



Moon Power

Human Exploration Project I

Energy and Power

A Standards-Based Elementary School Unit Guide



Engineering byDesign™

Advancing Technological Literacy

A Standards-Based Program Series

ELEM

International Technology Education Association
Center to Advance the Teaching of Technology and Science

Educational Product	
Educators	Grades 1-5

EP-2009-07-53-MSFC

Teacher Notes

This unit is intended to serve as part of an elementary school experience for students who are interested in exploring Technology Education and/or Pre-Engineering. In terms of Science, Technology, Engineering, and Mathematics (STEM) education, this unit primarily focuses upon the “T” and the “E” of STEM, with strong linkages to the “S” and “M.” There are no prerequisites for this unit.

Preface

NASA Project Management A Standards-Based Elementary School Unit

Acknowledgments

Many individuals committed to developing elementary school technological literacy made this publication possible. Their strong commitment to developing standards-based technology resources is reflected in this guide. Special thanks are expressed to:

Krista Jones, Author
Bellevue Elementary School, Bellevue, Idaho

Kendall N. Starkweather, Ph.D., DTE, Executive Director
International Technology Education Association (ITEA), Reston, Virginia

Barry N. Burke, DTE, Director
ITEA-Center to Advance the Teaching of Technology and Science, Reston, Virginia

Shelli D. Meade, Human Exploration Project Director
International Technology Education Association (ITEA), Christiansburg, Virginia

Robert C. Gray, DTE, Consultant
University of Maryland Eastern Shore, Princess Anne, Maryland

William E. Dugger, Jr., Ph.D., DTE, Senior Fellow
ITEA-Technology for All Americans Project (TfAAP), Blacksburg, Virginia

Peter Curreri
NASA, Huntsville, Alabama

Kathleen B. de la Paz, Editor-in-Chief
International Technology Education Association (ITEA), Reston, Virginia

Kathie F. Cluff, Editor
International Technology Education Association (ITEA), Reston, Virginia

Engstrom Consulting Services, Layout
West Newton, Pennsylvania

Cindy Curtis, Layout
Gurnee, Illinois

Reviewers

Special thanks are extended to the following expert and field reviewers who provided valuable feedback in the development of this resource:

William E. Dugger, Jr., DTE
ITEA Fellow
Blacksburg, VA

Stephen Proklemba
Bellevue Middle School
Bellevue, ID

William B. Giese
Downsville Elementary School
Downsville, WI

Judy Shelly
Bellevue Middle School
Bellevue, ID

Lois Standley
Bellevue Elementary School
Bellevue, ID

Engineering byDesign™ Curriculum Specialists

The Curriculum Specialists listed below have been trained to deliver workshops related to all Engineering byDesign™ (EbD™) curriculum. For more information, see <www.engineeringbydesign.org> or e-mail <ebd@iteaconnect.org>.

Daniel W. Caron, DTE
Kingswood Regional High School
Wolfboro, NH

John W. Hansen, DTE
The University of Texas at Tyler
Tyler, TX

Amy N. Gensemer
Clarksburg High School
Clarksburg, MD

Greg McGrew
Lakewood Ranch High School
Bradenton, FL

Aaron M. Gray
Burleigh Manor Middle School
Ellicott City, MD

Nicole M. Penn
Kiser Middle School
Greensboro, NC

The ITEA-CATTS Human Exploration Project (HEP)

People, Education, and Technology

v

*Moon
Power*

In May 2005, ITEA was funded by the National Aeronautics and Space Administration (NASA) to develop curricular units for Grades K–12 on Space Exploration. The units focus on aspects of the themes that NASA Engineers and Scientists— as well as future generations of explorers— must consider, such as Energy and Power, Transportation and Lunar Plant Growth Chambers (the STS-118 Design Challenges). Moreover, the units are embedded within a larger model program for technology education known as Engineering byDesign™.

The Human Exploration Project (HEP) units have several common characteristics. All units:

- Are based upon the Technological Literacy standards (ITEA, 2000/2002/2007).
- Coordinate with Science (AAAS, 1993) and Mathematics standards (NCTM, 2000).
- Utilize a standards-based development approach (ITEA, 2005).
- Stand alone and coordinate with ITEA-CATTS Engineering byDesign™ curricular offerings.
- Reflect a unique partnership between NASA scientists and engineers and education professionals.
- Incorporate leading-edge insight and practical experiences for students on how NASA works and plans.

These unit guides are designed to be practical and user-friendly. ITEA welcomes feedback from users in the field as we continually refine these curricular products, ensuring that the content remains as dynamic as the technological world in which we live. Please e-mail <ebd@iteaconnect.org> or call 703-860-2100.

Moon Power

Table of Contents

Teacher Notes

Preface

Acknowledgments	iii
Reviewers	iv
Engineering byDesign™ Curriculum Specialists	iv
The ITEA-CATTS Human Exploration Project (HEP)	v

Moon Power: A Standards-Based Elementary School Unit

Unit Overview

Standards	1
Benchmarks.....	2
Unit Objectives	4
Student Assessment Tools and/or Methods.....	5
Teacher Preparation and Resources.....	7

Lesson 1: Earth and Luna

Lesson Snapshot

Overview.....	9
Activity Highlights	9

Lesson 1: Overview

Lesson Duration.....	10
Standards/Benchmarks	10
Learning Objectives.....	11
Student Assessment Tools and/or Methods.....	11
Resource Materials	11
Required Knowledge and Skills	11

Lesson 1: 5-E Lesson Plan

Engagement	12
Exploration	12
Explanation.....	12
Extension	13
Evaluation	13
Enrichment.....	13

Lesson 1: Lesson Preparation

Teacher Planning.....	14
Tools/Materials/Equipment.....	14
Classroom Safety and Conduct	14

Engineering byDesign™
A National, Standards-Based Model for K-12 Technological Literacy

Moon Power

Lesson 2: Sources of Power

Lesson Snapshot

Overview.....	15
Activity Highlights	15

Lesson 2: Overview

Lesson Duration.....	16
Purpose of Lesson	16
Standards/Benchmarks	16
Learning Objectives.....	17
Student Assessment Tools and/or Methods	17
Resource Materials	17
Required Knowledge and Skills	17

Lesson 2: 5-E Lesson Plan

Engagement	18
Exploration	18
Explanation.....	19
Extension	19
Evaluation	19
Enrichment.....	19

Lesson 2: Lesson Preparation

Teacher Planning.....	20
Tools/Materials/Equipment.....	20
Classroom Safety and Conduct	20

Lesson 3: Exploring Energy

Lesson Snapshot

Overview.....	21
Activity Highlights	21

Lesson 3: Overview

Lesson Duration.....	22
Standards/Benchmarks	22
Learning Objectives.....	22
Student Assessment Tools and/or Methods	22
Resource Materials	23
Required Knowledge and Skills	23

Moon Power

Lesson 3: 5-E Lesson Plan

Engagement	24
Exploration	24
Explanation.....	24
Extension	25
Evaluation	25
Enrichment	25

Lesson 3: Lesson Preparation

Teacher Planning.....	26
Tools/Materials/Equipment.....	26
Classroom Safety and Conduct	26

Lesson 4: Research and Development

Lesson Snapshot

Overview.....	27
Activity Highlights	27

Lesson 4: Overview

Lesson Duration.....	28
Standards/Benchmarks	28
Learning Objectives.....	29
Student Assessment Tools and/or Methods	29
Resource Materials	29
Required Knowledge and Skills	29

Lesson 4: 5-E Lesson Plan

Engagement	30
Exploration	30
Explanation.....	30
Extension	30
Evaluation	31
Enrichment.....	31

Lesson 4: Lesson Preparation

Teacher Planning.....	32
Tools/Materials/Equipment.....	32
Classroom Safety and Conduct	32

Engineering byDesign™

A National, Standards-Based Model for K-12 Technological Literacy

Moon Power

Lesson 5: Promotion Poster

Lesson Snapshot

Overview.....	33
Activity Highlights	33

Lesson 5: Overview

Lesson Duration.....	34
Standards/Benchmarks	34
Learning Objectives.....	34
Student Assessment Tools and/or Methods	34
Resource Materials	34
Required Knowledge and Skills	35

Lesson 5: 5-E Lesson Plan

Engagement	36
Exploration	36
Explanation.....	36
Extension	36
Evaluation	36
Enrichment.....	36

Lesson 5: Lesson Preparation

Teacher Planning.....	37
Tools/Materials/Equipment.....	37
Classroom Safety and Conduct	37

Lesson 6: Poster Presentation

Lesson Snapshot

Overview.....	38
Activity Highlights	38

Overview

Lesson Duration.....	39
Standards/Benchmarks	39
Learning Objectives.....	39
Student Assessment Tools and Methods.....	39
Resource Materials	40
Required Knowledge and/or Skills.....	40

Lesson 6: 5-E Lesson Plan

Engagement	41
Exploration	41
Explanation.....	41
Extension	41
Evaluation	42

Engineering byDesign™

A National, Standards-Based Model for K-12 Technological Literacy

Moon Power

Lesson 6: Lesson Preparation

Laboratory-Classroom Preparation	43
Tools/Materials/Equipment	43
Classroom Safety and Conduct	43

Lesson 7: Research-Based Design

Lesson Snapshot

Overview	44
Activity Highlights	44

Overview

Lesson Duration	45
Standards/Benchmarks	45
Learning Objectives	46
Student Assessment Tools and/or Methods	46
Resource Materials	46
Required Knowledge and/or Skills	46

Lesson 7: 5-E Lesson Plan

Engagement	47
Exploration	47
Explanation	47
Extension	47
Evaluation	48
Enrichment	48

Lesson 7: Lesson Preparation

Laboratory-Classroom Preparation	49
Tools/Materials/Equipment	49
Classroom Safety and Conduct	49

Lesson 8: Lunar Power Station Construction

Lesson Snapshot

Overview	50
Activity Highlights	50

Overview

Lesson Duration	51
Purpose of Lesson	51
Standards/Benchmarks	51
Learning Objectives	52
Student Assessment Tools and/or Methods	52
Resource Materials	52
Required Knowledge and Skills	52

Engineering byDesign™

A National, Standards-Based Model for K-12 Technological Literacy

Moon Power

Lesson 8: 5-E Lesson Plan

First Day of Construction

Engagement	53
Exploration	53
Explanation.....	53
Extension	53
Evaluation	53
Enrichment.....	53

Lesson 8: 5-E Lesson Plan

Second Day of Construction

Engagement	54
Exploration	54
Explanation.....	54
Extension	54
Evaluation.....	54

Lesson 8: Lesson Preparation

Laboratory-Classroom Preparation	55
Additional Planning Activities	55
Tools/Materials/Equipment.....	55
Classroom Safety and Conduct	55

Lesson 9: Report and Reflect

Lesson Snapshot

Overview.....	56
Activity Highlights	56

Overview

Lesson Duration.....	57
Standards/Benchmarks	57
Learning Objectives.....	57
Student Assessment Tools and/or Methods	57
Resource Materials	58
Required Knowledge and Skills	58

Lesson 9: 5-E Lesson Plan

Engagement	59
Exploration	59
Explanation.....	59
Extension	59
Evaluation	60

Engineering byDesign™

A National, Standards-Based Model for K-12 Technological Literacy

Moon Power

Lesson 9: Lesson Preparation	
Laboratory-Classroom Preparation	61
Tools/Materials/Equipment	61
Classroom Safety and Conduct	61
Lesson 10: Video Report on Lunar Power Station	
Lesson Snapshot	
Overview	62
Activity Highlights	62
Lesson 10: Overview	
Lesson Duration	63
Standards/Benchmarks	63
Learning Objectives	63
Student Assessment Tools and/or Methods	64
Resource Materials	64
Required Knowledge and/or Skills	64
Lesson 10: 5-E Lesson Plan	
Engagement	65
Exploration	65
Explanation	65
Extension	65
Evaluation	65
Lesson 10: Lesson Preparation	
Laboratory-Classroom Preparation	66
Tools/Materials/Equipment	66
Classroom Safety and Conduct	66
Lesson 1: Resource Documents	67
Lesson 2: Resource Documents	74
Lesson 3: Resource Documents	85
Lesson 4: Resource Documents	103
Lesson 5: Resource Documents	119
Lesson 6: Resource Documents	130
Lesson 7: Resource Documents	140
Lesson 8: Resource Documents	145
Lesson 9: Resource Documents	151
Lesson 10: Resource Documents	160

Moon Power: A Standards-Based Elementary School Unit

Unit Overview

In the past, humans have set foot on the Moon's surface. Today, we continue our lunar exploration with orbiting and robotic probes. In the near future, we will live and work for extended periods on the Moon. Power helps make all of these things possible. Humans make the choice of which energy source and technological means we use to produce that power. In order to make informed choices, we must consider the efficiency, feasibility, and safety of the source as well as the global impacts on society and the environment.

Big Idea

Energy and power are needed to do work, so humans must decide what they want to accomplish when choosing energy sources and consider the impacts of the choices they make.

Teacher's Note: Big ideas should be made explicit to students by writing them on the board and/or reading them aloud.

Standards

Technology: Standards for Technological Literacy (STL) (ITEA, 2000/2002/2007)

- Students will develop an understanding of the core concepts of technology. (ITEA/STL 2)
- Students will develop an understanding of the cultural, social, economic, and political effects of technology. (ITEA/STL 4)
- Students will develop an understanding of the effects of technology on the environment. (ITEA/STL 5)
- Students will develop an understanding of the role of society in the development and use of technology. (ITEA/STL 6)
- Students will develop an understanding of the attributes of design. (ITEA/STL 8)
- Students will develop an understanding of engineering design. (ITEA/STL 9)
- Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving. (ITEA/STL 10)
- Students will develop the abilities to apply the design process. (ITEA/STL 11)
- Students will develop the abilities to assess the impact of products and systems. (ITEA/STL 13)
- Students will develop an understanding of and abilities to select and use energy and power technologies. (ITEA/STL 16)
- Students will develop an understanding of and abilities to select and use information and communication technologies. (ITEA/STL 17)

Science: National Science Education Standards (NRC, 1996)

- Science as Inquiry (NRC A)
- Physical Science (NRC B)
- Earth and Space Science (NRC D)
- Science and Technology (NRC E)
- Science in Personal and Social Perspectives (NRC F)
- History and Nature of Science (NRC G)

Mathematics: Principles and Standards for School Mathematics (NCTM, 2000)

- Measurement
- Number and Operations
- Data Analysis and Probability

Benchmarks

Technology: Standards for Technological Literacy (STL) (ITEA, 2000/2002/2007)

- Resources are the things needed to get a job done, such as tools and machines, materials, information, energy, people, capital, and time. (ITEA/STL 2H)
- The results of using technology can be good or bad. (ITEA/STL 4B)
- The use of technology can have unintended consequences. (ITEA/STL 4C)
- The use of technology affects the environment in good and bad ways. (ITEA/STL 5C)
- Because people's needs and wants change, new technologies are developed, and old ones are improved to meet those changes. (ITEA/STL 6B)
- Individual, family, community, and economic concerns may expand or limit the development of technologies. (ITEA/STL 6C)
- Everyone can design solutions to a problem. (ITEA/STL 8A)
- Design is a creative process. (ITEA/STL 8B)
- The design process is a purposeful method of planning practical solutions. (ITEA/STL 8C)
- The engineering process includes identifying a problem, looking for ideas, developing solutions and sharing solutions with others. (ITEA/STL 9A)
- Expressing ideas to others verbally and through sketches and models is an important part of the design process. (ITEA/STL 9B)
- When designing an object it is important to be creative and consider all ideas. (ITEA/STL 9D)
- Models are used to communicate and test design ideas and processes. (ITEA/STL 9E)
- Brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum. (ITEA/STL 9G)
- Asking questions and making observations helps a person to figure out how things work. (ITEA/STL 10A)
- Research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace. (ITEA/STL 10I)
- Build or construct an object using the design process. (ITEA/STL 11B)
- Compare, contrast, and classify collected information in order to identify patterns. (ITEA/STL 13C)
- Energy comes in many different forms. (ITEA/STL 16C)
- Tools, machines, products, and systems use energy in order to do work. (ITEA/STL 16D)
- Information is data that has been organized. (ITEA/STL 17A)
- Information can be acquired and sent through a variety of technological sources, including print and electronic media. (ITEA/STL 17E)
- Communication technology is the transfer of messages among people and/or machines over distances through the use of technology. (ITEA/STL 17F)
- Letters, characters, icons, and signs are symbols that represent ideas, quantities, elements, and operations. (ITEA/STL 17G)

Science: National Science Education Standards (*NRC, 1996*)

- Abilities necessary to do scientific inquiry. (NRC A Science as Inquiry)
- Properties of objects and materials. (NRC B Physical)
- Light, heat, electricity, and magnetism. (NRC B Physical)
- Objects in the sky. (NRC D Earth and Space Science)
- Abilities of technological design. (NRC E Science and Technology)
- Understanding about science and technology. (NRC E Science and Technology)
- Abilities to distinguish between natural objects and objects made by humans. (NRC E Science and Technology)
- Changes in environments. (NRC F Science in Personal and Social Perspectives)
- Science and technology in local challenges. (NRC F Science in Personal and Social Perspectives)
- Types of resources. (NRC F Science in Personal and Social Perspectives)
- Science as a human endeavor. (NRC G History and Nature of Science)

Mathematics: Principles and Standards for School Mathematics (NCTM, 2000)

- Understand measurable attributes of objects and the units, systems, and processes of measurement. (NCTM Measurement)
- Compute fluently and make reasonable estimates. (NCTM Number and Operations)
- Develop and evaluate inferences and predictions that are based on data. Select and use appropriate statistical methods to analyze data. (NCTM Data Analysis and Probability)

Geography: Geography for Life (*GSEP, 1994*)

- Understand the processes, patterns, and functions of human settlement. (GSEP 12)
- Understand how human actions modify the physical environment. (GSEP 14)
- Understand how physical systems affect human systems. (GSEP 15)

History: National Standards for History (*NCHS, 1996*)

- Understand major discoveries in science and technology, some of their social and economic effects, and the major scientists and inventors responsible for them. (NCHS 8)

Language Arts: Standards for the English Language Arts (*NCTE, 1996*)

- Students apply a wide range of strategies to comprehend, interpret, evaluate, and appreciate texts. (NCTE 1)
- Students adjust their use of spoken, written, and visual language to communicate effectively with a variety of audiences and for different purposes. (NCTE 4)
- Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audience for a variety of purposes. (NCTE 5)
- Students apply knowledge of language structure, language conventions, media techniques, figurative language, and genre to create, critique, and discuss print and nonprint texts. (NCTE 6)
- Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources to communicate their discoveries in ways that suit their purpose and audience. (NCTE 7)
- Students use a variety of technological and informational resources to gather and synthesize information and to create and communicate knowledge. (NCTE 8)
- Students use spoken, written, and visual language to accomplish their own purposes. (NCTE 12)

Unit Objectives

Lesson 1: Earth and Luna

Students will learn to:

1. Compare common features of Earth and the Moon.
2. Understand how environmental conditions affect technology.
3. Acknowledge the reciprocal relationship between technology developments, human needs, and the environment.
4. Appreciate the important role that exploration plays in technology development.

Lesson 2: Sources of Power

Students will learn to:

1. Identify items that use power.
2. Understand the relationship between power, energy, and electricity.
3. Identify seven different energy sources and their corresponding power technologies.
4. Acknowledge the importance of power to the human-made world.
5. Evaluate the reciprocal effects that technology and humans have on one another.

Lesson 3: Exploring Energy

Students will learn to:

1. Review different energy sources and their correlating power technology.
2. Explore energy sources through hands-on activities representing each source.
3. Express, in writing, the learning gained from each activity.

Lesson 4: Research and Development

Students will learn to:

1. Evaluate energy sources to identify three probable sources for lunar power.
2. Read about a specific energy source and select and record information about it.
3. Collaborate with other team members to complete an energy table.

Lesson 5: Promotional Posters

Students will learn to:

1. Apply knowledge of a specific energy source and its related technology to create an informational poster for the purpose of education and influence.
2. Communicate information using graphics and text.

Lesson 6: Promotion Presentation

Students will learn to:

1. Communicate information in an effort to persuade others.
2. Collaborate with team members to develop a general presentation sequence.
3. Orally present information in front of a live audience.
4. Listen attentively to gain information.

Lesson 7: Research-Based Design

Students will learn to:

1. Review and analyze research.
2. Collaborate and compromise with team members to decide on a lunar power station design.
3. Use the design process to develop and draw a final labeled design that reflects best research.
4. Communicate with other teams to ensure station-components compatibility.

Lesson 8: Lunar Power Station Construction

Students will learn to:

1. Develop a research-based design.
2. Utilize consumable materials to construct a model of a lunar-surface power station.
3. Collaborate and cooperate with team members to complete construction of a model station.
4. Communicate with other teams to ensure station-components compatibility.

Lesson 9: Report and Reflect

Students will learn to:

1. Revisit and communicate learned information.
2. Orally present information in front of a live audience.
3. Listen attentively to gain information.
4. Reflect upon learning gained throughout the entire design process.

Lesson 10: Optional Enrichment: Lunar Power Station Video Report

Students will learn to:

1. Synthesize knowledge of energy and power and the lunar environment.
2. Communicate knowledge and information through a student-created video production.
3. Develop competence in written and oral communication and video production.

Student Assessment Tools and/or Methods

1. Teacher Observations
2. Performance Rubrics
3. Selected Response Items
4. Brief Constructed Response Items

Optional Summative unit Rubric to Assess Overall Student Understanding

Key Understandings	Below Target	At Target	Above Target
Energy is needed to do work, and power technologies are developed to harness the energy so it can be used.	Student is unable to distinguish between an energy source and power technology.	Student recognizes that energy is what makes things move or change, and power is how we harness energy to do our work.	Student communicates the relationship between energy and power and is able to give a specific example illustrating this relationship.
There are many different types of energy sources.	Student is able to give only one example and/or gives “electricity” as the energy source.	Student is able to give at least three examples of different energy sources.	Student is able to give at least five examples of different energy sources.
Power technologies are used to harness the different energy sources.	Student can identify one or two power technologies and their energy sources but is unable to include any other factors in a comparison.	Student can identify and compare at least three different power technologies, including their source of energy and one example of cost or power efficiency or a trade-off.	Student can identify and compare four or more different power technologies, including their source of energy and an example each of cost, efficiency and trade-off.
Energy and power choices are based, in part, on the amount of energy required for a specific purpose.	Student is unable to interpret multiple factors from comparison data chart and is unable to conduct a data-driven evaluation.	Student uses data from an energy comparison chart to decide on a “best option” for power production on the Moon.	Student makes a data-driven choice of “best option” for power production on the Moon and justifies the choice by including: efficiency, cost, environmental/social impact, and technology readiness level.
Human needs, wants, and concerns determine how new technology is developed, improved, expanded, or limited.	Student is unable to see a correlation between the development of technology and human needs, wants, and concerns.	Student recognizes the correlation between the development of technology and human needs, wants, and concerns and is able to give one general example.	Student clearly articulates two or more specific examples of how human needs, wants, and concerns affect the development of technology.
The results of using technology can be negative or positive and can have unintended consequences.	Student views technology as either good or bad and is unable to provide any specific examples.	Student views technology itself as neutral and is able to describe two negative and two positive results of using that technology as well as one example of an unintended consequence.	Student views technology itself as neutral and is able to describe three positive and three negative results of using technology and unintended consequences. Further, student reasoning for positive or negative label is evident.
Design and modeling are valuable activities to further understanding.	Lunar power model is poorly constructed. The design does not reflect the understanding of energy data or basic lunar knowledge.	Lunar power model reflects a basic understanding of energy data and lunar environment. Model is satisfactorily constructed.	Lunar power model reflects a high level of understanding of the energy data and the lunar environment. Model includes many details and has been constructed with care.

Teacher Preparation and Resources

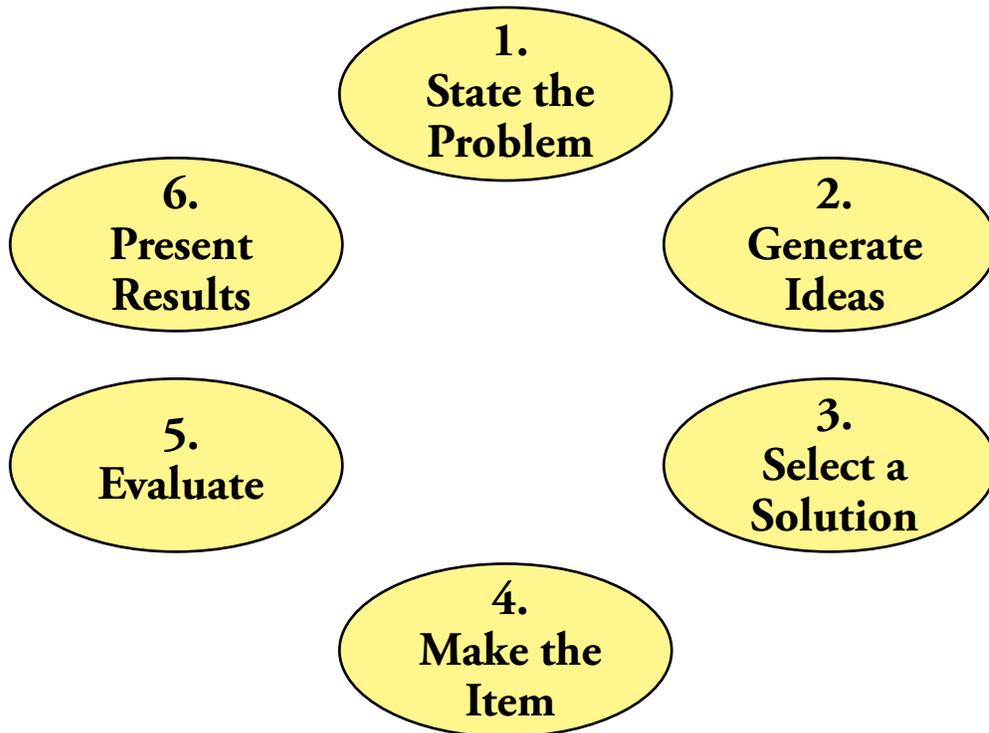
The Engineering Design Brief

Students participate in a class simulation in which they join NASA's mission of providing power for the first lunar colony. To accomplish this mission, students immerse themselves in the process of research and development and become part of NASA's Energy Research and Development Department. Frequent "Letters from NASA Headquarters" guide students through the simulation. Their mission assignments include:

- Exploring the lunar environment.
- The many sources of energy and the technology we use to harness that energy for usable power.
- Designing a specific energy and power system.
- Designing and constructing a lunar power station.

