

Understanding The Nuclear Industry Lesson Plan: KS4 (GCSE)

Teacher's Notes

Lesson Overview

In this lesson students will reinforce their existing knowledge of the different forms of renewable and non-renewable energy that make up the energy mix in the UK. Nuclear energy will then be explored in more detail to increase students' understanding of the processes of nuclear fission and fusion, nuclear reactors and the various uses of nuclear technology. The advantages and disadvantages of nuclear technology will then be researched, discussed and evaluated.

Learning Objectives

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

1. Understand the different renewable and non-renewable energy sources that make up our energy mix.
2. Describe the difference between nuclear fission and fusion and how a nuclear reactor works.
3. Identify and explain the use of nuclear technology in industry for power generation, medicine, space exploration, agriculture and defence.
4. Discuss and evaluate the benefits and risks, ethical, societal and environmental, associated with nuclear technology.

Curriculum Links

Science:

- Describe the main energy sources, compare ways they are used and distinguish between renewable and non-renewable sources.
- Explain patterns and trends in energy use.
- Understand the processes of nuclear fission and nuclear fusion.
- Describe the different uses of nuclear technology.
- Encourage students to analyse, evaluate and present evidence and understand real-world applications of science.

Geography:

- Resources and management
 - Overview of how humans use, modify and change ecosystems and environments in order to obtain energy
 - Recognise the changing characteristics and distribution of demand and supply, past and present impacts of human intervention and issues related to the sustainable use and management at a variety of scales.
 - Evaluate the environmental and societal impacts of energy sources.



Lesson Structure

1. Starter Activity (10 minutes)

Objective: Recap of prior knowledge about electricity and energy sources.

- **Prior knowledge quiz / perception of nuclear (Ask Questions and write ideas on the white board, then show the key answers on slides)**
 - What is electricity?
 - *Electricity is created when electrons move. The flow of these electrons is the electric current.*
 - How is electricity transported?
 - *Electricity is transported from where it is generated to homes and businesses either above ground through pylons or in underground cables.*
 - How is electricity made?
 - *An energy source causes liquid or gas to move. This movement (kinetic energy) is used to turn a turbine. Turbines are connected to generators, which contain a ring of magnets surrounded by a ring of tightly wrapped metal wires. When the generator turns, the magnets spin and the movement of magnets past the wires makes electricity flow through the wires.*
 - What are the main sources of energy and are they renewable or non-renewable?
 - *Renewable: solar, wind, hydro (water), wave, geothermal, tidal, biofuel - renewable sources will never run out and are a natural source of energy.*
 - *Non-Renewable: Coal, gas, oil and nuclear - these sources won't last forever as they use up materials that come from the earth. This is a finite resource which can't be quickly replaced once used up.*
 - What comes to mind when you hear the word nuclear?

2. Introduction to the Nuclear Industry (15 minutes)

Objective: Provide an understanding of nuclear reactions, energy generation and radiation.

- **Types of nuclear reactions**
 - **Nuclear Fusion:** This is the process that gives the sun its energy. It is when pairs of tiny particles (atoms) are fused together to make a heavier one.
 - **Nuclear Fission:** This is when heavy atoms (Uranium-235 or plutonium-239 atoms) are split to release energy.
- **Use of nuclear for power generation**
 - **Nuclear Power:** Nuclear power is currently produced using nuclear fission within a nuclear reactor to produce energy. In the future, engineers hope to perfect the use of fusion to create power, but that's not here yet.
 - **Nuclear Reactors** The UK currently has 9 nuclear reactors in 5 locations. Older reactors will soon be shut down and replaced by newer ones. In addition to these new large scale (Gigawatt) reactors, smaller SMRs (Small Modular Reactors) and AMRs (Advanced Modular Reactors) are being developed.



- **Nuclear radiation**
 - **Radiation:** Identify the three types of radiation: alpha, beta and gamma.
 - Radiation can be beneficial but can also be harmful
- **Uses of nuclear technology**
 - Nuclear has many beneficial uses - which arise either from the quantity of energy released in fission or the properties of radiation.
 - **SHOW THE SUPPLIED VIDEO 'Introduction to Nuclear'**

3. Applications of Nuclear Technology (30 minutes) OPTION 1

Activity: Split this section into 5 subtopics, with interactive tasks for each topic.

