways to lower home energy bills using various technology or energy-saving practices. Solar potential for their area can be determined using the Solar Energy Potential Map website. **Reading Summary** The National Institute of Standards and Technology has developed a "net-zero" house, which means the house generates as much electricity as it uses. The house is full of robots, who simulate a family of four living in the United States and using-energy efficient systems.
Procedure: Bringing It All Together TG: p. 180	***Bringing It All Together*** • Review the reading with comprehension questions found in the TG.
Assessment, Enrichment & Extension TG: p. 181–182	Briefly review, as time allows: • Assessment Rubrics: Formative Assessment • Extension: Summarize Informational Text (Literacy)

Resource/Page #	Lesson 10
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Lesson 11: Complete the Circuit

Electric circuits are designed so that electrical energy can power devices.

20 minutes

Students investigate the design of electrical systems by constructing circuits. They apply their understanding to designing a solution to an engineering problem.

On CSO, navigate to Lesson 11 using the numbers at the top of the screen.

Resource/Page #	Lesson 11
Overview TG: p. 183	Objectives: • Investigate how batteries, bulbs, and wires can be arranged to transfer an electric current. • Design, build, and test a switch that can be used to turn a light bulb on and off. Lesson Background Information: • The continuous path of electricity is called a "closed circuit." • If the pathway is not complete, it is called an "open circuit." Class Periods: 1 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 184	Materials: • Energy ball • Circuit materials for each group • SAG • Chart paper or whiteboard for group discussion Printed Materials: • Lesson 11 Notebook Sheet A • Lesson 11 Notebook Sheet B Digital Materials: • N/A *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.* next page →

Resource/Page #	Lesson 11
	To help participants better familiarize themselves with the lesson setup for implementation, the group will do some materials preparation during the workshop. For this lesson, the group should: • Assemble the circuit materials box for each group.
Procedure: Getting Started TG: p. 185–188	***Getting Started*** • Use the energy ball to introduce the idea of electricity moving through a circuit. • Divide into groups and assign group roles: Artist, Builder, Materials Manager, and Organizer. • Have each group collect circuit materials and make predictions about circuit designs on Lesson 11 Notebook Sheets A and B. • Have groups test their circuit designs and record whether the circuit works. • Come back together and have the whole group discuss the patterns of working circuits versus non-working circuits.
Procedure: Activity TG: p. 188–189 SAG: 11–13	***Activity*** • Ask participants if there is an easier way to turn the light on and off. • Have participants follow Steps 1–13 in the SAG to develop a working switch.
Procedure: Bringing It All Together TG: p. 189–191	***Bringing It All Together*** • Introduce the terms “open circuit” and “closed circuit.” • Create an energy model for the circuits the groups made on chart paper or a whiteboard.
Assessment, Enrichment & Extension TG: p. 192–194	Briefly review, as time allows: • Assessment Rubrics: Formative Assessment • Extension: Light Bulb Literacy (Literacy)

Resource/Page #	Lesson 11
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Lesson 12: Design a Device

Electric circuits are designed so that electrical energy can power devices.

20 minutes

Students interpret and use a new model of electrical systems, the circuit diagram, as they apply what they have learned about electrical energy and circuits to design and build handheld fans.

On CSO, navigate to Lesson 12 using the numbers at the top of the screen.

Resource/Page #	Lesson 12
Overview TG: p. 195	Objectives: • Use circuit diagrams (models of electric systems) to document, design, and build electric circuits. • Design, build, and test a handheld electric fan and identify ways to improve the design. Lesson Background Information: • Groups will create a circuit diagram and use their switch to build a device. Class Periods: 2 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 196-197	Materials: • Circuit kits from Lesson 11 • Fan kit • SAG Printed Materials: • N/A Digital Materials: • Battery-Bulb Circuit picture *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.* To help participants better familiarize themselves with the lesson setup for implementation, the group will do some materials preparation during the workshop. For this lesson, the group should: • Set out the circuit kits from Lesson 11. • Set out the fan components in an area where they can be seen by the whole group.

