EDUCATORS' GUIDE

nWave pictures distribution

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NED LAND FILMS

www.PLANETPOWER-THEFILM.com

A NOTE FROM THE FILMMAKERS

Our production company's motto is based on Jules Verne's aim for his work: *"To both teach and entertain."* That's exactly what we try to achieve with our films when we mix live action with animation and archival images to tell exciting science-based stories.

The making of ***Planet Power*** began with two questions: Is there a link between our growing needs in electricity and the current climate change, and how is the historic journey of Solar Impulse the latest example of the miracles achieved by electricity? Further, why is it significant for our future?

We felt such a film would be a perfect combination of science and adventure, with a story that would deliver a powerful and inspirational message of hope for our future.

As Bertrand Piccard says in the film: *"What is essential is allowing ourselves to dream."*

(L to R) Pascal Vuong, Bertrand Piccard, Catherine Vuong, André Borschberg, Ronan Chapalain

FILM SYNOPSIS

Planet Power tells the story of electricity, from the first spark created by a human hand to today's extraordinary industrial power plants. We learn about early scientists and inventors like Faraday, Volta, Franklin, Tesla, and Edison. And we see how modern-day adventurers Bertrand Piccard and André Borschberg, the inspirational team behind the record-breaking around-the-world flight of Solar Impulse 2, are inspired by the legacy of these historical figures.

Today, electricity is almost indispensable, but there are challenges ahead as we work to meet the growing energy needs of our industrialized world, while also protecting the health of our planet. The Solar Impulse 2 project set out to demonstrate that by developing new technologies, we can generate electricity in a clean, economical, and sustainable way. They proved their concept by completing a 43,000-km flight without using a single drop of fuel!

As we follow the journey of Solar Impulse 2, we examine current environmental challenges and how technologies that exist today, powered by abundant renewable natural resources, can positively impact the future. ***Planet Power*** and the flight of Solar Impulse 2 inspires the next generation of scientists and adventurers to continue their journey of discovery.

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EDUCATORS' INTRODUCTION

This Educators' Resource Guide is designed for use with students who view the new nWave Pictures Distribution release, ***Planet Power***. The guide includes STEAM-based classroom activities for students in grades K-2, 3-5, and 6-8. Before viewing ***Planet Power***, use a K-W-L chart to discuss with students what they Know about electricity and sources of energy, and what they Want to learn. After viewing the film, have students complete the chart by discussing what they Learned about different available sources of energy and their impact on the world.

EDUCATIONAL OBJECTIVES

- To introduce students to the film ***Planet Power*** and the remarkable flight of Solar Impulse 2.
- To educate students about the history of electricity and its role in shaping modern life.
- To teach students the difference between renewable and non-renewable sources of energy, including how they work and their impact on the environment.
- To use the Solar Impulse 2 project to illustrate the role of science and the importance of collaboration in solving problems and achieving dreams – however grand.
- To inspire students to be stewards of finding sustainable ways of providing a high quality of life that supports the environment.

PRE-VIEWING DISCUSSION QUESTIONS

Create a KWL graphic organizer on the chalkboard/whiteboard, with columns labeled "What I KNOW Already," "What I WANT to Find Out," and "What I LEARNED." Fill in the first column by asking students what they already know about electricity. Where do we get the electricity that powers our homes and school? What are the pros and cons of the way electric power is generated and used today? What other alternative sources of electricity exist? Then fill in the second column of the organizer by asking students what they want to find out about renewable energy and the Solar Impulse 2 flight. Prompt discussion with such questions as: What are the benefits of renewable energy sources? What unique challenges might a solar-powered plane face? How do our everyday choices impact the Earth, and what responsibility do individuals have to support the environment? Conclude by having students copy the organizer so they can fill in the final column after they have seen the film.

POST-VIEWING DISCUSSION QUESTIONS

- Return to the KWL graphic organizer on the chalkboard/whiteboard to fill in the "What I LEARNED" column. Have students contribute facts and insights from their own notes on the film. What did they learn about the Solar Impact 2 flight and alternative energy that most surprised them? What lessons can they apply to their own daily lives? What part of the film made them want to learn even more?
- Use the film to clarify students' understanding of the difference in environmental impact, cost, and efficiency between fossil fuels and renewable sources of energy, and to drive home the message that clean technologies and energy efficiency can reduce our emissions and improve our quality of life.

NEXT GENERATION SCIENCE STANDARDS

Grades K-2		Activity	
		1	2
K-ETS1-2	Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.	X	
K-ESS3-3	Communicate solutions that will reduce the impact of humans on land, water, air and/or other living things in the local environment.		X
2-ESS2-2	Develop a model to represent the shapes and kinds of land and bodies of water in an area.		X

Grades 3-5		Activity		
		1	2	3
3-ESS2-2	Obtain and combine information to describe climates in different regions of the world.			X
4-PS3-1	Use evidence to construct an explanation relating the speed of an object to the energy of that object.		X	
4-PS3-2	Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat and electric currents.		X	
4-PS3-4	Apply scientific ideas to design, test and refine a device that converts energy from one form to another.		X	
4-ESS2-2	Analyze and interpret data from maps to describe patterns of Earth's features.			X
4-ESS3-1	Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.		X	X
5-ESS3-1	Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.	X		

Grades 6-8		Activity			
		1	2	3	4
MS-ESS3-3	Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.	X			
MS-ESS3-4	Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.		X		
MS-ESS3-5	Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.		X		X
MS-PS3-5	Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.			X	

COMMON CORE—MATH

Grades K-2	Activity	
	1	2
CCSS.MATH.CONTENT.K.CC.A.1 Count to 100 by ones and by tens.	X	
CCSS.MATH.CONTENT.K.MD.A.2 Directly compare two objects with a measurable attribute in common, to see which object has "more of"/"less of" the attribute, and describe the difference.		X

