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# The Nuclear Option

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Segment Length: 7:12 minutes

## **Lesson Description:**

Is nuclear power a solution to climate change? Why/Why not? How does nuclear power compare with carbon-based and renewable energy? This lesson takes a brief look at the history of nuclear power, alleged dangers and political agendas, the consequences of increasing the use of nuclear energy, including the potential environmental impact of building more nuclear power plants in the United States and abroad. This lesson also highlights the importance of critical thinking on polarizing issues and how solutions should not be disregarded because of fear.

## **Concepts & Key Terms:**

*Existential* – of or relating to existence. (Is climate change an *existential* threat?)

*Climate change* – long-term shifts in temperatures and weather patterns, can be natural or due to human activities (primarily the burning of fossil fuels).

*Fearmongering* – the action of deliberately arousing public fear or alarm about a particular issue.

*Activists* – a person who campaigns to bring about political or social change.

*Nuclear energy* – the energy released during nuclear fission or fusion, especially when used to generate electricity.

*Nuclear reactor* – devices that control nuclear chain reactions to produce heat or electricity, the heart of a nuclear power plant.

*Emissions* – the production and discharge of something, especially gas or radiation

*Uranium (U-235)* – a common metal used as fuel by nuclear power plants for nuclear fission.

*Fission* – the action of dividing or splitting something into two or more parts.

## **Objectives:**

By the end of this lesson, students will be able to:

- list the pros and cons of nuclear power.
- identify potential environmental impacts that concern activists.
- explain in basic terms how a nuclear power plant works.
- hypothesize about the future of nuclear energy in America.

## **Preview Activity and Questions:**

Use Think, Pair, Share to have students answer A or B. After a few minutes, poll the students and ask the students to discuss their answers.

- A. Should a discussion of alternative power sources include nuclear energy? Why/Why not?  
Does reliability matter?
- B. What are the dangers of nuclear power? What are the benefits?

**Viewing Guide:**

We recommend that teachers show the video segment twice: once to allow students to view the video and focus on the issues presented, and once to allow them time to complete the viewing guide. After they complete the viewing guide, allow students a few minutes to work in pairs sharing and verifying answers.

**Answers to Viewing Guide:**

1. France's
2. partial meltdown
3. fearmongering
4. China
5. greenhouse gas
6. six

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## Viewing Guide

Name \_\_\_\_\_

Date \_\_\_\_\_

Class \_\_\_\_\_

Teacher \_\_\_\_\_

**Directions:** As you watch the video, fill in the blanks with the correct words.

1. Today, around 75% of \_\_\_\_\_ power comes from nuclear energy.
2. Absurdly, nuclear power came to a near halt in America because of a \_\_\_\_\_ at Three Mile Island, Pennsylvania.
3. There's been a campaign of \_\_\_\_\_ around radioactivity and radiation and nuclear power for decades now.
4. \_\_\_\_\_ is putting a nuclear reactor on the grid every two to three months.
5. The speediest drop in \_\_\_\_\_ pollution on record occurred in France, when that country transitioned to nuclear.
6. America may soon finish one [nuclear reactor]. Fifteen years after approval was sought, it still isn't operating. It took \_\_\_\_\_ years just to get permission to build.

**Now, take a few moments to reflect on the video and answer the question below:**

What did you learn from this video that surprised you? \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_

“The accident at Three Mile Island killed no one...but by coincidence, days before, Hollywood released a movie (*The China Syndrome*) that suggested a nuclear power plant accident could burn a hole all the way to China.”

Can you think of other instances or political issues where politicians and activists use entertainment and fear to push an agenda? Are there other films or songs you can think of that have been used to scare viewers? \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_

On what other cultural or political issues do politicians and activists use fear to push an agenda?