Teachers may find the resource, "Elementary School Standards-Based Engineering Design Process," helpful (next page).

Elementary School Standards-Based Engineering Design Process



1. State the Problem:
 - Explain the problem
 - Explain the guidelines
 - Set goals or desired results (teacher explanation)
2. Generate Ideas:
 - Brainstorm with others
 - Read books
 - Search the Internet
3. Select a Solution:
 - Sketches
 - Trial and error

4. Make the item:
 - Use resources
5. Evaluate:
 - Test, Revise; Test, Revise
 - Make adjustments/changes
 - Improve
6. Present Results:
 - Verbal explanations
 - Share models

Lesson 1: Earth and Luna

9

Lesson Snapshot

*Moon
Power*

Overview

Big Idea: Power is important to human exploration of space.

Teacher's Note: Big ideas should be made explicit to students by writing them on the board and/or reading them aloud.

*Lesson 1
Earth and
Luna*

Purpose of Lesson: This lesson helps students compare Earth and the Moon to gain an understanding of how environment, human needs, and society impact the development of technology.

Lesson Duration: Two hours.

Activity Highlights

Engagement: Students are introduced to the simulation of helping NASA prepare to send humans back to the Moon.

Exploration: Students discover some of the things humans will need to return to the Moon.

Explanation: The teacher guides students in comparing characteristics of the Moon and Earth.

Extension: Students discover some of the things humans will need on the Moon and come to focus on energy and power.

Evaluation: Throughout the discussion, the teacher checks for student understanding and corrects misconceptions.

Evaluation: Students engage in discussion of basic human needs on the Moon compared to additional needs. The teacher also introduces vocabulary.

Lesson 1: Overview

10

Lesson Duration

- Two hours.

Standards/Benchmarks

Technology: Standards for Technological Literacy (STL) (ITEA, 2000/2002/2007)

- Students will develop an understanding of the role of society in the development and use of technology. (ITEA/STL 6)
 - Because people’s needs and wants change, new technologies are developed, and old ones are improved to meet those changes. (6B)
 - Individual, family, community, and economic concerns may expand or limit the development of technologies. (6C)
- Students will develop an understanding of engineering design. (ITEA/STL 9)
 - Brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum. (9G)
- Students will develop the abilities to assess the impact of products and systems. (ITEA/STL 13)
 - Compare, contrast, and classify collected information in order to identify patterns. (13C)

Mathematics: Principles and Standards for School Mathematics (NCTM, 2000)

- Data Analysis and Probability
 - Develop and evaluate inferences and predictions that are based on data. Select and use appropriate statistical methods to analyze data. (NCTM Data Analysis and Probability)

Science: National Science Education Standards (NRC, 1996)

- Earth and Space Science (NRC D)
 - Objects in the sky. (NRC D Earth and Space Science)
- Science in Personal and Social Perspectives (NRC F)
 - Changes in environments. (NRC F Science in Personal and Social Perspectives)
 - Science and technology in local challenges. (NRC F Science in Personal and Social Perspectives)

Geography: Geography for Life (GSEP, 1994)

- Understand the processes, patterns, and functions of human settlement. (GSEP 12)
- Understand how human actions modify the physical environment. (GSEP 14)
- Understand how physical systems affect human systems. (GSEP 15)

History: National Standards for History (NCHS, 1996)

- Understand major discoveries in science and technology, some of their social and economic effects, and the major scientists and inventors responsible for them. (NCHS 8)

Language Arts: Standards for the English Language Arts (NCTE, 1996)

- Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources to communicate their discoveries in ways that suit their purpose and audience. (NCTE 7)

*Moon
Power*

*Lesson 1
Earth and
Luna*

Learning Objectives

Students will learn to:

1. Compare common features of Earth and the Moon.
2. Understand how environmental conditions affect technology.
3. Acknowledge the reciprocal relationship between technology developments, human needs, and the environment.
4. Appreciate the important role that exploration plays in technology development.

Student Assessment Tools and/or Methods

Assessment will consist of teacher observation of student participation in generating and completing the *Earth/Moon Comparison Chart*.

Resource Materials

Books, periodicals, pamphlets, and web sites may provide teachers and students with background information and extensions. Inclusion of a resource does not constitute an endorsement, either expressed or implied, by the National Aeronautics and Space Administration (NASA).

Lesson Resource Materials

- 1.1. Earth/Moon Information
Earth Facts <<http://solarsystem.nasa.gov/planets/profile.cfm?Object=Earth>>
Moon Facts
<<http://solarsystem.nasa.gov/planets/profile.cfm?Object=MoonandDisplay=Overview>>
- 1.2. NASA Online Video—“Moon, Mars And Beyond” <http://www.nasa.gov/mission_pages/exploration/main/index.html> (Lesson Resource 1.3)
- 1.3. NASA Online Videos “Lunar Landing” and “First Step” <<http://www.nasm.si.edu/collections/imagery/apollo/AS11/a11av.htm>> (Lesson Resource 1.4)
- 1.4. Earth/Moon Comparison Charts <<http://solarsystem.nasa.gov/planets/compchart.cfm>>
- 1.5. *Lunar Missions*
- 1.6. *Headquarters Letter 1*
- 1.7. *Moon and Earth Images*

Internet Sites

1. Earth Facts <<http://solarsystem.nasa.gov/planets/profile.cfm?Object=Earth>>
2. Moon Facts <<http://solarsystem.nasa.gov/planets/profile.cfm?Object=MoonandDisplay=Overview>>
3. Moon Facts <<http://www.nineplanets.org/luna.html>>
4. Earth/Moon Comparison <<http://solarsystem.nasa.gov/planets/compchart.cfm>>
5. Past lunar missions information <<http://solarsystem.nasa.gov/missions/profile.cfm?Sort=TargetandTarget=MoonandEra=Past>>
6. Apollo Program <<http://www.nasm.si.edu/exhibitions/attm/attm.html>>
7. President Kennedy’s speech <<http://vesuvius.jsc.nasa.gov/et/seh/ricetalk.htm>>
8. President Bush’s address online video “Into the cosmos...spirit of discovery” <http://www.nasa.gov/mission_pages/exploration/main/index.html>
9. Phases of the Moon <http://www.harcourtschool.com/activity/moon_phases2/>
10. Cooperative Learning information <<http://olc.spsd.sk.ca/DE/PD/instr/strats/coop/>>

Required Knowledge and Skills

1. Grade-level reading skills.
2. Basic understanding of the relationship and characteristics of Earth and the Moon.
3. Awareness of NASA as an agent of space exploration for the United States.

Lesson 1: 5-E Lesson Plan

Engagement

1. Students watch the online NASA video “Moon, Mars, and Beyond.”
2. The teacher shows students an envelope addressed to the school with no return address. (*Headquarters Letter 1*) The teacher opens the letter and reads it aloud to the class.
3. The teacher tells students that they are going to join NASA in this new challenge of exploration. Their role will be to educate themselves and others so NASA can send humans to live and work on the Moon.

Suggestion: When students ask, tell them this is a simulation—but don’t spoil the fun too soon!

4. The teacher asks students whether humans have been to the Moon before. (Yes.) Then the teacher gives a brief overview of past lunar missions, shows images of robotic lunar probes, describes the Apollo Program, and plays the online videos “Lunar Landing” and “First Step.” (*Lunar Missions*.)
5. The teacher discusses how past lunar missions, both manned and unmanned, have contributed to our knowledge of the Moon.

Exploration

1. The teacher poses these questions:
 - If we are going to send humans to live and work on the Moon, what are some things that might affect our mission?
 - What will humans need on the Moon?
2. The class discusses the first question. The teacher guides discussion to include how people feel about the technology or mission, available funds for technology and government support. The teacher asks students to speculate where space exploration would be if President Kennedy had never given his famous “Go To The Moon” speech and how President Bush’s statement will influence future space exploration.
3. The teacher shows the *Earth/Moon Comparison Charts* and asks students to take turns brainstorming the category titles. The teacher guides the brainstorming to include: Gravity, Temperature, Atmosphere, Day/Night Cycle, Surface/Orbit/Weather/Radiation/Size.
4. After category titles are complete, the teacher groups students into pairs. (Partners can be chosen by the teacher or the students.)

Explanation

1. The teacher distributes one copy of *Earth/Moon Information* to each pair and explains to student pairs that they will have 10 minutes to read through the sheet together and discuss their findings. The teacher may choose to use a timer if one is available.
2. After 10 minutes, the teacher directs student attention back to the *Earth/Moon Comparison Charts*.
3. Student pairs take turns providing information for each category. The teacher records ideas (for about 5 minutes).
4. The teacher asks students to interpret the chart, then give oral responses to the first question: Are there things about the Moon that are different from Earth that would affect our mission? The teacher records the responses.

Extension

1. The teacher reviews the second question: What will humans need while they are there?
2. Students are given 5 minutes to get back with their same partner and write a short list of human needs on the Moon. The teacher may use air and food as examples to guide student discussion. The teacher may choose to use a timer if one is available.
3. While students are writing their lists, the teacher displays a blank chart paper or transparency. After 5 minutes, the teacher directs student attention to the blank paper.
4. Each pair, in turn, reads their list. The teacher records ideas on paper as a compiled list of human needs on the Moon. (Acknowledge, but do not record duplicates.)
5. The teacher changes the discussion focus to make a generalized interpretation of the list. The teacher asks: Is there ONE thing that we HAVE to have for ALL of these needs to be met?
6. The teacher guides the discussion to focus on power, then tells the students: THIS IS YOUR MISSION. You will help NASA research and develop a power system for the Moon.
7. The teacher keeps all charts posted in the room for reference until completion of the unit.

Evaluation

1. As a whole group, the students analyze the compiled lists and include the completed *Earth/Moon Comparison Charts* in the analysis.
2. Throughout the discussion, the teacher checks for student understanding and corrects any misconceptions.

Enrichment

The teacher may choose to direct a discussion focusing on needs that are basic human needs and on special needs that exist only because the people would be living in the lunar environment.

Lesson 1: Lesson Preparation

14

Teacher Planning

- Review and prepare lesson resource materials prior to lesson.
- Display *Moon and Earth Images* in the classroom.
- Load and preview the online videos: NASA –“Moon, Mars, and Beyond,” Apollo “Lunar Landing” and “First Step.”

*Moon
Power*

*Lesson 1
Earth and
Luna*

Tools/Materials/Equipment

- Large chart paper with predrawn, labeled grid lines or a transparency of *Earth/Moon Comparison Charts* and a marker for recording the brainstorming session.
- Blank chart papers or blank overhead transparency.

Classroom Safety and Conduct

There are no specific safety requirements. Students are expected to follow standard classroom and school safety rules.

Lesson 2: Sources of Power

15

Lesson Snapshot

*Moon
Power*

*Lesson 2
Sources of
Power*

Overview

Big Idea: Energy and power are used on Earth in many ways, and there are many things to think about before choosing the energy and power source to be used for a specific purpose.

Teacher's Note: Big ideas should be made explicit to students by writing them on the board and/or reading them aloud.

Purpose of Lesson: This lesson will help students understand the meaning of power, energy, and electricity and the relationship of these concepts to one another. Students identify many different energy sources and the technology used to convert them into power. Students also acknowledge the reciprocal effects that technology and humans have on one another and the environment.

Lesson Duration: One hour.

Activity Highlights

Engagement: The teacher introduces the students to their mission: Bring power to the Moon.

Exploration: Students make observations about power in their own environment.

Explanation: The teacher explains energy symbols and sources, and guides students in a discussion about what “power technology” is used to convert each energy source into electricity or for converting energy into power.

Extension: Students explore how an energy source or power technology affects people or the environment.

Evaluation: Formative assessment occurs during student participation.

Enrichment: The teacher may choose to embed vocabulary with the lesson or use it as a distinct feature of the lesson (**Key Vocabulary 2**).

Lesson 2: Overview

16

Lesson Duration

- One hour.

Purpose of Lesson

This lesson will help students understand the meaning of power, energy, and electricity and the relationship of these concepts to one another. Students identify many different energy sources and the technology used to convert them into power. Students also acknowledge the reciprocal effects that technology and humans have on one another and the environment.

Standards/Benchmarks

Technology: Standards for Technological Literacy (STL) (ITEA, 2000/2002/2007)

- Students will develop an understanding of the core concepts of technology. (ITEA/STL 2)
 - Resources are the things needed to get a job done, such as tools and machines, materials, information, energy, people, capital, and time. (ITEA/STL 2H)
- Students will develop an understanding of the cultural, social, economic, and political effects of technology. (ITEA/STL 4)
 - The results of using technology can be good or bad. (ITEA/STL 4B)
- Students will develop an understanding of and abilities to select and use energy and power technologies. (ITEA/STL 16)
 - Energy comes in many different forms. (ITEA/STL 16C)
 - Tools, machines, products, and systems use energy in order to do work. (ITEA/STL 16D)

Mathematics: Principles and Standards for School Mathematics (NCTM, 2000)

- Data Analysis and Probability
 - Develop and evaluate inferences and predictions that are based on data. Select and use appropriate statistical methods to analyze data. (NCTM Data Analysis and Probability)

Science: National Science Education Standards (NRC, 1996)

- Physical Science (NRC B)
 - Properties of objects and materials. (NRC B Physical)
- Science and Technology (NRC E)
 - Understanding of science and technology. (NRC E Science and Technology)
 - Abilities to distinguish between natural objects and objects made by humans. (NRC E Science and Technology)
 - Types of resources. (NRC F Science in Personal and Social Perspectives)
- History and Nature of Science (NRC G)
 - Science as a human endeavor. (NRC G History and Nature of Science)

Geography: Geography for Life (GSEP, 1994)

- Understand how human actions modify the physical environment. (GSEP 14)
- Understand how physical systems affect human systems. (GSEP 15)

Language Arts: Standards for the English Language Arts (NCTE, 1996)

- Students apply a wide range of strategies to comprehend, interpret, evaluate, and appreciate texts. (NCTE 1)
- Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources to communicate their discoveries in ways that suit their purpose and audience. (NCTE 7)

*Moon
Power*

*Lesson 2
Sources of
Power*

Learning Objectives

Students will learn to:

1. Identify items that use power.
2. Understand the relationship between power, energy, and electricity.
3. Identify seven different energy sources and their corresponding power technologies.
4. Acknowledge the importance of power to the human-made world.
5. Evaluate the reciprocal effects that technology and humans have on one another.

Student Assessment Tools and/or Methods

Assessment will consist of teacher observation of student participation in class discussion and completion of the *Power and Energy Chart*.

Resource Materials

Books, periodicals, pamphlets, and web sites may provide teachers and students with background information and extensions. Inclusion of a resource does not constitute an endorsement, either expressed or implied, by NASA.

Lesson Resource Materials

- 2.1. *How Electricity is Generated*
- 2.2. *What Is Energy?*
- 2.3. *Graphic Map*
- 2.4. *Key Vocabulary 2*
- 2.5. *Power and Energy Chart*
- 2.6. *Graphic Map*
- 2.7. *Headquarters Letter 2*

Internet Sites

1. Interactive Energy Site for Kids—Department of Energy (DOE).
<<http://www.eia.doe.gov/kids/>>
2. Student Glossary of Energy Terms <<http://www.eia.doe.gov/kids/glossary/index.html>>
3. Energy Activities <<http://www.eia.doe.gov/kids/classactivities/teachersandstudents.html>>
4. How Antimatter Works <<http://science.howstuffworks.com/antimatter.htm/printable>>

Required Knowledge and Skills

Grade-level reading skills.

Lesson 2: 5-E Lesson Plan

18

Engagement

1. The teacher begins the lesson by telling students that he/she replied to NASA and has received another letter. The teacher reads *Headquarters Letter 2* aloud to the class.

Suggestion: Raise the class enthusiasm by telling the students, “TODAY WE BEGIN OUR NASA MISSION TO BRING POWER TO THE MOON! What we learn from our research today will be our first step.”

2. The teacher prompts a class discussion by asking these questions:
 - Why do we need power on the Moon? (Refer students back to the “Human Needs n the Moon Chart.”)
 - Do we need power here on Earth?
 - Why?
3. As the teacher asks “Why?” he/she begins passing out a few sticky notes to each student.
4. The teacher explains that they are going on a classroom scavenger hunt. They will have 5 minutes to stick a note to all of the items that require power to work. No duplicates are permitted.
5. The teacher may choose to use a timer is one if available and monitor the “hunt.” After 5 minutes, students return to their seating area.

Exploration

1. The teacher asks a few students for their observations regarding the many sticky notes. The teacher may include this additional observation: “Power was also used to transport or make most of the other items in the room, including student clothes!” The teacher should stress how important power has become in peoples’ lives.
2. The teacher starts a class question/response discussion by posing these questions in sequence.
 - So what is power? (The most common response will be “electricity.” This will be the main focus, but the teacher should also include combustion engines in transportation and will need to define the term “combustion.”)
 - Where do we get the electricity? (Examples include cords, power poles/lines and stations, among other possible answers.)
3. Where do the power stations get it? (Most students will not know.)
4. The teacher displays the *Power and Energy Chart*. The teacher has students read the definition of power and energy out loud with him/her. The teacher clarifies the terms conversion and energy.
5. The teacher prompts the discussion: “If power is converted energy, where do we get the energy?”
6. The teacher draws student attention to the energy symbols on the chart and explains that there are many different “sources” of energy, clarifying the term “sources.”

*Moon
Power*

*Lesson 2
Sources of
Power*

Explanation

1. The teacher asks students if they can guess what the energy symbols stand for and writes down correct student responses in the chart while giving brief explanations of each source. The teacher also mentions antimatter (though it is not on the chart) and includes details for each. (Examples: renewable/nonrenewable/clean-pollutive/safe-hazardous. Background information: *How Electricity Is Generated* and *Hydrogen Fuel Cells and Antimatter*).
2. After all of the symbols are labeled, the teacher guides the students in a discussion about what “power technology” is used to convert each energy source into electricity or for converting the energy into power. The teacher writes down correct student responses in the chart.

Extension

1. The teacher explains to the students that technology itself is neither good nor bad, but there are good and bad effects from technology on people and our environment. Because power is so important to people, they have very strong feelings about how and where we get it.
2. The teacher asks students to turn to their neighbor and share one example of how an energy source or power technology affects people or the environment. (Students should use the chart as a reference; however, their statements will and should be heavily weighted with opinion.)

Evaluation

After about 2 minutes, the teacher asks students to share their neighbor’s comments with the class (observing student participation), while explaining that NASA must take all of these “feelings or opinions” into account when they are developing new technologies, and so will the class.

Suggestion: A good way to conclude the lesson is by telling students: “Our NASA mission is to research and develop power for the Moon. Soon we will be finished with our research, and we will need everything we have learned to make a smart choice of which one of these energy sources will power our lunar station.”

Enrichment

The teacher may choose to embed vocabulary within the lesson or use it as a distinct feature of the lesson. (*Key Vocabulary 2*)

Lesson 2: Lesson Preparation

20

Teacher Planning

- Review: *How Electricity is Generated*, *What Is Energy?* and *Graphic Map*.
- Review *Key Vocabulary 2*.
- Project or print overhead transparency of *Power and Energy Chart* and *Graphic Map*.
- Ready sticky notes in preparation for the classroom scavenger hunt.

*Moon
Power*

*Lesson 2
Sources of
Power*

Tools/Materials/Equipment

- Overhead or computer projector.
- Sticky-note page markers (preferable) or sticky-note pads

Classroom Safety and Conduct

- The teacher should explain about walking safely during the scavenger hunt.
- Students are expected to follow standard classroom and school safety rules.

Lesson 3: Exploring Energy

21

Lesson Snapshot

*Moon
Power*

*Lesson 3
Exploring
Energy*

Overview

Big Idea: There are many different sources of energy, and each source has its own set of characteristics.

Teacher's Note: Big ideas should be made explicit to students by writing them on the board and/or reading them aloud.

Purpose of Lesson: This lesson allows students to gain hands-on understanding of various energy sources. Students make observations about each energy source and how different technology is used to harness the energy to provide usable power.

Lesson Duration: Two hours.

Activity Highlights

Engagement: Students review the *Power and Energy* chart from Lesson 2 and are introduced to research stations set up around the room.

Exploration: Students receive their team badges and coordinate with other members of their research teams.

Explanation: Student teams rotate throughout the research stations, using their *Exploring Energy Observation Sheets*.

Extension: After the final rotation is finished, student teams conference with another team to share learning experiences.

Evaluation: *Exploring Energy Observation* sheets are completed by students. The teacher may choose to embed vocabulary within the lesson or use it as a distinct feature of the lesson. (**Key Vocabulary 3**)

Lesson 3: Overview

22

Lesson Duration

- Two hours.

Standards/Benchmarks

Technology: Standards for Technological Literacy (STL) (ITEA, 2000/2002/2007)

- Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving. (STL 10)
 - Asking questions and making observations helps a person figure out how things work. (10A)
- Students will develop an understanding of and abilities to select and use energy and power technologies (ITEA/STL 16)
 - Energy comes in many different forms. (16A)
 - Tools, machines, products, and systems use energy in order to do work. (16D)

Mathematics: Principles and Standards for School Mathematics (NCTM, 2000)

- Measurement
 - Understand measurable attributes of objects and the units, systems, and processes of measurement. (NCTM Measurement)

Science: National Science Education Standards (NRC, 1996)

- Science as Inquiry (NRC A)
 - Abilities necessary to do scientific inquiry. (NRC A Science as Inquiry)
- Physical Science (NRC B)
 - Properties of objects and materials. (NRC B Physical)
- Science and Technology (NRC E)
 - Understanding of science and technology. (NRC E Science and Technology)
- Science in Personal and Social Perspectives (NRC F)
 - Types of resources. (NRC F Science in Personal and Social Perspectives)

Geography: Geography for Life (GSEP, 1994)

- Understand how human actions modify the physical environment. (GSEP 14)
- Understand how physical systems affect human systems. (GSEP 15)

Language Arts: Standards for the English Language Arts (NCTE, 1996)

- Students use spoken, written, and visual language to accomplish their own purposes. (NCTE 12)

Learning Objectives

Students will learn to:

1. Review different energy sources and their correlating power technology.
2. Explore energy sources through hands-on activities representing each source.
3. Express, in writing, the learning gained from each activity.

Student Assessment Tools and/or Methods

1. Participation in hands-on activities.
2. Completion of *Exploring Energy Observation Sheet*.

*Moon
Power*

*Lesson 3
Exploring
Energy*

Resource Materials

Lesson Resource Materials

- 3.1. One copy per team of *Exploring Energy Observation Sheet*.
 - 3.2. *Energy Exploration Rotation Badges* printed and trimmed (print on six different colors to represent rotation teams).
 - 3.3. *Energy Station Signs* printed and one posted at each station location.
 - 3.4. *Station Directions* (explaining sequential steps for completing each hands-on activity).
 - 3.5. Teacher information on *Energy Station Signs, Directions, Set up* for Energy Stations.
 - 3.6. *Key Vocabulary*
- 2.1. Teacher resource: *How Electricity Is Generated*.
 - 2.6. *Power and Energy Chart* transparency (completed in Lesson 2).

Internet Sites

1. Human Energy Use Timeline <<http://www.eia.doe.gov/kids/history/timelines/general.html>>
2. Energy Quest-Interactive Site <<http://www.energyquest.ca.gov/index.html>>
3. Geothermal Activity <<http://www.energyquest.ca.gov/projects/geothermal-pp.html>>
4. Biomass Energy <<http://www.energyquest.ca.gov/story/chapter10.html>>

Required Knowledge and Skills

1. Grade-level reading and writing skills.
2. Understanding of the definition of energy and power.
3. Identification of energy sources: solar/nuclear/geothermal/chemical/fossil fuel/wind/hydro-water.

Lesson 3: 5-E Lesson Plan

24

*Moon
Power*

*Lesson 3
Exploring
Energy*

Engagement

1. The teacher reviews the information on the *Power and Energy Chart* (from Lesson 2) briefly for student understanding of energy, power, and the different energy sources.
2. The teacher explains to the students that in order for them to make an educated choice for a source of lunar power, they will have to expand their research and explore the potential energy sources.
3. The teacher directs student attention to the stations set up around the room and tells them that they will rotate through each station to get hands-on experience with each energy source.

Teacher Note: Due to the burn risk from steam, a geothermal station is not included. However, a direct link to geothermal activity is provided in the **Additional Resource Materials**.

Exploration

1. The teacher begins by handing out a colored badge to each student and explains that the different colors represent the team that students will stay with throughout the rotation activity.
2. The teacher tells students to find others with the same color, then sit quietly and wait for instructions.
3. The teacher explains that each rotation team will have 15 minutes to complete each station. Team responsibilities at each station include:
 - Read information on Energy Station Signs.
 - Follow ALL safety precautions.
 - Follow ALL procedures for hands-on activity.
 - Complete the Exploring Energy Observation Sheet.
 - Dismantle and clean up.
4. The teacher may choose to use a timer if one is available. At 15-minute intervals, teams proceed sequentially to the next station listed on their *Exploring Energy Observation* Sheets.

Suggestion: Show an actual *Exploring Energy Observation* sheet, and model how the rotation will take place.