Grades 3-5	Activity		
	1	2	3
CCSS.MATH.CONTENT.3.MD.A.2 Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l). Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem.	X		
CCSS.MATH.CONTENT.5.NBT.B.5 Fluently multiply multi-digit whole numbers using the standard algorithm.	X		

Grades 6-8	Activity			
	1	2	3	4
CCSS.MATH.CONTENT.6.NS.B.2 Fluently divide multi-digit numbers using the standard algorithm.		X		
CCSS.MATH.CONTENT.6.NS.C.6 Understand a rational number as a point on the number line.		X		
CCSS.MATH.PRACTICE.MP2 Reason abstractly and quantitatively.		X		

COMMON CORE—ELA

Grades K-2	Activity	
	1	2
CCSS.ELA-LITERACY.RI.K.7 With prompting and support, describe the relationship between illustrations and the text in which they appear (e.g., what person, place, thing, or idea in the text an illustration depicts).	X	
CCSS.ELA-LITERACY.RI.K.10 Actively engage in group reading activities with purpose and understanding.	X	
CCSS.ELA-LITERACY.RI.1.2 With prompting and support, identify the main topic and retell key details of a text.	X	
CCSS.ELA-LITERACY.RI.1.4 Ask and answer questions to help determine or clarify the meaning of words and phrases in a text.	X	X
CCSS.ELA-LITERACY.RI.1.5 Know and use various text features (e.g., headings, tables of contents, glossaries, electronic menus, icons) to locate key facts or information in a text.		X
CCSS.ELA-LITERACY.RF.2.4 Read with sufficient accuracy and fluency to support comprehension.	X	X
CCSS.ELA-LITERACY.RI.2.3 Describe the connection between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text.	X	

Grades 3-5	Activity		
	1	2	3
CCSS.ELA-LITERACY.RI.3.1 Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.			X
CCSS.ELA-LITERACY.RI.3.3 Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect.	X		
CCSS.ELA-LITERACY.RI.4.7 Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, time lines, animations, or interactive elements on Web pages), and explain how the information contributes to an understanding of the text in which it appears.			X
CCSS.ELA-LITERACY.RI.4.9 & CCSS.ELA-LITERACY.RI.5.9 Integrate information from several texts on the same topic in order to write or speak about the subject knowledgeably.		X	X

Grades 6-8	Activity			
	1	2	3	4
CCSS.ELA-LITERACY.RI.6.2 Determine a central idea of a text and how it is conveyed through particular details; provide a summary of the text distinct from personal opinions or judgments.				X

ARTS EDUCATION

Grades	K-2		3-5			6-8			
Activity	1	2	1	2	3	1	2	3	4
VISUAL ARTS									
VA:Cr1.1.Ka Engage in exploration and imaginative play with materials.	X								
VA:Cr2.3.Ka Create art that represents natural and constructed environments.		X							
VA:Cr3.1.3a Elaborate visual information by adding details in an artwork to enhance emerging meaning.				X					
VA:Cr2.3.7a Apply visual organizational strategies to design and produce a work of art, design, or media that clearly communicates information or ideas.									X
VA:Cr2.3.8a Select, organize, and design images and words to make visually clear and compelling presentations.									X
MEDIA ARTS									
MA:Cr1.1.3 Develop multiple ideas for media artworks using a variety of tools, methods and/or materials.					X				X
MA:Pr4.1.5 Create media artworks through the integration of multiple contents and forms, such as a media broadcast.									X

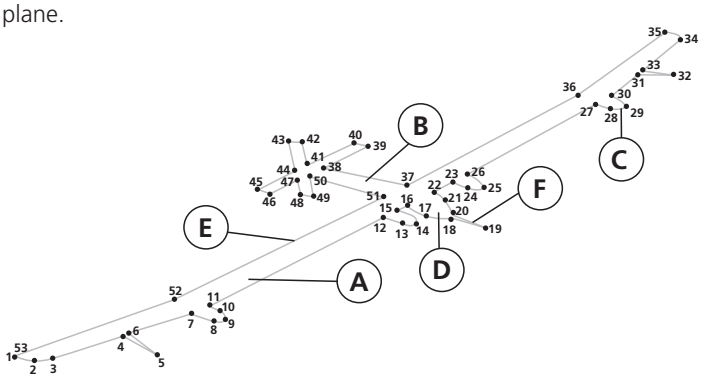
TEACHING NOTES FOR **GRADES K-2**

ACTIVITY 1 MAKING HISTORY

Part 1. Before you begin this exercise, read the introduction on the activity sheet to students. Then ask students if they know what electricity is. Have them share aloud the names of some electrical devices they rely on every day. Ask them to imagine that there was a time when there were no computers, mobile phones, TVs, or even light bulbs! Then, as you review the word-bank timeline, talk about each technology and how it affects our world today. For example, we still use generators like the one Faraday created to power our homes. And Morse code made it possible to send messages across the world; today, we take email and mobile phones for granted, but back then, people had to write letters and send them across the ocean by ship.

Answers: A. Greeks; B. lightning; C. battery; D. magnets; E. wires; F. Edison, light bulb; G. homes; H. sunlight; I. fossil fuels

Part 2. Have students connect the dots to show the outline of Solar Impulse 2 and write the letters of the plane parts where they belong on the resulting diagram. As time permits, you might encourage students to use art materials to make their own pictures of the plane.



