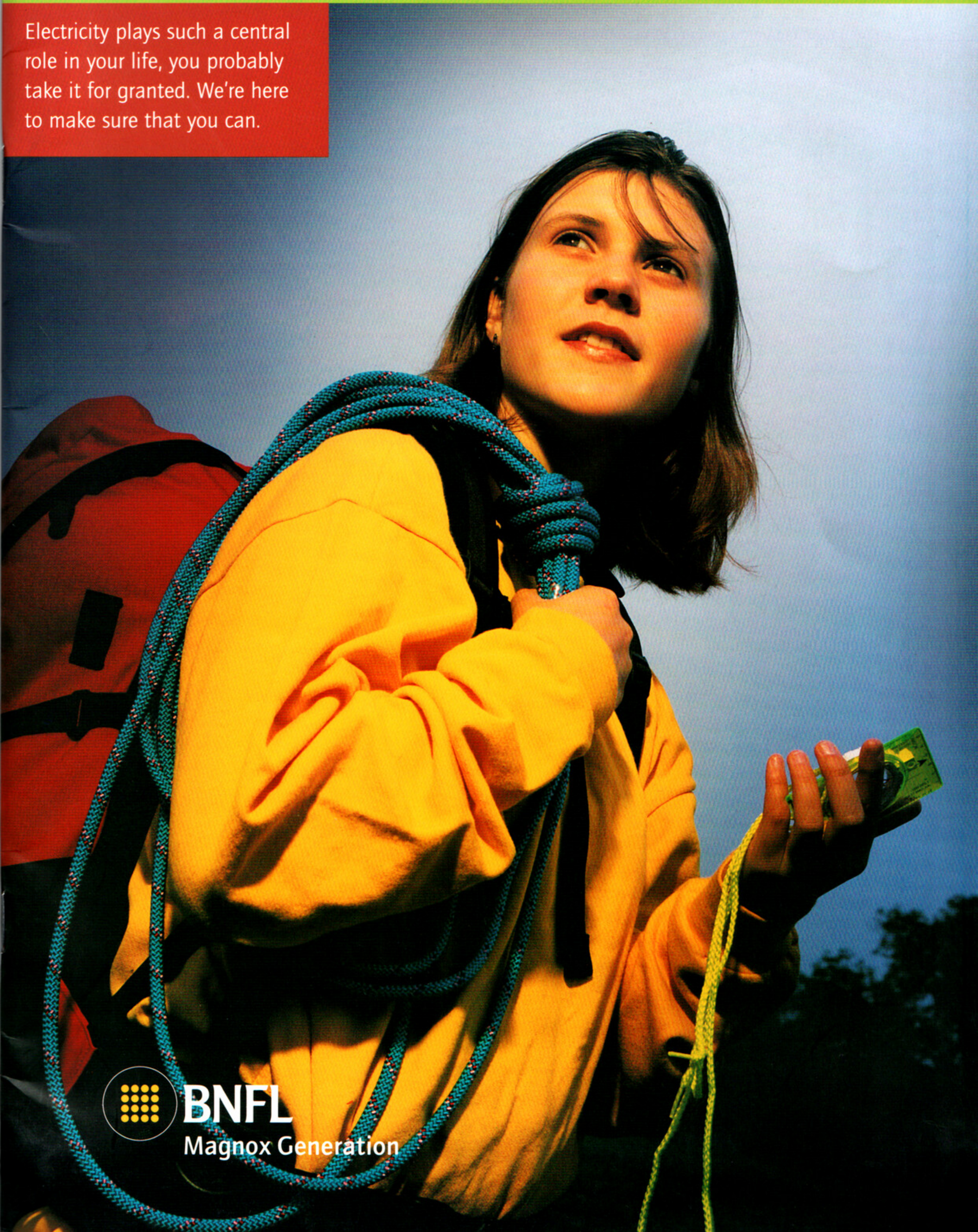
a power in your life

Electricity plays such a central role in your life, you probably take it for granted. We're here to make sure that you can.



