nuclear fission

Nuclear energy: what you get when the nuclei of atoms are split or fused. To make electricity we rely on a process called fission.

Fission occurs when the atomic nucleus is split into smaller parts, and energy is released. The energy is used to heat water to produce steam, which powers a turbine to produce electricity. (This is the method for any power station no matter what type of fuel is used.) Nuclear power plants are not very efficient: the ratio of steam to electricity produced is about 30%, but you need millions of times less nuclear fuel to produce the same amount of energy as produced by fossil fuel.

Decommissioning Dounreay
(photo Dounreay Site Restoration Ltd and NDA)

We only use about 2% of the energy available from uranium, the rest is wasted! The waste is highly radioactive and takes many thousands of years to decay to become safe. The big question is what to do with the waste? And are there any ways to produce less of it?

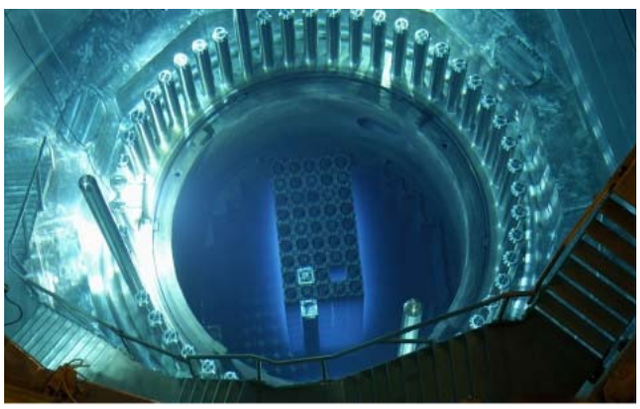
There are all sorts of ideas from burying it deep beneath the sea bed, to firing it into space. At the moment it is all being stored above ground until a suitable long term underground site can be found. After more than fifty years of nuclear power, the UK still has no permanent safe site. The latest attempts to locate a site in Cumbria were rejected by the council in early 2013.

Some types of reactor can re-use the waste to prevent the build-up of Polonium. It is used in nuclear weapons, and kills if ingested. Remember the case of Alexander Litvinenko?

Groundworks at Dounreay
(photoDounreay Site Restoration Ltd and NDA)

Waste is one issue. Safety is another. Nuclear power stations are using fuel which is highly dangerous, so they have to be looked after very carefully. Nearly all the accidents which have occurred at nuclear power plants have been caused by humans not looking after them, and sometimes even ignoring nuclear plant warning systems.

But the latest accident, at Fukushima in Japan in 2011, was caused by a tsunami, following an earthquake. It disabled the cooling systems and all three reactor cores melted. Over 100,000 people had to be evacuated from their homes. The clean-up is expected to cost at least £65bn, and take 30-40 years. The accident forced a rethink about nuclear power: Germany for example said it would phase out nuclear, by 2022.



A reactor core
(photo Kernkraftwerk Gosgen-Daniken AG / Creative Commons)

Decommissioning inside the main reactor hall
Photo credit Dounreay Site Restoration Ltd and NDA

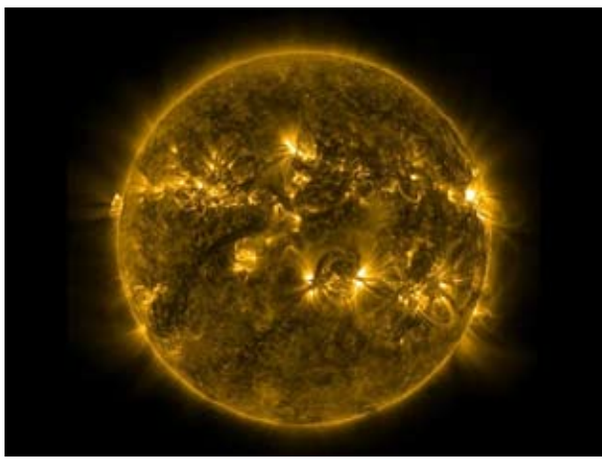
nuclear energy

nuclear fusion

Fusion happens when the nuclei of hydrogen atoms are forced together, producing huge amounts of energy. This is what keeps the sun shining.

Can we get electricity from fusion? The idea has been around for about a hundred years, but it's only in the past decade or so that scientists have actually been able to make it happen. But they haven't yet been able to get more energy out than they have to put in.

Fusion needs a lot of heat. In a fusion reactor, isotopes of hydrogen get heated to temperatures far greater than the sun, until you get something called plasma. You already know about solids liquids and gases: in this fourth state of matter, electrons are freed from their atoms, allowing current to flow.