Explanation

1. The teacher hands out a pencil and a clipboard (with the *Exploring Energy Observation* Sheets) to each team, then leads each team to a different station as their starting point.
2. The teacher tells teams to look at their *Exploring Energy Observation* Sheets to find the next station to which they will be rotating.

Suggestion: Have students visually locate their next station. (This will be their rotation routine.)

3. The teacher may choose to use a timer if one is available; but in any case, the teacher starts timing 15 minutes for the first rotation. (the teacher will do this six times during this activity.)

Suggestion: It is helpful to plan this activity with a recess or break in the middle to give students a rest.

4. The teacher monitors all teams for understanding, participation, and team cooperation.

Extension

After the final rotation is finished, student teams conference with another team to share learning experiences.

Evaluation

1. As a whole class, students participate in a brief sharing session. Each group has one minute to share observations and learning.
2. The teacher collects all team *Exploring Energy Observation Sheets*. (They will be used again in Lesson 4.)

Enrichment

The teacher may choose to embed vocabulary within the lesson or use it as a distinct feature of the lesson. (*Key Vocabulary 3*)

Lesson 3: Lesson Preparation

26

*Moon
Power*

*Lesson 3
Exploring
Energy*

Teacher Planning

- Review *Energy Station Signs, Directions, Setup*.
- Choose locations around the classroom (set up one day prior to rotation to ensure all materials are ready).
- Group students into six heterogeneous rotation teams.
- Give each team member the same colored rotation badge. (Members will wear their badges during rotation — doubled-up masking tape on back works well.)
- Provide each team with pencils, clipboards, and *Exploring Energy Observation Sheets*.

Tools/Materials/Equipment

Check *Energy Station Signs, Directions, Setup* for each energy station.

Classroom Safety and Conduct

- The teacher should explain about walking safely, following directions, and other responsible behavior during station rotation.
- Each station location will have safety precautions listed on student directions for hands-on activities.

Lesson 4: Research and Development

27

Lesson Snapshot

Overview

Big Idea: Research and development helps guide the choices made by professional scientists and engineers.

Teacher's Note: Big ideas should be made explicit to students by writing them on the board and/or reading them aloud.

Purpose of Lesson: This lesson helps students further experience the importance of the research process and realize that research can occur over very long periods of time before any actual development occurs. Students determine probable energy sources for lunar power and work as productive team members to collect and examine information.

Lesson Duration: 1 hour.

Activity Highlights

Engagement: The teacher reads *Headquarters Letter 4*. Students choose the energy sources available on the Moon.

Exploration: Students form solar, chemical, and nuclear research teams.

Explanation: The teacher explains that each team will contribute to completing the *Lunar Power Research: Development Data Report* and directs teams to stations around the room.

Extension: After the chart is complete, members discuss their findings within the team, while the teacher monitors.

Evaluation: The teacher evaluates student-completed *Energy Table*.

*Moon
Power*

*Lesson 4
Research
and
Development*

Lesson 4: Overview

28

Lesson Duration

- One hour.

Standards/Benchmarks

Technology: Standards for Technological Literacy (STL) (ITEA, 2000/2002/2007)

- Students will develop an understanding of the cultural, social, economic and political effects of technology. (STL 4)
 - When using technology, results can be good or bad. (4B)
 - The use of technology can have unintended consequences. (4C)
- Students will develop an understanding of the effects of technology on the environment. (STL 5)
 - The use of technology affects the environment in good and bad ways. (5C)
- Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving. (STL 10)
 - Research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace. (10I)
- Students will develop an understanding of and abilities to select and use information and communication technologies. (STL 17)
 - Information is data that has been organized. (17A)

Mathematics: Principles and Standards for School Mathematics (NCTM, 2000)

- Data Analysis and Probability
 - Develop and evaluate inferences and predictions that are based on data. Select and use appropriate statistical methods to analyze data. (NCTM Data Analysis and Probability)

Science: National Science Education Standards (NRC, 1996)

- Physical Science (NRC B)
 - Light, heat, electricity, and magnetism. (NRC B Physical)
- Science and Technology (NRC E)
 - Understanding of science and technology. (NRC E Science and Technology)
 - Abilities to distinguish between natural objects and objects made by humans. (NRC E Science and Technology)
- Science in Personal and Social Perspectives (NRC F)
 - Types of resources. (NRC F Science in Personal and Social Perspectives)

Geography: Geography for Life (GSEP, 1994)

- Understand how human actions modify the physical environment. (GSEP 14)
- Understand how physical systems affect human systems. (GSEP 15)

History: National Standards for History (NCHS, 1996)

- Understand major discoveries in science and technology, some of their social and economic effects, and the major scientists and inventors responsible for them. (NCHS 8)

Language Arts: Standards for the English Language Arts (NCTE, 1996)

- Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources to communicate their discoveries in ways that suit their purpose and audience. (NCTE 7)

*Moon
Power*

*Lesson 4
Research
and
Development*

Learning Objectives

Students will learn to:

1. Evaluate energy sources to identify three probable sources for *Lunar Power*.
2. Read about a specific energy source, and select and record information required for the *Energy Tables*.
3. Collaborate with other team members to complete an *Energy Table*.

Student Assessment Tools and/or Methods

1. Teacher observation of student participation in teams and class discussion.
2. Teacher evaluation of completed *Energy Tables*. Tables must be written neatly, with detailed information for each table category.

Resource Materials

Books, periodicals, pamphlets, and web sites may provide teachers and students with background information and extensions. Inclusion of a resource does not constitute an endorsement, either expressed or implied, by NASA.

Lesson Resource Materials

- 4.1. *Energy Information Sheets* (Students will cut sections apart during research.)
- 4.2. *Energy Tables*
- 4.3. *Lunar Power Research and Development Data Report*
- 4.4. Printed *Research and Development Team Badges*
- 4.5. *Headquarters Letter 4*
- 4.6. *Technology Readiness Levels Summary*
- 4.7. *Key Vocabulary*
- 3.1. Copies of student observations from *Exploring Energy Observation Sheet*.

Internet Sites

1. Solar Energy <<http://science.howstuffworks.com/solar-cell.htm>>
2. Chemical Energy <<http://science.howstuffworks.com/battery.htm>>
3. Nuclear Energy
 - General Information <<http://science.howstuffworks.com/nuclear-power.htm>>
 - Fission <<http://www.historyoftheuniverse.com/nuclfiss.html>>
 - Fusion <<http://www.historyoftheuniverse.com/fusion.html>>
4. Interactive Power Simulation Game (illustrates tradeoffs) <<http://www.kineticcity.com/controlcar/activity.php?virus=enerviaandact=4>>

Required Knowledge and Skills

1. Grade-level reading skills.
2. Familiarity with the definitions of energy and power, and the energy sources explained in Lesson 2.
3. Experience working in a cooperative group.

Engagement

1. The teacher hands out *Headquarters Letter 4* and reads it aloud to the class.
2. The teacher displays the *Power and Energy Chart* completed in Lesson 2.
3. The teacher reminds students that now that they have a better understanding of potential energy sources and their mission requires them to choose sources that could be used on the Moon.
4. The teacher tells students to think back to when they first started their research and learned about the lunar environment and asks students to analyze the chart to see if there are any energy sources that could not be used on the Moon, and give their reasons why. The teacher crosses out these sources (geothermal, fossil fuel, hydro, wind).
5. The teacher identifies the three sources not crossed out (solar, chemical, and nuclear).

Exploration

1. The teacher reminds students about *Headquarters Letter 4* and explains that in this stage of research and development, NASA will sometimes form specialized research teams to find out all they can so a final decision can be made.
2. The teacher guides students in choosing solar, chemical, or nuclear energy for their specialized research.

Suggestion: Encourage students to follow their own interest versus their friends' to form the three teams. Monitor the process to keep student numbers balanced.

3. After solar, chemical, and nuclear research teams are formed, teams sit together for further instructions.

Explanation

1. The teacher hands out team badges and displays the *Lunar Power Research and Development Data Report* as a transparency or projection. The teacher explains that each research team will be searching for information that will help them complete this chart.

Suggestion: Refer to the displayed chart as you explain each category. (Refer to *Key Vocabulary 4*.)

2. The teacher checks for understanding of chart completion procedures.
3. All members read for information. (Each will choose a section of information to read, then use scissors to cut apart from original page).
4. All team members participate in team discussion and recording onto chart.
5. The teacher hands out *Energy Information Sheets* and also has several copies of completed *Exploring Energy Observation Sheets* (from Lesson 3) available for teams to share. The teacher also hands out pencils and clipboards with *Energy Tables*.
6. The teacher directs students to different locations in the classroom to begin their research and monitors team progress for understanding, work quality, and time. The teacher may need to adjust time allowed according to need.

Extension

After the chart is complete, members discuss their findings within the team, while the teacher monitors.

Evaluation

The teacher collects all team work, badges, and information sheets (save in a team folder), then asks each team to briefly tell and explain if they think their energy source should be chosen for Lunar power and why.

Teacher Note: The TEACHER will be recording all team research findings onto the *Lunar Power Research and Development Data Report*. (The completed chart will be used in Lesson 6.)

Enrichment

1. If teams finish early, they can play the “Power Up” computer simulation game at <http://www.kineticcity.com/controlcar/activity.php?virus=enerviaandact=4>.
2. The teacher may choose to embed vocabulary within the lesson or use it as a distinct feature of the lesson. (*Key Vocabulary 4*)

Lesson 4: Lesson Preparation

32

Teacher Planning

- Preview *Energy Information Sheets*.
- Review *Key Vocabulary 4* and *Technology Readiness Levels Summary*.
- Print or have ready an overhead transparency or projection of the *Energy Table* and *Lunar Power Research and Development Data Report*.
- Print one *Energy Table* for each team.
- Print, trim, and hand out *Research and Development Team Badges*.
- Guide the formation of teams according to their choice of energy source.
- Recommended: Briefly read background information on solar/chemical/nuclear energy located on the “How Stuff Works” web sites.

*Moon
Power*

*Lesson 4
Research
and
Development*

Tools/Materials/Equipment

Overhead or computer projector.

Classroom Safety and Conduct

There are no specific safety requirements. Students are expected to follow standard classroom and school safety rules.

Lesson 5: Promotion Poster

33

Lesson Snapshot

*Moon
Power*

Overview

Big Idea: Research must be presented in an organized manner.

Teacher's Note: Big ideas should be made explicit to students by writing them on the board and/or reading them aloud.

*Lesson 5
Promotion
Poster*

Purpose of Lesson: This lesson requires that students apply knowledge of a specific energy source and its related technology to create an informational poster for the purpose of education and influence.

Lesson Duration: Two hours.

Activity Highlights

Engagement: The teacher reads *Headquarters Lesson 5*, which explains that students are competing for a monetary grant.

Exploration: Students become familiar with the tools and requirements for creating a poster and a presentation about their energy source.

Explanation: As teams work on posters, the teacher monitors all teams, providing explanations as necessary and adjusting time and assistance as needed.

Extension: As teams progress, the teacher can suggest (or designate) that several members begin discussing how they will present the poster.

Evaluation: Rubrics to guide and assess: *Poster Rubric* and *Presentation Rubric*

Enrichment: The teacher may choose to embed vocabulary within the lesson or use it as a distinct feature of the lesson. See *Key Vocabulary 5*.

Lesson 5: Overview

34

Lesson Duration

- Two hours.

Standards/Benchmarks

Technology: Standards for Technological Literacy (STL) (*ITEA, 2000/2002/2007*)

- Students will develop an understanding of and abilities to select and use information and communication technologies. (STL 17)
 - Letters, characters, icons, and signs are symbols that represent ideas, quantities, elements, and operations. (17G)

Science: National Science Education Standards (*NRC, 1996*)

- Physical Science (NRC B)
 - Light, heat, electricity, and magnetism. (NRC B Physical)

Language Arts: Standards for the English Language Arts (*NCTE, 1996*)

- Students adjust their use of spoken, written, and visual language to communicate effectively with a variety of audiences and for different purposes. (NCTE 4)
- Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences for a variety of purposes. (NCTE 5)
- Students use spoken, written, and visual language to accomplish their own purposes. (NCTE 12)

Learning Objectives

Students will learn to:

1. Apply knowledge of a specific energy source and its related technology to create an informational poster for the purpose of education and influence.
2. Communicate information using graphics and text.

Student Assessment Tools and/or Methods

1. Teacher observation of individual participation in completing poster.
2. Teacher evaluation of completed poster, using *Poster Rubric*.
3. *Presentation Rubric*.

Resource Materials

Lesson Resource Materials

- 5.1. Research team folders (badge, research and development charts, information sheets, copy of blank Poster Rubric Form).
- 5.2. *Digital Graphics* file for each energy source.
- 5.3. *Poster Rubric Form*.

Internet Sites

1. From the Archives, “Teaching With Documents: Powers of Persuasion” Poster Art: <<http://www.archives.gov/education/lessons/wwii-posters/>>
2. NASA’s Lunar Mission: <<http://www.nasa.gov/missions/solarsystem/cev.html>>
3. NASA Human Space Exploration video clips: <http://www.nasa.gov/worldbook/space_exploration_worldbook.html>
4. The Artemis Lunar Colony (potential designs and virtual tour): <<http://www.asi.org/index2.html>>

*Moon
Power*

*Lesson 5
Promotion
Poster*

Required Knowledge and Skills

1. Grade-level reading and writing skills.
2. Basic ability to manipulate size of digital graphics.
3. Understanding of energy and power.
4. Knowledge of specific sources: solar, chemical, and nuclear energy.

*Moon
Power*

*Lesson 5
Promotion
Poster*

Lesson 5: 5-E Lesson Plan

36

Engagement

1. The teacher sends research teams to their predesignated work areas.
2. The teacher praises teams on their progress and tells them that the long, hard, detailed work of research is finally over! But, even though they have all of the information, the teams must now persuade the whole class that THEIR energy source should be chosen to provide power for the Moon.
3. The teacher reads *Headquarters Letter 5*, which explains that they are competing for a monetary grant. This grant will ensure that they can develop their energy source and keep their jobs!

Suggestion: In addition you could also include “bonuses” (e.g., snacks, stickers, free time points).

Exploration

1. The teacher explains that students will be creating and presenting a persuasive, informational poster about their energy as the primary source for providing power to the Moon.
2. The teacher hands out team folders and refers to the *Poster Rubric* and *Presentation Rubric*, explaining that this will be used to evaluate the quality of their posters. (The teacher should be sure to mention individual participation and cooperation and the team evaluation section.)
3. The teacher shows the class where the supplies are located and briefly explains the process they will use to access text and graphics.

Suggestion: Check for understanding of procedures and assist team “badging” (new tape).

Explanation

As teams work on posters, the teacher monitors all teams, providing explanation as necessary and adjusting time and assistance as needed.

Extension

As teams progress, the teacher can suggest (or designate) that several members begin discussing HOW they will present the poster.

Evaluation

1. Teams discuss and complete the “Team Evaluation” section of the *Poster Rubric*.
2. All teams turn in completed posters and Team Folders.
3. *Presentation Rubric*.

Enrichment

The teacher may choose to embed vocabulary within the lesson or use it as a distinct feature of the lesson. (*Key Vocabulary 5*)

*Moon
Power*

*Lesson 5
Promotion
Poster*

Lesson 5: Lesson Preparation

37

Teacher Planning

- Designate areas of room for specific teams.
- Open word processing program and digital graphic collection.
- Set up a central supply area for art supplies.
- Pre-organize team folders to include all materials.

*Moon
Power*

*Lesson 5
Promotion
Poster*

Tools/Materials/Equipment

- Computer access to photos and graphics files (included) of each energy source. Teams can choose and change size of graphics to print out for use in posters.
- Computer access to a word processing program for poster text. (If printers are not available to students, they will write text, and the teacher will need to give each team a preprinted selection of graphics.)
- Poster board (white or colored).
- Note paper, pencils, crayons, markers, glue, and scissors.

Classroom Safety and Conduct

There are no specific safety requirements.

Lesson 6: Poster Presentation

38

Lesson Snapshot

Overview

Big Idea: Research must be presented in an organized manner.

Teacher's Note: Big ideas should be made explicit to students by writing them on the board and/or reading them aloud.

Purpose of Lesson: This lesson helps students develop public speaking and listening skills by orally presenting information in a persuasive manner.

Lesson Duration: Two hours.

Activity Highlights

Engagement: Students discover that they will use all of their findings to guide their choice for the energy source that will produce power on the Moon.

Exploration: Student teams sequence their presentations and practice.

Explanation: The presentation order is established and recorded.

Extension: Student teams take turns giving presentations. Students vote and the energy source is chosen by majority.

Evaluation: The written assessment may be administered any day after this lesson is completed.

*Moon
Power*

*Lesson 6
Poster
Presentation*

Lesson Duration

- Two hours.

Standards/Benchmarks

Technology: Standards for Technological Literacy (STL) (*ITEA, 2000/2002/2007*)

- Students will develop an understanding of and abilities to select and use information and communication technologies. (*STL 17*)
 - Information can be acquired and sent through a variety of technological sources, including print and electronic media. (*17E*)
 - Letters, characters, icons, and signs are symbols that represent ideas, quantities, elements, and operations. (*17G*)

Science: National Science Education Standards (*NRC, 1996*)

- Physical Science (NRC B)
 - Light, heat, electricity, and magnetism. (NRC B Physical)

Language Arts: Standards for the English Language Arts (*NCTE, 1996*)

- Students adjust their use of spoken, written, and visual language to communicate effectively with a variety of audiences and for different purposes. (NCTE 4)
- Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audience for a variety of purposes. (NCTE 5)
- Students use spoken, written, and visual language to accomplish their own purposes. (NCTE 12)

Learning Objectives

Students will learn to:

1. Communicate information in an effort to persuade others.
2. Collaborate with team members to develop a general presentation sequence.
3. Orally present information in front of a live audience.
4. Listen attentively to gain information.

Student Assessment Tools and Methods

1. Teacher observation of oral presentation.
2. Teacher evaluation of presentation using rubric form.

*Moon
Power*

*Lesson 6
Poster
Presentation*

Resource Materials

Books, periodicals, pamphlets, and web sites may provide teachers and students with background information and extensions. Inclusion of a resource does not constitute an endorsement, either expressed or implied, by NASA.

Lesson Resource Materials

- 6.1. *Poster Rubric*
- 6.2. *Poster/Presentation Sequence Sheets*
- 6.3. Completed Team Posters
- 6.4. Written Assessment
- 6.5. *Headquarters Letter 6*

Internet Sites

1. Developing a Persuasive Speech <<http://www.lessonstutor.com/dppersuasive.html>>
2. Writing A Presentation <<http://lorien.ncl.ac.uk/ming/Dept/Tips/present/comms.htm>>
3. Phases of the Moon <<http://www.ktca.org/newtons/15/phases.html>>
4. NASA Lunar Colony <<http://www.lpi.usra.edu/education/EPO/explore/colony.pdf>>

Required Knowledge and/or Skills

1. Grade-level reading skills.
2. Understanding of team topic.
3. Familiarity with presentation sequence.

Lesson 6: 5-E Lesson Plan

41

*Moon
Power*

*Lesson 6
Poster
Presentation*

Engagement

1. The teacher tells the class that today is the day that they will use all of their findings to guide their choice for the energy source that will produce power for the Moon.
2. The teacher displays *Lunar Power Research and Development Data Report* (team research should already be recorded on this chart by the teacher).
3. The class discusses the team findings on the chart. The teacher reminds students that their presentations today will play a very important role in making the final energy source decision.

Exploration

1. The teacher displays a blank *Poster/Presentation Sequence* sheet then a *Teacher Example*.
2. The class reads through the sheets while the teacher explains that each team will use this as a guide for planning their presentation.
3. The teacher checks for understanding of procedures and sends teams to work areas.
4. The teacher hands out completed team posters, clipboards, pencils, cue cards, and *Poster/Presentation Sequence* sheets.
5. The teacher announces to teams that they will have one hour to sequence their presentation and practice. At the end of the hour, all teams must stop working.

Suggestion: Warn teams at 30 minutes and 10 minutes.

Explanation

The presentation order is established and recorded (team volunteers or teacher choice). The teacher explains the presentation procedure (e.g., presentation, applause, 2 minutes for questions from audience).

Suggestion: Take a break; time is at your discretion. (While students are taking a break, the teacher can stack posters in presentation order and get everything ready for the presentations.)

Extension

1. Break over! Teams take turns giving presentations. (The teacher will need to take notes on each presentation after each team finishes. The question/answer time works well.)

Suggestion: Praise ALL teams for their great efforts!

2. The teacher tells the class that they will have 2–5 minutes to silently reflect on ALL of the research, explorations, and presentations. After that time they will vote on the energy source that will provide power to the Moon.
3. The teacher explains the election procedure: “Each of you will be called up in turn to vote. You will receive a slip of paper, and you will quickly write an S for solar, C for chemical, or N for nuclear. We will count when all votes are in.” The teacher places all votes in a container.

Suggestion: Speak aloud and tally on the board for each vote. (Make it a BIG DEAL!)

4. The teacher announces the first-place, primary energy source. The teacher then explains that secondary and support sources will be needed as well. The teacher announces second place as “secondary” and third place as “support.”

Suggestion: Model and encourage exuberant applause for each winner — they deserve it!

5. The teacher pulls out *Headquarters Letter 6* and reads it to the class.
6. The teacher calls up each team to receive its grant money.

Suggestion: Giving students a treat and having your administrator present the grants are nice touches.

Suggestion: Take a picture of each team holding up its grants.

Evaluation

The written assessment may be administered any day after this lesson is completed.

Teacher's Note: If you are short on time, Lesson 6 can be the last lesson. (You will still need to administer the written test and give back rubric evaluations.)

It is **HIGHLY RECOMMENDED** that you continue with the development of the research. Lessons 7–9 will allow your students to actually design and build their part of the Lunar Power Station. It will give your students the opportunity to experience the entire process, apply their knowledge, and see their ideas “come to life.”

If you are proceeding to the construction level, you will need to begin collecting consumable materials (junk) now for the construction activity in Lesson 8.

Lesson 6: Lesson Preparation

43

Laboratory-Classroom Preparation

- Designate areas for presenters and audience (optional: provide podium/table for presenters).
- Review *Presentation Sequence Sheet* and *Teacher Example*.
- Have ready:
 - *Lunar Power Research and Development Data Report* (record all team findings).
 - Print out two sets of *Presentation Sequence Sheets* for each team.
 - Print out \$\$ *Grants* and trim. (Make enough of each for the largest team; you will not know until the end of this lesson which team will be the winner.)
- If videotaping, set up camera prior to presentations.

*Moon
Power*

*Lesson 6
Poster
Presentation*

Tools/Materials/Equipment

- Optional: Video camera for taping presentations. Podium or table for presenters.
- Index cards, pencils, clipboards.

Classroom Safety and Conduct

There are no specific safety requirements.

Lesson 7: Research-Based Design

44

Lesson Snapshot

*Moon
Power*

Overview

Big Idea: Design is a process of steps that engineers and others use while considering certain specifications.

Teacher's Note: Big ideas should be made explicit to students by writing them on the board and/or reading them aloud.

*Lesson 7
Research-
Based
Design*

Purpose of Lesson: This lesson requires that students apply knowledge of the lunar environment, energy and power, mission requirements, and technological impacts. Students come to understand the design process by developing a research-based lunar power station design.

Lesson Duration: One to two hours.

Activity Highlights

Engagement: Students are introduced to the *Design Process*.

Exploration: Students walk through the *Design Specifications*.

Explanation: The teacher monitors team discussions and reminds the teams that each member will be presenting and justifying his or her “best design features.”

Extension: After team folders are assembled, students create a name for their team’s power station.

Evaluation: Team design folders are checked for compliance and quality.

Enrichment: The students may choose to draw a top and side view of their design. Also, the teacher may choose to embed vocabulary within the lesson or use it as a distinct feature of the lesson (*Key Vocabulary 7*).

Lesson Duration

- One to two hours.

Standards/Benchmarks

Technology: Standards for Technological Literacy (STL) (ITEA, 2000/2002/2007)

- Students will develop an understanding the attributes of design. (STL 8)
 - Everyone can design solutions to a problem. (8A)
 - Design is a creative process. (8B)
 - The design process is a purposeful method of planning practical solutions. (8C)
- Students will develop an understanding engineering design. (STL 9)
 - Expressing ideas to others verbally and through sketches and models is an important part of the design process. (9B)

Mathematics: Principles and Standards for School Mathematics (NCTM, 2000)

- Data Analysis and Probability
 - Develop and evaluate inferences and predictions that are based on data. Select and use appropriate statistical methods to analyze data. (NCTM Data Analysis and Probability)

Science: National Science Education Standards (NRC, 1996)

- Science and Technology (NRC E)
 - Abilities of technological design. (NRC E Science and Technology)
 - Understanding of science and technology. (NRC E Science and Technology)
 - Abilities to distinguish between natural objects and objects made by humans. (NRC E Science and Technology)
- Science in Personal and Social Perspectives (NRC F)
 - Types of resources. (NRC F Science in Personal and Social Perspectives)
- History and Nature of Science (NRC G)
 - Science as a human endeavor. (NRC G History and Nature of Science)

Geography: Geography for Life (GSEP, 1994)

- Understand the processes, patterns, and functions of human settlement. (GSEP 12)
- Understand how human actions modify the physical environment. (GSEP 14)
- Understand how physical systems affect human systems. (GSEP 15)

Language Arts: Standards for the English Language Arts (NCTE, 1996)

- Students apply knowledge of language structure, language conventions, media techniques, figurative language, and genre to create, critique, and discuss print and nonprint texts. (NCTE 6)
- Students use spoken, written, and visual language to accomplish their own purposes. (NCTE 12)

Learning Objectives

Students will learn to:

1. Review and analyze research.
2. Collaborate and compromise with team members to decide on a lunar power station design.
3. Use the Design Process to develop and draw a final labeled design that reflects best research.
4. Communicate with other teams to ensure station-components compatibility.

Student Assessment Tools and/or Methods

1. Teacher evaluation of designs (using *Design Specifications* as the guide).
2. Teacher observation of student participation and team work.