FOLLOW-UP

Demonstrate electricity in action! Students can build a simple, safe, circuit with just a few basic items: 1 or 2 D batteries, aluminum foil, electrical tape, and a light bulb from a flashlight. Divide the class into teams and have each team follow this procedure:

- Cut foil into two strips each about 12" long and 2" wide.
- Fold each strip lengthwise until it is about ¼" wide.
- Using the electrical tape, attach one end of a foil strip to the metal ring at the base of the light bulb (not the tip).
- Attach the other end of this same strip to the negative end of the battery, making sure to cover the center of the battery.
- Take the second strip and tape one end to the positive end of the battery.
- Touch the other end to the metal tip of the bulb to make a complete circuit.
- Ask students to try different configurations using one or two strips connected to the positive and negative ends of the battery, and the tip and metal ring of the light bulb.

[Note: Adapted from https://www.whatdowedoallday.com/simple-circuit-science-project/ and https://www.youtube.com/watch?v=s6XP6pAHjvM]

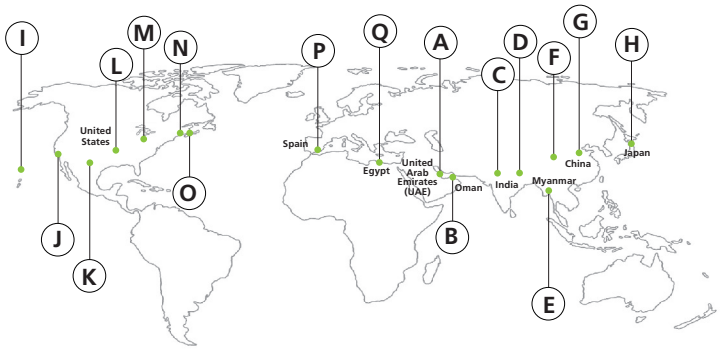
Alternatively, you may wish to have students take apart a small battery-powered toy or simple solar light to examine the circuitry inside. See http://www.osh.com/c/Paradise-Mini-Size-Solar-Path-Light-with-crackle-Lens/p/7006562.

ACTIVITY 2 WORLD OF POWER

Part 1. As your class begins this activity, lead a class discussion on the meaning of "renewable" and why that might be better than something that is "non-renewable." Renewable things can replenish themselves, while non-renewable things require more effort and/or resources that can have negative effects.

Answers: Renewable – sunlight, rivers, wind, cow manure. Non-renewable – fossil fuels like natural gas and coal, as well as uranium used in nuclear power

Part 2. Have students fill in the map on the activity sheet to track the flight of Solar Impulse 2. You can familiarize yourself with the flight path at http://www.solarimpulse.com/adventure/route. Depending on student abilities, you can also use this link as a reference to help students complete the activity, along with a globe to help them understand the relationship between each of the locations on the map. Encourage students to give their map its own identity by adding colors and/or textures to represent land, oceans, etc.



Answers to questions: 1. 9; 2. From Japan to Hawaii; 3. From Pennsylvania to New York; 4. Answers will vary; 5. Pacific Ocean

FOLLOW-UP

How does solar power work? Explain to students that the sun gives us energy in the form of light and heat. Take your class outside to see the sun in action. For example, they might use the sun's light to melt ice cubes or use a simple garden tool to compare the warmth of the sunniest spots outdoors to that of places that are shaded.

You can find additional ideas at https://theeducatorsspinonit.com/2014/05/solar-science-experiments-for-kids.html.

TEACHING NOTES FOR GRADES 3-5

ACTIVITY 1 POWERING HISTORY

Part 1. In this activity, students learn about the history of electricity and how humans worked for centuries to understand and harness this powerful force that we now rely on in every part of our lives. The activity concludes with an assessment of how much electricity students use daily.

First have students recall what they learned from the film and match each development in the timeline with the corresponding benefit by writing the correct letter in the space provided.

Answers: 1-E, 2-B, 3-G, 4-D, 5-C, 6-F, 7-A, 8-H

Part 2. Have students log each daily activity, from the moment their alarm clock sounds to the nightlight or music they use when they go to sleep. Then have them use the energy calculator at https://www.pacificpower.net/res/sem/eeti/euc.html, and engage them in a class discussion about what they discovered.

Students can extend the energy-tracking lesson by estimating their family's carbon footprint. They'll need to work with a parent. See https://www3.epa.gov/carbon-footprint-calculator/.

MATH CHALLENGES

Answers:

1. Approximate distances in miles between cities:

Abu Dhabi to Muscat:	273 miles
Muscat to Ahmedabad:	889 miles
Ahmedabad to Varanasi:	671 miles
Varanasi to Mandalay:	859 miles
Mandalay to Chongqing:	835 miles
Chongqing to Nanjing:	745 miles
Nanjing to Nagoya:	1,063 miles
Nagoya to Honolulu:	4,021 miles
Honolulu to San Francisco:	2,398 miles
San Francisco to Phoenix:	754 miles
Phoenix to Tulsa:	1,065 miles
Tulsa to Dayton:	753 miles
Dayton to Lehigh Valley:	517 miles
Lehigh Valley to New York:	93 miles
New York to Seville:	3,561 miles
Seville to Cairo:	2,810 miles
Total all miles:	26,700

2. Answers will vary depending on cities chosen.

3. 133,500 gallons of fuel

ADDITIONAL RESOURCES

Early applications of electricity: http://ethw.org/Early_Applications_of_Electricity
Impact of digital technology on energy use: http://science.time.com/2013/08/14/power-drain-the-digital-cloud-is-using-more-energy-than-you-think/
History of solar power: http://news.energysage.com/the-history-and-invention-of-solar-panel-technology/
Appliance power usage: https://www.energy.gov/energysaver/estimating-appliance-and-home-electronic-energy-use

FOLLOW-UP

For a hands-on demonstration of electric circuits and batteries, see:
Electric Circuits: https://ny.pbslearningmedia.org/resource/phy03.sci.phys.mfe.lp_electric/electric-circuits/#.Wf_F27bMyRs
Lemon Battery: http://pbskids.org/zoom/activities/sci/lemonbattery.html
Super Duper Simple Circuit: https://www.whatdowedoallday.com/simple-circuit-science-project/

ACTIVITY 2 ENERGY POTENTIAL

Part 1. The goal of this activity is to get students thinking about solar energy as a powerful alternative to fossil fuels, resulting in minimal waste or pollution. Direct them to the Department of Energy or the U.S. Energy Information Association websites listed on the activity sheet for background, as needed. Review their answers in a class discussion. Ask them if they remember from Activity 1 how magnets figured into the development of electricity. (Michael Faraday used magnets and motion to create electricity in the early 1800s.)

