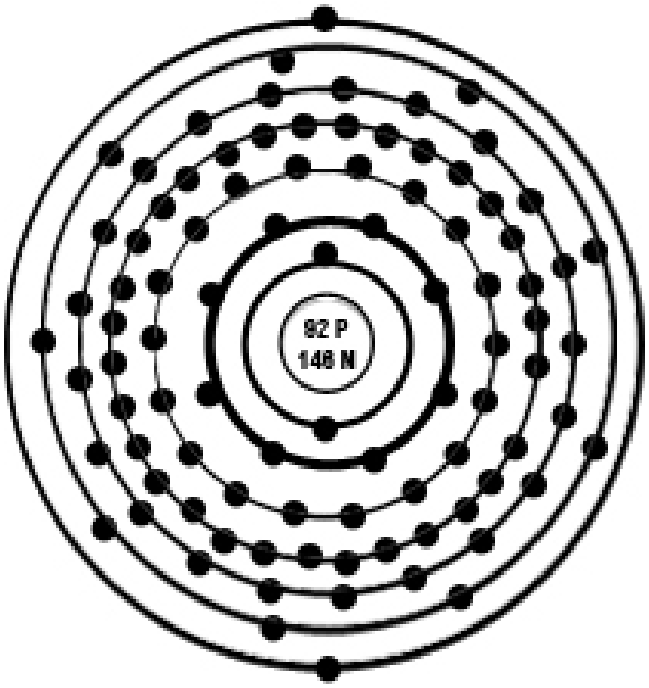
Teacher Guide

Exploring Nuclear Energy and Energy From Uranium

Integrated activites which provide a comprehensive understanding of the scientific, economic, environmental, technological, and societal aspects of nuclear energy to secondary students.

GRADE LEVEL
Intermediate
Secondary

SUBJECT AREAS
Science
Social Studies
Language Arts



NEED
2009-2010
Putting Energy into Education

NEED Project PO Box 10101 Manassas, VA 20108 1-800-875-5029 www.NEED.org

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NEED Mission Statement

The mission of the NEED Project is to promote an energy conscious and educated society by creating effective networks of students, educators, business, government and community leaders to design and deliver objective, multi-sided energy education programs.

Teacher Advisory Board Vision Statement

In support of NEED, the national Teacher Advisory Board (TAB) is dedicated to developing and promoting standards-based energy curriculum and training.

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Correlations to National Science Standards 3-4
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**EXPLORING NUCLEAR ENERGY was developed by the NEED Project
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The Lenfest Foundation, Washington and Lee University, and the Council on Foreign Relations.**

APPLICABLE NATIONAL SCIENCE EDUCATION CONTENT STANDARDS

SECONDARY CONTENT STANDARD–B: PHYSICAL SCIENCE

1. Structure of Atoms

a. Matter is made of minute particles called atoms, which are composed of even smaller components. These components have measurable properties, such as mass and electrical charge.

b. Each atom has a positively charged nucleus surrounded by negatively charged electrons. The electric force between the nucleus and electrons holds the atom together.

c. The atom's nucleus is composed of protons and neutrons, which are much more massive than electrons. When an element has atoms that differ in the number of neutrons, these atoms are called isotopes of the element.

d. The nuclear forces that hold the nucleus of an atom together, at nuclear distances, are usually stronger than the electric forces that would make it fly apart.

e. Nuclear reactions convert a fraction of the mass of interacting particles into energy, and they can release much greater amounts of energy than atomic interactions.

f. Fission is the splitting of a large nucleus into smaller pieces.

h. Radioactive isotopes are unstable and undergo spontaneous nuclear reactions, emitting particles and/or wavelike radiation.

5. Conservation of Energy and the Increase in Disorder

a. The total energy of the universe is constant. Energy can be transferred by collisions in chemical and nuclear reactions, by light waves and other radiations, and in many other ways. However, it can never be destroyed. As these transfers occur, the matter involved becomes steadily less ordered.

b. All energy can be considered to be either kinetic energy—the energy of motion; potential energy—which depends on relative position; or energy contained by a field, such as electromagnetic waves.

SECONDARY CONTENT STANDARD–F: SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES

3. Natural Resources

a. Human populations use resources in the environment to maintain and improve their existence.

b. The earth does not have infinite resources; increasing human consumption places severe stress on the natural processes that renew some resources, and depletes those resources that cannot be renewed.

c. Humans use many natural systems as resources. Natural systems have the capacity to reuse waste but that capacity is limited. Natural systems can change to an extent that exceeds the limits of organisms to adapt naturally or humans to adapt technologically.

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4. Environmental Quality

a. Natural ecosystems provide an array of basic processes that affect humans. Those processes include maintenance of the quality of the atmosphere, generation of soils, control of the hydrologic cycle, disposal of wastes, and recycling of nutrients. Humans are changing many of these basic processes, and the changes may be detrimental to humans.

b. Materials from human societies affect both physical and chemical cycles of the earth.

c. Many factors influence environmental quality. Factors that students might investigate include population growth, resource use, population distribution, overconsumption, the capacity of technology to solve problems, poverty, the role of economic, political, and religious views, and different ways humans view the earth.