\_\_\_\_\_  
\_\_\_\_\_

### **Discussion and Analysis:**

1. Which European countries get a lot of electricity from nuclear power?
2. Why does environmentalist Josh Goldstein say that nuclear power can save the world?
3. What is Three Mile Island? What happened there? What about Fukushima? What about Chernobyl?
4. In 2021, the USA had 93 operable nuclear reactors, which generated 19.6% of the country's electricity. Does that surprise you? Why/Why not?
5. In the video, environmentalist Bjørn Lomborg says that we kill many more people by using a lot of fossil fuels. How might fossil fuels cause death?
6. Do you think the time it takes to get permission and then build a nuclear power plant in the United States impacts the number of utility companies that apply for permission? Should that be changed? Please explain.
7. Shutting down electrical generating plants that run on coal, oil, and natural gas will reduce our electrical supply, which wind and solar will not be able to make up. Yet there is a push to get people to buy electric cars. Is there a contradiction here? How so?/How not?
8. Is the fear of nuclear power based on actual dangers, or is it more about a narrative of fear to implement further regulations, and mandate other climate-related controls on society?
9. What seems to have had a worse impact, the radioactivity itself or the fear of radioactivity?
10. What is nuclear waste? How much nuclear waste is produced from nuclear power reactors?
11. While there is no *perfect* energy supply, when it comes to energy production, how might the surrounding geology, ecology, and climate impact energy production? That is, are there conditions in certain areas that make a particular means of energy production a better choice?
12. What special interest groups exist in the energy production debate, whether nuclear vs non-nuclear, wind, solar, natural gas, coal, oil, etc.? Do they admit they are special interests pushing their agenda, or does each group argue that they know what's best?
13. What is the role of government when it comes to energy production? Should politicians cater to special interests? Should they regulate industries? How can regulation be done objectively?

### **Discuss These Lines from the Video:**

1. The world is going to end in 12 years if we don't address climate change.
2. Climate change is the existential threat.

3. That “worst” accident killed no one. It would have been largely forgotten, except that by coincidence, days before, Hollywood released a movie that suggested an accident could burn a hole all the way to China.
4. It’s a virtual inevitability that we’re going to have another disaster.
5. The fear of radioactivity really did kill people.
6. Nobody was harmed at Three Mile Island.
7. If you took all the nuclear waste, all the spent fuel from all of America’s reactors for 60 years, it would fit into a Walmart.
8. America more than doubled construction time, and cost, by increasing regulations.
9. Batteries are environmentally nasty.
10. But even including Chernobyl’s deaths, nuclear power is much safer than coal, oil, natural gas, almost as safe as wind and solar.
11. There’s been a campaign of fearmongering around radioactivity and radiation and nuclear power for decades.
12. Nuclear energy has been tested; it could reduce greenhouse gases and keep energy cheap. If only we didn’t fear it so much.

### **Quotes for Discussion:**

I would like nuclear fusion to become a practical power source. It would provide an inexhaustible supply of energy, without pollution or global warming. – Stephen Hawking

The oil companies regard nuclear power as their rival, who will reduce their profits, so they put out a lot of disinformation about nuclear power. – James Lovelock

Nuclear is ideal for dealing with climate change, because it is the only carbon-free, scalable energy source that’s available 24 hours a day. – Bill Gates

Nuclear power can save the world. – Josh Goldstein

I foolishly once believed the myth that nuclear energy is clean and safe. That myth has completely broken down. Restarting nuclear reactors while we still have no place to dispose of nuclear waste is a criminal act toward future generations. – Morihiro Hosokawa

Nuclear power is the only green solution. – James Lovelock

We rejected nuclear for several reasons. First, it’s not carbon-free, no matter what the advocates tell you. Vast amounts of fossil fuels must be burned to mine, transport and enrich uranium and to build the nuclear plant. – Mark Z. Jacobson

The search for a sustainable solution for the issue of nuclear waste is and has been one of the most important challenges for the nuclear industry. Here, in Onkalo [Finland], half a kilometer underground we see that the solution exists... – Rafael M. Grisso

**Activities: While these activities are separated by grade level, teachers know their students best and we encourage you to peruse the entire list and select the activities you believe are appropriate for your students' grade level and abilities.**

### **Grades 4-8**

1. Have students complete the worksheet "Scientists & Discoveries."
2. Have students work in groups to complete the worksheet "The Nuclear Option PMI Chart."
3. Have students work in groups to complete the worksheet "The Nuclear Option KWL Chart."
4. Research the history and evolution of nuclear power. Who were the primary drivers of research? What was the "Atoms for Peace" program? How and when was nuclear energy first used to power communities?
5. Write a letter to a local politician or your congressional representative (in the House of Representatives or in the Senate). Provide your thoughts on nuclear power and whether he or she should support nuclear energy production in America or be against it.
6. Create a poster board or slide show that shows the drawbacks of each of the energy sources now in use in the United States.