Resource/Page #	Lesson 12
Procedure: Getting Started TG: p. 197–199	***Getting Started*** • Introduce circuit diagrams using the Battery-Bulb Circuit picture.
Procedure: Activity TG: p. 199–201 SAG: p. 14–17	***Activity*** • Divide into the same groups as in Lesson 11 and assign group roles: Artist, Builder, Materials Manager, and Speaker. • Follow steps 1–10 in the SAG to create a fan and a diagram in your notebook showing the circuit that runs the fan. • Fans will be different depending on how groups choose to build them and what materials they use.
Procedure: Bringing It All Together TG: p. 202	***Bringing It All Together*** • Have groups show off their fans and circuit diagrams. • Have everyone reflect on what changes they would make if they made another version of the fan.
Assessment, Enrichment & Extension TG: p. 202–205	Briefly review, as time allows: • Assessment Rubrics: Formative Assessment • Extension: Read About Real-Life Engineering (Literacy), Symbol Study (Art)
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

SESSION 4:

Lessons 13–15

The trainer introduces the final Engineering Design Challenge (Lessons 13-15/ Focus Question 4).

Goal: The trainer facilitates Lessons 13-15, with participants experiencing the lessons as learners and debriefing each focus question as teachers.

At various points in the training, there may be differing ideas presented by participants, especially when introducing claims and evidence. For strategies on handling differing opinions, please see Appendix 4.

AGENDA AND TIMING

Sections	Minutes	Materials/Notes
Lesson 13	30 minutes	Set up the photovoltaic station
Lesson 14	30 minutes	Set up the photovoltaic station for testing
Lesson 15	30 minutes	Final presentations
Wrap Up	15 minutes	

Lesson 13: I'm Here! Let Me In!

Electrical devices are designed to meet specific needs.

30 minutes

In a written assessment, students design a solution for a family interested in installing solar panels. Their solutions weigh environmental effects and use models of energy flow. Groups begin their design challenge, developing a plan for solving the problem and using models to document their plan.

On CSO, navigate to Lesson 13 using the numbers at the top of the screen.

Resource/Page #	Lesson 13
Overview TG: p. 207	Objectives: • Work collaboratively to develop circuit diagrams for a solar-powered device in a model house that meet the criteria of the design problem. • Use full-size floor plans to ensure that the design plans meet the size constraint of the problem. • Use the circuit diagrams and floor plans to prepare comprehensive lists of materials needed to build the solar-powered device. Lesson Background Information: • Students will design a doorbell system for a hearing-impaired or visually impaired person. Class Periods: 2 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 208–209	Materials: • 1 clamp lamp • 1 light bulb, 72-watt • 3 photovoltaic cells, 1-volt • 1 wire cutter • 2 wire connectors • 2 wire leads with alligator clips • SAG Printed Materials: • Lesson 13 Notebook Sheet • Lesson 13 Activity Sheet next page →

Resource/Page #	Lesson 13
	Digital Materials: • N/A *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.* To help participants better familiarize themselves with the lesson setup for implementation, the group will do some materials preparation during the workshop. For this lesson, the group should: • Set up the photovoltaic cell station.
Procedure: Getting Started TG: p. 209-210	***Getting Started*** • Give a high-level review about what has been covered regarding the question, "How can we provide energy to people's homes?" • Provide an overview of the Engineering Design Challenge, which will cover Lessons 13-15. Teams are going to design a doorbell device that lights up and makes noise, and runs on solar energy. Each team will then have an opportunity to design and build their circuit, test it using PV cells, and improve their design. • Have students complete the Lesson 13 Notebook Sheet. This Notebook Sheet acts as a written summative assessment for the module.
Procedure: Activity TG: p. 210-213 SAG: p. 18-20	***Activity*** • Divide into groups and assign group roles: Artist, Builder, Materials Manager, and Questioner. Participants will keep these groups and roles for Lessons 13-15. • Have participants review the criteria and constraints in the SAG and Lesson 13 Activity Sheet. Use the guiding questions to help students make sense of the challenge. • Following steps 1-11 in the SAG, have students create a circuit diagram on Lesson 13 Notebook Sheet and a materials list for their doorbell system.

Resource/Page #	Lesson 13
Procedure: Bringing It All Together TG: p. 214–215	***Bringing It All Together*** • Discuss models that have been used throughout the module and how this paper house model is helpful.
Assessment, Enrichment & Extension TG: p. 216–220	Briefly review, as time allows: • Assessment Rubrics: Performance Summative Assessment • Extension: The Solar Decathlon (Literacy)
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Lesson 14: Model House Doorbell Part 1

Electrical devices are designed to meet specific needs.