5. Natural and Human-induced Hazards

a. Normal adjustments of earth may be hazardous for humans.

b. Human activities can enhance potential for hazards. Acquisition of resources, urban growth, and waste disposal can accelerate rates of natural change.

c. Some hazards are rapid and spectacular, others are slow and progressive.

d. Natural and human-induced hazards present the need for humans to assess potential danger and risk. Many changes in the environment designed by humans bring benefits to society, as well as cause risks. Students should understand the costs and trade-offs of various hazards—ranging from those with minor risk to a few people to major catastrophes with major risk to many people.

6. Science and Technology in Local, National, and Global Challenges

a. Science and technology can indicate what can happen, not what should happen. The latter involves human decisions about the use of knowledge.

b. Understanding basic concepts and principles of science and technology should precede active debate about the economics, policies, politics, and ethics of various science and technology related challenges. However, understanding science alone will not resolve local, national, and global challenges.

c. Individuals and society must decide on proposals involving new research and the introduction of new technologies into society.

Nuclear Teaching Guide

Background

This is an integrated curriculum designed to teach students about the use of uranium as an energy source for generating electricity. Two different texts have been written on the topic, but both student guides cover the same materials. The reading level has been adjusted in the student guides so that they are appropriate for both intermediate and secondary students.

Accompanying the text is one teacher's guide. Teachers should look through the guide carefully and choose which activities will be most appropriate for their students.

ACTIVITY 1 - INTRODUCTION

Time: 1 Day

Materials: Science Notebooks, or copies of page 8 in the Teacher Guide for each student

Objective: Engage students' prior knowledge about nuclear energy.

Procedure:

1. Use page 8 in the Teacher Guide, or in Science Notebooks have students set up a t-chart. On one side of the t-chart have students write "What do I think I know about nuclear energy?" On the other side have students write, "New Learning About Nuclear Energy." At the bottom of the page have students write "Questions I have about nuclear energy."
2. Give students 3-5 minutes to brainstorm everything they know about nuclear energy, and some questions they have. When students are done take two minutes and let students share their thoughts with a partner, then have a class discussion.
3. During the discussion write students' thoughts on the board or chart paper. Students may try to correct each other's misconceptions during the conversation, allow this discussion to take place. However, if there is something that remains in dispute, do not correct the misconception yourself, but make note of it. Let students know that they should be looking for supporting evidence for their ideas and answers to their questions in the coming days.

Assign students to read the Energy Introduction in the text. As students read, they should keep notes on their new learning.

Day 2 – Radioactivity

Time: 1 Day

Materials: Isotope Stability Chart on page x, graph paper, Radiation Dose Chart*

Students will understand that many different elements are radioactive and that radiation is a part of everyday life.

Procedure

1. As a class, review new learning from yesterday's reading. Carefully review the topic of radiation and radioactive isotopes.
2. Using the Isotope Stability Page on page x of the Teacher Guide, students should find the missing information and complete the chart.
3. Students should plot the stable isotope points on a graph with the protons along the X axis and the neutrons along the Y axis.
4. When the points have been plotted students should draw a bold curve through the points, creating as smooth of a curve as possible.
5. Students plot the points of the unstable isotopes on the same graph.

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Technology Connection: Have students search the Table of Isotopes at http://ie.lbl.gov/education/isotopes.htm. Students can choose which element and their isotopes they would like to graph. Using Excel or another graphing program, students will be able to more easily graph larger proton to neutron ratios.

Give each student a copy of the Radiation Dose Chart on page x of the Teacher Guide. Discuss with students the different sources of radiation and have them determine the yearly amount of radiation to which they are exposed. Are students surprised by the results?

* The Radiation Dose Chart has been used with permission from the U.S. Nuclear Regulatory Commission.

ACTIVITY 3 and 4 – M&M Chemistry

Time: 1-2 Days

Materials: M&Ms, small cup, paper towel, balance, Half-Life Worksheet page x, Graph Paper, Average Atomic Weight Worksheet page x

Students will understand how atoms decay and how different isotopes are found in the same element.

Preparation: Put 100 M&Ms in a small cup for each pair of students.

Half-Life Procedure:

1. Review the concept that unstable (radioactive) elements want to be stable. Radioactive isotopes go through a process of decay to reach a stable state. When an element decays so that half of its atoms remain, this is a half-life.
2. Pass out the Half-Life Worksheet and have students complete the activity. If you want students to re-use the M&Ms for the next activity make sure they don't eat them.
3. When all of the atoms have been decayed students should graph their data.

Atomic Weight Procedure:

1. Explain to students that natural uranium contains 99.28% U-238, 0.71% U-235, and 0.04% U-234. This is similar to other elements, in nature many of their isotopes are comibined. Scientists then look at the average atomic weight of the element, taking into account the weights of each isotope and the percentage that is found.
2. Students will need two separate colors of M&Ms and a scale. Pass out the Average Atomic Weight worksheet.
3. Students follow the directions to find the average atomic weight of boron.
4. In nature boron contains 18.4 B-10 and 81.6 B-11 so the results students obtain are close to real life.