Resource Materials

Books, periodicals, pamphlets, and web sites may provide teachers and students with background information and extensions. Inclusion of a resource does not constitute an endorsement, either expressed or implied, by NASA.

Lesson Resource Materials

- 7.1. *Engineering Design Process*
- 7.2. *Research Team Badges* (optional)
- 7.3. *Design Specifications* and *Task List* sheet
- 7.4. *Key Vocabulary 7*
- 7.5. Team research folders for: solar, nuclear, and chemical teams
- 7.6. Completed charts from previous lessons (displayed)
- 7.7. *Complete a Sketch Volume One-Orthographic*, By Melvin Peterman. A drawing workbook for elementary-aged children.

Internet Sites

1. An introduction to orthographic drawing <http://www2.arts.ubc.ca/TheatreDesign/crslib/drft_1/orthint.htm>
2. Free online Computer Aided Drawing for Children <http://www.freewarehome.com/index.html?%2FGraphics%2FDrawing_and_CAD_t.html>

Required Knowledge and/or Skills

1. Grade-level reading/writing skills.
2. Understanding of the design process.
3. Rudimentary experience with drawing sketches.
4. Knowledge of lunar environment and energy sources/power technology, covered in previous unit lessons.

Engagement

1. The teacher explains to students that they will develop and draw their lunar power station components today.
2. The teacher discusses the importance of using the collected research as a base for their design ideas.
3. The teacher discusses the *Design Process* and tells students that they will be working through this process as they complete their design.

Exploration

1. Students move into their solar, nuclear, and chemical teams. (Supplies and Team Folders should be laid out at designated locations.)
2. The teacher hands out copies of *Design Specifications* to each team and explains that if designs do not comply with the “specs,” they will not be accepted. Only teams with approved designs will be able to proceed with construction.

Suggestion: Lead all teams in a choral reading of the *Design Specifications*.

3. Teams follow along as the teacher reads through the *Task List* (on the back side of *Design Specifications*).
4. Students check off each task as it is completed.
5. The teacher checks for understanding of procedures, then allows the teams to begin the process.
6. The teacher monitors all teams.

Suggestion: After about 10 minutes of team research discussion, give students a “time reminder” about wrapping up discussion and moving on to individual designs.

Suggestion: After about 20 minutes, give students another “time reminder” for finishing their individual designs and moving on to the group evaluation.

Explanation

1. The teacher reminds the teams that each member will be presenting and justifying his or her “best design features” to the team. Best design features from EVERY member MUST be included in the final team design.
2. The teacher monitors team discussions, prompting teams to check off completed tasks and providing explanations as needed.

Extension

1. As teams sketch a combined “ideas” design, the teacher reminds them to make sure that their combined sketch complies with the “specs” and their research.
2. If the sketch “looks good,” the team draws a final design including labels.

Suggestion: Give the teams a “10 minutes remaining” warning.

3. When time is up, the teacher directs the teams to do one last final check of the design and of the task list, then place all materials back into their team folder; sketches and final design go on top.

4. The teacher tells the teams that they should now create and choose an appropriate name for their team's power station. The names should directly relate to their energy source and the Moon. Teams write their station name on outside of the team folder.

Evaluation

The teacher examines each team design and checks for “specs” compliance and quality.

Enrichment

1. The students may draw a top and side view of their design.
2. The teacher may choose to embed vocabulary within the lesson or use it as a distinct feature of the lesson. (*Key Vocabulary 7*)

Lesson 7: Lesson Preparation

49

Laboratory-Classroom Preparation

- Display or make accessible all charts from previous lessons.
- Print (back-to-back) one copy of *Design Specifications* and *Task List* for each team.
- Provide pencils, rulers, and blank paper for each team.
- Optionally, print and distribute new copies of *Research Badges* (place in team folders).

*Moon
Power*

Tools/Materials/Equipment

Blank paper, pencils, and rulers.

*Lesson 7
Research-
Based
Design*

Classroom Safety and Conduct

There are no specific safety requirements. Students are expected to follow standard classroom and school safety rules.

Lesson 8: Lunar Power Station Construction

50

Lesson Snapshot

Overview

Big Idea: Modeling can be an important part of the design process.

Teacher's Note: Big ideas should be made explicit to students by writing them on the board and/or reading them aloud.

Purpose of Lesson: This lesson helps students understand and apply the design process by cooperatively constructing a research-based model of a lunar power station.

Lesson Duration: Four hours.

Activity Highlights

Engagement: Students view the NASA online video “Back to the Moon.”

Exploration: Student build.

Explanation: The teacher monitors the teams as they work, providing explanations as necessary.

Extension: Time is allowed for cleanup.

Evaluation: Teacher observation and guidance of each team's construction process.

Enrichment: The teacher may choose to embed vocabulary within the lesson or use it as a distinct feature of the lesson (*Key Vocabulary 8*).

*Moon
Power*

*Lesson 8
Lunar Power
Station
Construction*

Lesson Duration

- Four hours.

Purpose of Lesson

This lesson helps students understand and apply the design process by cooperatively constructing a research-based model of a lunar power station.

Standards/Benchmarks

Technology: Standards for Technological Literacy (STL) (ITEA, 2000/2002/2007)

- Students will develop an understanding engineering design. (STL 9)
 - The engineering process includes identifying a problem, looking for ideas, developing solutions and sharing solutions with others. (9A)
 - When designing an object it is important to be creative and consider all ideas. (9D)
 - Models are used to communicate and test design ideas and processes. (9E)
- Students will develop the abilities to apply the design process. (ITEA/STL 11)
 - Build or construct an object using the design process. (11 B)

Mathematics: Principles and Standards for School Mathematics (NCTM, 2000)

- Number and Operations
 - Compute fluently and make reasonable estimates. (NCTM Number and Operations)

Science: National Science Education Standards (NRC, 1996)

- Science and Technology (NRC E)
 - Abilities of technological design. (NRC E Science and Technology)
 - Understanding of science and technology. (NRC E Science and Technology)
 - Abilities to distinguish between natural objects and objects made by humans. (NRC E Science and Technology)
- Science in Personal and Social Perspectives (NRC F)
 - Types of resources. (NRC F Science in Personal and Social Perspectives)

Geography: Geography for Life (GSEP, 1994)

- Understand the processes, patterns, and functions of human settlement. (GSEP 12)
- Understand how human actions modify the physical environment. (GSEP 14)
- Understand how physical systems affect human systems. (GSEP 15)

Language Arts: Standards for the English Language Arts (NCTE, 1996)

- Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources to communicate their discoveries in ways that suit their purpose and audience. (NCTE 7)
- Students use a variety of technological and informational resources to gather and synthesize information and to create and communicate knowledge. (NCTE 8)

Learning Objectives

Students will learn to:

1. Develop a research-based design.
2. Utilize consumable materials to construct a model of a lunar-surface power station.
3. Collaborate and cooperate with team members to complete construction of model station.
4. Communicate with other teams to ensure station-components compatibility.

Student Assessment Tools and/or Methods

1. Teacher evaluation of team station models (using the *Construction Specifications* as the guide).
2. Teacher observation of student participation and team work.

Resource Materials

Books, periodicals, pamphlets, and web sites may provide teachers and students with background information and extensions. Inclusion of a resource does not constitute an endorsement, either expressed or implied, by NASA.

Lesson Resource Materials

- 8.1. *Engineering Design Process*.
- 8.2. *Construction Specifications* and *Task List* sheets
- 8.3. Research team badges (optional)
- 8.4. *Key Vocabulary 8*
- 8.5. Team research folders for: solar, nuclear, and chemical teams
- 8.6. Materials cost list and team report (a blank template to be filled out by teacher)
- 8.7. “Beginner’s Guide to Living in Space (Future Files),” Colin Uttley and Sara Angliss, Copper Beech Books, 1998.
- 8.8. “Moon Quest (Choose Your Own Adventure,” No. 167) A. Montgomery, Bantam Books 1996.

Internet Sites

1. NASA online video “Back to the Moon” <http://www.nasa.gov/externalflash/cev/index_noaccess.html>
2. The Artemis Project—private venture to establish a permanent, self-supporting community on the Moon <<http://www.asi.org/>>
3. The Artemis Project virtual tour of a potential lunar colony design <<http://www.asi.org/adb/01/04/tour-01.html>>
4. Lunar and Planetary Institute <<http://www.lpi.usra.edu/education/explore/colonies/extensions.shtml>>
5. Choices for Moon music to be played with NASA online video “Back To The Moon” (All music selections are licensed downloadable instrumental versions)
 - Moon-related music: <http://www.inconstantmoon.com/not_mus.htm>
 - Moon Songs and Lyrics: <<http://www.moonlightsys.com/themoon/song.html>>

Required Knowledge and Skills

1. Grade-level reading skills.
2. Understanding of the design process.
3. Experience with building from a design.
4. Knowledge of the research information that was the basis for the station-model design.
5. Familiarity with safety and usage of simple hand tools: hammer, screwdriver, pliers.

Lesson 8: 5-E Lesson Plan

First Day of Construction

53

*Moon
Power*

*Lesson 8
Lunar Power
Station
Construction*

Engagement

1. Students view the online NASA video: “Back To The Moon.” This is a silent video; teachers can download licensed Moon music referenced in additional resources, choose their own CD, or select “The Story” option and narrate using the text version of this video.
2. The teacher tells students: “Today, we build!”

Exploration

1. Students move into their solar, nuclear, and chemical teams.
2. The teacher hands out team folders and copies of the *Construction Specifications* and *Task List* and reminds the teams about the procedures that were followed during the design stage. (They will be doing that again in this construction stage.)
3. Students engage in a choral reading of the *Construction Specifications*.
4. The teacher reviews general safety rules and the requirement of wearing safety gear and using tools only with teacher supervision.
5. Teams follow along as the teacher reads through the *Task List* (on the back side of *Design Specifications*).
6. The teacher shows students the location of each supply and materials area and explains that these are the materials that can be used in their lunar power station construction. The teacher should remind students that they MUST follow their final research-based design, *Construction Specifications*, and the *Design Process* throughout construction.
7. The teacher should remind teams that they will be working cooperatively and to check off each task as it is completed.
8. The teacher checks for understanding of procedures, then tells teams that they will begin by discussing their designs, who will work on what part, and what kind of materials might be used. The teacher should explain that each material has a cost, and that students will figure out how much their station “costs” tomorrow, but they should keep cost in mind as they choose materials today.
9. The teacher tells the students to start their procedures.

Explanation

1. The teacher monitors teams as they work, providing explanation as necessary.
2. The teacher encourages students to take on and rotate roles within their group to increase construction efficiency. Some role examples: chief engineer, materials coordinator, design reviewer, contractor and builder.

Extension

1. The teacher allows teams to work until time is up but allows ample time for cleanup.
2. The teacher tells teams that they will have a short period to finish construction the next day.

Evaluation

Teacher observation and guidance of each team’s construction process.

Enrichment

The teacher may choose to embed vocabulary within the lesson or use it as a distinct feature of the lesson. (*Key Vocabulary 8 Day 1*)

Lesson 8: 5-E Lesson Plan

Second Day of Construction

54

*Moon
Power*

*Lesson 8
Lunar Power
Station
Construction*

Engagement

1. Explain that all teams work on construction until the timer rings. (You will determine the time.)
2. Remind the teams that the time constraints are final—when the bell rings, construction is over.

Exploration

1. Hand out team folders, set the timer, and allow teams to continue construction.
2. Give teams a 10-minute warning before timer rings. (It is okay to be a little flexible.)
3. When timer rings, the teacher directs the teams to clean up.
4. Direct teams to do a final check of their model for specs compliance and quality.
5. The teacher gives teams a short time to remedy any noncompliance.

Explanation

1. The teacher explains to the teams that their stations must be somewhat compatible with the other stations, as they will work together as a lunar power system.
2. The teacher explains that each team will meet with all other station teams to look at their designs and models, and have a brief discussion about making sure the stations can work together.
3. The teacher leads each team in a meeting rotation. The teacher also monitors discussions and assist teams that find compatibility problems with questions. Example: “What can you do to make it work?”
4. The teacher monitors time and stops meetings appropriately.

Extension

1. The teacher hands out a *Materials Cost* sheet to each team and explains that teams will now examine their models for material costs.
2. Teams fill out the “*Materials Cost Report*” template and calculate their station total.
3. After totals, the teacher tells the teams to check to see if they are within their budget (grant \$\$).
4. If they are over budget, the teams will have to remove something from their model and recalculate.
5. When all teams are within budget, end the construction lesson.

Evaluation

1. Teacher observation and guidance of each team’s construction process.
2. Examination of each team’s lunar power station model. Check for quality and compliance with the *Construction Specifications*.

Lesson 8: Lesson Preparation

55

Laboratory-Classroom Preparation

Prior to Construction Day

- Collect consumable materials.
- Optional—Have students create a table top “lunar surface.” (Mix flour and water to make a gooey clay and form the clay to mimic lunar features. This takes a day to dry. Sprinkle with a little dry flour.)
- Complete the *Materials Cost List* with your choice of materials and costs.

Additional Planning Activities

- Set up a designated “Supplies” area.
- Set up a designated “Tools” area.
- Set up a designated “Building Materials” area with boxes of consumable materials.
- Print (back to back) one copy of *Construction Specifications* and *Task List* for each team.
- Print several copies of *Station Model Signs* for each team. (Optionally, print on different colors for each team.)

Tools/Materials/Equipment

- Building Materials: Gather consumables— ideas— small wood scraps/cardboard/poster board/construction paper/straws/cardboard tubes/pins/nails/corks/plastic, paper, and styrofoam cups/plastic wrap, bags, and containers/thin wire/styrofoam forms/tinfoil... Place materials in open boxes (easily accessed by students).
- Supplies: Duct/masking tape/glue and glue sticks/scissors/rulers/pencils/colored permanent markers/string/thin wire.
- Tools: Safety goggles/gloves/screwdrivers/hammer/nails/screws/pliers.

Classroom Safety and Conduct

- General safety procedures for using hand tools.
- Safety gear (e.g., goggles and gloves— child-sized leather garden gloves work well).
- Direct supervision by teacher when tools are in use.

*Moon
Power*

*Lesson 8
Lunar Power
Station
Construction*

Lesson 9: Report and Reflect

56

Lesson Snapshot

*Moon
Power*

Overview

Big Idea: Models should be neatly labeled and presentation of models should be well organized.

Teacher's Note: Big ideas should be made explicit to students by writing them on the board and/or reading them aloud.

*Lesson 9
Report and
Reflect*

Purpose of Lesson: This lesson requires that students demonstrate understanding of lunar environment, energy source, and power technology by reporting information and explaining station model to peers. Students individually reflect upon personal learning and performance.

Lesson Duration: One to two hours.

Activity Highlights

Engagement: The teacher provides examples of team work.

Exploration: Teams work on finalizing presentations.

Explanation: The teacher explains presentation procedures.

Extension: Teams report.

Evaluation: The student reflection questionnaire is used.

Lesson Duration

- One to two hours.

Standards/Benchmarks

Technology: Standards for Technological Literacy (STL) (ITEA, 2000/2002/2007)

- Students will develop an understanding engineering design. (STL 9)
 - The engineering process includes identifying a problem, looking for ideas, developing solutions and sharing solutions with others. (9A)
 - Expressing ideas to others verbally and through sketches and models is an important part of the design process. (9B)

Science: National Science Education Standards (NRC, 1996)

- Science and Technology (NRC E)
 - Abilities of technological design. (NRC E Science and Technology)
 - Understanding of science and technology. (NRC E Science and Technology)
 - Abilities to distinguish between natural objects and objects made by humans. (NRC E Science and Technology)
- Science in Personal and Social Perspectives (NRC F)
 - Types of resources. (NRC F Science in Personal and Social Perspectives)

Geography: Geography for Life (GSEP, 1994)

- Understand the processes, patterns, and functions of human settlement. (GSEP 12)
- Understand how human actions modify the physical environment. (GSEP 14)
- Understand how physical systems affect human systems. (GSEP 15)

Language Arts: Standards for the English Language Arts (NCTE, 1996)

- Students adjust their use of spoken, written, and visual language to communicate effectively with a variety of audiences and for different purposes. (NCTE 4)
- Students use a variety of technological and informational resources to gather and synthesize information and to create and communicate knowledge. (NCTE 8)
- Students use spoken, written, and visual language to accomplish their own purposes. (NCTE 12)

Learning Objectives

Students will learn to:

1. Revisit and communicate learned information.
2. Orally present information in front of a live audience.
3. Listen attentively to gain information.
4. Reflect upon learning gained throughout the entire design process.

Student Assessment Tools and/or Methods

Student reflection on learning and process.

Resource Materials

Books, periodicals, pamphlets, and web sites may provide teachers and students with background information and extensions. Inclusion of a resource does not constitute an endorsement, either expressed or implied, by NASA.

Lesson Resource Materials

- 9.1. *Station Report Signs* and *Station Sign Teacher Example*
- 9.2. Student *Self Reflection*
- 9.3. *Certificates of Completion*
- 9.4. *Headquarters Letter 9*
- 9.5. *Unit Rubric*
- 9.6. Team Research Folders

Required Knowledge and Skills

1. Grade level reading/writing skills.
2. Understanding of the design process.
3. Knowledge of the research information that was the basis for the station-model design.

Lesson 9: 5-E Lesson Plan

59

*Moon
Power*

*Lesson 9
Report and
Reflect*

Engagement

1. The teacher announces to the students that this is their day to show off all of their hard work and explains that students will be presenting a brief report on their station model to the class.

Teacher's Note: If you will not be teaching the Extension Lesson 10, you may want to video tape these brief reports).

2. Students move into their teams and the teacher hands out team folders and copies of the *Station Report Signs*.

Suggestion: You may want to save the colored copies for final drafts.

1. The teacher shows *Station Sign Teacher Example* and explains each area that will be completed and then displayed in front of their station model (show how to fold report).
2. The teacher checks for understanding and gives additional directions for final drafts (colored signs/ tracing over text with a thin, black marker)
3. The teacher shows the teams the sticky-note page markers (use in Lesson 2). The teacher explains that when their “station report signs” are completed, they will be using these sticky notes to label the different parts of their stations. Remind them that the sticky note labels should match those on their final design.
4. After labels are neatly written, the teams stick them to the appropriate model parts.
5. The teacher checks again for understanding of all directions and reminds teams that they are working cooperatively together to complete this last stage of their lunar power station project.

Exploration

1. The teacher directs teams to begin working. The teacher sets a timer for 30 minutes. (This is a flexible time and should be adjusted as needed.)
2. The teacher monitors and assists all teams, giving a time warning about 10 minutes before timer rings.
3. When timer rings, the teacher collects all team folders.

Explanation

1. The teacher tells the teams that they will have 10 minutes to practice reading their “Report Sign” together. They can choose choral style or taking turns.
2. After time is up, the teacher moves teams to the floor in an audience position, facing the models.
3. The teacher calls up each team in turn to read its report to the class.
4. The teacher reminds the class to be clear speakers, and respectful, attentive, and appreciative listeners.

Extension

1. The teacher allows for a 1–2 minute question/compliment time after each report.
2. After all reports are finished, the teacher reads aloud the last NASA Headquarters Letter (*Headquarters Letter 9*) and passes out *Certificates of Completion*.

Evaluation

1. Explain the “student reflection” questionnaire and give to each student to complete.
2. Collect all questionnaires and use along with the other lesson assessments for final unit evaluation.

Note: The “student reflection” questionnaire can, but does not have to be given on this day.

Lesson 9: Lesson Preparation

61

Laboratory-Classroom Preparation

- Print several copies of *Station Report Signs* for each team. (Optionally, copy them on different colors for each team.)
- Print *Certificates of Completion*. (Optionally, copy them on colors matching the “report signs.”)
- Print student *Self Reflection* questionnaire.
- Ready sticky-note page markers. (Optionally, match the label colors with “report signs.”)

*Moon
Power*

*Lesson 9
Report and
Reflect*

Tools/Materials/Equipment

- Sticky-note page markers
- Pencils and thin, black markers

Classroom Safety and Conduct

No specific safety requirements.

Lesson 10: Video Report on Lunar Power Station

62

Lesson Snapshot

*Moon
Power*

Overview

Big Idea: Multimedia can help inform others about research.

Teacher's Note: Big ideas should be made explicit to students by writing them on the board and/or reading them aloud.

Purpose of Lesson: This lesson requires that students communicate information using electronic multimedia technology.

Lesson Duration: Six hours.

*Lesson 10
Video Report
on Lunar
Power
Station*

Activity Highlights

Engagement: Students learn that they will be producing an informational video about their lunar power stations.

Exploration: Students learn about video format.

Explanation: With teacher assistance, students work in teams to discuss video content.

Extension: Teams create videos and include teleprompters, microphones, and video editing software.

Evaluation: Teacher observations and the **Presentation Rubric** from Lesson 6.

Lesson Duration

- Six hours.

Standards/Benchmarks

Technology: Standards for Technological Literacy (STL) (*ITEA, 2000/2002/2007*)

- Students will develop an understanding of and abilities to select and use information and communication technologies. (STL 17)
 - Information can be acquired and sent through a variety of technological sources, including print and electronic media. (17E)
 - Communication technology is the transfer of messages among people and/or machines over distances through the use of technology. (17F)

Science: National Science Education Standards (*NRC, 1996*)

- Physical Science (NRC B)
 - Light, heat, electricity, and magnetism. (NRC B Physical)
- Science and Technology (NRC E)
 - Abilities of technological design. (NRC E Science and Technology)
 - Understanding of science and technology. (NRC E Science and Technology)
- Science in Personal and Social Perspectives (NRC F)
 - Changes in environments. (NRC F Science in Personal and Social Perspectives)
 - Types of resources. (NRC F Science in Personal and Social Perspectives)

Geography: Geography for Life (*GSEP, 1994*)

- Understand how human actions modify the physical environment. (GSEP 14)
- Understand how physical systems affect human systems. (GSEP 15)

History: National Standards for History (*NCHS, 1996*)

- Understand major discoveries in science and technology, some of their social and economic effects, and the major scientists and inventors responsible for them. (NCHS 8)

Language Arts: Standards for the English Language Arts (*NCTE, 1996*)

- Students adjust their use of spoken, written, and visual language to communicate effectively with a variety of audiences and for different purposes. (NCTE 4)
- Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audience for a variety of purposes. (NCTE 5)
- Students apply knowledge of language structure, language conventions, media techniques, figurative language, and genre to create, critique, and discuss print and nonprint texts. (NCTE 6)
- Students use spoken, written, and visual language to accomplish their own purposes. (NCTE 12)

Learning Objectives

Students will learn to:

1. Synthesize knowledge of energy and power and the lunar environment.
2. Communicate knowledge and information through a student-created video production.
3. Develop competence in written and oral communication and video production.

*Moon
Power*

*Lesson 10
Video Report
on Lunar
Power
Station*

Student Assessment Tools and/or Methods

Teacher and peer observation of production process and individual production roles.

Resource Materials*Lesson Resource Materials*

- 10.1. *Video Production Student Sheets*
- 10.2. *Teacher Example of “Video Storyboard”*

Internet Sites

An Introduction to Making Videos <<http://www.youthlearn.org/learning/activities/multimedia/video.asp>>

Required Knowledge and/or Skills

1. Grade level reading/writing skills
2. Familiarity with the use of video camera and computer.

*Moon
Power*

*Lesson 10
Video Report
on Lunar
Power
Station*

Lesson 10: 5-E Lesson Plan

65

*Moon
Power*

*Lesson 10
Video Report
on Lunar
Power
Station*

Engagement

The teacher explains to students that they will be producing an informational video about their Lunar Power Stations so that others can learn from their experience.

Teacher's Note: The video format could be a straight informational documentary or like a news program.

Exploration

1. The teacher begins by discussing the chosen video format.
2. The teacher explains that all members will be involved in developing the video, but they will also have specialized individual production roles.
3. The teacher displays and discusses each *Video Production Sheet* and explains that, by using these sheets first, the production will basically be finished except for the videotaping, which comes last. This will be a brief overview; the teacher will need to review with each team when they choose their production roles.
4. The teacher checks for understanding of *Student Sheets*.

Explanation

1. The teacher moves students into their teams and gives them copies of each student sheet (for reference).
2. The teacher directs teams to discuss and make choices about production roles. The teacher monitors discussions.
3. After teams have made their choices, the teacher records their names on the *Video Crew Positions* sheet. (This will be the teacher's master copy.)
4. Teams begin by using their Team Research Folders to complete the first Student Sheet: *Video Content Information*. They will complete this together as a team.
5. After teams have completed the Content Information, team members begin to complete their individual *Production Role* sheets.

Teacher's Note: The teacher will need to meet with each team to assess its video equipment skills. Do this while other teams are working on "Role" sheets.

6. When all team and individual sheets are completed, the teacher meets again with each team. This is to evaluate quality and completion of student sheets and discuss organization and flow of video with the director.
7. Teams that have completed all student sheets and have met with the teacher are ready for rehearsal.
8. Students follow the same "oral speaking" procedures as they did in Lesson 6.
9. Teams should practice together until they feel "ready." However, a time deadline should be set for starting videotaping.
10. The teacher assigns specific times for team videotaping.
11. The class views final video.

Extension

Include the use of a teleprompter/microphone/video editing computer software.

Evaluation

1. Teacher observation of student participation in production process.
2. Teacher observation: use Presentation Rubric (Lesson 6) as an evaluation tool of final video.

Lesson 10: Lesson Preparation

66

Laboratory-Classroom Preparation

- Assess and instruct student use of video equipment.
- Set up a designated area for the video camera and anchor desk.
- Print, review, and make transparencies of all student and teacher “Video Production Sheets.”

Tools/Materials/Equipment

- Video camera and TV
- Computer video editing software/microphone/teleprompter (optional).

Classroom Safety and Conduct

Care and responsible use of video equipment.