30 minutes

Groups use their models to build their doorbell systems. They test their models to determine whether they meet the criteria of the design challenge and investigate the impact of design changes through fair tests.

On CSO, navigate to Lesson 14 using the numbers at the top of the screen.

Resource/Page #	Lesson 14
Overview TG: p. 221	Objectives: • Build a doorbell device in a model house according to student-designed circuit diagrams and floor plans, and make adjustments to ensure that the devices are within the constraints of the problem. • Test the doorbell and analyze the test results in terms of the criteria for the problem. Lesson Background Information: • Engineers must try multiple designs and adjust their models during the design and testing process. Class Periods: 1 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 222-223	Materials: • Doorbell materials • Photovoltaic station • SAG Printed Materials: • Lesson 14 Notebook Sheet A • Lesson 14 Notebook Sheet B Digital Materials: • N/A *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.* next page →

Resource/Page #	Lesson 14
	To help participants better familiarize themselves with the lesson setup for implementation, the group will do some materials preparation during the workshop. For this lesson, the group should: • Make material boxes for each group, based on their materials list from Lesson 13.
Procedure: Getting Started TG: p. 223-224	***Getting Started*** • This is the beginning of the performance assessment. • Review the criteria and constraints for the doorbell challenge.
Procedure: Activity TG: p. 224-226 SAG: 21-24	***Activity*** • Have participants collect their materials including the SAG. • Follow Steps 1-21 to build and test their doorbell circuit following their drawing. • As participants encounter challenges, encourage them to adjust their model. • As groups are ready, have them test and adjust their circuit. To keep the testing space clear, have teams return to their desks to discuss what needs to change and make adjustments.
Procedure: Bringing It All Together TG: p. 226	***Bringing It All Together*** • Discuss how testing went and whether each team had a fair test. • Groups will present their circuits in Lesson 15.
Assessment, Enrichment & Extension TG: p. 227-229	Briefly review, as time allows: • Assessment Rubrics: Performance Summative Assessment • Extension: Reflect on Successes and Challenges (Literacy), Interior Designers (Art)

Resource/Page #	Lesson 14
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Lesson 15: Model House Doorbell Part 2

Design teams analyze their solutions and communicate their results to peers

30 minutes

Groups analyze and communicate the success of their doorbell systems. Their presentations include evidence-supported claims and the use of models showing the presence and flow of energy in their systems.

On CSO, navigate to Lesson 15 using the numbers at the top of the screen.

Resource/Page #	Lesson 15
Overview TG: p. 231–232	Objectives: • Analyze the success of a doorbell system design in meeting the criteria of the challenge within the constraints. • Develop and present a team report about a model house doorbell that demonstrates an understanding of how an electric circuit transfers energy. • Identify the strengths and weaknesses of a doorbell circuit and steps that could be taken to optimize a design. • Explain that a complete circuit, including solar cells and useful devices, is a model for a house that runs on renewable energy. Lesson Background Information: • Groups will present their designs. • All designs are valid and this should not be treated as a competition. Class Periods: 2 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 232	Materials: • Completed door bell designs from Lesson 14 • SAG Printed Materials: • N/A Digital Materials: • N/A next page →

Resource/Page #	Lesson 15
	The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information. This lesson does not require any additional setup.
Procedure: Getting Started TG: p. 233	***Getting Started*** • This is the conclusion of the performance assessment. • Ask participants how this challenge relates to the focus question: How can you design a house that runs on renewable energy?
Procedure: Activity TG: p. 233-234 SAG: p. 25-27	***Activity*** • Have participants follow steps 1-6 in the SAG to create a presentation about their doorbell solution. • Have teams present their doorbell solutions and get feedback from the whole group.
Procedure: Bringing It All Together TG: p. 235	***Bringing It All Together*** • Have groups reflect on what they have accomplished in this unit.
Assessment, Enrichment & Extension TG: p. 236-238	Briefly review, as time allows: • Assessment Rubrics: Performance Summative Assessment • Extension: Powerful Presentations (Literacy)
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Wrap Up

Take a few minutes to check in with the group before dismissing everyone.