Answers: 1. fossil; 2. steam; 3. turbine; 4. magnets; 5. electric current

Part 2. Now divide students into teams to complete the following experiment. For each team, you will need three empty food cans with the tops and bottoms removed; masking tape; one paper clip; one thumbtack or pin; two books or blocks, and one pinwheel (you can make the pinwheel by cutting diagonally in from the corners of a six-inch square sheet of paper to within a quarter inch of the center, bending every other point from the corners to the center and taping them in place). You will also need a timer or clock with a secondhand.

INSTRUCTIONS

1. Tape the three cans together, one on top of the other.
2. Unbend the paper clip and use it to create an arch shape.
3. Tape the arch to the top of your tower, with the thumbtack or pin taped in at the apex; the point should be sticking up.
4. Secure the pinwheel, face down, to the thumbtack or pin.
5. Place two books or blocks next to each other, a few inches apart, in a very sunny location or beneath a lamp that generates a lot of heat.
6. Place the tower on top of the blocks, so that there is space for airflow underneath.

Have students experiment by observing the speed of the pinwheel (slow, medium, fast) and the duration of the resulting spin under conditions equating to dim light, normal light, and bright light. The more heat there is, as generated by the strength of the sunlight, the faster the pinwheel should spin. Duration is dependent on the continuous application of light/heat.

After the teams have written their reports, have students as a group use what they learned by deciding where the best place would be to install solar panels in and around their school.

[Note: This experiment was adapted from http://almostunschoolers.blogspot.com/2015/04/simple-solar-thermal-projects-for-kids.html.]

ADDITIONAL RESOURCES

How power plants create and deliver electricity:
- https://energy.gov/articles/infographic-understanding-grid
- https://www.eia.gov/energyexplained/index.cfm?page=electricity_delivery

TEACHING NOTES FOR GRADES 3-5

ACTIVITY 3 CLEAN ENERGY

Part 1. Help students understand the practical considerations of renewable energy by reviewing the climatic and topographical requirements of each source of energy. Provide time for them to fill in their answers in the comparison chart.

Answers:

Features of Renewable Energy Sources	Solar	Wind
Dependent on the weather	x	x
Can produce electricity for a single home or an entire city	x	x
Can be noisy		x
Can produce electricity 24 hours a day		x
Can be mounted on the roof of an existing building or on the ground	x	x
Best in rural or coastal areas with lots of open space and few obstructions like buildings		x
Best in hot, sunny climates without a lot of trees or cloud cover	x	
Can be programmed to tilt or move in order to capture more energy	x	x
Provides virtually unlimited, free energy	x	x
Electricity can be stored for times when energy sources are low or transferred back to the grid	x	x

Answers to questions: 1. Answers will vary; 2. Answers will vary; 3. Solar energy can be collected in the Arctic during the times of the year when the sun is out. In fact, cold temperatures can make the photovoltaic cells more efficient! 4. Deserts and prairies are ideal locations for wind farms because they offer wide, open spaces with no obstructions.

Part 2. Have students use the map provided for Activity 1 to study the Solar Impulse 2 flight path. Explain that many factors were considered in planning the flight path, including seasonal weather expectations, air traffic areas, and topography. A team of engineers and meteorologists based in Monaco Mission Control Center determined the best route for the plane and then prepared the flight plan. For example, since the mission began in March, they avoided flying over India during that month because of the potential for monsoons. The Arabian Gulf region near Abu Dhabi was chosen because it has the constant sunshine needed to recharge the plane with solar energy.

Now ask students to choose one country on the flight path. Allow them some time to research its climate, seasonal weather patterns, topography, and any renewable energy initiatives, either by the government or private industry. After they use the information they researched to answer the questions, have them share their findings with the rest of the class.

ADDITIONAL RESOURCES

How energy is generated in your town:

- http://www.powerplantmaps.com
- https://energy.gov/eere/wind/wind-energy-technologies-office
- http://www.nordicenergy.org/article/solar-power-at-the-arctic-circle/

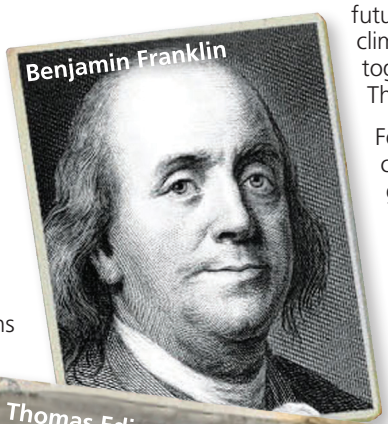
USEFUL SITES FOR STUDENT RESEARCH

Countries leading the world in solar energy: http://www.businessinsider.com/best-solar-power-countries-2016-3/#8-australia-4130-megawatts-3
The sunniest places on Earth: https://www.seeker.com/10-best-places-to-harness-solar-power-1766271287.html
The best wind farm locations: http://www.wisegeek.org/what-are-the-best-wind-farm-locations.htm
The basics of wind power: https://www.awea.org/wind-power-101