### **Grades 9-12**

7. Have students complete the worksheet "The Science Behind Nuclear Power."
8. Have students work in groups to complete the worksheet "The Nuclear Option PMI Chart." Then encourage students to research the topic and come up with their own conclusions on nuclear power and regulations.
9. Organize a debate or panel. Divide into two teams (or split in multiple even groups depending on size of the class), one for nuclear power and one against. Provide some time to prepare and then hold an official debate or panel discussion on the pros and cons of nuclear power. Determine who presented the best case based on research and points made.
10. Research one or more of the nuclear power disasters, including Three Mile Island, Fukushima, and Chernobyl. Were there design flaws in the nuclear plant(s)? What caused the disaster? How many deaths were there? What were the environmental impacts? What are some long-term consequences? Are there current radiation leaks or heightened radiation above levels considered to be safe?
11. Compare the death rates for nuclear energy to other forms of energy (solar, wind, nuclear, natural gas, oil, coal).
12. Find a recent news article or TV news clip about nuclear power in America or another country. Choose from the following activities:
  - A. Summarize the article or news clip.
  - B. Using information from the article, write a persuasive essay arguing for or against nuclear power.

- C. Write about the future you foresee for nuclear energy in America, Europe, or Asia.
13. Write a scientific research paper on how a nuclear power reactor works, its components, what fuels nuclear reactors and relate what types of nuclear power reactors currently exist.
  14. Produce a “man-on-the-street” video in which you ask people what they know about nuclear energy. Then ask if their answer was a fact or an opinion.

### College

15. Discuss how the media and government officials use fear to manipulate society and social movements.
16. Find an expert to interview, either a nuclear power official, a politician who has made nuclear power a part of his or her platform, or a climate activist. Ask the expert about his or her stance on nuclear power, why he or she holds that position, and what facts support that position.
17. Research the various organizations that have formed around nuclear energy such as the International Atomic Energy Agency (IAEA), World Nuclear Association, and European Organization for Nuclear Research (CERN). Deep dive into their websites and positions on nuclear power. Choose one organization and write an informative essay about it. Be sure to discuss:
  - A. What data can be gathered from their sites?
  - B. Do any of the organizations provide enough fact-based information that influences your opinion of nuclear energy? Has any of the research changed your mind?
18. Discuss the value of critical thinking and finding information for yourself, rather than allowing the media and politicians to dictate what we as a society should be afraid of.
19. Listen to Josh Goldstein, author of A Bright Future, read the show notes that follow it, and summarize his podcast.

<https://www.titansofnuclear.com/experts/JoshuaGoldstein>

**References:** (Added as support for information above and references for student research.)

Why Fukushima Was Preventable

<https://carnegieendowment.org/2012/03/06/why-fukushima-was-preventable-pub-47361>

Fukushima disaster was preventable, new study finds

<https://news.usc.edu/86362/fukushima-disaster-was-preventable-new-study-finds/>

A future for nuclear energy?