Assign students to read the section on Nuclear Energy.

Social Studies Connection: Have students conduct further research on pioneers in nuclear science and present a short report that gives the who, what, where, when, why and how of their accomplishments.

Activity 5 – Generating Electricity with Nuclear Power

Time: 3 Days

Materials: Poster Board, markers, blank diagrams of the nuclear power plant
Students will understand the processes involved in and associated with generating electricity from nuclear energy.

Divide students into small groups and have each group read one of the following sections from the Student Guide:

Fission
Nuclear Fuel Cycle
Nuclear Power Plants and Reactors
Safeguards and Fuel Waste
*Nuclear Weapons and Proliferation**
Economics of Nuclear Energy

Additional Topics can be found online at www.need.org/nuclear:

The Nuclear Navy
Nuclear Medicine
Marie Curie
Nuclear Weapons and Proliferation (more in depth than in the Student Guide)
Nuclear Accidents

Day 1 –Students read their section, brainstorm ways to present the information to the class, and start to prepare presentations.
Day 2 – Students finish preparations and begin sharing their information with the class.
Day 3 – Continue student presentations

During presentations students should take note of their new learning on their KWL charts or in science notebooks. Blank diagrams of a nuclear power plant are included on page x of the Teacher Guide. Students may use these during the presentation to take notes as well.

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ACTIVITY 6 – Advantages and Challenges, Introduction to the Final Project

Time: The amount of time for the final activity can be modified to meet the time you have available.

Materials Needed: Copies of the Mock Hearing Directions on page x of the Teacher Guide
Students will understand that there are advantages and challenges to using nuclear energy.

Brainstorm with students some of the opportunities and challenges they see for using nuclear energy as an energy source. After the class has come up with a list, then read the section in the student guide on Advantages and Challenges on Page 16 of the Student Guide. Discuss both lists. Are there some items that are more important than others? What do you need to take into consideration if you were to decide whether or not a new nuclear plant was to be built?

Choose which culminating activity to do with your class, persuasive letter writing or a mock NRC Site Licensing Hearing.

1. Mock Hearing: Directions are on page x in the Teacher Guide assign pairs or small groups of students different roles to take on. Explain to students that an Early Site Permit is the first stage in getting a new nuclear power plant built. In this stage the NRC is open to hearing information on three issues, environmental protection, safety at the plant, and emergency procedures. In the hearing for the class issues involving costs will also be heard. Students will present their side to a NRC Panel who will decide whether or not to allow plans for the plant to proceed.

To start students on their research direct them to a concept map on www.need.org/nuclear which has been created specifically for this assignment.

Suggestion: Rather than having students make up the NRC Panel recruit members of your staff and/or community to be on the NRC panel to hear student presentations. If students are going to be the panel, they should do some research and brainstorm their own questions. If you are able to get volunteers, a suggested list of questions is on page x of the Teacher's Guide.

2. Persuasive Letters: In this assignment students complete additional research to write a persuasive letter to an elected representative, the Nuclear Regulatory Commission, or the Department of Energy. Letters may be submitted to the teacher, or, you may give students the option to actually send their letter to someone specific. Further details of the letter assignment are on page 23.

Uranium in the Round: This is a quick, fun game to reinforce information about nuclear energy.

Materials and Preparation: Uranium in the Round Cards on page 13-15 of the Teacher Guide, copy these onto cardstock and cut into individual cards.

Procedure

1. Distribute one card to each student. If you have cards left over, give some students two cards so that all of the cards are distributed.
2. Have the students look at their bolded words at the top of the cards; give them five minutes to review the information about their words using their Student Guides.
3. Choose any student to go first and have them read the question on their card. The student with the correct answer should stand up and read the bolded answer, "I have _____." That

   student will then read the question on his/her card, and the round will continue until the first

   student stands up and answers the final question signaling the end of the round.

Final Assessment: A final assessment on nuclear energy is located on page x of the Teacher's Guide. You may choose to give this assessment at any time.

Additional Web Resources: Many websites have interactive simulations of fission, decay, and models of nuclear power plants. Recommended sites are:

ALSOS Nuclear Database - Nuclear weapons and nuclear power have greatly influenced history from 1945 to the present. This digital library provides an annotated bibliography of over 2,700 books, articles, films, CDs, and websites about a broad range of nuclear issues, http://alsos.wlu.edu

Council on Foreign Relations - The CFR aims to be a resource to government officials, business executives, journalists, educators and students, civic and religious leaders, and other interested citizens to help them better understand the world and the foreign policy choices facing the United States and other countries, www.cfr.org

U.S. Department of Energy - For more information about energy sources you can visit the DOE site, www.energy.gov

U.S. Department of Energy Kids' Page - Energy information tailored for students, www.doe.gov/kids

Energy Information Administration - The EIA keeps statistical data on nuclear production and consumption, and all of our other energy sources as well, www.eia.doe.gov.