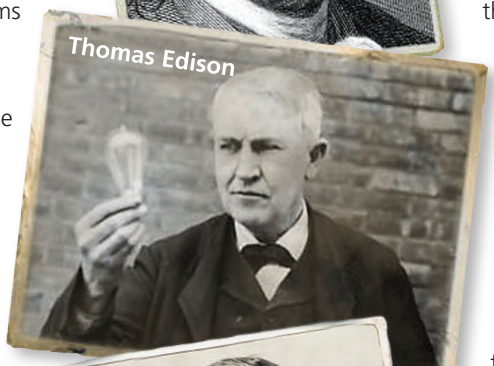
TEACHING NOTES FOR GRADES 6-8

ACTIVITY 1 INDUSTRIAL IMPACT

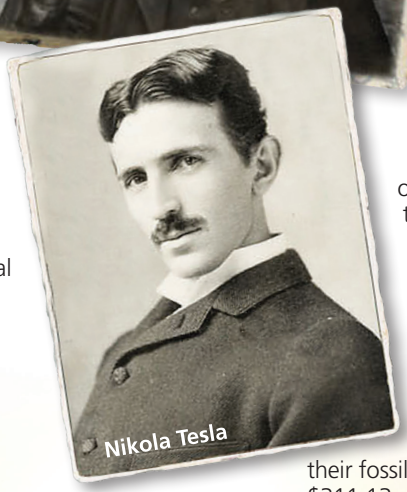
Part 1. In this activity, students learn about some of the key discoveries that laid the foundation for much of the technology we depend upon today. From the light bulb to the power grid that delivers electric power to our homes, the inventors and scientists of the 19th century changed the way we live and work, arguably more than their counterparts in any other century.



Begin the lesson by asking students to recall what they remember from the film about each development on the timeline. Choose one development and use it in a class discussion to review each of the questions students will explore in their research. Morse's discovery (1838) is a good place to start, because you can make a direct parallel to the communications devices and social media students are likely already using. Point out that new forms of communication make it easier and faster to share news with family that is far away, but they also can reduce our in-person interactions and increase the expectation that we are always available.



Engage students in thinking critically about the connections between how they live every day and the science and hard work that made it possible, as well as the understanding that nearly all progress has both pros and cons, even though it's often much easier to see the benefits. For example, wind power is a great renewable source of energy, but wind farms can disrupt migration patterns of animals and habitats of birds.



Part 2. Now have students work together to brainstorm contemporary environmental or economic problems that may have a scientific solution. Make a list of their responses, then divide them into small groups to complete the list and come up with ideas for solving one of the issues.

ADDITIONAL RESOURCES

Industrial Revolution: http://www.history.com/topics/industrial-revolution
Early applications of electricity: http://ethw.org/Early_Applications_of_Electricity

ACTIVITY 2 GLOBAL GREENHOUSE

Part 1. This lesson is an opportunity for students to apply grade-level math and social studies to real-world problems. First, they'll practice reading a graph and calculating averages in order to better understand climate change over time and as projected into the future. Begin by asking students what they already know about climate change and greenhouse gases. Look at the graph together and ask them to make some observations about it. Then, provide time for them to complete the calculations.

For question 4, in order to project the estimated temperature change for 2050 and 2500, students will need to extend the graph onto another piece of paper, following the smooth curve they created in question 2. Before they begin, point out how temperatures have risen steadily since the late 1800s. Have students discuss the significance of the rising curve in the last few decades. Ask them to consider how the curve might change if our carbon emissions increase, decrease or remain the same over time. They can draw their curves accordingly.

Answers (estimated): 1. 1.17°C change. 2. Answers will vary. 3. The biggest change can be seen from 1990-2000; the smallest change was in the early 20th century, i.e., from 1900-1910. 4. If the curve stays the same, by 2050 the average temperature will have increased by 2.25°C. 5. For 2500, answers will vary based on students' curves. This simulation from NASA offers just one set of possibilities: https://earthobservatory.nasa.gov/features/GlobalWarming/page5.php

Part 2. Explain that most power plants burn fossil fuels in order to create energy. In the United States, the most common fuels are natural gas and coal. Ask students to hypothesize which of these fuels creates more or less energy and pollution. Tell them that the numbers used in the word problem examples are based on real 2016 costs for power generation in the U.S. While the exact amount of energy and CO^2 produced varies across every power plant (and every day), these estimates will give them a look at real choices that consumers like their parents can consider.

Answers: **A.** – 1. Power plant X: a. 10,766 pounds of coal; b. 30,790.76 pounds of CO^2. Power plant Y: a. 29,905.55 cubic feet of natural gas; b. 8,971.67 pounds of CO^2. 2. 2,691.50 hours. If this family got 4 hours of full sunlight per day, they could replace nearly half of their fossil fuel-powered usage with solar. **B.** – 1. $25.93 per month; $311.13 per year. 2. $147.03 per month; $1,764.37 per year. 3. $39,146,376,600. Those are huge savings!

ADDITIONAL RESOURCES

How international agencies measure and observe climate change: https://earthobservatory.nasa.gov/Features/WorldOfChange/decadaltemp.php
Electricity usage: www.eia.gov/energyexplained/index.cfm?page=electricity_use
Efficiency of power plants: www.eia.gov/tools/faqs/faq.php?id=107&t=3
Understanding energy units: www.greenbuildingadvisor.com/blogs/dept/musings/understanding-energy-units
Natural gas plants vs. coal plants: www.bizjournals.com/denver/blog/earth_to_power/2014/01/natural-gas-power-plants-produce-40.html

TEACHING NOTES FOR GRADES 6-8

ACTIVITY 3 ROOM FOR HOPE

Part 1. In ***Planet Power***, we learn that Solar Impulse 2 weighed as much as a car, with the motor strength equal to that of a motorcycle, and spanned the width of two passenger planes. Its design enabled it to run with 97% efficiency, meaning that nearly all the solar power created was used for flight. When Bertrand Piccard proposed such a goal, most people told him it was impossible, but he defied the odds! Engineers and scientists carefully spent more than a decade designing, building, and testing every element of the plane with incredible precision. Every ounce of food the pilot would need was calculated, and every square inch of space was maximized with the lightest-weight, strongest materials available.