*Moon
Power*

*Lesson 10
Video Report
on Lunar
Power
Station*

Lesson 1:
Resource Documents



NASA Headquarters

Energy Research and Development Review Committee

Regarding: Energy Research For Lunar Power System

Dear Instructor,

As you may know, the National Aeronautics and Space Administration has been given a new focus in space exploration. This assignment comes straight from the President of the United States of America. His goal is for NASA to develop new reusable spacecraft, finish the International Space Station, and eventually by the year 2020, return humans to the Moon.

NASA needs your help! We are writing this letter to you on behalf of the NASA Energy Department. Our committee will be supervising all research and development that is connected with providing power on the lunar surface.

We are currently searching for students with extraordinary intelligence, innovative nature, and interest in space exploration. It has come to our Committee's attention that your students have all of the qualities that we are looking for! We hope that you can persuade them to join us in our new challenge of exploration and help us to send humans back to the Moon!

The future of space exploration depends on them!

Please send us your reply as soon as possible.

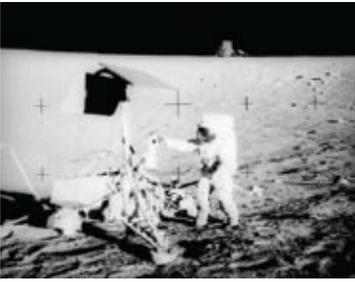
Sincerely,

A. C. Volts

Energy Research & Development Chief Administrator

D. C. Watts

Energy Research & Development Review Director



Lunar Missions

Lunar Exploration Timeline

Lunar Missions

1959

- Luna 1–Jan. 2, 1959–Flyby
- Pioneer 4–Mar. 3, 1959–Flyby
- Luna 2–Sep. 12, 1959–Impact
- Luna 3–Oct. 4, 1959–Probe

1961

- Ranger 1–Aug. 23, 1961–Attempted Test Flight
- Ranger 2–Nov. 18, 1961–Attempted Test Flight

1962

- Ranger 3–Jan. 26, 1962–Attempted Impact
- Ranger 4–April 23, 1962–Impact
- Ranger 5–Oct. 18, 1962–Attempted Impact

1963

- Luna 4–April 2, 1963–Flyby

1964

- Ranger 6–Jan. 30, 1964–Impact
- Ranger 7–July 28, 1964–Impact

1965

- Ranger 8–Feb. 17, 1965–Impact
- Ranger 9–March 21, 1965–Impact
- Luna 5–May 9, 1965–Impact
- Luna 6–June 8, 1965–Attempted Lander
- Zond 3–July 18, 1965–Flyby
- Luna 7–Oct. 4, 1965–Impact
- Luna 8–Dec. 3, 1965–Impact

1966

- Luna 9–Jan. 31, 1966–Lander
- Luna 10–March 31, 1966–Orbiter
- Surveyor 1–May 30, 1966–Lander
- Lunar Orbiter 1–Aug. 10, 1966–Orbiter
- Luna 11–Aug. 24, 1966–Orbiter
- Surveyor 2–Sep. 20, 1966–Attempted Lander
- Luna 12–Oct. 22, 1966–Orbiter
- Lunar Orbiter 2–Nov. 6, 1966–Orbiter
- Luna 13–Dec. 21, 1966–Lander

The Apollo Missions



The NASA Apollo Missions sent humans to the Moon and set the stage for the United States' new vision of human space exploration.

The Space Age began in 1957, when the Soviet Union orbited Sputnik I, the world's first artificial satellite. During this time, the United States and the Soviet Union competed for primacy in a global struggle pitting a democratic society against totalitarian communism. This struggle, called the Cold War, motivated the first explorations of space by both countries.

1967

- Lunar Orbiter 3–Feb. 4, 1967–Orbiter
- Surveyor 3–April 17, 1967–Lander
- Lunar Orbiter 4–May 8, 1967–Orbiter
- Surveyor 4–July 14, 1967–Attempted Lander
- Lunar Orbiter 5–Aug. 1, 1967–Orbiter
- Surveyor 5–Sep. 8, 1967–Lander
- Surveyor 6–Nov. 7, 1967–Lander

1968

- Surveyor 7–Jan. 7, 1968–Lander
- Luna 14–April 7, 1968–Orbiter
- Zond 5–Sep. 15, 1968–Return Probe
- Zond 6–Nov. 10, 1968–Return Probe
- Apollo 8–Dec. 21, 1968–Crewed Orbiter

1969

- Apollo 10–May 18, 1969–Orbiter
- Luna 15–July 13, 1969–Orbiter
- Apollo 11–July 16, 1969–Crewed Landing
- Zond 7–Aug. 7, 1969–Return Probe
- Apollo 12–Nov. 14, 1969–Crewed Landing

1970

- Apollo 13–April 11, 1970–Crewed Landing (aborted)
- Luna 16–Sep. 12, 1970–Sample Return
- Zond 8–Oct. 20, 1970–Return Probe
- Luna 17–Nov. 10, 1970–Rover

1971

- Apollo 14–Jan. 31, 1971–Crewed Landing
- Apollo 15–July 26, 1971–Crewed Landing
- Luna 18–Sep. 2, 1971–Impact
- Luna 19–Sep. 28, 1971–Orbiter

1972

- Luna 20–Feb. 14, 1972–Sample Return
- Apollo 16–April 16, 1972–Crewed Landing
- Apollo 17–Dec. 7, 1972–Crewed Landing

1973

- Luna 21–Jan. 8, 1973–Rover

1974

- Luna 22–June 2, 1974–Orbiter
- Luna 23–Oct. 28, 1974–Lander

1976

- Luna 24–Aug. 14, 1976–Sample Return
- Hiten–Jan. 24, 1990–Flyby and Orbiter

1994

- Clementine–Jan. 25, 1994–Orbiter

1997

- AsiaSat 3/HGS-1–Dec. 24, 1997–Lunar Flyby

1998

- Lunar Prospector–Jan. 7, 1998–Orbiter

In 1958, Congress established a new agency—the National Aeronautics and Space Administration (NASA). Prior to the creation of NASA, ongoing studies in aeronautics and space science were conducted under the supervision of the Department of Defense.

In 1961, when President John F. Kennedy called for a lunar journey by the end of the decade, landing humans on the Moon became the focus of the space race.



On July 20, 1969, Astronaut Neil Armstrong, took the first human steps on the Moon. Five more flights carried astronauts to the Moon, the last in 1972. No human has been there since.

The various experiments placed on the surface provided information on seismic, gravitational, and other lunar characteristics. But perhaps the most dramatic result of the missions was to return a total of more than 800 pounds of lunar rock and soil for analysis on Earth.

2003

- SMART 1 – Sep., 2003 – Lunar Orbiter

2006

- Lunar-A – 2006 – Orbiter and Penetrators

2007

- Chandrayaan-1 – Sep., 2007 – Lunar Orbiter
- Chang'e 1 – Sep., 2007 – Lunar Orbiter
- Selene – 2007 – Lunar Orbiter

2009

- Lunar Reconnaissance Orbiter – June, 2009 – Lunar Orbiter
- Lunar Crater Observation and Sensing Satellite – June, 2009 – Impact

Lunar Missions Information Provided By:

Author/Curator:

Dr. David R. Williams

NASA Goddard Space Flight Center

Greenbelt, MD 20771

Apollo Missions Information Provided By:

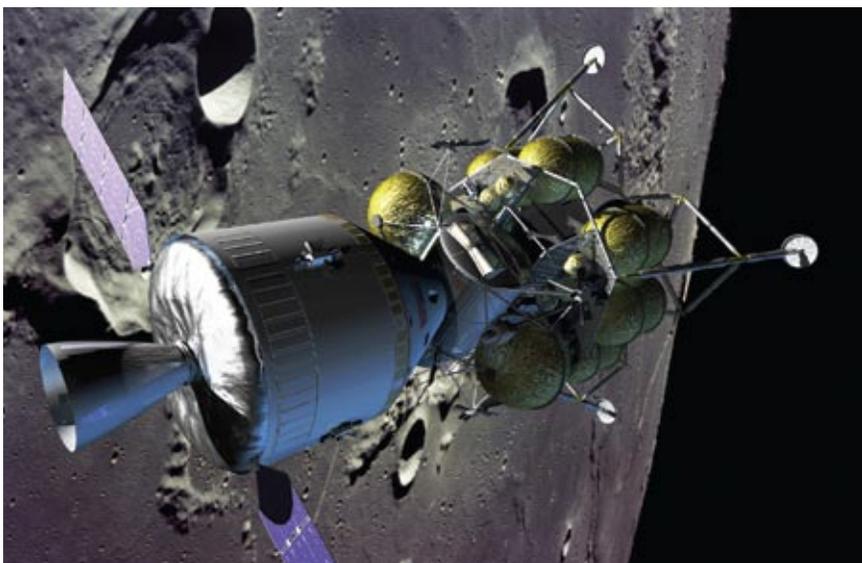
NASA and the National Air and Space Museum's

Center for Earth and Planetary Studies

<http://www.nasm.si.edu/collections/imagery/apollo/apollo.htm>



This 4.4-billion-year-old rock is a sample collected from the lunar highlands of the Moon by Apollo 16 astronauts. This type of rock makes up the lighter-colored part of the Moon visible from Earth.



NASA's future Crew Exploration Vehicle in lunar orbit.
Artist's concept by John Frassanito and Associates.



The Apollo-Saturn V Stack stood 363 feet high, and weighed 6,100,000 pounds at liftoff.

Lunar Features



Earth's only natural satellite orbits around our planet once a month. It was called Luna by the Romans, Selene and Artemis by the Greeks. We call it the Moon.



We can see the Moon because sunlight is reflected off its surface. The Moon rotates synchronously; that means it is locked in phase with its orbit so that the same side is always facing toward the Earth. So, there really is no "dark side" of the Moon. All parts of the Moon get sunlight half of the time (except for a few deep craters near the poles), we just don't see it. When the angle between the Earth, Moon, and the Sun changes, we see this as the cycle of the Moon's phases.

The gravitational forces between the Earth and the Moon cause Earth's ocean tides. The Moon's gravitational attraction is stronger on the side of the Earth nearest to the Moon and weaker on the opposite side. Because oceans are not rigid, they are stretched and bulged out along the line toward the Moon. Since the Earth rotates faster than the Moon moves in its orbit, the bulges move around the Earth about once a day, giving two high tides per day. Although the Moon has no oceans, it experiences the same tidal forces. Instead of tides, the force causes Moon quakes.

The most widely accepted theory of the Moon's origin is the Impact Theory. This theory states the Moon was formed when Earth collided with a very large object, as big as Mars or more. The ejected material then fused together to form the Moon.

Most of the Moon's surface is covered with regolith, a mixture of fine dust and rocky debris produced by meteor impacts. It has two primary types of terrain, the heavily cratered and very old highlands and the relatively smooth and younger maria. Craters on the Moon were primarily caused by millions of years of meteor impacts. Although some craters were caused by volcanic eruptions in the past, the Moon's interior is no longer active.

The Moon has no global magnetic field, but some of its surface rocks show residual magnetism indicating that there may have been a global magnetic field early in the Moon's history. With no magnetic field and no atmosphere, the Moon's surface is constantly exposed to radiation from the Sun and space.

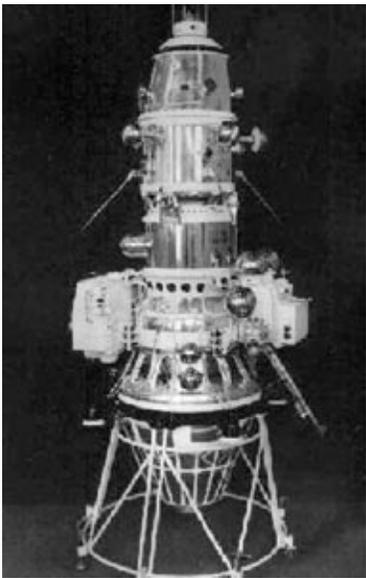
The Moon is the only extraterrestrial body to have been visited by humans. The first humans to land on the Moon were the NASA Apollo astronauts on July 20, 1969. The last human lunar mission was in December of 1972.

The Moon is approximately 239,000 miles from the Earth. Because of this distance, radio signals from the Earth to the Moon and back take about two seconds. This means that communication between the lunar astronauts and Earth would have a several second delay.

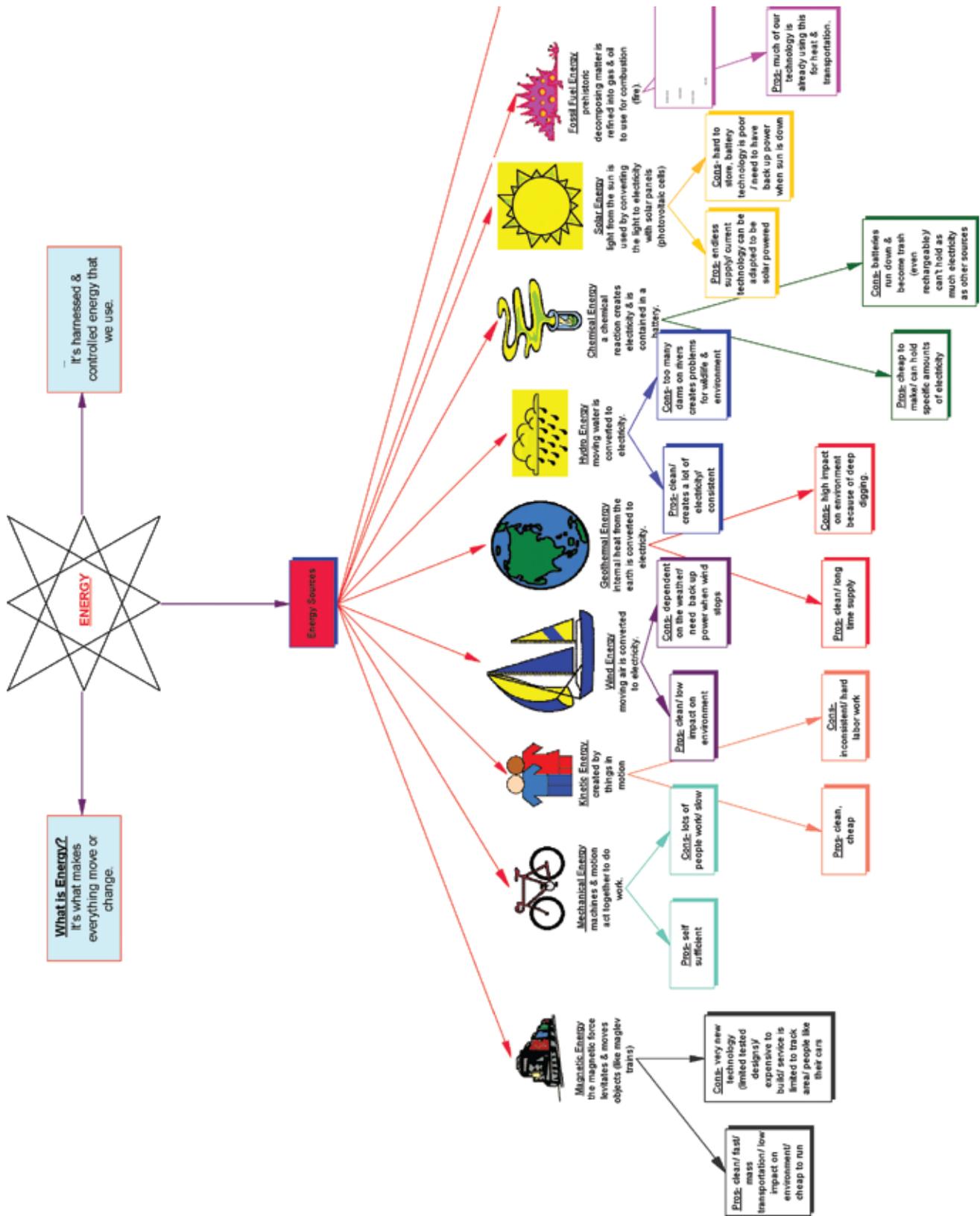
Information on this page was gathered from the following sites:

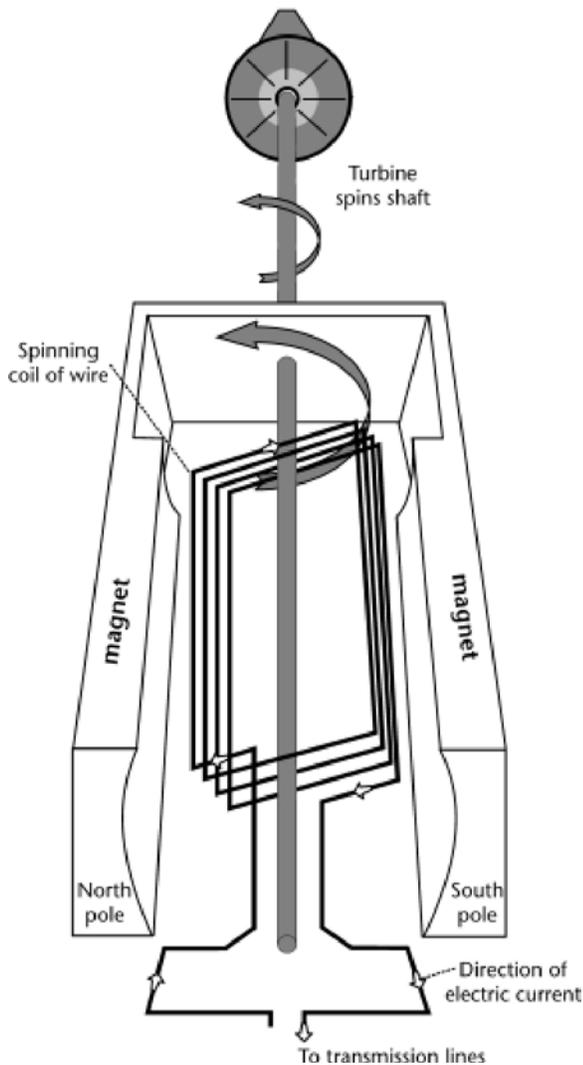
- <http://solarsystem.nasa.gov/planets/profile.cfm?Object=Moon&Display=Facts>
- www.school-for-champions.com
- <http://nineplanets.org/luna.html>

Moon and Earth Images



Lesson 2:
Resource Documents





An electric generator is a device for converting mechanical energy into electrical energy. The process is based on the relationship between magnetism and electricity. When a wire or any other electrically conductive material moves across a magnetic field, an electric current occurs in the wire. The large generators used by the electric utility industry have a stationary conductor. A magnet attached to the end of a rotating shaft is positioned inside a stationary conducting ring that is wrapped with a long, continuous piece of wire. When the magnet rotates, it induces a small electric current in each section of wire as it passes. Each section of wire constitutes a small, separate electric conductor. All the small currents of individual sections add up to one current of considerable size. This current flow against the resistance of the wire is what is used for electric power.

An electric utility power station uses either a turbine, engine, water wheel, or other similar machine to drive an electric generator or a device that converts mechanical or chemical energy to generate electricity. Steam turbines, internal-combustion engines, gas combustion turbines, water turbines, and wind turbines are the most common methods to generate electricity. Most power plants are about 35 percent efficient. That means that for every 100 units of power produced by the turbine, we obtain 35 units of electric power to use.

Energy Sources

Coal, petroleum (oil), and natural gas are burned in large furnaces to heat water to make steam that in turn pushes on the blades of a turbine. Did you know that coal is the largest single primary source of energy used to generate electricity in the United States? In 2003, more than half (51%) of the country's 3.9 trillion kilowatt-hours of electricity used coal as its source of energy.

Natural gas, in addition to being burned to heat water for steam, can also be burned to produce hot combustion gases that pass directly through a turbine, spinning the blades of the turbine to generate electricity. Gas turbines are commonly used when electricity utility usage is in high demand. In 2003, 16% of the nation's electricity was fueled by natural gas.

Petroleum can also be used to make steam to turn a turbine. Residual fuel oil, a product refined from crude oil, is often the petroleum product used in electric plants that use petroleum to make steam. Petroleum was used to generate about three percent (3%) of all electricity generated in U.S. electricity plants in 2003.

Nuclear power is a method in which steam is produced by heating water through a process called nuclear fission. In a nuclear power plant, a reactor contains a core of nuclear fuel, primarily enriched uranium. When atoms of uranium fuel are hit by neutrons they fission (split), releasing heat and more neutrons. Under controlled conditions, these other neutrons can strike more uranium atoms, splitting more atoms, and so on. Thereby, continuous

fission can take place, forming a chain reaction releasing heat. The heat is used to turn water into steam, that, in turn, spins a turbine that generates electricity. Nuclear power was used to generate 20% of all the country's electricity in 2003.

Hydropower, the source for almost 7% of U.S. electricity generation in 2003, is a process in which flowing water is used to spin a turbine connected to a generator. There are two basic types of hydroelectric systems that produce electricity. In the first system, flowing water accumulates in reservoirs created by the use of dams. The water falls through a pipe called a penstock and applies pressure against the turbine blades to drive the generator to produce electricity. In the second system, called run-of-river, the force of the river current (rather than falling water) applies pressure to the turbine blades to produce electricity.

Geothermal power comes from heat energy buried beneath the surface of the earth. In some areas of the country, enough heat rises close to the surface of the earth to heat underground water into steam, which can be tapped for use at steam-turbine plants. This energy source generated less than 1% of the electricity in the country in 2003.

Solar power is derived from the energy of the Sun. However, the Sun's energy is not available full-time, and it is widely scattered. The processes used to produce electricity using the Sun's energy have historically been more expensive than using conventional fossil fuels. Photovoltaic conversion generates electric power directly from the light of the Sun in a photovoltaic (solar) cell. Solar-thermal electric generators use the radiant energy from the Sun to produce steam to drive turbines. In 2003, less than 1% of the nation's electricity was based on solar power.

Wind Power is derived from the conversion of the energy contained in wind into electricity. Wind power, less than 1% of the nation's electricity in 2003, is a rapidly growing source of electricity. A wind turbine is similar to a typical windmill.

Biomass includes wood, municipal solid waste (garbage), and agricultural waste, such as corn cobs and wheat straw. These are some other energy sources for producing electricity. These sources replace fossil fuels in the boiler. The combustion of wood and waste creates steam that is typically used in conventional steam-electric plants. Biomass accounts for about 2% of the electricity generated in the United States.

The Transformer—Moving Electricity

To solve the problem of sending electricity over long distances, George Westinghouse developed a device called a transformer. The transformer allowed electricity to be efficiently transmitted over long distances. This made it possible to supply electricity to homes and businesses located far from the electric generating plant. The electricity produced by a generator travels along cables to a transformer, which changes electricity from low voltage to high voltage. Electricity can be moved long distances more efficiently using high voltage. Transmission lines are used to carry the electricity to a substation. Substations have transformers that change the high voltage electricity into lower voltage electricity. From the substation, distribution lines carry the electricity to homes, offices and factories, which require low voltage electricity.

Sources: Energy Information Administration, Energy INFOcard, October 2004.
The National Energy Education Development Project, Intermediate Energy Infobook, 2004.
<<http://www.eia.doe.gov/kids/energyfacts/sources/electricity.html#Generation>>



NASA Headquarters

Energy Research and Development Review Committee

Regarding: Energy Research for Lunar Power System

Dear Instructor and Students:

We are so pleased that you have chosen to assist us in our mission to provide power for the lunar surface! Our hope is that you have some understanding of the lunar environment, as it is very different from our Earth, and it will definitely affect our development choices. Our first request of you is that you investigate the possible energy sources and technology that we can develop to provide power for the Moon.

Again, we thank you for assisting us in this very important matter.

Sincerely,

A. C. Volts

Energy Research & Development Chief Administrator

D. C. Watts

Energy Research & Development Review Director

What is Hydrogen?

Hydrogen is a gas. It makes up 75% of the universe's ordinary matter, but it is found on Earth only in combination with other elements like oxygen, carbon, and nitrogen. We're very familiar with one combination— H_2O ! Hydrogen, when burned, is very high in energy and gives off almost zero pollution (just water). NASA uses liquid hydrogen as fuel for the space shuttles, and in fuel cells that provide heat, electricity and drinking water for astronauts. In the future, it could be used to fuel vehicles and aircraft, and provide power for homes and offices. But if we want to use hydrogen for power, it needs to stand alone.

How do we do that?

- We can send an electrical current through the water to separate it into its components of oxygen and hydrogen. This process is called electrolysis (easiest).
- We can make hydrogen from natural gas by applying heat to the hydrocarbon molecules. This process is called reforming hydrogen.
- We can use technology to give nature a boost. Some algae and bacteria, using sunlight as their source, give off hydrogen.

What do we do with it?

- Burn it, like in a rocket launch.
- Store it in fuel cells, like a battery.
- A fuel cell uses oxygen and hydrogen to produce electricity. The oxygen required for a fuel cell comes from the air.

What is a fuel cell?

A fuel cell is a device that converts chemical energy into electrical energy. It works like a battery, except that it is continually fed with a fuel like hydrogen that is chemically bound to oxygen to produce the electricity. Then it stores the electricity until it's needed. Fuel cells are silent and reliable, but are expensive to produce.

Reference: <<http://www.energyquest.ca.gov/story/chapter20.html>>
<<http://science.howstuffworks.com/fuel-cell.htm>>

What is antimatter?

