



STEM PROJECT STARTER
Transform Energy

Topic

From Atoms to Electricity

PROJECT DETAILS

Course

Physical Science

Grade Span

6-8

Duration

x2 45–60-minute sessions

Concept

Transformation of Energy

Overview

This project provides students with the opportunity to synthesize what they have learned about energy transformation in other power systems to develop a model that describes the energy conversions in a nuclear power plant. Nuclear power plants work by using the heat from fission to create mechanical energy, which turns an electric generator. This heat is used to make steam, that turns a turbine, and then turns the generator. Nuclear power is the only energy source with near-zero carbon emissions that can sustainably deliver energy to our industrial society.

Essential Question

How does the energy stored in an atom's nucleus transform into the electricity that powers our lives?

Materials

- Image of nuclear power plant
- Projector to display video
- From Atom to Electricity Rubrics student handout
- Chart paper for students to sketch their diagram
- Nuclear Power Plant Diagram student handout (optional)

Procedure

Think Energy

- 1 Display an image of a nuclear power plant.



- 2 Encourage students to look closely and try to observe as many details as possible. Give students five minutes to jot down answers to the following questions:
 - What do you see? Remind students to only report on things they actually see in the image.
 - What do you think about that?
 - What does it make you wonder?
 - Facilitate a group discussion about the questions.
 - Ask students to use the following stems when sharing: “I see...,” “I think...,” “I wonder...”
- 3 Prior to watching/reading/listening to the video below, divide students into teams of four students and assign each a perspective ‘hat’ to take while watching the content:
 - a. Blue: Thinking Hat - Processes information through summarizing, building conclusions, and using information gained to make decision
 - b. Red: Feelings Hat - Processes information through feeling, emotions, and intuition.
 - c. White: Information Hat - Processes information through what information is currently accessible and what facts need to be gathered.
 - d. Yellow: Benefits Hat - Processes information through a sunny disposition of what’s good, positive, and valuable in situations.
- 4 Next, share the linked video for students to investigate how a nuclear power plant works using their “hat”. Invite students to share with their groups after the video. You may need to play the video more than once for students to collect the information.
[How Does a Nuclear Power Plant Work?](#)
- 5 Summarize by sharing that nuclear power begins with uranium in a ceramic form, pressed into a small pellet and then placed into long pipes called fuel rods. Facilitate a group discussion about the questions.
 - How does the plant turn the binding energy of the atom into electricity we use?
 - What mechanisms and how many energy transformations are involved?

Create

Energy Transformation

- 1 Explain to students that they will create a model of a nuclear power plant, explain the transformation of energy, and calculate the energy losses in the plant. This project builds on what students have learned about energy transformations in other power systems. Distribute the *From Atoms to Electricity Rubrics* for students to track the requirements of the project.
- 2 Provide students with the basic parts of a nuclear reactor and the forms that energy takes. You may wish to use the *Nuclear Power Plant Diagram* as a starting point for students. Students should sketch, diagram, or build a model of a nuclear power plant. Their nuclear reactor should include fuel rod heating, boiling water, steam moving in a pipe, a turbine spinning, and a generator. If they build a physical model, they should take a picture and diagram the pieces.
Sample Answer: Diagram should show the fuel rod heating taking place in the water, which leads it to boil becoming steam. This steam should pass through a turbine that is connected to a generator.

Connect

Energy Conversions

- 1 Guide students to use their model as a basis and describe all the energy conversions that take place in the nuclear reactor system. The process should note potential and kinetic energy as necessary.

Sample Answer: Student answers will vary but should begin by noting the potential nuclear energy in the ceramic fuel pellets. This potential energy in the binding energy of an atom is converted into heat, which is transferred to the water and then contributes to the phase change of turning the water into steam. The water expands as it becomes steam, and the thermal energy involved in that is converted into the kinetic energy that spins the turbine. The turbine is connected to a generator making it spin as well, which converts this kinetic energy into electrical energy.

Efficiencies

- 1 Finally, provide the efficiencies of the various energy conversions in the following table. Ask students to calculate the efficiency of the nuclear reactor as a whole, showing their work.

Energy conversion	Efficiency
Nuclear boiler	90%
Turbine	45%
Generator	88%

Sample Answer: Student responses should calculate the overall efficiency as $90\% \times 45\% \times 88\% = 35.64\%$, which we round to 36%.

- 2 Summarize with students the self-monitoring and research nuclear power plants perform because of the potential risk of radioactive material leaks. Energy researchers look at the impact of energy systems like nuclear, coal, natural gas, wind, and solar to understand release into the air and water and other land/water impacts.
 - a. How do nuclear power plants generate energy without creating carbon?
 - b. And how does their efficiency compare to that of coal or natural gas power plants? Invite students to use data from their calculations as an example.
 - c. For the same energy output how much land area is used?

National Standards

Next Generation Science Standards

Constructing Explanations and Designing Solutions

Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system.

PS3.B: Conservation of Energy and Energy Transfer

When the motion energy of an object changes, there is inevitably some other change in energy at the same time.

The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.

PS3.A: Definitions of Energy

The term “heat” as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects.

The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule (whichever is the appropriate building block for the system’s material). The details of that relationship depend on the type of atom or molecule and the interactions among the atoms in the material. Temperature is not a direct measure of a system’s total thermal energy. The total thermal energy (sometimes called the total internal energy) of a system depends jointly on the temperature, the total number of atoms in the system, and the state of the material.

Crosscutting Concept

Energy and Matter

Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion).

The transfer of energy can be tracked as energy flows through a designed or natural system.

Evaluation Criteria

Your answer will be evaluated based on the following criteria:

- Accurate flow of energy through nuclear reactor
- Correct identification all parts of the nuclear reactor

Rubric

Criteria	2	1	0
Energy Flow	Diagram accurately shows all steps of the flow of energy through the reactor.	Diagram accurately shows most steps of the flow of energy through the reactor.	Diagram is inaccurate or missing.
Identification	All parts of the nuclear reactor are identified and labeled correctly.	Most parts of the nuclear reactor are identified and labeled correctly.	The parts of the nuclear reactor are not labeled or are labeled incorrectly.

Evaluation Criteria

Your answer will be evaluated based on the following criteria:

- Clear, correct description of the energy conversions in the nuclear reactor

Rubric

Criteria	2	1	0
Description of Energy Conversions	Description of energy conversions is clear and correct and includes all conversions. Applications are well-described, complete, and accurate.	Description of energy conversions is unclear or poorly organized or is missing one or more conversions.	Description of energy conversions is incorrect or missing.

Evaluation Criteria

Your answer will be evaluated based on the following criteria:

- Calculate the overall efficiency and show your work

Rubric

Criteria	2	1	0
Calculations	Calculation is complete and accurate, and all the work is shown.	Calculation is accurate, but the work is not shown.	Calculation is incorrect or missing.