15 minutes

	Key Points
Q&A	Invite participants to ask any final questions about materials, implementation, strategies, or anything else on their mind.
Continuing Support	If you are willing, provide your contact information for questions and concerns that the participants may have in the future.

APPENDIX 1: GROUP DISCUSSION

The goal of group discussions is to provide an opportunity for shared learning by asking multiple people to propose connections between their individual experience and the new content of focus.

The facilitator has three primary jobs during group discussions:

1. Support individuals sharing.
   It may be unnerving for individuals to share their thoughts in a group. When facilitating group discussions, use the following techniques to boost individuals' confidence and likelihood of sharing their thoughts:
   - Pay attention to speakers.
   - Smile and nod at appropriate moments to nonverbally communicate that you are engaged.
   - Provide anonymous sharing opportunities using chart paper or sticky notes.
2. Manage group participation.
   It is important to have active and balanced participation from the group to gain as many perspectives as possible. While it is important to hear from everyone, not every person needs to comment on every question. Here are some techniques to help you manage participation of individuals during a group discussion:
   - Use small groups with a designated sharer/speaker.
     - Assigning roles: Change roles for each lesson.
   - When no one wants to speak up:
     - Use the silence. Generally someone will speak up within 15 seconds.
     - Make eye contact with someone you would like to hear from.
   - How to stop a monopolizing speaker:
     - Do not make eye contact with them.
     - Redirect comments and questions from monopolizers to others.
3. Support group thinking.
   - Record individual member suggestions or points in a central location.
   - Ask guiding questions to have the group highlight connections.
   - Summarize.

If you would like to see group discussions in practice, please visit:
TERC Inquiry Project videos: https://inquiryproject.terc.edu/prof_dev/library.cfm.html

APPENDIX 2: QUESTIONING/GUIDING THOUGHT

Questioning is a useful tool with many applications. For this application we will focus on questioning as a way to discover what people are thinking, encourage further thought, and develop group understanding.

The best questions to use are open-ended questions, which do not have a set answer and often require a sentence or more to answer. Questions like:

- What do you know about . . . ?
- Does anyone have anything to add?
- Why do you agree/disagree?

Generally the first level will be eliciting new ideas by asking questions about what people already know or can observe during the lesson:

- What did you observe?
- Has anyone ever encountered . . . ?
- What are some ways to introduce students to . . . ?

The second level is encouraging further thought by asking people to reflect on what has been said, to identify connections to the current topic:

- What do you mean by . . . ?
- Can you tell me more about . . . ?
- What is the evidence for/against . . . ?

The final level we will look at is creating a group understanding by coming to consensus on what has been discussed:

- What idea do you think best connects what everyone is saying?
- Can someone summarize for me?
- Based on what the group is saying, how would this affect . . . ?

Further suggestions for questioning:

- Give thinking time of three to five seconds after posing a question.
- Avoid saying “correct/incorrect.” Instead, let the group validate or clarify what someone is saying.
- Avoid the habit of only collecting one “correct” response and moving on. Always have at least two people answer a question, even if their answers are similar.
- Questioning can also be used to help keep time by letting people know how much longer the discussion can go on.
- Validate everyone’s input by thanking them for speaking up.

APPENDIX 3: GROUP ROLES

Each person in a group having a role can provide many positive outcomes. Some benefits of using group roles include:

- Increases participant motivation by having a unique role
- Models positive classroom behaviors
- Decreases the amount of time spent waiting for a group to decide or discuss who will do what
- If a job is assigned, it pushes participants to participate in different ways

Here are some ideas for how to begin using group roles:

- Change roles regularly to maintain interest.
- Try to give everyone a chance at each role.
- Have a system in place for assigning roles. Possible systems include:
    - Colored dots and frames—Give each person in the group a colored dot. Place a matching color frame around their role for the day. Change the frame placement as needed.
    - Numbers—Assign each member of the group a number (1-4). Place a sticky note with the corresponding number on their role for the day.
    - Badges—Give each person in the group a badge or card with their role for the day listed.
    - Desk tents—Give each person in a group a desk tent with their role for the day.

More information about group roles can be found at: https://ctl.wustl.edu/resources/using-roles-in-group-work

The chart here shows which roles are used in each lesson. The roles and rotation are based on having four members in each group. The numbers in each column suggest how to rotate roles.