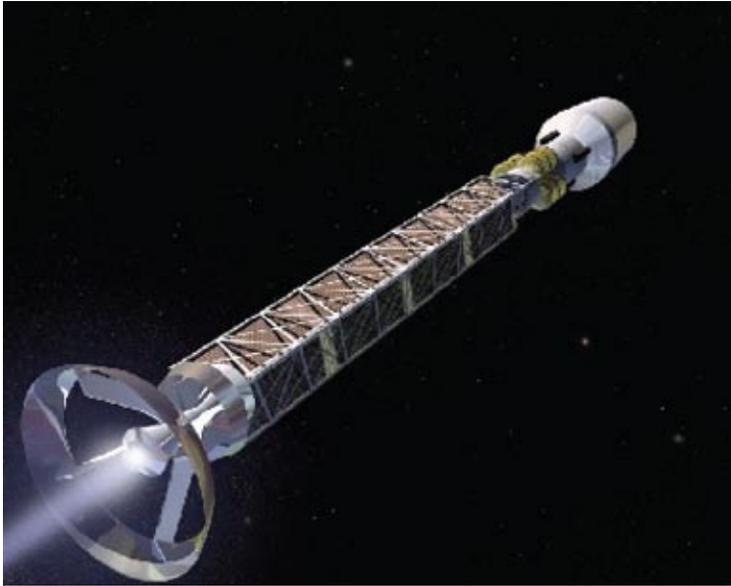
The opposite of normal matter. These antiparticles are mirror images of normal matter. Each antiparticle has the same mass as its corresponding particle, but the electrical charges are reversed.

What happens when antimatter and matter get together?

When antimatter comes into contact with normal matter, these equal but opposite particles collide to produce an explosion emitting pure radiation, which travels out of the point of the explosion at the speed of light. This explosion transfers the entire mass of both objects into energy. Scientists believe that this energy can provide more power for a given weight of fuel than any that can be generated by other propulsion methods.

Can we use antimatter?

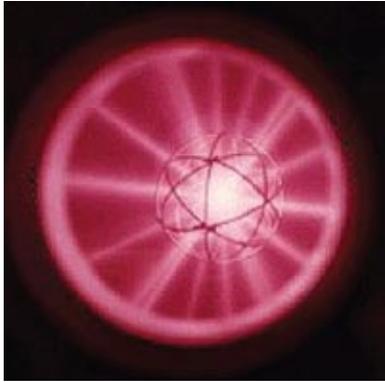
Not yet. NASA is possibly only a few decades away from developing an antimatter spacecraft that could generate enormous thrust with only small amounts of antimatter fueling it. However, one huge problem with developing antimatter propulsion is that there is a lack of antimatter existing in the universe.



Antimatter spacecraft like this one could some day shorten a trip to Mars from 11 months to one month.

Can we create antimatter?

There is technology available to create antimatter through the use of high-energy particle colliders, also called “atom smashers.” Atom smashers are large tunnels lined with powerful supermagnets that circle around to propel atoms at near-light speeds. When an atom is sent through this accelerator, it slams into a target, creating particles. Some of these particles are antiparticles that are separated out by the magnetic field. These high-energy particle accelerators only produce one or two trillionths of a gram of antimatter. All of the antiprotons produced in one year would only be enough to light a 100-watt electric light bulb for three seconds. It will take tons of antiprotons to travel to interstellar destinations.



A Penning trap is tested at Penn State University. Penning traps use a combination of low temperatures and electromagnetic fields to store antimatter.



Photo courtesy Laboratory for Energetic Particle Science at the Pennsylvania State University.

Energy— The ability to do work or the ability to move an object.

Power— The rate at which energy is transferred or converted so it can be used to do work.

Electricity— A form of energy characterized by the presence and motion of elementary charged particles generated by friction, induction, or chemical change.

Harness— To control something in order to use its power.

Convert/Conversion— To change from one form or use to another.

Renewable Energy Sources— Fuels that can be easily made or “renewed.” We can never use up renewable fuels. Types of renewable fuels are solar, wind, hydropower (water), geothermal, and biomass.

Turbine/Generator— A device in which blades are turned by a force, e.g., that of wind, water, or high-pressure steam. The mechanical energy of the spinning turbine is converted into electricity by a generator.

Power Technology— The technology developed and used to convert energy into usable power or electricity.

Combustion— Chemical oxidation accompanied by the generation of light and heat (burning).

Steam— Water in vapor form; used as the working fluid in steam turbines and heating systems.

Energy Sources:

Nuclear

Solar

Fossil Fuel

Hydro

Wind

Chemical

Geothermal

Mechanical

Biomass

Specific Energy Sources are defined in the Resource: “How Electricity is Generated.”

Antimatter— Mirror images of normal matter in which the electrical charges are reversed.

Hydrogen Fuel Cells— A fuel cell is a device that converts chemical (hydrogen and oxygen) energy into electricity.

Power and Energy Chart

The rate at which energy is transferred or converted so it can be used to do work.

Energy Research and Development Chief Administrator

Energy Research and Development Review Director

<p>Energy Source The ability to do work or the ability to move an object.</p>	<p>Power Technology The technology used to transfer or convert the energy.</p>
	
	
	
	
	
	
	

TEACHER INFORMATION:

Energy is defined as: The ability to do work. It is the cause of making things move or change.

Energy is one of the most fundamental parts of our universe. Everything we do is connected to energy in one form or another.

For example, energy powers lights and various transportation methods (e.g., vehicles, trains, planes, and rockets). Energy is used in cities, factories, farms, and homes. It warms, cooks our food, plays music, and provides pictures on television.

The Sun's energy provides light, which can dry clothes on a clothesline and help plants grow. The plants store energy, which is eaten by animals—so animals receive energy from plants. Predator animals eat plant-eating animals, which is how predators receive energy. Humans transform the energy they receive in their food into the energy they need to do work.

Everything we do is connected to energy in one form or another.

Reference: <<http://www.energyquest.ca.gov/story/index.html>>

Lesson 3:
Resource Documents



NASA

Lunar Energy
Department
of
Research



NASA

Lunar Energy
Department
of
Research



NASA

Lunar Energy
Department
of
Research



NASA

Lunar Energy
Department
of
Research



NASA

Lunar Energy
Department
of
Research



NASA

Lunar Energy
Department
of
Research



NASA

Lunar Energy
Department
of
Research



NASA

Lunar Energy
Department
of
Research



NASA

Lunar Energy
Department
of
Research



NASA

Lunar Energy
Department
of
Research



NASA

Lunar Energy
Department
of
Research



NASA

Lunar Energy
Department
of
Research



NASA

Lunar Energy
Department
of
Research



NASA

Lunar Energy
Department
of
Research



NASA

Lunar Energy
Department
of
Research





Solar Energy



Light and heat from the Sun



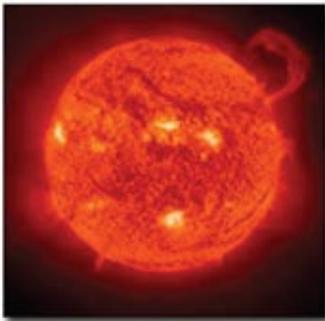
Photovoltaic panels are used to generate electrical power from sunlight.

Photo credit: NASA



Picture Courtesy: NASA

Vehicles are being developed for Earth and beyond, that use solar energy for power.



Basically the Sun is responsible for ALL of our energy.

Photo credit: NASA - SOHO Project
Extreme Ultraviolet Imaging Telescope



Parabolic mirrors focus sunlight onto water pipes, which makes steam for turning turbines and generating electricity.

Photo credit: California Energy Commission



The heat energy from the Sun can be used to warm things like water.

Photo credit:
California Energy Commission

Exploration Station Activity and Setup: Solar Energy

Display Station Signs and Student Direction Cards at each station

Setup:

1. Set up a table next to an electrical outlet. Plug in two adjustable lamps.
2. Organize supplies and oven mitts on the table.
3. Preclip—attach open wire ends to the alligator clips before students start.

Safety:

1. Warn students about potential burning from a hot light bulb or solar cell.
2. For extra safety, keep several oven mitts on location.
3. Solar cells are fragile; they must be handled with care.
4. Solar cells should not touch the lamp bulb or be left unattended. They melt.
5. The amount of electricity generated by small solar cells is NOT dangerous.

Materials:

- Solar cells— inexpensive solar panel kits can be purchased from <www.kelvin.com>.
- Electrical wire, alligator clips, and LED lights or motors: <www.kelvin.com>.
- Two adjustable lamps or spotlights with 100–150 watt bulb.
- Several 2" disks cut out of tagboard, with swirl designs drawn on top.

Activity Lesson #1: Make Electricity From Light

Student Directions:

1. Students can work in pairs, individually, or as a team depending on the amount of lamps, solar cells, and circuitry supplies you are providing.
2. Students start with one solar cell, then experiment with more in an effort to light a bulb or run a motor to spin a propeller or a cardboard disk.
3. Students read and discuss Discovery, then complete Station Observation Forms and clean up.

Background: It is light energy, not heat energy from the Sun or lamp, that activates the photovoltaic cells (PV cells). Most are made of silicon, which is an element common in sand. When sunlight strikes the solar cell, electrons are knocked loose. They move toward the treated front (blue) surface. When the two surfaces are joined by a wire, a current of electricity occurs between the positive and negative sides. If significant amounts of power are needed, PV cells are grouped together in large arrays or panels. Solar energy is a clean and renewable source for power, but when it's dark—no power. So batteries are used to store some of the solar energy during the day; then power can be provided through the night. Utility-scale solar power technology is still developing. It takes a large quantity of solar panels and batteries to generate and store enough energy to power cities or cars. This makes solar power more expensive—for now.

Information from: <www.historyoftheuniverse.com/nuclfiss.html and www.howstuffworks.com> and <<http://www.powernaturally.org/Programs/SchoolPowerNaturally/InTheClassroom/level2.asp?i=9>>
Activity adapted from: <www.energyquest.ca.gov/story/chapter15.html>



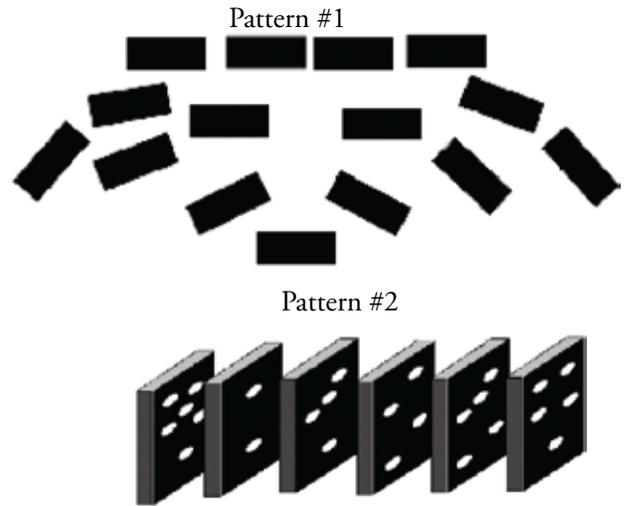
Student Directions:

1. As a whole team, watch the “Splitting Atoms” computer video.
2. After watching the video, group students into pairs. Do activity: “Fission Chain Reaction” simulation. (Follow the activity directions in order.)
3. Discuss Discovery and complete Station Observation Forms.
4. Clean up.

Activity Directions:

Fission Chain Reaction

(A simulation with dominos)



Pretend that these dominos are U-235 atoms:

1. Set up 15 dominos like pattern #1.
2. Knock over the single front domino in the pattern. Watch what happens.
3. Now set the dominos up in a straight line.
4. Knock over the single front domino in the line. Watch what happens.
5. The lined up dominos are like a chain reaction inside of a reactor.
6. Now set up the dominos in a line again. This time, take the ruler and hold it anywhere between two dominos. Keep the ruler in there.
7. Knock over the front domino and watch what happens.
8. The ruler is like a control rod. It goes in between so it breaks the chain reaction. This is similar to what happens in a nuclear reactor.

Discovery and Discussion: Have you ever heard of Albert Einstein, the world’s most famous scientist? It was his famous equation, $E=mc^2$, that gave scientists the key to unlocking atomic energy. One way we can unlock the energy of atoms is to split them apart. This is called fission. Controlled fission takes place inside of a reactor in a nuclear power plant. In the reactor, a radioactive atom of Uranium-235 is split. When this happens, a lot of energy is released from the “glue” that held together the two parts of the atom, and two neutrons are flung out. They strike another two U-235 atoms, which split, and do the same thing to another two atoms. This striking and splitting of atoms keeps continuing and becomes bigger and bigger with each split. This is called a chain reaction, and it releases huge amounts of energy. Control rods in the reactor absorb some of the flung out neutrons and keep them from striking more atoms. Control rods keep a balance between releasing energy safely and getting out of control. Were the reactor to get out of control, it would melt; or if the situation were energetic enough, it would explode like an atom bomb.

Display station signs and student direction cards at each station.

Setup:

1. Set up a table next to a computer. (The computer will be used to show “Splitting Atoms” video disk.)
2. Place 3 sets of 15 dominos on a table (uranium atoms).
3. Place 6 rulers on the table (control rods).

Materials:

- “Splitting Atoms” 5-minute videodisk and computer
- 45 dominos/ruler/flat table that doesn't shake

Activity Lesson #1: Watch “Splitting Atoms” computer video disk.

Activity Lesson #2: Simulate fission chain reaction with dominos.

Student Directions:

1. As a whole team, students watch the “Splitting Atoms” computer video.
2. After the video, students group into pairs to work through the “Fission Chain Reaction” simulation. (Follow the activity directions in order.)
3. Students read and discuss Discovery, then complete Station Observation Forms and clean up.

Background: In a nuclear fission reaction in a nuclear power plant, the radioactive element Uranium-235 is used in a chain reaction. The fission of U-235 splits the atom into two parts and releases particles called neutrons. When this happens, a lot of energy is released. Then those neutrons strike two other atoms, which then split, and it keeps on going—creating a chain reaction. The chain reaction increases exponentially with each split, releasing large amounts of energy. Control rods within the reactor absorb neutrons, preventing them from striking other atoms. This slows down the chain reaction and keeps the energy up without letting it get out of control. The chain reaction gives off heat, which is used to boil water in the core of the reactor. The steam is then used to turn turbines to generate electricity.

Out-of-control chain reactions can lead to dangerous radiation leaks from the reactor or a core meltdown.

Information from: <www.historyoftheuniverse.com/nuclfiss.html> and <www.howstuffworks.com>

Activity adapted from: <www.energyquest.ca.gov/story/chapter13.html>

Videodisk provided by: U.S. Department of Energy Office of Nuclear Energy, Science and Technology

Exploration Station Activity and Setup: Chemical Energy

Display Station Signs and Student Direction Cards at each station.

Setup:

1. Set up a table with activity supplies for each lesson, at opposite ends.
2. For Activity #2, you will need to pre-cut, or bend a small paper clip, and strip two pieces of 18-gauge copper wire.

Materials:

- Two pencils (sharpened at both ends)
- 9-volt battery
- Container of room temperature salt water
- Index card
- Small glass
- Electrical wires and alligator clips
- 2–6 lemons (depends how they last)
- 6 paper clips and 6" pieces of thick copper wire
- Small paper towel and fine-grained sandpaper

Activity Lesson #1: H₂O Electrolysis

Activity Lesson #2: Voltaic Battery

Student Directions:

1. As a whole team (you may want to split the team in half) students work through Activity #1, then # 2.
2. Students read and discuss Discovery, then complete Station Observation Forms and clean up.

Background: Energy cannot be created or destroyed, but it can be captured and stored. Alessandro Volta knew this when he created the first battery in 1800. The stacked, alternating layers of zinc, salt-water-soaked cardboard and silver were called the voltaic pile. Batteries have changed since then, but the process is the same—chemical reaction. Different types of batteries use different types of chemicals and chemical reactions. For example, when a zinc rod (or a steel clip) is inserted into an acid, the acid eats away at the zinc, releasing hydrogen gas and heat energy. If you put in a carbon rod (or a copper wire) and connect it to the zinc with a wire, you've made a circuit. The energy flowing through that circuit can now give power. There is a limit to how much energy can be stored in a single battery; you need a lot of batteries for large energy storage. Eventually the zinc rod is completely dissolved by the acid, and the battery goes dead. Some batteries are rechargeable, but ultimately they all end up in the trash. New energy storage technology like hydrogen fuel cells, or better batteries to store solar or wind energy, could make a huge impact on future energy possibilities.

*Electrolysis is also used for electroplating objects with metal.

Information from: <www.historyoftheuniverse.com> and <www.howstuffworks.com>

Activity adapted from: <www.energyquest.ca.gov/story/chapter05.html>



Chemical Energy Exploration Station



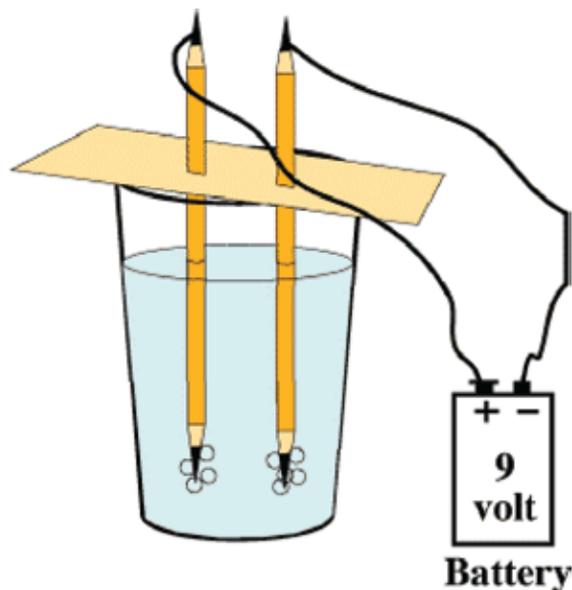
92

Student Directions:

1. As a whole team, do activities #1 (H₂O Electrolysis) and #2. (Voltaic Battery) (Follow the activity directions in order.) Discuss.
2. Discovery and complete Station Observation Forms.
3. Clean up.

Activity #1 Directions: H₂O Electrolysis

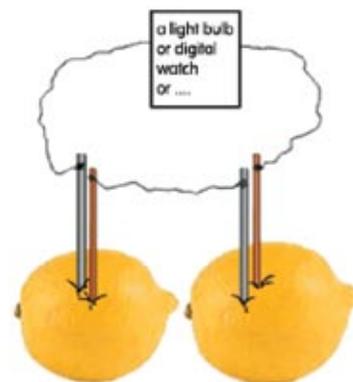
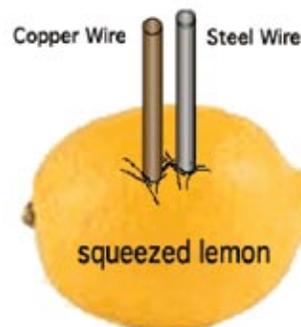
1. Pour a new glass of salt water.
2. Carefully push the two pencils into the cardboard about 1 inch apart.
3. Connect one wire from the positive (+) side of the battery to the graphite pencil tip.
4. Do the same for the negative (-) side of battery and other pencil tip.
5. Wait and observe.



Discovery and Discussion: Water is actually a simple chemical made from two gases, Hydrogen (2 atoms) and Oxygen (1 atom). Get it? H₂O! If an electrical current is sent through water between electrodes, the water is split into its two parts: oxygen and hydrogen. This is called electrolysis. Hydrogen by itself is high in energy. It can be stored in hydrogen fuel cells and used like a battery. Something cool? The pollution from using pure hydrogen is... clean water!

Activity #2 Directions: Voltaic Battery

1. Dry and lightly sand ends of copper and steel.
2. Gently squeeze the lemon (don't let the skin get damaged).
3. Push one copper wire and one steel clip into each lemon—close but not touching.
4. Use gator clips to connect one wire (copper-to-steel).
5. Use gator clips to connect wires (steel-to-bulb, bulb-to-copper).
6. Wait and observe.



Discovery and Discussion: The lemon battery is called a voltaic battery, which changes chemical energy into electrical energy. A chemical reaction between the two different metal electrodes (the steel paper clip and the copper wire), and the lemon juice (acid), create an electric current, and it's stored in the lemon battery. The electrodes are the parts of a battery where the current enters or leaves. The salt water solution is a good conductor and helps the electricity travel around (circuit).



Fossil Fuel Energy

The remains of 360 million year old plants and marine animals



Burning Coal

Photo credit: American Coal Foundation



Drilling for Oil

Photo credit: California Energy Commission



Photo credit: California Energy Commission



Photo: American Coal Foundation
Inside a Mine Shaft



Coal Strip Mine

Photo: American Coal Foundation

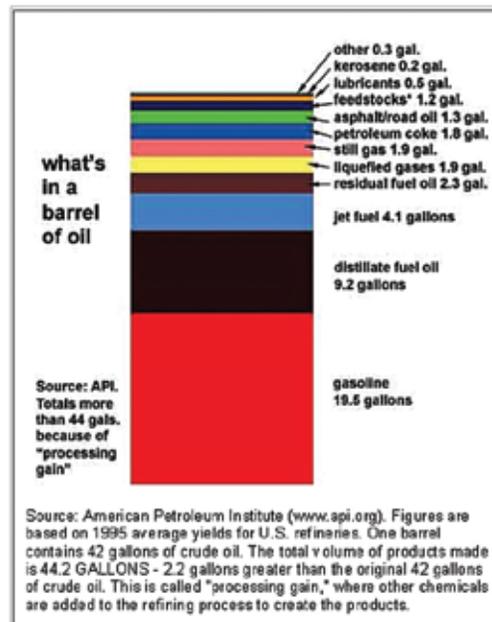


Chart Courtesy Department of Energy

Display Station Signs and Student Direction Cards at each station.

Setup:

1. Set up a table with fossil fuel example items.
2. Tape name labels to examples. (These items should not leave the table.)

Materials:

- A variety of objects in the classroom that can be moved by students.
(Optional: Also provide some special example items—camping propane tank, lighter, sealed can of motor oil, empty gas can, plastic bottle, nylon)

Activity Lesson #1: Fossil Fuel Find

Student Directions:

1. As a whole team, students first read the Discovery and Discuss information.
2. After discussion, students do the activity: Fossil Fuel Find. (Follow the activity directions in order.)
3. Students discuss their found items and any observations and opinions, then complete Station Observation Forms.
4. Replace all found items, and clean up.

Background: There are three major forms of fossil fuels; coal, oil, and natural gas. All three were formed from the remains of animals and plants that lived around 360 millions of years ago—BEFORE the time of the dinosaurs. Coal is mined out of the ground in strip mines, or shaft mines, and it is the number one energy source in the world. Petroleum oil and natural gas are pumped out of the ground by drilling through the Earth's surface (land or sea). They are then pumped through pipelines or sent in containers by ship to refineries where they will be processed into usable forms. We use petroleum products for so many things, such as: fueling airplanes, cars, and trucks, heating, and running appliances in our homes, making medicine, clothing, and plastics. Some problems with fossil fuels: mining and drilling and transfer of fossil fuels have a huge impact on (air and water pollution, digging up the land, ocean oil spills). Another BIG problem is that we are quickly using up the fossil fuels that took millions of years to make—and once we run out, they are gone, and we cannot make more.

Information from: www.historyoftheuniverse.com
www.howstuffworks.com
www.energyquest.ca.gov/story/chapter13.html
www.eia.doe.gov/kids/energyfacts/sources/non-renewable/oil.html

Information from: www.historyoftheuniverse.com/nuclfiss.html
www.howstuffworks.com
www.eia.doe.gov/kids/energyfacts/sources/non-renewable/oil.html
Activity adapted from: www.energyquest.ca.gov/story/chapter08.html



Wind Energy

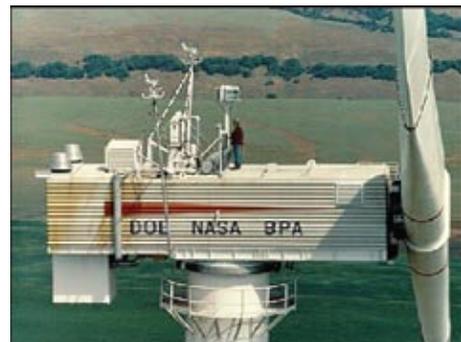
Moving Air



95



Image left: NASA's first experimental wind turbine at Plum Brook Station in Sandusky, Ohio. Credit: NASA



Wind Turbine Yaw Drive

Display Station Signs and Student Direction Cards at each station.

Setup:

1. Set up one side of a table with several lightweight objects (for hoisting).
2. Tie a string around each object.
3. Provide a trash can and organize materials on the other side of the table.
4. Tie a bent, large-sized paperclip to one end of a 12" string.

Materials:

- Thick drinking straw
- Flower stick or skinny dowel (slightly sharp at one end)
- String with paperclip “hook”
- Paper or card stock printed with rotor design
- 1 cork
- 2 washers to fit over stick
- 1 map or quilting pin
- Modeling clay
- Objects for lifting with turbine

Activity Lesson: Build a wind turbine

Student Directions:

1. Students work together as a team to assemble and test a working wind turbine. (Follow the activity directions in order.)
2. After testing, students discuss Discovery and complete Station Observation Forms.
3. Students will take apart the wind turbine, reorganize parts, and clean up.

Background: The wind is one of our earliest energy resources; it is used to power boats and grind grain, to pump water, press oil, saw lumber, and to make paper. Wind turbines in operation today are used primarily to generate electricity. Modern, utility-scale wind turbines are 300 to 350 feet tall and produce electricity that flows into a utility’s transmission lines along with the electricity produced by other power plants. There are wind farms in 27 states, generating enough electricity to power over 1.3 million average American homes. Some wind farms are being built out at sea—to take advantage of the constant sea breezes. There are even future designs in the works for building wind farms that will be tethered to the ground and “hover” thousands of feet up in the air!

Information from: www.historyoftheuniverse.com/nuclfiss.html

www.howstuffworks.com

Activity adapted from: www.energyquest.ca.gov/story/chapter16.html

Exploration Station: Water-Hydro Energy

Display Station Signs and Student Direction Cards at each station.

Setup:

1. Set up a table (preferably next to a sink).
2. Place three large empty bowls, cups, and pitchers of water on one end of the table.
3. Place all construction materials on the other end of the table.
4. Precut water wheel blades and U-shaped cardboard strip for holder. (It is a good idea to prefold so the students will have a clean line to refold on.)

Materials:

- 3 large corks with end-to-end slits cut into the cork (for tagboard/plastic strips).
- 24 precut rectangles of tagboard or plastic (from container lids). The size should fit the corks you will use.
- 3 empty bowls, 3 empty cups, and pitchers of water
- 6 stick pins
- 3 sturdy strips of cardboard, folded into a U shape

Activity Lesson: Build a water wheel

Student Directions:

1. Students work in pairs to assemble and test a working water wheel. (Follow the activity directions in order.)
2. After testing, students discuss discovery and complete station observation forms.
3. Students will take apart the water wheels, reorganize parts, and clean up.