<https://impact.economist.com/perspectives/energy/future-nuclear-energy>

Nuclear Power: Time to Choose

<https://content.time.com/time/subscriber/article/0,33009,972823,00.html>

World Nuclear Association

<https://www.world-nuclear.org/>

International Atomic Energy Agency

<https://www.iaea.org/>

France announces plans to build up to 14 nuclear reactors

<https://www.cnn.com/2022/02/11/business/nuclear-power-france/index.html>

Nuclear Power by Country 2023

<https://worldpopulationreview.com/country-rankings/nuclear-power-by-country>

Bill Gates: Nuclear power will 'absolutely' be politically acceptable again

<https://www.cnbc.com/2021/02/25/bill-gates-nuclear-power-will-absolutely-be-politically-acceptable.html>

Nuclear 101: How Does a Nuclear Reactor Work? (used for Activity 3)

<https://www.energy.gov/ne/articles/nuclear-101-how-does-nuclear-reactor-work>

Ask an Expert: Nuclear's World-Class Safety Standards

<https://www.nei.org/news/2022/ask-an-expert-nuclear-energy-safety-standards>

Outline History of Nuclear Energy (used for Activity 1)

<https://world-nuclear.org/information-library/current-and-future-generation/outline-history-of-nuclear-energy.aspx>

How Nuclear Power Can Stop Global Warming

<https://www.scientificamerican.com/article/how-nuclear-power-can-stop-global-warming/>

Nuclear power is too risky

<https://www.cnn.com/2010/OPINION/02/22/jacobson.nuclear.power.con/index.html>



Name \_\_\_\_\_

Date \_\_\_\_\_

Class \_\_\_\_\_

Teacher \_\_\_\_\_

## The Nuclear Option Matching Activity

**Directions:** Match the scientists and influencers to their work.

### Name of Researcher:

1. \_\_\_\_\_ Martin Klaproth
2. \_\_\_\_\_ Albert Einstein
3. \_\_\_\_\_ Wilhelm Röntgen
4. \_\_\_\_\_ Niels Bohr
5. \_\_\_\_\_ Irene Joliet-Curie
6. \_\_\_\_\_ Dwight D. Eisenhower
7. \_\_\_\_\_ Enrico Fermi
8. \_\_\_\_\_ The MAUD Committee
9. \_\_\_\_\_ James Chadwick

### Discoveries & Actions:

- A. Mechanical engineer and physicist who discovered ionizing radiation.
- B. Opened nuclear research for civilians with "Atoms for Peace" initiative.
- C. Physicist who worked on The Manhattan Project, ushering in the Nuclear Age.
- D. Summarized how uranium could be used as a source of power.
- E. Physicist who built the first nuclear reactor.
- F. Physicist who discovered the neutron.
- G. Set the stage for nuclear power by explaining how mass and energy are interchangeable.
- H. Chemist who discovered uranium.
- I. Scientist who discovered that radioactive elements could be artificially produced.

Answer Key:

1. H.
2. G.
3. A.
4. C.
5. I.
6. B.
7. E.
8. D.
9. F.

Name \_\_\_\_\_

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Class \_\_\_\_\_ Per \_\_\_\_\_

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### The Nuclear Option: PMI Chart

**P = Plus:** What might be some advantages of using nuclear power for energy?

**M = Minus:** What might be some disadvantages of using nuclear power for energy?

**I = Interesting:** List some interesting perspectives and/or myths about the production and use of nuclear energy?

+ Plusses +	- Minuses -	Interesting

Who are some supporters of nuclear energy and what do they say about it? Who are some non-supporters and why do they hold this position? \_\_\_\_\_

When it comes to energy production, does the U.S. government regulate too much, too little, or just enough? Explain your answer. \_\_\_\_\_

What do you think about nuclear power? Why? Do you feel strongly one way or the other? \_\_\_\_\_

Name \_\_\_\_\_

Date \_\_\_\_\_

Class \_\_\_\_\_ Per \_\_\_\_\_

Teacher \_\_\_\_\_

## The Nuclear Option K-W-L Chart

**Directions:** Complete the **K** and **W** sections prior to watching the video. After you have seen the video, complete the **L** section and answer the two questions below the K-W-L chart.

<b>K</b>	<b>W</b>	<b>L</b>
What I know about nuclear energy...	What I want to know about nuclear energy...	What I've learned about the debate over nuclear energy...

Why is this video titled "The Nuclear Option"?

Do you think that the fears surrounding nuclear energy have been exaggerated? Why / Why not?