Sun
(photo NASA)

The power of the atom isn't just used to create energy. It is used to make nuclear weapons. The Nuclear Non-Proliferation treaty is an international agreement to halt the spread of nuclear weapons and encourage peaceful uses of nuclear energy. But the concern is that some countries have used a nuclear energy programme to hide their attempts to create a nuclear weapon.

A Comprehensive Nuclear Test Ban treaty, which would ban nuclear explosions anywhere on the planet, has yet to come into force because some countries with nuclear weapons have not signed up, for example North Korea, Pakistan and India. The United States has signed up but has not yet committed to the treaty.

nuclear applications

• Medicine

Nuclear medicine gives doctors a way of looking inside our bodies. Examples are: X rays: these are a type of radiation which can pass through the body. The energy is absorbed at different rates by bone and soft tissue and these show up as either white areas (bone) or darker areas (soft tissue) on an X ray image.

Other techniques (pet scanning and cardiovascular imaging) allow doctors to study the functioning of the body. They work by detecting the radiation from substances injected into the body. The substance will have an added radioactive atom, such as Carbon 11, which decays quickly (called radioactive isotopes).

• Industry

There are numerous applications in industry, such as food irradiation to kill bacteria and increase the shelf-life of food; checking for water pollution; checking for cracks in aircraft welding. Radioisotopes are a good power source for where just a small amount of energy is needed e.g. a remote weather station, a weather balloon. Here there is no waste, which makes them better than using batteries.

• Archaeology

Archeology often uses carbon dating: the fact that radioactivity hangs around can be very useful. You may have heard of the discovery of remains of King Richard III in 2012 in a car park in Leicester. As part of checking that the skeleton was indeed his, scientists used carbon dating to work out how old the bones were. They do this by measuring the ratio of two types of carbon atom: 'normal' carbon C12 and the carbon isotope C14. After death, an organism stops taking in C14. This decays and is not replaced, whereas the amount of Carbon 12 remains constant. Measuring the ratio of C12 to C14 gives a fairly accurate estimate of the age of a dead body.

Medical imaging
(photo Wellcome Images)

nuclear energy

fast facts

- Scientists at MIT have designed a power plant which can use nearly all the waste left over by a conventional nuclear reactor. The catch? It is very expensive.

- Calder Hall in Cumbria was the world's first commercial nuclear power station, although initially its main purpose was to make weapons grade plutonium. It is now being decommissioned, a process which will take a hundred years.

- Plasma is a state of matter produced by intense heat. Our Sun and all stars are made up of plasma, and lightning is a plasma. Here on earth, fluorescent light tubes contain plasma.
http://www.spaceweathercenter.org/amazing_plasmas/02/02.html

- Isotopes are atoms of the same element which have the same number of protons but a different number of neutrons. The differing number of neutrons gives a different atomic mass which brings different physical properties.

- Radioactive isotopes are used in medicine, and made in a particle accelerator.
http://ed.ted.com/lessons/how-does-an-atom-smashing-particle-accelerator-work-don-lincoln

find out more

- Try this fun quiz: **http://nuclearsafety.gc.ca/cnsconline/ff4-mr4/eng/index.html**

- Fission and Fusion:
http://news.bbc.co.uk/1/shared/spl/hi/sci_nat/06/global_energy/html/nuclear.stm
http://www.iter.org/sci/fusionfuels

- Waste:
http://www.guardian.co.uk/environment/2012/jul/30/fast-breeder-reactors-nuclear-waste-nightmare
http://www.theguardian.com/environment/damian-carrington-blog/2013/jan/30/nuclear-waste-cumbria-copeland-allerdale

- Carbon dating:
http://science.howstuffworks.com/environmental/earth/geology/carbon-14.htm
http://www.bbc.co.uk/history/ancient/archaeology/carbon_dating_01.shtml

- Nuclear Medicine: **http://www.howstuffworks.com/nuclear-medicine.htm**

- Nuclear weapons: **http://edition.cnn.com/interactive/2013/03/world/nuclear-weapon-states/**

- Get to grips with the periodic table:
http://www.open.edu/openlearn/science-maths-technology/science/chemistry/elements-the-periodic-table

questions to ask

- How much Uranium is left in the world? What other fuels could be used?
- How can we produce less waste?
- What are other countries doing with their nuclear waste?
- Who would you trust to look after our nuclear waste?
- How would you spend your money on energy research?
- Nuclear produces more electricity than wind and solar, but is it greener than renewable options?

debate motions

This House would go nuclear
This House would spend its money on renewables rather than nuclear power
This House believes nuclear power is essential to combatting climate change

nuclear in fiction and film

When the wind blows by Raymond Briggs
Book and animated film, about a nuclear attack on the UK
The hunt for Red October by Tom Clancy
This story is about what happens when a Russian nuclear submarine has an accident. It was also made into a film.
Chain Reaction film with Keanu Reeves and Morgan Freeman
Two researchers in a green alternative energy project go on the run when they are framed for murder and treason.