Background: Dams and water wheels both use the energy of moving water to do work. Water wheels were used to grind flour or corn and to power boats and dams are used for making electricity. Hydro dams are one of the largest renewable energy producers of electricity in the U.S. dams and can be built to stop the flow of a river, forming a reservoir. Dams can also be built across larger rivers where the water is sent directly through a hydroelectric power plant. In both cases, the moving water is used to turn turbines, which spin generators to produce the electricity. Dams do, however, have a great impact on the environment, and there is a limit to how many rivers we can dam. Although hydro energy is a renewable source, it depends heavily on the hydrologic cycle (H₂O cycle); if there is a lack of rain near the plant, there is less water flow—less flow, less electricity.

Information from: www.historyoftheuniverse.com

www.howstuffworks.com

Activity adapted from: www.energyquest.ca.gov/story/chapter12.html

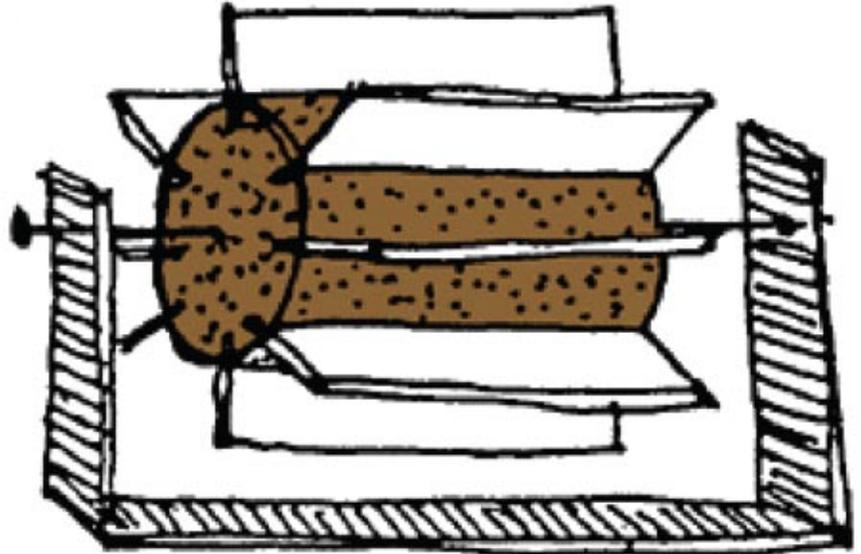
Student Directions:

1. Work together in pairs to assemble and test a working wind turbine. (Follow the activity directions in order)
2. Discuss Discovery and complete Station Observation Forms.
3. Clean up: Take apart wind turbine and reorganize parts.

Activity Directions:

Build A Water Wheel

1. Study the water wheel design.
2. Carefully slide the water “blades” into the cork slits.
3. Fold the cardboard strip into a square-shaped U (hold it).
4. Start on the outside of the U and poke a pin through both top sides of the cardboard.
5. Place the cork in between the U and poke the pins into each side of the cork.
6. Give it a spin.
7. Hold your water wheel over the empty bowl while your partner pours a cup of H_2O over the top.
8. What happens? How can you make it spin faster or slower?



Discovery and Discussion: Do you know what H_2O is? It's water! Another name for water is hydro, and thanks to Earth's natural water cycle, we've got plenty of it! Dams and waterwheels both use this renewable energy of moving water to do work. Waterwheels were used to grind flour or corn and power boats; and dams are used for making electricity. Hydroelectric dams are one of the largest renewable energy producers of electricity in the U.S. and dams can be built to stop the flow of a river, forming a reservoir, and then controlling it as it flows through. Dams can also be built across larger rivers where the water is sent directly through a hydroelectric power plant. In both cases, the moving water is used to turn turbines, which spin generators to produce the electricity. Dams do however, have a great impact on the environment, and there is a limit to how many rivers we can dam.

Exploring Energy

Station Observation Sheet

1. Energy Source _____



2. How is this source used to produce power (include process and technology)?

3. What did you learn about this energy source (one idea from each member)?

1. Energy Source _____



2. How is this source used to produce power (include process and technology)?

3. What did you learn about this energy source (one idea from each member)?

Exploring Energy

Station Observation Sheet

1. Energy Source



2. How is this source used to produce power (include process and technology)?

3. What did you learn about this energy source (one idea from each member)?

1. Energy Source



2. How is this source used to produce power (include process and technology)?

3. What did you learn about this energy source (one idea from each member)?

Exploring Energy

Station Observation Sheet

1. Energy Source _____



2. How is this source used to produce power (include process and technology)?

3. What did you learn about this energy source (one idea from each member)?

1. Energy Source _____



2. How is this source used to produce power (include process and technology)?

3. What did you learn about this energy source (one idea from each member)?

Key Vocabulary 3

Energy—The ability to do work or the ability to move an object.

Power—The rate at which energy is transferred or converted so it can be used to do work.

Electricity—A form of energy characterized by the presence and motion of elementary-charged particles generated by friction, induction, or chemical change.

Harness—To control something in order to use its power.

Convert/Conversion—To change from one form or use to another.

Renewable Energy Sources—Fuels that can be easily made or “renewed.” We can never use up renewable fuels. Types of renewable fuels are solar, wind, hydropower (water), geothermal, and biomass.

Turbine/ Generator—A device in which blades are turned by a force, e.g., that of wind, water, or high-pressure steam. The mechanical energy of the spinning turbine is converted into electricity by a generator.

Power Technology—The technology developed and used to convert energy into usable power or electricity.

Combustion—Chemical oxidation accompanied by the generation of light and heat (burning).

Steam—Water in vapor form; used as the working fluid in steam turbines and heating systems.

Energy Sources:

Nuclear

Solar

Fossil Fuel

Hydro

Wind

Chemical

Geothermal

Specific Energy Sources
are defined in the
document:
“How Electricity
Is Generated”

Lesson 4:
Resource Documents

Resources for included information:

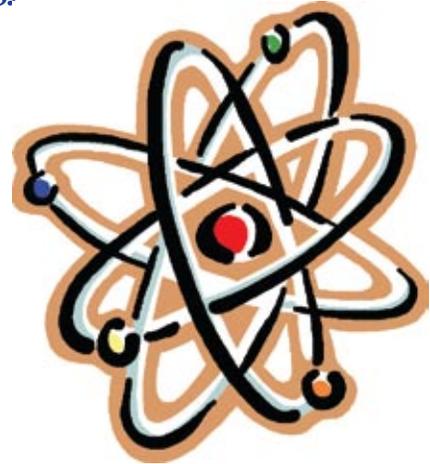
NASA: www.nasa.gov

Energy Quest: www.energyquest.ca.gov/story/index.html

How Stuff Works: www.howstuffworks.com

U.S. Department Of Energy: www.eia.doe.gov

Idaho National Laboratory: www.inl.gov



Team Directions:

1. Divide sections of Information Sheet with your team (cut apart).
2. Team members will read and highlight different sections.
3. After reading, members report back to the whole team to discuss information.
4. Your whole team helps to record information on the R&D table.
5. As a team, read about your energy source (on the energy exploration observation and activity direction sheets from Lesson 3).
6. Discuss and record onto the R&D table.
7. Discuss and record any other pertinent information. (Check your facts first!)
8. Make sure each area on the data table is completed.

General Information

Nuclear (Atomic) energy is the energy trapped inside each atom.

Have you ever heard of the famous scientist, Albert Einstein? It was his famous equation, $E=mc^2$, that gave scientists the key to unlocking atomic energy.

Power Technology

One way we can unlock the energy of atoms is to split them apart. This is called fission. Controlled fission takes place inside a reactor in a nuclear power plant. In the reactor, a radioactive atom of Uranium-235 is split. When this happens, a lot of energy is released and neutrons are flung out. They strike other U-235 atoms, which split, and do the same thing to other atoms. This striking and splitting of atoms continues and becomes bigger and bigger with each split. This is called a chain reaction, and it releases huge amounts of energy. The chain reaction gives off heat, which is used to boil water in the core of the reactor. The steam is then used to turn turbines to generate electricity.

Control Rods in the reactor absorb some of the flung-out neutrons and keep them from striking more atoms. Control rods keep a balance between releasing energy and getting out of control. Out-of-control chain reactions can lead to dangerous radiation leaks from the reactor or a core meltdown.

Another way to release nuclear energy is through radioisotope thermoelectric generators (or RTG for short). RTG converts the heat generated by the decay of radioactive plutonium into electrical energy. The RTG method has been in use since the 1960s.

One more promising technology is nuclear fusion, which is combining two nuclear particles (the process that produces the energy released by the Sun). Scientists are working hard to develop this method past the 4th or 5th Technology Readiness Level.

Impacts

Nuclear power provides abundant power for people and technology. It is a very clean source of power and does not produce any air pollution. Nuclear fission power plants actually release LESS radioactivity into the atmosphere than a coal-fired power plant. However, if a nuclear power plant is not operating correctly it can cause big problems. If the chain reaction does not stay in balance, a reactor core meltdown can happen, scattering radioactive dust into our atmosphere. Also, after the radioactive fuel rods are spent, they need to be stored in a safe way, as they remain radioactive for thousands of years. Some people associate the splitting of atoms with a nuclear weapon known as an atomic bomb, which is an out-of-control chain reaction. Because of these issues, fears of nuclear weapons, and lack of understanding, a lot of people in the U.S. have decided that although having a clean source of power is extremely important to human society, it is not worth the risk. This feeling toward nuclear power has made new developments in this technology more difficult.

On The Moon

Nuclear fission would most likely be able to fill most of the need for power on the Moon. The containment structures for the fission reactor could be built on the Moon using materials from the lunar surface, but the reactors and uranium or plutonium (radioactive material) would need to come from Earth and be launched to the Moon.

RTG generates consistent power for over 20 years, but it does not produce enough electricity to power a colony by itself. Both RTG and fission technologies need to be modified for use on the Moon—like underground reactors with regolith (lunar soil) built up around it to protect the colony and astronauts from the additional radiation (there will already be a lot of radiation on the surface coming from the Sun). All reactors and radioactive materials would need to be shipped to the Moon; this would be heavy and expensive at first, but a nuclear fission power station would produce lots of power day and night.

Resources for included information:

NASA: www.nasa.gov

Energy Quest : www.energyquest.ca.gov.html

How Stuff Works: www.howstuffworks.com

U.S. Department Of Energy: www.eia.doe.gov

Idaho National Laboratory: www.inl.gov



Team Directions:

1. Divide sections of Information Sheet with your team. (cut apart)
2. Team members will read and highlight different sections.
3. After reading, members report back to the whole team to discuss information.
4. Your whole team helps to record information on the research and development (R&D) table.
5. As a team, read about your energy source (on the energy exploration observation and activity direction sheets from Lesson 3).
6. Discuss and record onto the R&D table.
7. Discuss and record any other info you know. (Check your facts first!)
8. Make sure each area on the data table is completed

General Information

Humans have always used the energy of the Sun. We can use its thermal (heat) energy to warm us or change the sunlight directly into electricity with solar cells. Plants use solar energy very efficiently—it is called photosynthesis.

Power Technology

It is light energy, not heat energy from the Sun or a lamp, that activates a photovoltaic cell (PV Cell). When sunlight strikes the solar cell, some of the cell's electrons are knocked loose. They move toward the blue top of the cell. A current of electricity occurs between the positive (+) and negative (–) sides. If a lot of power is needed, PV cells are grouped together in large panels.

When it is dark or really cloudy, no power can be generated. So batteries are used to store some of the solar energy during the day, then power can be provided through the night. Photovoltaic panels have a fairly low power output. They are used to power systems on spacecraft, calculators, street signs, lights, homes, and experimental cars. Large-scale (power a city) solar power technology is still developing. It takes a large quantity of solar panels and batteries to generate and store enough energy to power cities or cars. This makes solar power on Earth, expensive—for now.

Impacts

Solar energy is clean, it does not produce any environmental pollution. However, because solar energy cannot generate power when it is too cloudy or dark, batteries are needed to store the energy for those times. LOTS of batteries will be needed, and the technology of better batteries will need more development. The batteries will eventually go dead and end up as trash. Or, solar thermodynamic generators could concentrate the Sun's energy with mirrors to heat up fluid to turn turbines (like on Earth). Most people view solar energy in a positive manner. They understand that Solar Energy is a clean and renewable source for power and is not threatening to life on Earth. However, people are accustomed to using fossil fuels and will usually only use solar if it is provided as the main source by their local power station. Right now the technology readiness is about a 9 (on a scale of 1–10) for low-level power needs, but still around a 3 for high-level power needs. As the time for running out of fossil fuels gets closer, people may be more willing to actively support more research and development of solar power technology.

On The Moon

There are no clouds on the Moon to block the Sun's rays. In fact, because the Moon does not have an atmosphere, the Sun's radiation comes down in full force. However, the Moon does have approximately 14 days of night. That is a big problem. Many batteries would need to be periodically launched up to the Moon to keep a fresh supply. The NASA study of lunar base sites found "Fortunately however at the south pole there are some areas that receive sunlight almost 90 percent of the time. These would be good locations for solar power arrays to power a lunar outpost." <<https://aerospacescholars.jsc.nasa.gov/HAS/cirr/em/6/5.cfm>>

If solar were to be used for large power needs, huge solar arrays would be needed. PV cells are expensive and can be very heavy because we have to launch so many. The astronauts will require a great deal of constant and reliable power for habitats and machinery. Luckily, the Moon's surface soil has the materials that are needed to make solar cells. That means that eventually, the photovoltaic cells could actually be made on the Moon from the soil, instead being launched up. Once the costs of transport from Earth are eliminated by using lunar materials, an almost limitless supply of solar power could be produced using lunar materials. The power could be beamed by microwaves to rovers and other parts of the Moon and into space. Some scientists believe that all the future energy needs of Earth could be supplied from photovoltaic arrays in space made from lunar materials. <http://science.nasa.gov/newhome/headlines/space98pdf/photovolt.pdf>

Student Directions:

1. Divide sections of Information Sheet with your team (cut apart).
2. Each team member will read and highlight a different section.
3. After reading, members report back to their own team.
4. As a team, read the station exploration observation sheets.
5. Your whole team helps to record information on the R&D table.
6. Discuss and record any other information you know. (Check your facts first!)
7. Make sure each area on the data table is completed.

Energy Source: Solar

General Information:

(energy background/power tech used and how it works/what this energy source is good for powering)

How do we get power from _____?
 (how much power—watts/cost/power output)

What kinds of impacts does using this energy make?
 (environmental/social) (tradeoffs) (people’s views make a difference)

How can we use this energy on the lunar surface?
 (what kind of tech would it take?) (TRL)

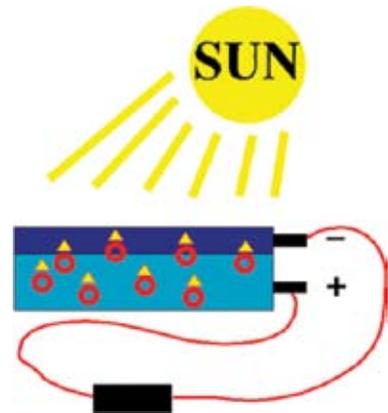
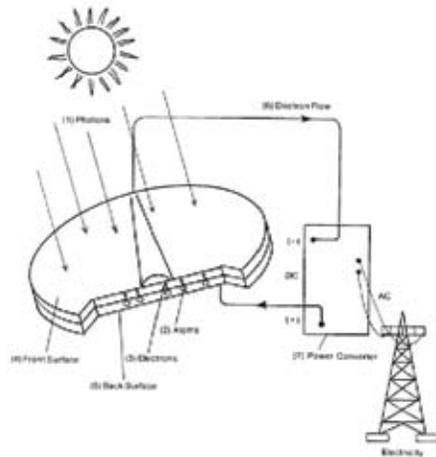
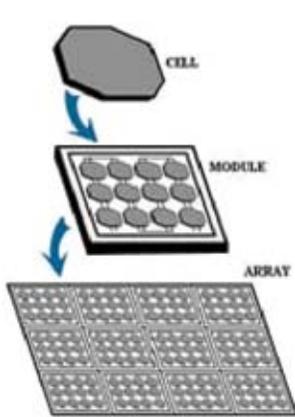


Photo credit: NASA

Resources for included information:

NASA: www.nasa.gov

Energy Quest: www.energyquest.ca.gov.html

How Stuff Works: www.howstuffworks.com

U.S. Department Of Energy: www.eia.doe.gov

Idaho National Laboratory : www.inl.gov

**Team Directions:**

1. Divide sections of Information Sheet with your team (cut apart).
2. Team members will read and highlight different sections.
3. After reading, members report back to the whole team to discuss information.
4. Your whole team helps to record information on the R&D table.
5. As a team, read about your energy source (on the energy exploration observation and activity direction sheets from Lesson 3).
6. Discuss and record onto the R&D table.
7. Discuss and record any other information you know. (Check your facts first!)
8. Make sure each area on the data table is completed.

General Information

The energy held in the bonds between atoms in a molecule is called chemical energy. Every different atom bond has a certain amount of energy. When chemical bonds are broken or new bonds are made, they release some of the energy. Chemists constantly work to find new or better ways of releasing, capturing and storing that energy so it can do work. Some examples: Hand warmers are a mix of chemicals that release heat energy when they touch. Some chemicals like liquid oxygen or hydrogen are used as rocket fuel. They release a lot of energy when they are burned.

Power Technology

Energy cannot be created or destroyed, but it can be captured and stored. Alessandro Volta knew this when he created the first battery in 1800. The stacked alternating layers of zinc, salt water-soaked cardboard and silver, were called the voltaic pile. Batteries have changed since then, but the process is the same—chemical reaction. Different types of batteries use different types of chemicals and chemical reactions. For example, when a zinc rod (electrode) is inserted into an acid the acid eats away at the zinc, releasing hydrogen gas and heat energy. If you put in a carbon rod (electrode) and connect it to the zinc with a wire, you have made a circuit. That is when the action starts—the energy flowing through that circuit can now give power. There is a limit to how much energy can be stored in a single battery; you need a lot of them for large energy storage. They take up a lot of space and they are heavy. Eventually the zinc rod is completely dissolved by the acid, and the battery goes dead. Some batteries are rechargeable, but ultimately they all end up in the trash. New energy storage technologies like hydrogen or methane fuel cells, or better batteries to store solar or wind energy could make a huge impact on future energy possibilities.

Water is actually a simple chemical made from two gases, hydrogen (2 atoms) and oxygen (1 atom). Get it? H_2O ! **110**
If an electrical current is sent through water between electrodes, the water is split into its two parts: oxygen and hydrogen. This is called electrolysis. Hydrogen by itself is high in energy. It can be stored in hydrogen fuel cells and used like a battery. The pollution from using pure hydrogen is clean water. This is what NASA uses to run the electrical systems on the Space Shuttle. Astronauts can use the fuel cell waste for experiments, washing, and drinking!

Impacts

Chemical energy itself is a natural process, but the technology we use to capture that energy can affect the environment. Burning chemicals (combustion) is a Technology Readiness Level 9 (on a scale of 1–10) It is a very efficient and fairly cheap way to release the energy directly or use it to heat up air or fluids to turn turbines. But it is also one of the main causes of air pollution. The better we become at developing batteries to store energy, the easier it will be to take the power where we need it. However, batteries take up space and are heavy. The more batteries we make, the more we will have to throw in the trash.

On The Moon

Both combustion and fuel cells require oxygen to produce power. There is no air on the Moon, but the lunar surface has oxygen trapped within the rocks. Lunar scientists could break down the molecular bonds of the rocks to release the oxygen. Batteries could be used along with other energy sources, like solar for example. The batteries could store energy during the day, to be used during the long lunar night (14 days). Launching heavy batteries up to the Moon could get to be very expensive. Eventually we might develop new batteries that are made from the lunar soil and rock.

Energy Source	Environmental Impact		Social Impact		Tradeoffs General Advantages and Disadvantages (availability of materials, ease and time of construction, safety, other...)		Cost	Power Output	Technology Readiness Level
	Positive	Negative	Positive	Negative	Positive	Negative			
Chemical									

Energy Source	Environmental Impact		Social Impact		Tradeoffs General Advantages and Disadvantages (availability of materials, ease and time of construction, safety, other...)		Cost	Power Output	Technology Readiness Level
	Positive	Negative	Positive	Negative	Positive	Negative			
Nuclear									

Energy Source	Environmental Impact		Social Impact		Tradeoffs General Advantages and Disadvantages (availability of materials, ease and time of construction, safety, other...)		Cost	Power Output	Technology Readiness Level
	Positive	Negative	Positive	Negative	Positive	Negative			
Solar									



NASA Headquarters

Energy Research and Development Review Committee

Regarding: Energy Research For Lunar Power System

Congratulations!

You have explored many different possible energy sources, and have completed your first step of the research process. This is an important and detailed process that can sometimes take years to complete. Massive amounts of information must be collected and analyzed before actual technology design and development can occur. We are very impressed by the quality and efficiency of your work and have decided to let you continue with your mission. Today, you must determine which three energy sources would be the most probable for a power system on the Moon. You will then conduct a detailed investigation of each source.

Your work today will help us to determine which team will receive funding to develop their energy as the source for power on the Moon.

Thank you, and keep up the good work!

Sincerely,

A. C. Volts

Energy Research & Development Chief Administrator

D. C. Watts

Energy Research & Development Review Director

Environmental Impact—The effects that a specific technology has on the environment.

Social Impact—The effects that a specific technology has on individual people and society.

Tradeoffs—The general advantages/disadvantages. Example: Solar energy is renewable and clean, but in order to store the energy when it's cloudy or dark, we would have to have many, many batteries which, would eventually become trash.

Cost—The general monetary cost of the development and use of a technology (expensive/economical).

Power Output—The amount of usable power that an energy source can produce in relation to how much energy is wasted.

Technology Readiness Level (TRL)—A systematic measurement system that is used by NASA to assess and compare the maturity of development (or readiness) of different technologies.

Energy Source	Environmental Impact		Social Impact		Tradeoffs General Advantages and Disadvantages (availability of materials, ease and time of construction, safety, other...)		Cost	Power Output	Technology Readiness Level
	Positive	Negative	Positive	Negative	Positive	Negative			
Solar									
Nuclear									
Chemical									

Primary Energy Source: # of Votes:
Secondary Energy Source: # of Votes:
Support Energy Source: # of Votes:



- TRL 1** Basic principles observed and reported.
- TRL 2** Technology concept and/or application formulated.
- TRL 3** Analytical and experimental critical function and/or characteristic proof of concept.
- TRL 4** Component and/or breadboard validation in laboratory environment.
- TRL 5** Component and/or breadboard validation in relevant environment.
- TRL 6** System/subsystem model or prototype demonstration in a relevant environment (ground or space).
- TRL 7** System prototype demonstration in a space environment.
- TRL 8** Actual system completed and “flight qualified” through test and demonstration (ground or space).
- TRL 9** Actual system “flight proven” through successful mission operations.

TECHNOLOGY READINESS LEVELS

A White Paper

April 6, 1995

John C. Mankins
Advanced Concepts Office
Office of Space Access and Technology
NASA

Lesson 5:
Resource Documents

Chemical Energy Graphics





Photo courtesy [Ballard Power](#)

**Photos and Graphics From:
Microsoft Clip Art**

Nuclear Energy Graphics



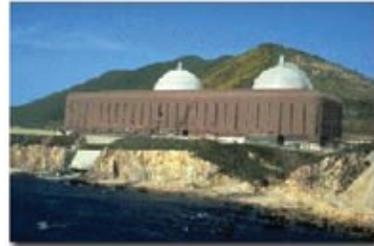
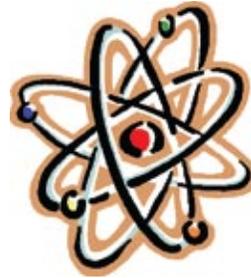


Photo credit: Pacific Gas & Electric Company

Reference: Graphics and photos from Microsoft Clip Art

Solar Energy Graphics

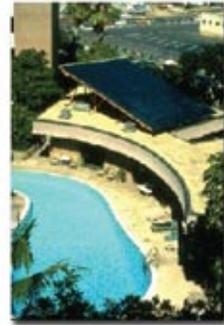
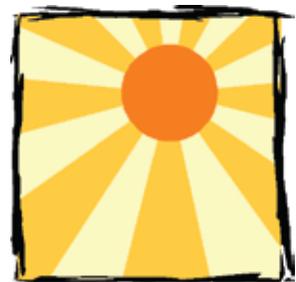
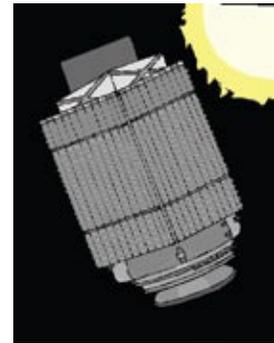
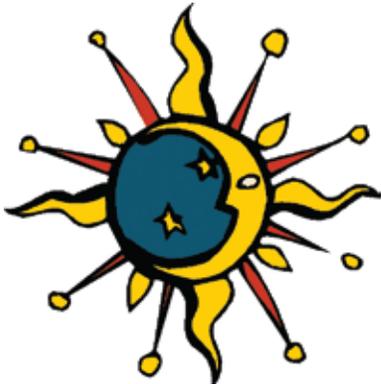


Photo credit:
California Energy Commission





Reference: Graphics and photos from Microsoft Clip Art

Energy Poster Rubric

Energy Team:

Process	Unsatisfactory	Satisfactory	Excellent
1. Has clear vision of final product	1	2	3
2. Properly organized to complete project	1	2	3
3. Managed time wisely	1	2	3
4. Acquired needed knowledge base	1	2	3
5. Team members worked respectfully and productively together	1	2	3
Product (Poster)	Unsatisfactory	Satisfactory	Excellent
1. Format	1	2	3
2. Inclusion of text and graphics	1	2	3
3. Organization and structure	1	2	3
4. Creativity	1	2	3
5. Demonstrates knowledge of energy source	1	2	3
6. Reflects neat, careful work	1	2	3
Evaluation From Team	Unsatisfactory	Satisfactory	Excellent
1. General quality of poster	1	2	3

Total Score: _____

Teacher Comments:

Reference; Created with: TeAch-nology.com-Rubrics Generator (www.teach-nology.com)

Energy Presentation Rubric

Energy Team: _____

Team Member Names: _____

	Criteria				Points
	1	2	3	4	
Organization	Audience cannot understand presentation because there is no sequence of information.	Audience has difficulty following presentation because student jumps around.	Student presents information in logical sequence that audience can follow.	Student presents information in logical, interesting sequence that audience can follow.	_____
Content Knowledge	Team does not have grasp of information; student cannot answer questions about subject.	Team is uncomfortable with information and is able to answer only rudimentary questions.	Team is at ease with content, but fails to elaborate.	Team demonstrates full knowledge (more than required) with explanations and elaboration.	_____
Delivery	Team mumbles, incorrectly pronounces terms, and speaks too quietly for students in the back of class to hear.	Team incorrectly pronounces terms. Audience members have difficulty hearing presentation.	Team voice is clear. Student pronounces most words correctly.	Team used a clear voice and correct, precise pronunciation of terms.	_____
Evaluation By Team (give one score)					_____
				Total	_____

Teacher Comments:

Reference: Created with TeAch-nology.com-Rubrics Generator (www.teach-nology.com)



NASA Headquarters

Energy Research and Development Review Committee

Regarding: Energy Research for Lunar Power System

Dear Research Teams:

Thank you! We have reviewed your current research and are extremely pleased with the thoroughness and quality of your work. However, we are still unable to make a decision about which energy source should provide power for the lunar surface. We need you to produce a persuasive research presentation to convince us that your source should be chosen. The chosen team will continue to work with NASA and proceed on to the development and construction stage of the lunar power project. This team will be awarded with a ten-million-dollar grant to continue their mission.