This activity demonstrates why that 97% efficiency mark for Solar Impulse 2 is so exciting. Cars, by contrast, run at 30% efficiency, thus burning a *lot* of excess fuel. This is largely due to their engines, which run on internal combustion.

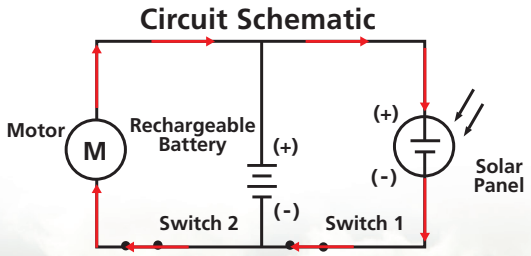
Use the animation at https://kids.britannica.com/kids/assembly/view/171065 to show students how an internal combustion engine generates power. Then have students label the diagrams on the activity sheet to describe the process. Explain that during each step, a transfer of energy takes place. Eventually, this takes the form of kinetic energy, or the motion of the car.

Answers: 1-B; 2-A; 3-D; 4-C

Part 2. Explain that Solar Impulse 2 uses a propeller system powered by an electrical motor that runs on a streamlined solar circuit. Part of the efficiency of this type of system is that there are far fewer opportunities for energy loss. Review the photo of the Easter Solar Engine at www.instructables.com/id/The-Easter-Solar-Engine, using the mouse-over callouts to help students understand how electrical energy generated by sunlight travels through the circuitry to the motor. If possible, have students build their own solar engines using the instructions on this webpage. Then have students mark the schematics to show how electricity flows through the circuitry in three different configurations.

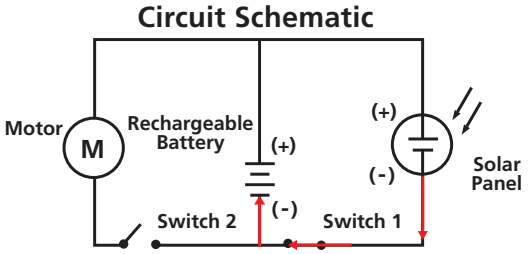
Answers:

1. The motor is being run directly by energy from the solar cell.



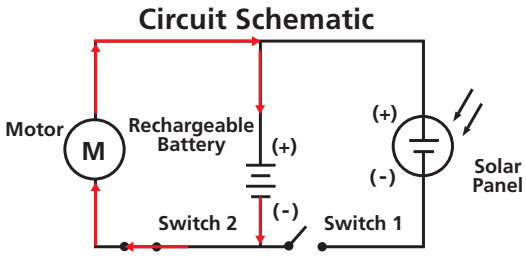
Switches Closed

2. The battery is being charged.



Switch 1 Closed

3. The motor is running on battery power.



Switch 2 Closed

FOLLOW-UP

The technical success behind Solar Impulse 2 took 13 years, including designing, studying, and testing. Have students research one of the following features of Solar Impulse 2 and explain how it helped the plane achieve maximum efficiency. Oral or written presentations should demonstrate understanding of how energy is transferred from one form to another in order to obtain flight, and how mass and other factors can impact efficiency.

- Ultra-light materials
- Wingspan
- Optimal thermal insulation
- LED lighting
- Maximized motor and battery performance
- Computerized energy management
- Un-pressurized cockpit
- Solo pilot with minimal comforts or time allotted for sleep

ADDITIONAL RESOURCES

Design features of Solar Impulse 2: https://sketchfab.com/models/dead5753e2ae4883ba1f64b0bfaa59c3
Comparison of the efficiency of different types of cars: https://www.fueleconomy.gov/feg/atv.shtml

TEACHING NOTES FOR **GRADES 6-8**

ACTIVITY 4 STRATEGIES FOR THE FUTURE

Part 1. Bertrand Piccard laid out the 7 Principles for Solving Climate Change to emphasize how change *is* possible, if it's approached correctly. He proved it with the flight of Solar Impulse 2 around the world. These 7 Principles can be used at all levels of community – from the United Nations to your school or neighborhood council. Locally, a simple initiative such as a walkathon can set a great example.

Review each of the 7 Principles with your class, and ask them to consider how the flight of Solar Impulse 2 achieved these goals.

Part 2. Continue the discussion by asking students how *they* could make a difference, and which of the 7 Principles would be most relevant to any efforts they made. Review the idea of a community walkathon with them, and then ask students to come up with additional ideas and related initiatives. Begin by creating a Mission Statement and Fact Sheet for your initiative. This document should include goals and background, such as data outlining the environmental impact of our dependence on cars.

To get this initiative really going, you will need to form a committee of educators, students, and parents. You can even include local police to help provide guidelines for safety. Begin by determining an appropriate distance for your walkathon – perhaps two miles, as it would provide great opportunities for visibility, excitement, and fundraising! You will need to select a date based on weather and community/school schedules. The planning committees can use the checklist that is on the worksheet, but additional resources are available online.