Environmental Protection Agency - For more information about radiation visit, www.epa.gov/radiation

Nuclear Energy Institute - The NEI is the policy organization for the nuclear technologies industry in the United States, www.nei.org

Nuclear Regulatory Comission - The NRC is the governing body overseeing the nuclear energy industry in the United States, www.nrc.gov

Office of Nuclear Energy - A division of the DOE the Office of Nuclear Energy promotes nuclear power as a resource capable of meeting the Nation's energy, environmental and national security needs by resolving technical and regulatory barriers through research, development and demonstration. They have a Nuclear Energy Kids' Zone, www.nuclear.energy.gov

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Name _____ Date _____

What do I think I know about nuclear energy?	New Learning About Nuclear Energy

Questions I Have About Nuclear Energy

Name _____ Date _____

Stable and Unstable Isotopes

The Periodic Table of the Elements lists all of the chemical elements which have been identified so far. On the table you will see one listing per element. However, many elements have variations called isotopes. They have the same number of protons, but a different number of neutrons.

Isotopes are identified by their atomic mass. An atom's atomic number represents the number of protons in the element. When you subtract the atomic number from the atomic mass you find the number of neutrons in the element or isotope.

Unstable isotopes want to be stable. Atoms undergo a variety of different processes to change the proton/neutron ratio in the nucleus as it becomes stable. Atoms with 83 or more protons in the nucleus can emit alpha particles which reduce the size of the nucleus. Atoms can also decay by losing a beta particle which converts a nuetron into a proton. Other methods for becoming stable include positron emission where a proton is converted to an electron, or electron capture where protons are converted to neutrons. Gamma radiation, a very short wavelength of pure energy can also be released during radioactive decay.

There are multiple decay paths for isotopes, and some isotopes decay faster than others. Below is a table showing one decay path for Uranium-238.

Isotope	Half-life	Decay Mode
Uranium-238	4.5 Billion years	Alpha
Thorium-234	24.1 days	Beta, gamma
Protactinium-234	1 minute	Beta, gamma
Uranium-234	245,000 years	Alpha, gamma
Thorium-230	76,000 years	Alpha, gamma
Radium-226	1,600 years	Alpha, gamma
Radon-222	3.8 days	Alpha
Polonium-218	3.0 minutes	Alpha
Lead-214	27 minutes	Beta, gamma
Bismuth-214	20 minutes	Beta, gamma
Polonium-210	138 days	Beta, gamma
Lead-206	stable	

Directions

1. Complete the tables on the following page.
2. On a separate piece of graph paper draw a vertical Y axis and label it "Neutrons" with a scale from 0-150
3. Draw a horizontal X axis and label it "Protons" with a scale from 0-100.
4. Plot the points of the stable isotopes. When all isotopes have been plotted draw a bold curve through the points. Make the curve as smooth as possible. This is the "band of stability."
5. Next, plot the unstable points on the graph. Use a key so you can identify the different isotopes.
6. Think about how the unstable isotopes on your chart might start to decay toward stability.

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Name _____ Date _____

Stable and Unstable Isotopes

Stable Isotope	Atomic Number	Protons (X axis)	Neutrons (Y axis)
Helium – 14			
Carbon – 12			
Silicon – 28			
Scandium – 45			
Iron – 56			
Silver – 109			
Xenon – 131			
Gadolinium – 160			
Tungsten – 184			
Lead - 206			

Unstable Isotope	Atomic Number	Protons (X axis)	Neutrons (Y axis)
Carbon – 14			
Silicon – 32			
Iron – 52			
Xenon – 135			
Lead – 214			
Radium – 226			

Name _____ Date _____

Radioactive Decay

Radioactive isotopes emit particles in an effort to become stable. For some elements this takes a long time, and in other gases it happens very quickly. The route to stability is not always the same. There are many different paths an element could take as it works to stabalize.

Directions:

1. Create a data table at the bottom of this sheet to represent the amount of M and M's that are left after each half-life through 11 half lives.
2. Place all 100 M & M's in your cup.
3. Lightly shake the cup and spill the contents onto the paper towel.
4. Remove all the M & M 's that are face up (with the M showing)
5. These M & M's represent the atoms that you have decayed, set these aside.
6. Record the number of M & M's that remain in your data table
7. Place the leftover M & M's back into the cup, shake lightly and repeat
8. Repeat this process for 10 half lives of the M & M's
9. Graph this data on a piece of graph paper.

Shake	Decayed M&Ms	Remaining M&Ms
0	n/a	100

Data Analysis:

1. Create a graph showing the decay of your element. Label the X axis "Shakes" and the Y axis "Number of M&Ms."
2. Compare your graph to a neighbor's.

Conclusion:

As you look at your graph and your neighbor's what do you notice? How is this activity similar to what happens in the natural world?