Photo credit Dounreay Site Restoration Ltd and NDA

Angeli Mehta & ESU Scotland

r.e.a.l. guide and sample speech structure

introduction, preview, rebuttal of other speakers' points

reason

example/evidence

analysis

link

reason

example/evidence

analysis

link

reason

example/evidence

analysis

link

review of main points and conclusion

nuclear energy teacher's notes 1

Introduction

The topic can be used for either a formal debate or as a starting point for a discussion or role-play. All will require pupils to research different aspects of the topic thoroughly and plan and build their arguments. The **find out more** section of the factsheet directs pupils to websites that will provide plenty of material and information.

The most successful way to integrate this activity into your teaching is to spread the activity over 2-3 lessons to ensure that pupils have plenty of time to think, research and plan. Pupils will benefit much more from this method and it will help to shift the main focus from the debate itself (which will be the highlight for many pupils) to the whole process of independent and collaborative learning: research, weighing up evidence, developing coherent and convincing arguments, and finally evaluating and using what they have discovered.

Stage 1: Planning
This stage is vital so the pupils really know what they will be debating. Better planning means a better debate. You may decide to do this stage over several sessions.

In class:
Introduce the topic and some general discussion around the background information and questions on the factsheets. What do they already know? The questions are designed to help pupils to identify areas to research, but more questions will certainly come up during the brainstorming session.

• defining the motion
Introduce pupils to the motion and work together to define the motion i.e. explain what the debate will be about. Are there terms in the motion that need explaining,? For example, what is meant by "This House"? Who are you talking about? The group, the country, the world? It may be easiest to explain this in terms of a problem that needs to be solved. The proposition will have to put forward a policy or a mechanism to solve this problem and explain the benefits of their solution and how it is going to be better than the status quo.

Motion definition is the job of the proposition, but for new debaters it is easier to do this as a whole class. For more experienced debaters, leave this step for the proposition team and move straight to brainstorming.

• brainstorming
Brainstorming can be done as a class or in small groups, pooling the ideas later. The best way to brainstorm is for one person (either you or one of the pupils) to take notes and everyone else to say things they know about the subject. The easiest way is to divide the page or white board into two halves and put down ideas for and against the motion. It is important to think of arguments on both sides as it's good to have an idea about what the other side might say. It will also help pupils with rebuttal during the debate itself. At this stage the key is to get as many ideas as possible so it doesn't matter about the order or whether some arguments seem weak. Often the first arguments that a group thinks up will help stimulate further questions about what the debate is really about.

This process can help to involve pupils who may find debating difficult, as they can make a direct contribution without having to make an extended speech in public, which can help to build confidence. You could go round the class so everyone has the opportunity to contribute.

There are ideas for brainstorming on the final page of the notes.

• grouping arguments
Usually this is done by each side, but for new debaters it might be easiest to do this as a class the first time.

Once a class or group has brainstormed, it is important to prioritise these arguments and group them together. Look at all the different arguments. Are any of them really different ways of saying the same thing? In which case, you can combine these. They may be different points, but related thematically. These points can be grouped together under the same heading, with sub-points within it.

nuclear energy teacher's notes 2

• allocating teams and roles

For a formal debate you may need to explain the format, roles and steps. You could have a mini-debate or an alley debate to help the class understand the format. You may choose to talk about structure here or leave it to the next lesson. You will need to allocate roles within the debate. It is up to you how many speakers you have on each side, and whether you have a third group as reporters to make speeches from the floor supporting either side. Once the teams (proposition, opposition and reporters/neutral) have been agreed, pupils can be allocated the task of researching particular facts or aspects of their side's arguments.

At home:

Pupils research their arguments or topics. You may wish pupils to start writing their speeches.

Stage 2: Debate

By this stage the pupils should have a good idea of their main arguments and have done the research to find evidence to support their case.