Walkathon planning guides:

- https://blog.discountmugs.com/10-steps-to-planning-the-perfect-walkathon
- https://blog.fundly.com/walkathons/

RESOURCES

HISTORIC FLIGHT
http://aroundtheworld.solarimpulse.com/adventure

SOLAR IMPULSE FOUNDATION
https://www.solarimpulse.com

CALCULATORS AND MAPS
https://www.pacificpower.net/res/sem/eeti/euc.html
https://www.energy.gov/energysaver/estimating-appliance-and-home-electronic-energy-use
https://www3.epa.gov/carbon-footprint-calculator/
http://www.powerplantmaps.com
http://www.greenbuildingadvisor.com/blogs/dept/musings/houses-versus-cars#ixzz4y9E1LOLo

ENGINEERING AND TECHNOLOGY HISTORY WIKI
http://ethw.org/

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE
http://www.ipcc.ch/report/ar5/

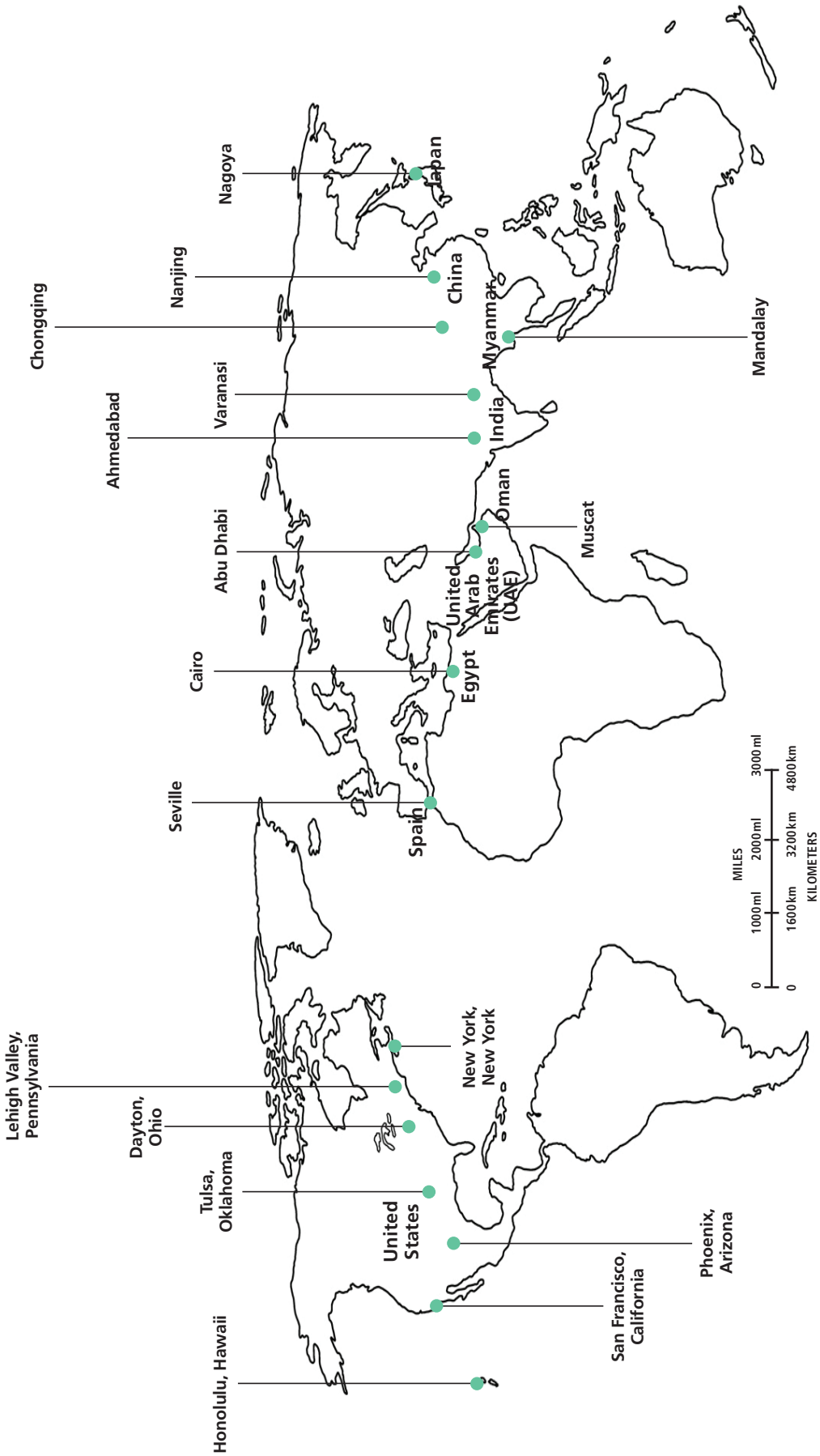
NORDIC ENERGY RESEARCH, NORDIC COUNCIL OF MINISTERS
http://www.nordicenergy.org

SOLAR CIRCUITS AND OTHER ACTIVITIES
https://www.homesciencetools.com
https://theeducatorsspinonit.com/2014/05/solar-science-experiments-for-kids.html
https://www.whatdowedoallday.com/simple-circuit-science-project/
https://www.youtube.com/watch?v=s6XP6pAHjvM
https://ny.pbslearningmedia.org/resource/phy03.sci.phys.mfe.lp_electric/electric-circuits/#.Wf_F27bMyRs
http://pbskids.org/zoom/activities/sci/lemonbattery.html
http://almostunschoolers.blogspot.com/2015/04/simple-solar-thermal-projects-for-kids.html
https://www.nrel.gov/docs/gen/fy01/30828.pdf

U.S. DEPARTMENT OF ENERGY
https://energy.gov
https://energy.gov/maps/quiz-test-your-solar-iq

U.S. ENERGY INFORMATION ADMINISTRATION
https://www.eia.gov
https://www.eia.gov/kids/

U.S. ENVIRONMENTAL PROTECTION AGENCY
https://www.epa.gov



BERTRAND PICCARD

"The adventure today is not about returning to the moon. It's about achieving other, just as incredible feats. Like freeing ourselves from our dependence on fossil fuels or resolving environmental problems but in a cost-effective way, otherwise no one will ever support environmental protection. But what is absolutely essential is allowing ourselves to dream.