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Name _____ Date _____

Average Atomic Weight Modeling

In this activity you will assemble two stable isotopes of boron, boron-10 and boron-11 and calculate the average weight of boron.

Materials: M&Ms (two colors), balance

Directions:

1. Choose one color to represent protons and the other color will represent neutrons.
2. Make one atom of boron-10 with five protons and five neutrons.
3. Make four atoms of boron-11, each boron-11 atom has five protons and six neutrons.
4. Measure the weight of boron-10.
5. Measure the weight of boron-11.
6. Calculate the average weight of boron by dividing the total weight by the number of atoms (five).

Draw a diagram of each boron atom. Label the protons and neutrons.

Boron-10

Boron-11

Mass of boron-10 atom_____

Mass of boron-11 atom _____

Percentage of Isotope _____

Percentage of Isotope _____

Average Weight of Boron

_____

Name _____ Date _____

Radiation Dose Chart

Our natural environment exposes us to radiation, as do some of our everyday activities. Complete the information below to find out how many millirems of radiation you are exposed to each year.

mrems dose

Where You Live

1. Cosmic radiation (from outer space) at sea level 26

2. Select the number of millirems for your elevation (in feet) ..... ____

up to 1000 = 2	1000-2000 = 5
2000-3000 = 9	3000-4000 = 9
4000-5000 = 21	5000-6000 = 29
6000-7000 = 40	7000-8000 = 53
8000-9000 = 70	

3. Terrestrial (from the ground):
   - If you live in states that border the Gulf or Atlantic Coast, add 23 ..... ____
   - If you live in the Colorado Plateau area (around Denver), add 90 ..... ____
   - If you live in middle America (rest of the U.S.), add 46 ..... ____

4. House construction
   - If you live in a stone, brick, or concrete building, add 7 ..... ____

What You Eat and Drink

5. Internal radiation (in your body)*
   - From food and water 40
   - From air (radon) 200

Other Sources

6. Weapons test fallout (less than 1):** 1
7. Jet plane travel: For each 1,000 miles you travel, add 1 ..... ____
8. If you have porcelain crowns or false teeth, add 0.07 ..... ____
9. If you use gas lantern mantles when camping, add 0.003 ..... ____
10. If you wear a luminous (LCD) wristwatch, add 0.006 ..... ____
11. If you use luggage inspection at airports (using a typical x-ray machine), add 0.002 ..... ____
12. If you watch TV**, add 1 ..... ____
13. If you use a video display terminal**, add 1 ..... ____
14. For each smoke detector you have add 0.008 ..... ____
15. If you wear a plutonium-powered cardiac pacemaker, add 100 ..... ____
16. If you have had medical exposures:*

Diagnostic x-rays (e.g., upper and lower gastrointestinal, chest) add 40 ..... ____

If you have had nuclear medical procedures (e.g., thyroid scans) add 14 ..... ____

17. If you live within 50 miles of a nuclear power plant (PWR), add 0.0009 ..... ____
18. If you live within 50 miles of a coal-fired power plant, add 0.03 ..... ____

My total annual mrems dose: _____

Some of the radiation sources listed in this chart result in an exposure to only part of the body. For example, false teeth result in a radiation close to the mouth. The annual dose numbers given here represent the "effective dose" to the whole body.

* These are yearly average doses.

** The value is actually less than 1.

In the United States the average person is exposed to 360mrem of whole body radiation each year from all sources.