	Lesson #											
Group Role	**1**	**2**	**3**	**4**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13-15**
Artist					4	1				3	1	2
Builder										2	3	1
Materials Manager										1	2	3
Organizer	1	4	2	3	1	4	2	3	1	4		
Recorder								2	4			
Speaker	2	3	4	1	2	3	4	1	3		4	
Tester				2			3					
Questioner	3,4	1,2	3,1	4	3	2	1	4	2			4

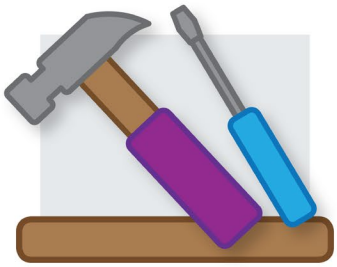
For these trainings, use the roles listed in each lesson, as described on the Group Roles poster.

Smithsonian
Science Education Center

Scientists and Engineers in Our Classroom: Group Roles

Artist

Draws any sketches, diagrams, or graphs.

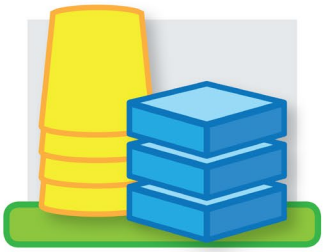


Builder

Takes the lead in putting together materials.

Gardener/Zookeeper

Makes sure live organisms are cared for and treated with respect.



Materials Manager

Collects, cleans up, and puts away materials neatly.

Messenger

Asks questions of the teacher for the group.

Organizer

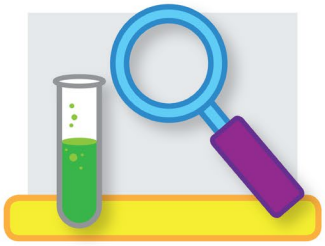
Makes sure group members work together and complete work on time.

Recorder

Writes down data, observations, and explanations.

Speaker

Shares the group's final work or ideas with the whole class.



Tester

Takes the lead in carrying out investigations and testing designs.

Questioner

Asks questions of group members to make sure all points of view are considered.

APPENDIX 4: MANAGING DIFFERING OPINIONS

At some point, it is highly likely that participants will have different opinions and thoughts. Working through these differences and coming to a point of mutual understanding is important to keep the group moving forward. This is also at the core of inquiry science and changing education practices.

Hearing different opinions and thoughts shows there is not always one "right" answer and there are multiple ways to interpret evidence. Often we are trying to come to consensus, which may require each participant to compromise or focus on where they agree and come back to the other areas.

To have meaningful conversations around different interpretations and ideas, it is important to build a culture of discussion and argumentation. At the beginning of the training, set group norms for how to interact when people do not agree, such as:

- Disagree with an idea, not the person.
- Use respectful language.
- Use phrases like "I disagree about . . ." or "I agree on . . ."
- Listen quietly to other people.
- Ask questions politely.
- Speak loudly and clearly.
- Always use evidence.

As with any other discussion, everyone needs to have the opportunity to be heard. Make sure you are allowing a variety of people to speak and that people are not cutting each other off.

Not every discussion of different opinions can come to a complete end every time. One way to table a discussion in order to move on is to take advantage of a parking lot or other idea repository. The chart on the next page lists a few ideas about when the parking lot should be used instead of having the discussion continue. Note: Every circumstance is different. These are suggested criteria, not hard rules.

Parking Lot	Keep Going
Requires input from people outside of training	Is specific to the current topic
Will be covered more in future lessons or sessions	Will likely be wrapped up in the session
Not related to the current topic	Multiple participants are highly engaged
Discussion becomes combative	Group has good evidence to come to consensus
Only one participant is speaking	

Sometimes the difference of opinions and ideas stems from a misconception. The Teacher Guide has a list of content and practice-based misconceptions that may come up in each module. Additionally, it is important to ask participants about what sources they are using, why they believe this information, or other questions to get at the root of their misconception while avoiding an accusatory or negative tone of voice. You can also use their peers' input to help clarify. If you must correct misconceptions to support learning later in the module, try using a supportive phrase such as, "Many people think that is true but the evidence so far supports . . ."

www.ssec.si.edu

Smithsonian
Science Education Center