BNFL
Magnox Generation

Wylfa power station on Anglesey.

Oldbury power station turbine hall.

From rustling up a piece of toast or a cup of tea, to lighting your workplace and powering your local hospital, our product is part of your everyday life.

You, along with everyone who lives and works in Great Britain, are a consumer of nuclear electricity.

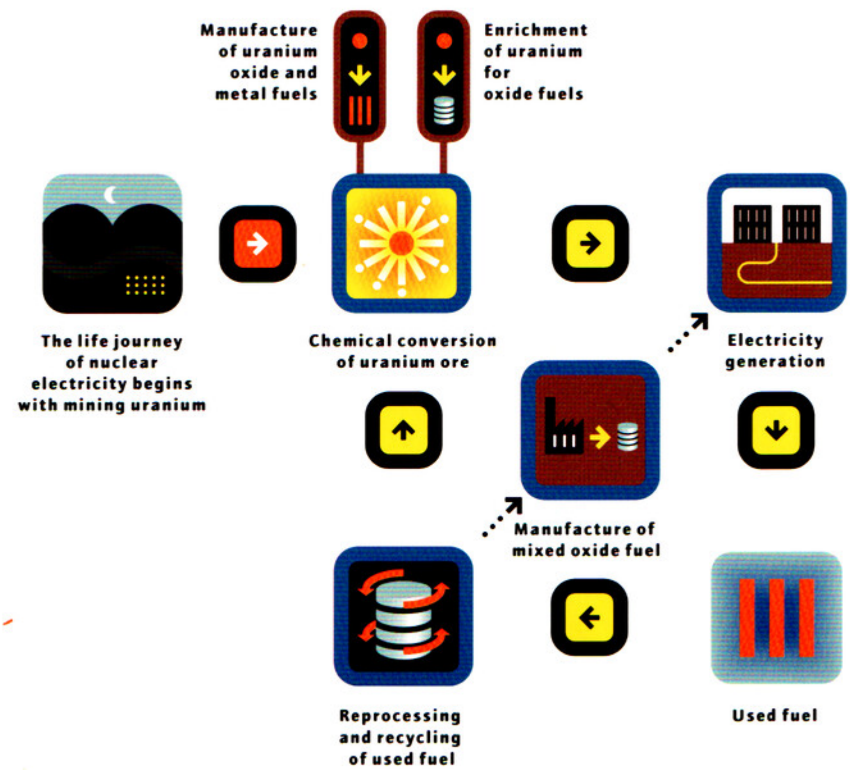
Nearly a third of all the electricity you use comes from nuclear power stations. Some 8% is made by us at BNFL Magnox Generation.

With a complement of eight Magnox type nuclear power stations, we operate some of Britain's most proven and productive nuclear reactors.

Together with one hydro electric plant, these stations generate more than 24 Terawatt hours (TWh) each year - enough electricity to meet the annual demand of Greater London. And their lifetime contribution is fast approaching the landmark figure of 1,000TWh; that's 1,000 billion standard units (kilowatt hours - kWh) of electricity.

We are the electricity generation business of British Nuclear Fuels Group, one of the world's largest nuclear services companies. BNFL is recognised for its world class technology and expertise throughout the nuclear fuel cycle, and is a multi-million pound export earner for Britain.

WHAT IS THE NUCLEAR FUEL CYCLE?



proven, productive, powerful

9.15

The junior class at St Andrew's begin their school day.

nuclear: planet-friendly power

Here's a problem for you. Imagine you're in charge of the world. It is a world that, by the middle of the next century, is likely to have 50% more people than it does now. The need for energy, with each passing year, will become ever more acute.

But there's another problem. Electricity made by burning fossil fuels is the biggest single cause of carbon dioxide emissions. And CO_2 is the main contributor to the planet's greatest environmental threat: global warming.

Of course, there's solar, wind, wave and tidal power. No gases there. But you'd need a very large wind farm to generate the same amount of electricity as just one nuclear power station. An area of 275 square miles, in fact, to produce the equivalent of, say, Wylfa power station.