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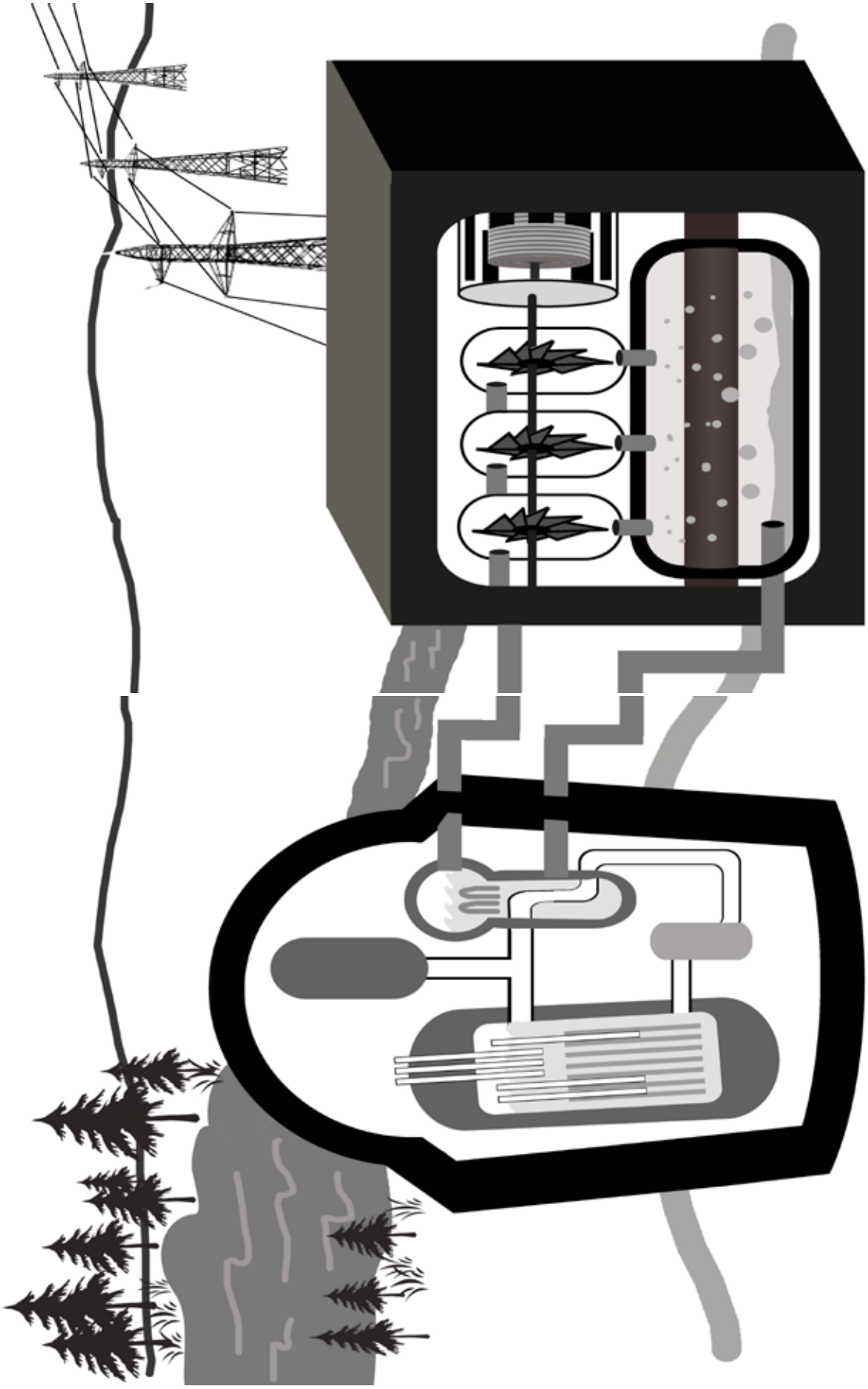

I have thermal energy. Who has the term defined as the ability to produce change or do work?	**I have fusion.** Who has the form of energy emitted into space from the sun by fusion?
I have energy. Who has the form of energy stored in the bonds of atoms and molecules?	**I have radiant energy.** Who has the process in which an atom is split?
I have chemical energy. Who has the center of an atom?	**I have fission.** Who has the fuel used in nuclear power plants for nuclear fission?
I have nucleus. Who has the form of energy stored in the nucleus of an atom?	**I have uranium.** Who has the types of energy released during nuclear fission?
I have nuclear energy. Who has the process that combines hydrogen atoms into helium in the sun?	**I have heat and radiation.** Who has the term for an energy source such as uranium that cannot be replenished quickly?

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I have nonrenewable. Who has the neutron-bombardment process that keeps fission going in a nuclear reactor?	**I have 20.** Who has the place where fission occurs in a nuclear power plant?
I have chain reaction. Who has the production facility where electricity is generated?	**I have reactor.** Who has the isotope of uranium used for nuclear fuel whose atoms are easily split?
I have power plant. Who has the number of nuclear reactors operating in the United States?	**I have U-235.** Who has the form into which uranium is processed to be used for nuclear fuel?
I have 104. Who has the usable energy produced by a nuclear power plant?	**I have ceramic pellet.** Who has the term for a bundle of fuel rods in a reactor's core?
I have electricity. Who has the percentage of electricity produced by nuclear energy in the U.S.?	**I have fuel assembly.** Who has the term for the U-235 that has been fissioned and removed from a reactor?

I have used fuel. Who has the term for the waste from a nuclear power plant that is dangerous for many years and must be stored carefully?	**I have carbon dioxide.** Who has the first submarine that ran on nuclear power for more than two years and traveled 62,562 miles before refueling?
I have radioactive. Who has the natural process that describes how used fuel cools and loses most of its radioactivity?	**I have the USS Nautilus.** Who has a career that starts up, shuts down and monitors operations at a nuclear power plant?
I have radioactive decay. Who has the term for places to store nuclear waste underground?	**I have reactor operator.** Who has a career that protects nuclear power plant workers and the general public from radiation?
I have repositories. Who has the location in the U.S. where radioactive waste may be stored?	**I have health physicist.** Who has a career that uses nuclear energy for electricity, space exploration, world food and water supply, environmental protection, medicine and transportation?
I have Yucca Mountain, NV. Who has the greenhouse gas that is NOT produced by a nuclear power plant since no fuel is burned?	**I have nuclear engineer.** Who has the form of energy produced deep within the earth by the slow decay of radioactive particles?

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Culminating Activity: Nuclear Power Plant Hearing

The Background: You live in a rural community with 450 people within the city limits. Your county, which is 500 square miles, has an overall population of 25,000 people.