"If all the efficient technologies used on Solar Impulse were implemented today everywhere in the world, we could already cut mankind's energy consumption in half, and by the same token, CO^2 emissions. We absolutely need to replace all the outdated polluting systems with clean, efficient technologies that are more profitable, that create jobs and economic growth. Because today, the goal is not to be ecological, but simply logical."

SOLARIMPULSE
AROUND THE WORLD IN A SOLAR AIRPLANE
© www.solarimpulse.com

It is in Bertrand Piccard's education to push back the boundaries of the possible, as he did with his two round-the-world flights, non-stop in a balloon and more recently with a solar-powered airplane. With his dual identities as psychiatrist and explorer, he constantly sets out to challenge certitudes and habits, and advocates for a pioneering spirit to solve the challenges of our times. Over the years, Bertrand has become an influential voice heard among the most distinguished institutions across the globe as a forward-thinking leader for progress and sustainability.

RORY O'NEIL

"***Planet Power*** and its incredible inspiring story proves that we're coming to an age when the impossible is no longer impossible, when dedication and relentless pursuit of a dream shows the way forward. The energy industry hasn't changed much since the time of Edison and Tesla, but now we are soaring into a Clean Energy Industrial Revolution. Resource constraints, environmental pollution, and climate change are only a few dangers that humanity has been facing, and we are finally confronting them with viable solutions. Dedication to explore new frontiers is the means of achieving a cleaner, more sustainable world, a better world for us to live in. ***Planet Power***'s visually stunning and exceptionally informed approach is an important means to show the public and future generations that the power to save the planet rests with the simplest sources around us, if we only knew about them. After all, the sun, directly or indirectly, is the source of all life on Earth. With the spirit to break through the seemingly impossible, the human race can achieve things that were once part of science fantasy, such as the eternal flight that Bertrand Piccard and André Borschberg experienced in ***Planet Power***."

EuropaGrid

Cleantech innovator, energy market disruptor, and pioneer of the energy internet, Rory O'Neill, Founder and Chairman of Europagrid, embodies the innovation that instigates positive environmental and social change. With 20 years of experience in leadership positions and strategic planning in long-term energy infrastructure, his projects and innovation continue to bring new ways of solving complex problems through uniquely designed global infrastructure connecting the world's vast renewable energy generation resources.

HANS-JOSEF FELL

"To secure its survival, mankind has to master great challenges in the coming two decades. The temperature increases of the global atmosphere, wars over resources, life-threatening pollution of air, water, and soil, as well as the nuclear threat posed by atomic energy and nuclear bombs, have to be finally brought to an end. The main cause of these threats to the existence of humanity lies in the old energy system based on the use of oil, natural gas, coal, and uranium.

"The sun provides us humans with an abundance of energy. We only have to utilize that energy by completely transitioning to a global energy supply based on 100% renewable energy in order to secure the survival of mankind. Already today, solar, wind, and hydropower, as well as bioenergy and geothermal energy, are the most economical form of energy generation. They enable us to power cars, ships, and planes, to provide heating and cooling, to produce drinking water from sea water, and to carry out industrial processes without emissions. A clean world with great prosperity for everyone without harmful greenhouse gas emissions, environmental degradation, and radioactive pollution is within reach, if only we fully deploy zero emission technologies immediately and at a global level.

"With many examples, ***Planet Power*** demonstrates how this can be achieved, for instance, with the first solar-powered flight around the world."

DWR eco
PUBLIC AFFAIRS · PUBLIC RELATIONS · STRATEGY

Hans-Josef Fell, member of the German Parliament from 1998-2013 and spokesperson for energy policy of the Alliance 90/The Greens, is an internationally known political advocate for 100% Renewable Energy. He is President of the Energy Watch Group (EWG), Ambassador for 100% Renewable Energy and Senior Advisor at DWR eco GmbH. Hans-Josef Fell is the father of the German Renewable Energy legislation (EEG), which has been a model policy for almost 100 countries worldwide.

MARY O'DONNELL

"***Planet Power*** gives me unlimited hope and joy about our planet's future. My generation has been complicit in allowing fossil fuel to harm our environment without any accountability. For our children, the film shows what determination and commitment for a better world can do. I now have true hope and belief that our generation will be around to see all of this changed. Hallelujah and thanks to you for putting this on film for all of us to see and be inspired."

Mary O'Donnell is the owner and founder of 10 companies, spanning the real estate, construction, agriculture, and renewable energy industries. A serial entrepreneur, Mary is on a mission to stop global warming by developing 17 megawatts of wind and solar energy facilities in her home state of Massachusetts, and brokering utility-scale wind and solar energy internationally via her company, Clean Power Inc. Her intent is creating a gigawatt of clean power before she dies.

It started with a dream

P·L·A·N·E·T POWER

Limiting Global Warming

Solar Impulse Adventure

Clean Electricity Production

Future is Clean

The Age of ACTION

An N3D Land Films production

An **nWave Pictures Distribution** release

PLANET POWER explores the history of electricity – from the first spark created by man's hand to today's industrial power plants. We meet scientists who changed the world, like Faraday, Franklin, and Tesla and we glimpse the future, as Solar Impulse becomes the first plane to complete a round-the-world flight powered only by the Sun.

For additional educational resources and online activities, please visit www.planetpower-thefilm.com

nWave picturesdistribution

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