A. Power Generation (6 minutes)

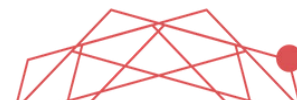
- **Explanation:** Nuclear power stations convert energy from fission into electricity as outlined above.
- **Benefits:** Nuclear energy has a high energy output but low carbon emissions. Burning fossil fuels produces pollution because it releases gases like carbon dioxide and sulfur dioxide, which contribute to the greenhouse effect, which is warming the earth, leading to climate change. Nuclear power uses a nuclear reaction to produce heat rather than burning fuel. It therefore doesn't release any carbon dioxide and as a result is a low-carbon energy source. Renewable sources such as wind and solar are clean but can only be generated when the wind blows or the sun shines.
 - **Challenges:** Waste, accidents, cost.
 - **Task:** Rank nuclear energy against other renewable and non-renewable energy sources according to efficiency, environmental impact and safety.

B. Medicine (6 minutes)

- **Explanation:** Nuclear medicine uses radioactive isotopes to diagnose and treat medical conditions and to sterilise medical equipment.
- **Task:** Match the following terms to their definitions
 - Terms: 1) PET scans, 2) radiotherapy, 3) sterilisation
 - Definitions: a) the treatment of disease, especially cancer, using radiation. b) the process of making something free from bacteria or other living microorganisms: c) An image made using positron emission tomography.

C. Space Exploration (6 minutes)

- **Explanation:** Radioisotope Thermoelectric Generators (RTGs) power deep-space missions (e.g., Voyager, Perseverance). Nuclear technology also provides the potential for faster space travel.
- **Task:** Research the benefits of using nuclear power in space - identifying why it is better than existing solutions for propulsion and power generation?



D. Agriculture (6 minutes)

- **Explanation:** Radiation can be used to develop pest-resistant crops or to kill pests during a process called food irradiation. Radioisotopes can also be used to monitor soil and water use in farming.
- **Task:** Research 3 ways nuclear is used in the agricultural industry.

E. Defence (6 minutes)

- **Explanation:** Nuclear technology can be used for defence as nuclear warheads on weapons - which are also known as 'deterrents' - and as a power source in nuclear submarines to provide long-lasting energy for underwater operations.
- **Task:** Research and discuss these two aspects in pairs
 1. What is the Non-Proliferation Treaty and what is the role of a nuclear deterrent?
 2. What alternative submarine power sources are there and why choose nuclear?

OR OPTION 2

Group Activity: Split the class into small groups. Assign each group a topic to research and discuss the advantages and disadvantages of nuclear technology. Each group presents a 1-2 minute summary of their findings to the class. (Potential discussion points are noted beneath each topic).

A. Nuclear Energy

- Advantages: low emissions, continuous power (to support renewables), energy density
- Disadvantages: waste, radiation risk, cost, accident potential

B. Medicine

- Advantages: diagnostics, cancer treatment, innovative targeted treatments
- Disadvantages: cost, isotope accessibility, time required to test new innovations

C. Space Exploration

- Advantages: dark-zone operations, long-term habitats, fuel-efficient propulsion
- Disadvantages: waste, radiation risk, cost, accident potential

D. Agriculture

- Advantages: environmentally friendly, opens up new water sources, animal health
- Disadvantages: potential for contamination, waste



E. Defence

- Advantages: deterrent to war, long distance submarine operation, border security
- Disadvantages: risk of inciting of war, waste streams

4. Plenary and Assessment (5 minutes)

Objective: Reinforce key concepts and assess understanding.

- **Quick Quiz (Verbal or Written):**
 1. What is nuclear fission?
 2. Name one advantage and one disadvantage of nuclear energy.
 3. How does nuclear power help reduce carbon emissions?
 4. Why is managing nuclear waste a challenge?
 5. Name one use of nuclear technology in medicine.
 6. What powers NASA's deep-space missions like Voyager?
 7. How is radiation used in agriculture?
 8. Should the UK invest more in nuclear energy? Why or why not?
 9. Which application of nuclear technology do you think is most beneficial and why?

Homework/Extension Activities

1. **Research Tasks:**
 - a. Define fusion / fission and explain the capabilities of each for producing energy.
 - b. Investigate a specific application of nuclear technology (e.g., cancer treatment, nuclear submarines, RTGs) and present findings in a poster or presentation.
2. **Creative Task:**
 - a. Design a poster promoting nuclear safety or highlighting innovations in the nuclear industry.
 - b. Design a concept for a new nuclear-powered technology, explaining its benefits and challenges.
3. **Ethics Essay:**
 - Should nuclear weapons be banned worldwide? Write a balanced argument discussing the pros and cons.

Resources Needed

1. Nuclear Institute video resource
2. Powerpoint slides / Diagrams
3. Internet access / Printed fact sheets on nuclear uses