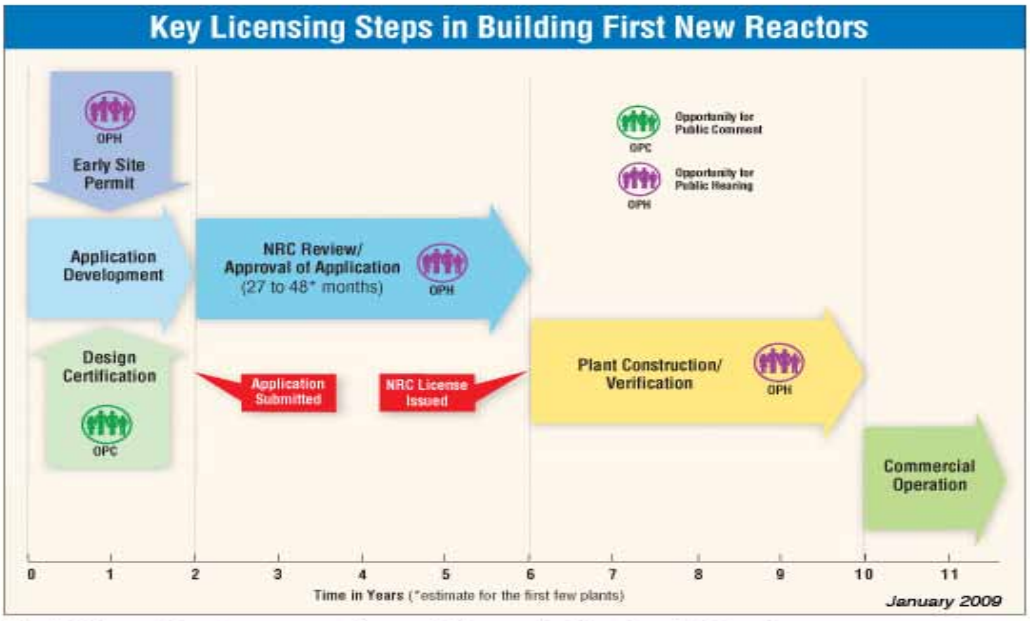
Your state has long been known for coal production; however the legislature recently implemented a policy which requires energy companies to decrease their greenhouse gas emissions. The state population is rapidly growing and the demand for electricity continues to increase. Atomic Energy Incorporated is a power company already supplying your area with electricity from nuclear power. In order to meet energy demand, and fulfill state energy and environmental requirements, Atomic Energy Inc., has submitted an Early Site Permit to the Nuclear Regulatory Committee asking to build a new nuclear reactor at their existing nuclear power plant.

The Early Site Permit: The site in question is x acres of open land which includes two miles of shoreline along the city's public lake, currently owned by Atomic Energy Incorporated.

On the site the company would like to build one pressurized water reactor which would produce 1500 megawatts of electricity. This is enough electricity to power 375,000 homes.

During the early site permit phase there are three issues up for debate: safety at the plant, environmental protection, and emergency plans. In this modified hearing issues pertaining to the cost of building on the site, recurring costs after plant construction, and costs to the local community will also be discussed. Interested parties will present their case before a three member panel from the Nuclear Regulatory Committee. If the permit is issued, Atomic Energy Inc., will be able to continue on to the next steps required to build a new nuclear reactor. If the permit is denied, the company will have to start over and choose a new site if it wishes to continue.

Your Assignment: You represent a citizen either for or against the proposed nuclear power plant. You need to research the topic from the perspective of your assigned role and find evidence to support your position. Give at least three reasons for your position and support each reason with three facts. You also need to address at least one argument that the opposite viewpoint might bring up. Write a persuasive letter based on your viewpoint to be presented to the NRC who will make the final decision based on the testimony at the meeting.



The NRC's new licensing process offers multiple opportunities for public input.

Roles:

- NRC Panel – Will hear all arguments and make a ruling on the early site permit
- Atomic Energy Inc. – Trying to provide consumers more electricity
- Residential Consumer – Wants cheap electricity, does not want to pay higher rates.
- NRC Inspector – Provides oversight for the safety concerns of the nuclear power plant
- Parent – Concerned about health risks
- Global Warming Activist – Proponent of nuclear energy as a non-CO^2 energy source
- Mayor and City Council – Improve business options and way of life
- Nuclear Scientist – Enthusiast for advancing nuclear energy technology
- Director of Transportation – Focuses on the transportation of products associated with the nuclear power plant
- Biologist – Studies impacts on the local environment and animal populations
- Environmentalist – Looks at impact of the power plant on the environment
- Sustainable Energy Enthusiast – Wants sustainable energy development
- Coal Miner – Wants to ensure job security.
- Representative from the U.S. Environmental Protection Agency (EPA) – responsible for environmental impacts of new plant
- Representative of U.S. Homeland Security Department – responsible for evacuations in case of an accident or terrorist attack
- Local Law Enforcement – Concerned about how their own department will be impacted by the building of a nuclear power plant in their jurisdiction and the energy management plan.
- Representative of lead contractor for plant construction – explains type of nuclear reactor and its advantages over older types
- Representative of the press – reports news of the proposed plant construction to region
- Representative of state utility commission – determines electricity rates and approves plant construction
- Representative of financial organization – determines if a loan for the construction of the plant is feasible for the company
- Nuclear Power Opponent – Opposed to using nuclear energy because of environmental or proliferation risks.