We look forward to viewing your presentations!

Good Luck!

Sincerely,

A. C. Volts

Energy Research & Development Chief Administrator

D. C. Watts

Energy Research & Development Review Director

Key Vocabulary 5

Communication—To give or exchange information.

Graphics—Pictures or photographs.

Text—Written or typed words.

Persuade—To convince a person to believe that something is a good idea.

Lesson 6:
Resource Documents

Name: _____

Power and Energy on the Moon
Lessons 1-6

- List different sources of energy (as many as you can).

- Match the energy sources to a technology that is used for harnessing and converting that energy into usable power (draw a line).

Energy	Power Technology
Nuclear	Dams
Solar	Fission Reactors
Hydro	Photovoltaic Panels
Wind	Mills or Turbines

- A battery is an example of stored _____ energy.
(Choices: fossil fuel/chemical/geothermal)
- _____ causes everything to move or change.
- We are running out of this energy source: _____.
- Cross out the energy sources that are not available on the lunar surface.
Solar Hydro Nuclear Wind Geothermal Chemical

7. Give a positive and negative result of using:

Nuclear Energy
Positive
Negative

Solar Energy
Positive
Negative

True or False (write T/F)

- 8. ___ Energy and power are the same.
- 9. ___ With technology there are no tradeoffs; it is either good or bad.
- 10. ___ People’s needs, wants, and values can affect the development of technology.
- 11. ___ Research is a quick process, and is not important to technology development.
- 12. ___ The gravity on Earth and the Moon are the same.
- 13. ___ The Moon has about 14 Earth-Days each of sunlight and darkness.
- 14. ___ Humans have never actually been to the lunar surface.

15. Give an Impact example for each Energy Source:

	Solar	Chemical	Nuclear
Social Impact			
Environmental Impact			

16. Match the words that are related: (write the letter in the blank)

- | | |
|--------------|-----------------------|
| A Solar | _____ Heat from Earth |
| B Nuclear | _____ Luna |
| C Geothermal | _____ Electricity |
| D Hydro | _____ Sun |
| E Power | _____ Development |
| F Research | _____ Splitting Atoms |
| G Moon | _____ Gasoline |
| H Petroleum | _____ Water |

NASA
Research & Development
Grant Committee

Congratulations! Your team has been chosen to receive this monetary grant for further research and development of development of As the Support Energy Source for Lunar Power.



Pay to
the

Ten Million Dollars And No Cents

\$ 10,000,000.00

This Grant Is For Educational Purposes
And Has No Monetary Value

Dr. Thémica Conductorata Valls
Energy Research & Development Grant Administrator

NASA
Research & Development
Grant Committee

Congratulations! Your team has been chosen to receive this monetary grant for further research and development of development of As the Support Energy Source for Lunar Power.



Pay to
the

Ten Million Dollars And No Cents

\$ 10,000,000.00

This Grant Is For Educational Purposes
And Has No Monetary Value

Dr. Thémica Conductorata Valls
Energy Research & Development Grant Administrator

NASA
Research & Development
Grant Committee

Congratulations! Your team has been chosen to receive this monetary grant for further research and development of development of As the Support Energy Source for Lunar Power.

Pay to
the

\$ 5,000,000.00

Five Million Dollars And No Cents

Dr. Themia Condutera Valls
Energy Research & Development's Chief Administrator

This Grant Is For Educational Purposes
And Has No Monetary Value

NASA
Research & Development
Grant Committee

Congratulations! Your team has been chosen to receive this monetary grant for further research and development of development of As the Support Energy Source for Lunar Power.

Pay to
the

\$ 5,000,000.00

Five Million Dollars And No Cents

Dr. Themia Condutera Valls
Energy Research & Development's Chief Administrator

This Grant Is For Educational Purposes
And Has No Monetary Value



NASA
Research & Development
Grant Committee

Congratulations! Your team has been chosen to receive this monetary grant for further research and development of development of As the Support Energy Source for Lunar Power.



Pay to
the

\$ 2,000,000.00

Two Million Dollars And No Cents

This Grant Is For Educational Purposes
And Has No Monetary Value

Dr. Heñmica Conductara Valls
Energy Research & Development Chief Administrator

NASA
Research & Development
Grant Committee

Congratulations! Your team has been chosen to receive this monetary grant for further research and development of development of As the Support Energy Source for Lunar Power.



Pay to
the

\$ 2,000,000.00

Two Million Dollars And No Cents

Dr. Heñmica Conductara Valls
Energy Research & Development Chief Administrator

This Grant Is For Educational Purposes
And Has No Monetary Value



NASA Headquarters

Energy Research and Development Review Committee

Regarding: Energy Research for Lunar Power System

Dear Research Teams:

All of your research was very persuasive! This makes it difficult for our Committee to choose just one! As you know, providing power on the lunar surface will be a big job! We will need power support systems to insure the success and safety of our astronauts and technology. After meeting with top NASA officials, we have good news! We have been given permission to expand the lunar project to include a secondary and support energy source. This expansion will allow the development of a complete power station on the lunar surface.

You have proven your resourcefulness and reliability, so we leave the choice of which energy will be the primary, secondary, or support source to you!

We have enclosed the appropriate grant checks so that you may begin construction on your stations as soon as possible. We look forward to the further development of these lunar power stations and excitedly await their completion!

Sincerely,

A. C. Volts

Energy Research & Development Chief Administrator

D. C. Watts

Energy Research & Development Review Director

- | |
|---|
| <p>1. What do you want your audience to know?</p> <p>List the main ideas of your presentation. Then number them in the order that would make the most sense to your audience.</p> <ol style="list-style-type: none">1. Energy source is wind2. Renewable and nonpolluting energy3. Uses the technology of windmills or turbines to make electricity4. Can be located on land, sea, or air |
| <p>2. Tell them the details.</p> <p>List the main ideas numbers in order. Write the important details that will explain that main idea (notes—not sentences).</p> <ol style="list-style-type: none">1. Energy source is wind—moving air can move things2. Renewable and nonpolluting energy air is already on Earth/safe for animals and plants and people/ we won't run out3. Uses the technology of windmills or turbines to make electricity/wind moves blades, blades turn gears and generator4. Can be located on land, sea or air/some are catching air over the seas/future tech is tethering wind turbines from ground and making wind farms thousands of feet up in the air |
| <p>3. Show them what you mean.</p> <p>List the main ideas numbers; follow these directions for each number:
List the poster graphics/photos/drawings you will show. Write movements/expressions/voice tone you will use.</p> <ol style="list-style-type: none">1. Wind graphic/blow on a piece of paper to show moving2. Earth photo/wave hands around in air/blow/breathe deep and loud3. Turbine graphic/point to parts and tell how it works4. Wind farm photo on land/windmill drawing/graphic of sky windfarm |

1. What do you want your audience to know?

List the main ideas of your presentation. Then number them in the order that would make the most sense to your audience.

2. Tell them the details.

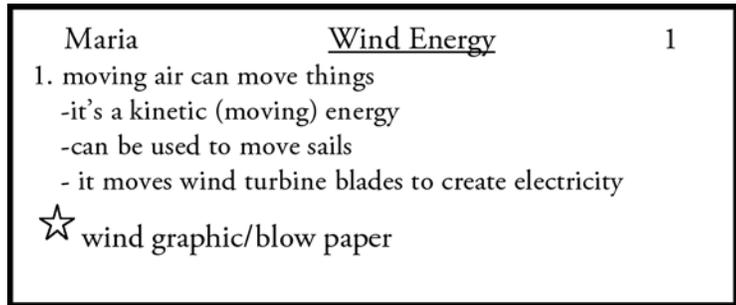
List the main ideas numbers from Step 1. Write the important details that will explain that main idea. (Write notes—not sentences.)

3. Show them what you mean.

List the main ideas numbers. For each number, list the poster graphics you will show, and write any movements/expressions or voice tone that you will use.

4. Making Cue Cards. Follow this procedure for every card:

- a. Write one *main idea* on the top of each card.
- b. Write the *order number* on a top corner.
- c. Choose and write the *speaker's name* on the other top corner.
- d. List and number each *detail* using key words and notes (don't write the whole sentence).
- e. Under each detail, write *more details and facts*.
- f. Draw a ★ at the bottom of each card, then write the graphics/movements expressions/voice tone that you will be using.



5. Lay It All Out

- a. Lay each cue card on the floor. Put them in order.
- b. Each speaker takes turns **READING** their cue card (you will **NOT READ** it when presenting).
- c. Does it make sense? Does it flow? If not, add information or change card order numbers.
- d. If it looks good, start practicing.

6. Practice Makes Perfect (almost)

- a. Each speaker must first learn his or her part and practice using (not reading) the cue card.
- b. After students know their parts, start practicing out loud and in order of the presentation.
- c. Give each other constructive suggestions for improving the presentations.
- d. Practice (out loud) with the whole team many times until you have gotten it.

7. Presentation Pointers (dos and don'ts)

Voice:

Dos: Speak clearly and project your voice/talk naturally/speak loudly
 Don'ts: Mumble/rush/shout or whisper (unless you have planned for it)

Body:

Dos: Look at your audience/move if needed/use hand gestures
 Don'ts: Hide behind your card or look at the floor/be stiff or wiggle/wave hands all around

Appearance:

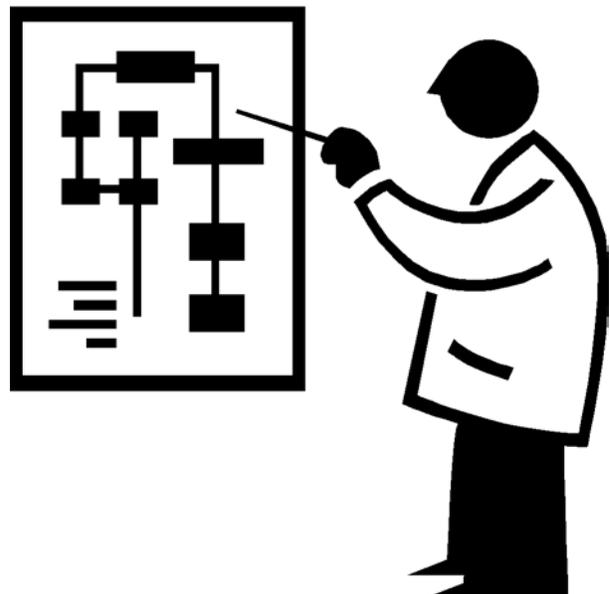
Dos: Dress appropriately/realize that first impressions are very powerful
 Don'ts: Dress inappropriately/think that how you look does not make a difference

Reference: University of Newcastle upon Tyne—Chemical Engineering and Advanced Materials
<http://lorien.ncl.ac.uk/ming/Dept/Tips/present/comms.htm>

Lesson 7:
Resource Documents

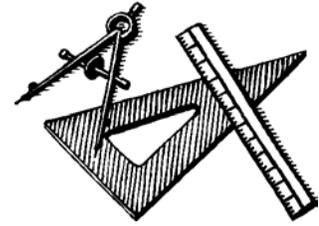


1. Define the problem.
2. Brainstorm ideas for possible solutions.
3. Select a solution.
4. Test the solution.
5. Construct the item.
6. Evaluate.
7. Present the results.



Design Specifications

For Lunar Power Station



All Final Designs Must Meet These Specifications:

- Neatly drawn in pencil.
- Title of energy team is neatly written on the center/top part of the paper.
- Design is drawn to fill most of the paper area, except title area.
- Design illustrates research-based ideas.
- Design includes best features from each team member's design.
- Design shows all best features working together as a unit or system.
- Design includes many important details, but NO decorations.
- Labels are neatly written next to each design part, with a small line pointing to the part.

Key Vocabulary 7

143

Sketch—A drawn representation of an idea.

Design—A detailed plan representing an idea or blueprints for construction of an idea.

Research-Based—Using collected research as the base for all ideas and decisions.

Specifications—Established constraints or details that must be included in the design or project.

Task List

For Lunar Power Station Design

1. **Each Team Member:** Collaborate with your team to complete the tasks. (Remember to be helpful, cooperative, and respectful.)
2. **Team:** Check off each procedure on this task list as you complete it (pencils only for everything).
3. **Team:** Each time you begin a new task, check the *Design Process Sheet* to see “where you are” in the process.
4. **Team:** Read and discuss your collected team research.
 - **Pay close attention to:** Your “Research and Development Chart,” “Poster Presentation Sequence Sheets,” cue cards, and class chart “Earth/Luna.”
 - This information should be the reason for making EVERY design decision.
1. **Each Team Member:** Draw your own sketch of what YOU think your energy-power component of the station should look like. You need to show your own ideas, but you must use the research as your guide.
2. **Each Team Member:** Present your sketch to the team. Explain how your design works and highlight the “best features” of your design.
3. **Team:** After listening to all members, discuss and choose which “best features” will be included as part of the final design (at least one “best feature” from each member’s design MUST be included). On each member’s sketch, circle the “best features” that were chosen by the team.
4. **Team:** Work together to draw a “combined sketch.” This sketch doesn’t have to be perfect, but it MUST:
 - Combine all of the circled “best features” sketch them so they are connected and working together as one system.
 - Show that you used the research to make all of your decisions.
 - Comply with the “Design Specifications.”
5. **Team:** Work together to solve any problems. When the sketch looks good, carefully draw a large, Final Design.
6. **Team:** Neatly print a label for each part of your design. Labels should describe each part in as few words as possible.
7. **Team:** Check your final design for “specs” compliance and quality.
8. **Team:** Place all materials back in your Team Folder. All sketches and the Final Design should be placed on the top.
9. **Team:** Turn in completed Team Folder.

Lesson 8:
Resource Documents

Key Vocabulary 8, Day 1

146

Model—A small constructed object made to serve as the plan for the final, larger object.

Compatibility—The ability to fit or work together.



Materials Cost List

Material

Cost



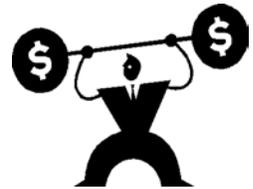
Materials Cost Team Report



What is your NASA Grant Budget? _____

Material

Cost



TOTAL:



Model Specifications

For Construction of
Lunar Power Station



All Final Station Components Must Meet These Specifications:

- Model Station has been constructed as closely to the final design as possible.
- Model Station clearly shows that it is a power station designed for the Moon, not one designed for the Earth.
- Model Station clearly shows the type of energy source being used.
- Model Station clearly shows the type of power technology used to produce power.
- Model Station is compatible with other stations.
- Model Station includes many important details, (NO decorations).
- Construction work is neat, planned, and carefully done.
- Model Station parts are neatly labeled.

Task List For Lunar Power Station Construction

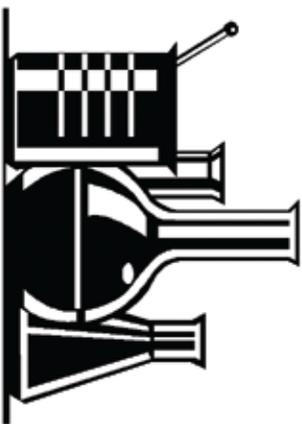
1. **Each Team Member:** Collaborate with your team to complete the tasks. (Remember to be helpful, cooperative, and respectful.)
2. **Team:** Check off each procedure on this task list as you complete them (pencils only for everything).
3. **Team:** Each time you begin a new task, check the Design Process Sheet to see “where you are” in the process.
4. **Team:** Discuss the final design to see where to start and to determine who will work on which part as well as the materials that might best fit with your design.
5. **Each Team Member:** Carefully construct your part, which part is determined by the team.
6. **Team:** While working through the construction, you **MUST**:
 - Collaborate with members to choose ideas for Model appearance.
 - Show that you used the research to make all of your construction decisions.
 - Comply with the “Construction Specifications.”
7. **Team:** Work together to solve any problems.
8. **Team:** Check your model for “specs” compliance and quality.
9. **Team:** Make sure all materials are put back into your Team Folder.
10. **Team:** Clean up area and materials.
11. **Team:** Turn in completed Team Folder.

Lesson 9:
Resource Documents

Certificate of Completion

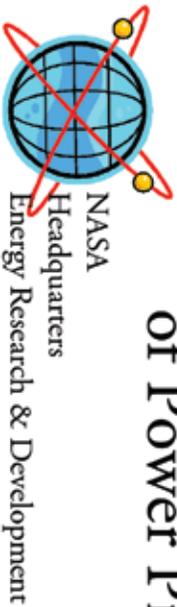
Awarded To

Lunar Energy & Power Chemical Power Station



For The Research, Development, and Construction
of Power Production for The Lunar Surface.

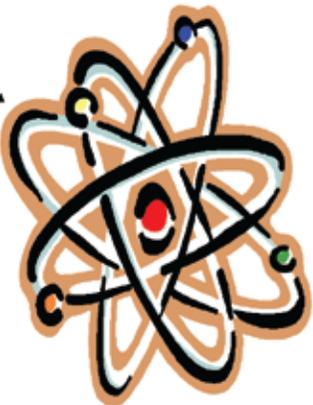
Dr. Mónica Conduetara Valls
Energy Research & Development Study Administrator



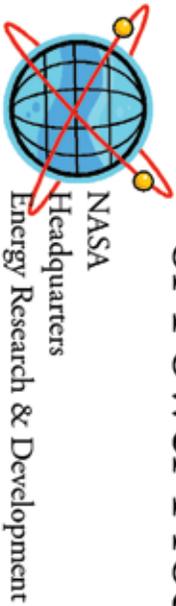
Certificate of Completion

Awarded To

Lunar Energy & Power Nuclear Power Station



For The Research, Development, and Construction
of Power Production for The Lunar Surface.



Dr. Mónica Conduetara Valls
Energy Research & Development Study Administrator

Certificate of Completion

Awarded To

Lunar Energy & Power Solar Power Station



For The Research, Development, and Construction
of Power Production for The Lunar Surface.



Dr. Atmika Conduetara Watts
Energy Research & Development Study Administrator



NASA Headquarters

Energy Research and Development Review Committee

Regarding: Energy Research for Lunar Power System

Thank You Lunar Power Station Teams!

We congratulate you on the completion of your Lunar surface power station models.

Again, we are so very pleased with the creativity and quality of your work! Thanks to your efforts, our NASA engineers will be able to begin the process of developing the technology that will make your ideas become a reality. We thank you for your assistance with this Lunar Power and Energy Project. You have helped NASA, as well as the world, take another giant leap in our journey of human space exploration.

Please accept these certificates as tokens of our appreciation and gratitude.

Sincerely,

A. C. Volts

Energy Research & Development Chief Administrator

D. C. Watts

Energy Research & Development Review Director

Name _____



Self-Reflection

1. Give yourself a score for your performance on the following items:
(Scale of 1–4, with 4 as the highest score. Be honest.)

- I worked cooperatively with my team. 1 2 3 4
- I am respectful of other's ideas. 1 2 3 4
- I always did my share of the work. 1 2 3 4
- I always worked to the best of my ability. 1 2 3 4
- I followed teacher and project directions. 1 2 3 4
- I used my time wisely. 1 2 3 4
- I understand the project information. 1 2 3 4

2. List three of the most important new things you learned from this project. Explain why they were so important to you.

3. What part of the project did you find most interesting?

4. What part of the project did you find most difficult?

5. What would you do differently next time?

Lunar Landers Wind Power Station

This station produces Wind power for the Lunar Surface.

Energy Source: Moving Air

Station Status: Primary/ Secondary/ Support energy source.

Power Technology used to harness the energy Uses turbines, gears and generators to convert the moving air into electricity.

Main Use: Rovers, spacecraft, daytime habitat use...grinding lunar wheat!

Research & Development Team: Maria, Sue, Tom, Jose, Davonn, Janessa

This station produces _____ power for the Lunar Surface.

Energy Source: _____

Station Status: _____ energy source.

Power Technology used to harness the energy _____

Main Use: _____

Research & Development Team:

Optional Summative Unit Rubric to Assess Overall Student Understanding 159

Key Understandings	Assessment Criteria		
	Below Target	At Target	Above Target
Energy is needed to do work, and power technologies are developed to harness the energy so it can be used.	Student is unable to distinguish between an energy source and power technology.	Student recognizes that energy is what makes things move or change, and power is how we harness that energy to do our work.	Student communicates the relationship between energy and power and is able to give a specific example illustrating this relationship.
There are many different types of energy sources.	Student is able to give only one example and/or gives “electricity” as the energy source.	Student is able to give at least three examples of different energy sources.	Student is able to give at least five examples of different energy sources.
Power technologies are used to harness the different energy sources.	Student can identify one or two power technologies and their energy sources but is unable to include any other factors in a comparison.	Student can identify and compare at least three different power technologies, including their source of energy and one example of cost or power efficiency or a tradeoff.	Student can identify and compare four or more different power technologies, including their source of energy and an example each of cost, efficiency, and tradeoff.
Energy and power choices are based, in part, on the amount of energy required for a specific purpose.	Student is unable to interpret multiple factors from comparison data chart and is unable to conduct a data-driven evaluation.	Student uses data from an energy comparison chart to decide on a “best option” for power production on the Moon.	Student makes a data-driven choice of “best option” for power production on the Moon and justifies the choice by including: efficiency, cost, environmental/social impact, and technology readiness level.
Human needs, wants, and concerns determine how new technology is developed, improved, expanded, or limited.	Student is unable to see a correlation between the development of technology and human needs, wants, and concerns.	Student recognizes the correlation between the development of technology and human needs, wants, and concerns and is able to give one general example.	Student clearly articulates two or more specific examples of how human needs, wants, and concerns affect the development of technology.
The results of using technology can be negative or positive and can have unintended consequences.	Student views technology as either good or bad and is unable to provide any specific examples.	Student views technology itself as neutral and is able to describe two negative and two positive results of using that technology as well as one example of an unintended consequence.	Student views technology itself as neutral and is able to describe three positives and three negative results of using technology as well as unintended consequences. Further, student reasoning for positive or negative label is evident.
Design and modeling are valuable activities to further understanding.	Lunar Power model is poorly constructed. The design does not reflect the understanding of energy data or basic lunar knowledge.	Lunar Power model reflects a basic understanding of energy data and lunar environment. Model is satisfactorily constructed.	Lunar Power model reflects a high level understanding of the energy data and the lunar environment. Model includes many details and has been constructed with care.

Lesson 10:
Resource Documents

Video Storyboard

Your plan (numbered in order) of what your video will look like
BEFORE taping starts.

- C** means computer (stuff you will add in from the computer)
 - A** means audio (computer sound)
 - P** means picture (computer photos or clip art)
 - V** means video (video straight from the camera)
 - G** means graphic (a drawn picture or poster that will be shown to the video camera)
 - T** means transition (a special effect between clips, like the screen peeling away)
-

List events first

Then label what kind
of event it is

- CAP** 1. Explosion with photo of a rocket
(You will add in a computer audio sound and picture.)
- V** 2. Anchor Crew sitting and talking about topic
(You will have live video of the anchor crew sitting and talking to camera.)
- VT** 3. Screen peels away to show graphic
(This transition will be added in from the computer.)
- VG** 4. Anchor Crew talks about and points to graphic
(You will have live video showing the anchor crew explaining graphic.)
- VT** 5. Screen peels away to show project
(This transition will be added in from the computer.)
- V** 6. Project is demonstrated
(You will have live video showing the demonstrators explaining the project.)
- VT** 7. Screen peels away to show anchor crew
(This transition will be added in from the computer.)
- V** 8. Anchor crew says goodbye
(You will have live video showing the anchor crew.)
- VT** 9. Screen peels away to credits
(This transition will be added in from the computer.)
- CAP** 10. Credits roll while music plays
(You will add in typed credits and music from the computer.)

List events first (blue)

Then label what kind
of event it is (red)

National Aeronautics and Space Administration

George C. Marshall Space Flight Center

Huntsville, AL 35812

www.nasa.gov/marshall

www.nasa.gov