Name \_\_\_\_\_

Date \_\_\_\_\_

Class \_\_\_\_\_

Teacher \_\_\_\_\_

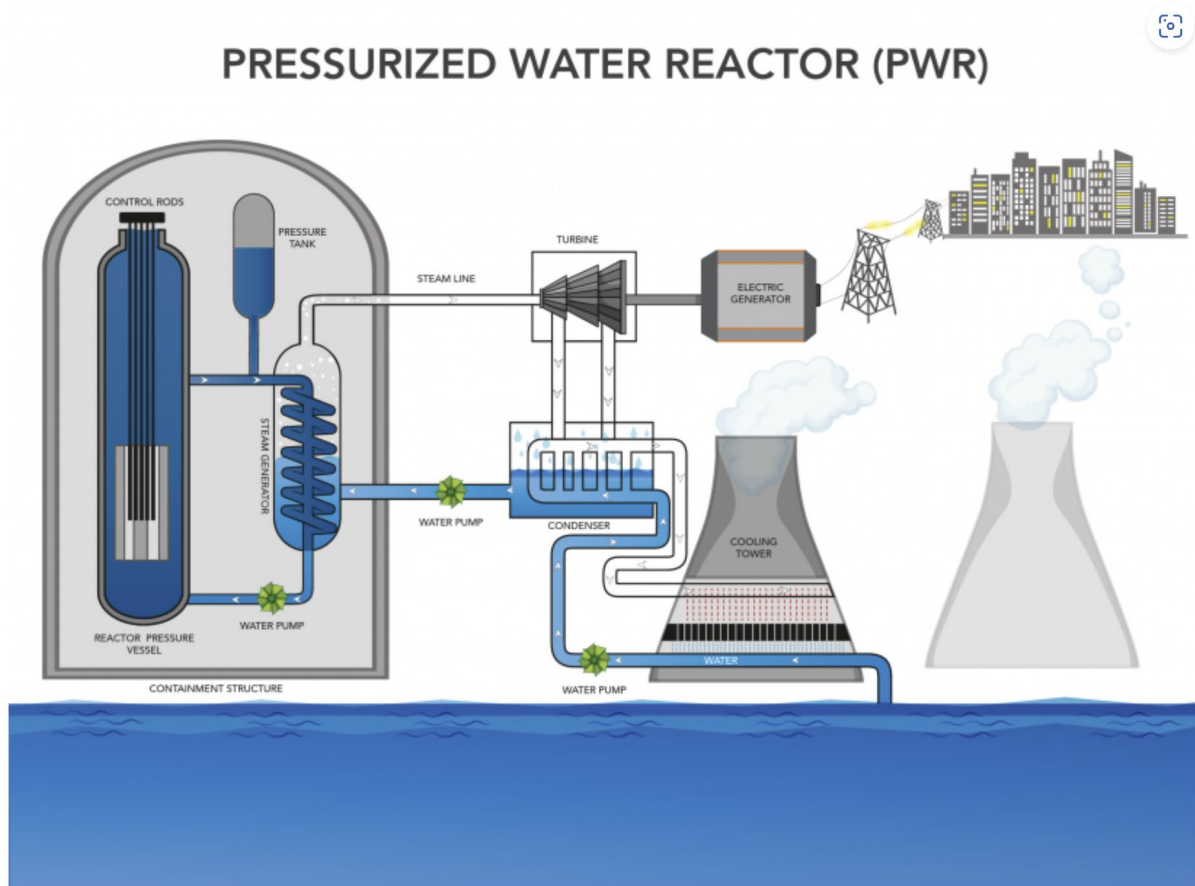
## The Nuclear Option

### The Science Behind Nuclear Power

**Directions:** To learn the science behind nuclear power, research nuclear reactors and how they work, and answer the questions below.

According to Energy.Gov, "More than 65% of the commercial reactors in the United States are pressurized water reactors (PWRs)."