Culminating Activity: Nuclear Energy Letter Prompt

As the United States looks to increase electricity production while cutting greenhouse gas emissions increasing the use of nuclear energy is one option. Write a persuasive letter to a local or state representative presenting your position for or against nuclear energy.

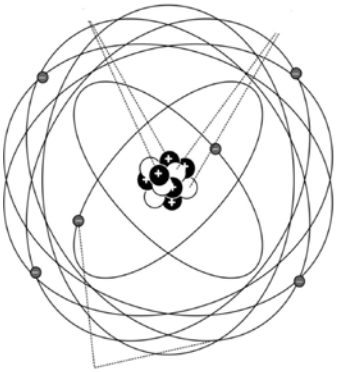
Your letter should have three parts. First, explain your understanding of energy and why this is an important topic. Second, explain your understanding of how a nuclear power plant works. Finally, state your position for or against the use of nuclear energy. Support your position with at least three reasons and at least two pieces of evidence for each reason. Clearly communicate your position so that the representative might be persuaded to agree with you and think about your letter when he or she makes energy policy recommendations and decisions.

Extension: Have students present an alternative choice to nuclear energy if they are against it, or tell what issues need to be resolved before they could support nuclear power.

Name _____ Date _____

Nuclear Energy Assessment

1.) Draw a diagram of an atom including the following parts, electron cloud, nucleus, proton, neutron, electron. Beside each label give a brief description of the function of the part.



2.) List five r**enewable energy** sources.

3.) List five **non-renewable** energy sources.

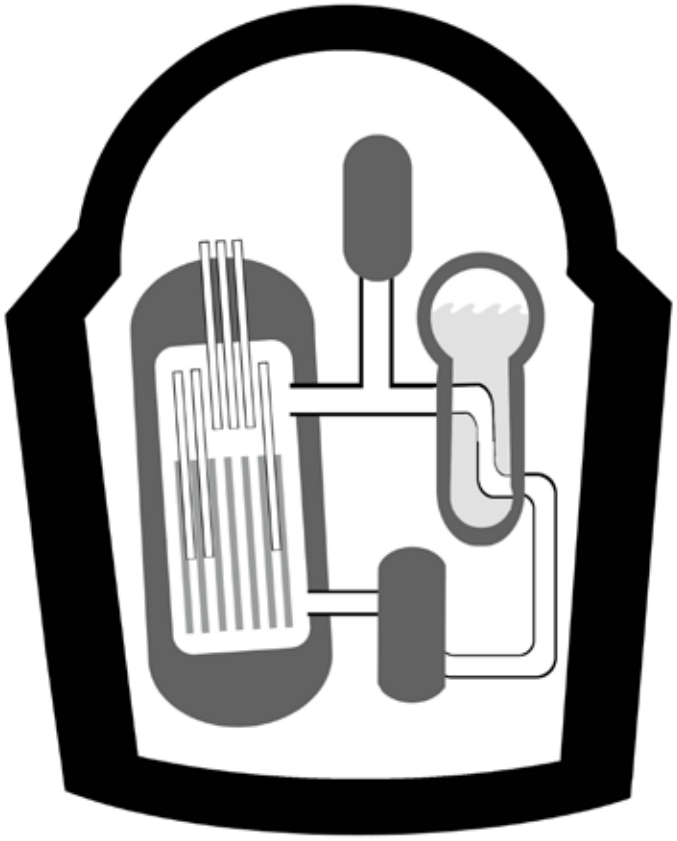
4.) Make a diagram that shows the relationship(s) between electricity and magnetism, and then describe the relationship.

5.) What are the two things that nuclear reactions may release?

6.) Why must uranium be enriched before it can be used as a fuel source in a nuclear reactor?

7.) What is the purpose of a **moderator** in a chain reaction? Name two different moderators used in common nuclear reactors.

8.) From the following diagram of a nuclear reactor, label the following parts: **reactor vessel, pump, fuel assemblies, control rods, moderator, pressurizer, containment building**. Next to each term, describe its main purpose in one sentence.



9.) What does the term **nuclear proliferation** mean? Why should people be concerned about uncontrolled nuclear proliferation?

10.)What is the biggest challenge with **used fuel** in the United States?

11.) Describe at least one lesson learned from each of the accidents at Chernobyl and Three Mile Island.

12.) What are at least three safety features built into a nuclear power plant?

13.) Choose one historical event related to nuclear energy and tell how it shapes people's views about nuclear energy.

14.) Other than a fuel source to create electricity, name at least two other ways that nuclear science has benefitted society.

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