In class:

If you haven't done so already, go through speech structure with your pupils. Remind the pupils about making their arguments R.E.A.L. This will help them to refine their arguments and structure their speeches. Pupils can then pool their ideas from their groups to finish writing their speeches. (This could have been done for homework). Encourage them to make notes and bullet points rather than writing the speeches out in full. This will help to avoid reading their speeches, which will make the speakers more persuasive and help them to interact with the audience more effectively.

During the debate itself, you can allocate a position to every pupil. There can be three chairs, one to welcome the audience and direct questions during the floor speeches (after the main debate), and two to introduce the speakers on each side. You will also need at least one timekeeper. You can have as many judges as you wish, and you could task each judge with giving positive feedback, for example two things they liked about each speech, and something to work on. The floor debate can last as long as you wish, it's up to you. You can task each member of the audience to ask a question of the speakers, make a comment, or a short speech. This can be a great way of building confidence and moving from asking a brief question, to making a short speech, to eventually becoming one of the main speakers (if desired!). After the debate you may want to hold a vote to decide who won. You may wish to encourage a free vote rather than pupils being tied to their team's policy.

There is more guidance on how to conduct the debate in the Teacher's Handook.

Lesson 3: Follow-up

A lot of the research, learning, and understanding will have taken place during the preparation and debate stages, but the follow-up stage is important to review and consolidate what has been discovered.

In class:

Start by discussing the main points with your pupils. Did the most important arguments come out during the debate? Were there any surprises? Was the outcome as expected? What have they learnt during the process?

Optional extension tasks:

There are various ways that the information gathered can be recorded. Here are some ideas:

- Posters for the classroom showing the main arguments and facts.
- Newspaper style reports, or article for the school newspaper/magazine/website
- A report for assembly or a podcast for the school website
- Discursive essays, based on the debate
- Write a (sample) letter to your MSP or local newspaper explaining your decision

nuclear energy - brainstorming ideas

for nuclear

• Clean compared to fossil fuels as it produces no greenhouse gas emissions.

• There is an abundant supply of elements in the ground and uranium can, in principle, be extracted from seawater.

• Nuclear power would free us from concerns of importing oil and gas and provide energy security. The dispute between Russia and the Ukraine over gas in 2009 had an impact on Europe's gas supplies and showed just how vulnerable we can be to political disputes in other countries.

• Few deaths compared to other forms of energy generation.

• Nuclear generates more electricity than fossil fuels or renewables for less money.

• Nuclear energy is reliable : wind and solar are not.

• Nuclear is not just used for power. There are applications in medicine (CT, PET scans; killing cancer cells); industrial uses: sterilising food, medical equipment; oil and mineral exploration; scientific research; archaeology (carbon dating).

• It is not just fission which can provide energy. Fusion is being researched and will not have same waste issues.

• In practice it would be very difficult to steal radioactive material from a nuclear plant and it would be difficult to hide.

• Not as much land is needed to build a nuclear plant as to generate the same amount of electricity from solar or wind.

• According to the US Nuclear Regulatory Commission, we get much more exposure to radiation from natural sources in the earth and air. For example, residents of Aberdeen, the granite city, get exposed to a background radiation twice the rate of the rest of the UK. But because of ongoing public concerns, America's National Academy of Sciences has embarked on a major study to look at cancer rates of those living near nuclear power plants.

against nuclear

• Fuel for nuclear plants has to be mined and transported. Building a plant is very energy intensive and there is currently no viable means of disposing of highly dangerous radioactive waste.

• Uranium deposits will one day run out. It is uneconomical to extract uranium from seawater.

• Nuclear provides no real energy security because some countries, for example Kazakhstan and Russia, control the world's reserves of uranium. Wind, solar and tidal power don't have to be imported.

• Serious and long lasting consequences of accidents, for example at Fukushima in Japan.

• The up-front construction costs are enormous; safe storage of waste is expensive; much of the energy from Uranium is either wasted or not used

• More money could be invested to improve the efficiency of all forms of renewable energy and to develop ways of storing the energy produced when the wind blows and the sun shines. We could also invest more money in energy efficiency measures which will help cut demand for fuel in the first place.

• That's fine. We should keep nuclear for those applications.

• Fusion is very expensive and a long way off.

• It could be used to build weapons. It is difficult to keep track of large amounts of accumulated waste, so there's a threat of theft or sabotage.

• Land cannot be re-used when the plant is decommissioned because of toxic waste; a large amount of water is needed for cooling, and the water discharged back into lakes and the sea may be contaminated.

• Nuclear could be dangerous to human health. Radiation exposure can kill. Some studies have suggested a link between living near a nuclear plant and higher rates of cancer.

Angeli Mehta and ESU Scotland