#### PRESSURIZED WATER REACTORS



1. Through your research on nuclear reactors, summarize how a PWR works so that another student can understand: \_\_\_\_\_

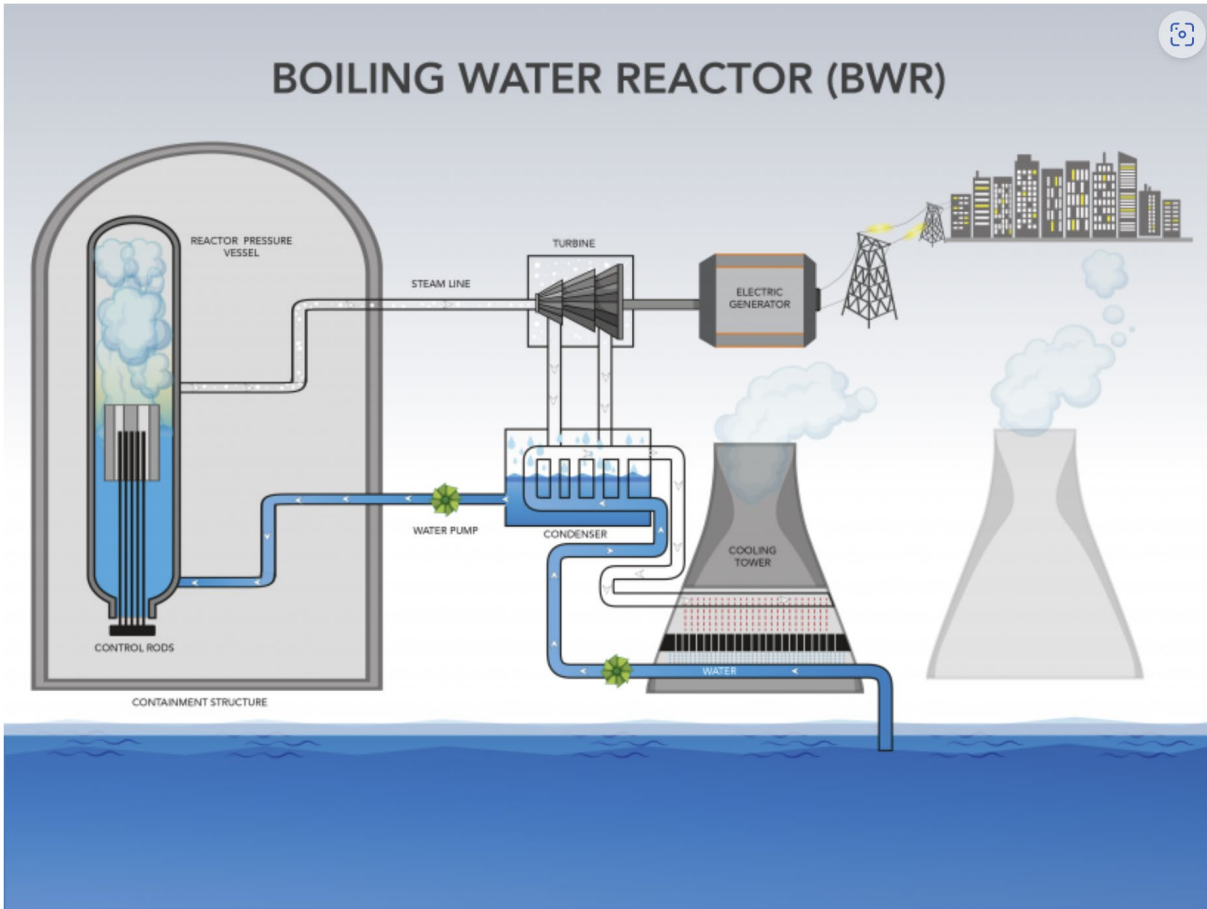
\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Roughly a third of the reactors operating in the United States are boiling water reactors (BWRs).

### BOILING WATER REACTORS



Graphic by Sarah Harman | U.S. Department of Energy

2. Through your research on nuclear reactors, summarize how a BWR works so that another student can understand: \_\_\_\_\_

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3. Does understanding the science behind nuclear energy make you feel more comfortable or less comfortable about the production of nuclear energy? Please explain. \_\_\_\_\_

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