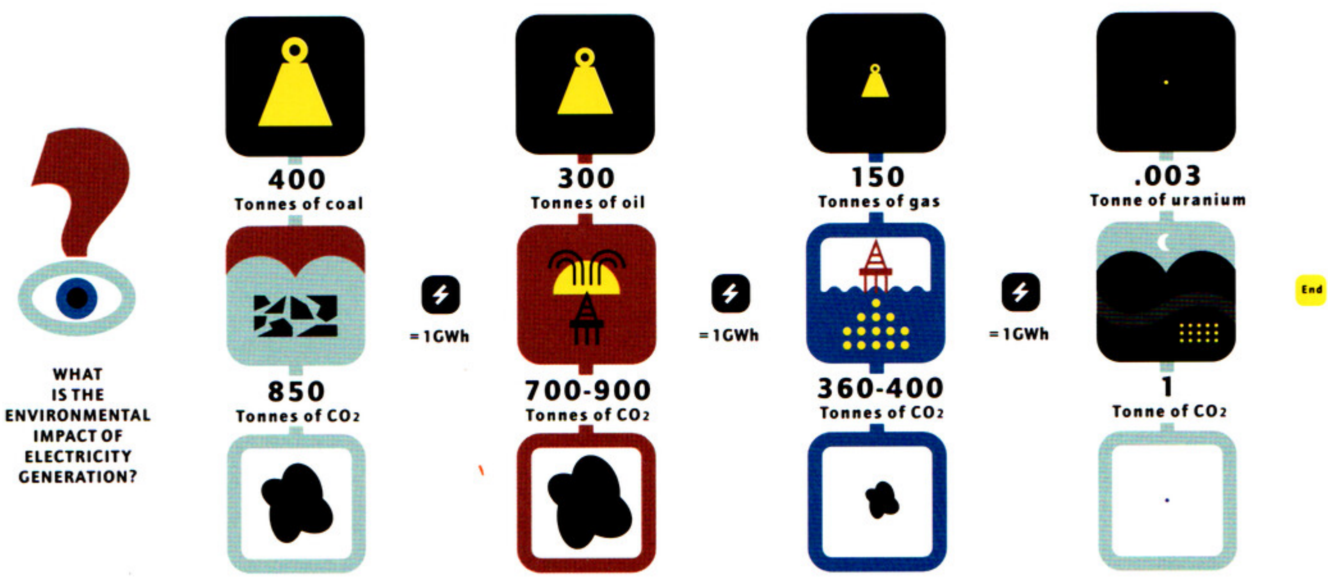
So, where's the energy we need, in the volume we need, going to come from? The answer lies in a balanced mix of all available sources; and that means a major contribution from nuclear generation.

Nuclear power generation does not produce harmful gases. Unlike burning fossil fuels, nuclear fission produces no CO_2. Nor does it emit sulphur dioxide or nitrogen oxides, the principal culprits behind acid rain.

In fact, if nuclear power didn't exist in Britain, alternative generation sources such as gas would discharge almost 40 million tonnes of additional CO_2 into the atmosphere each year.

The coal alternative would produce as much as 80 million tonnes.

That's why nuclear power is playing a vital role in giving us power without pollution.



Designer Ryan Wills fits in an
hour at the gym before getting
back to the studio.

10.30

WHAT WOULD THE MAIN EFFECTS OF GLOBAL WARMING BE?

=

Drought

+

Drinking water contamination

+

Lowland flooding

End

global warming

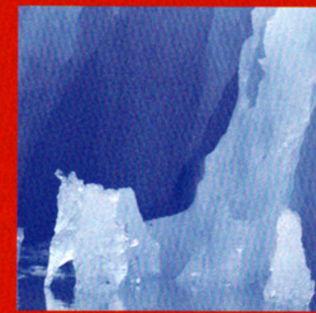
Our earth is warming up at a faster rate than at any time during its existence.

Mankind's impact on this phenomenon has been recognised by scientists all over the world, and by heads of state at the Kyoto Earth Summit of 1997.

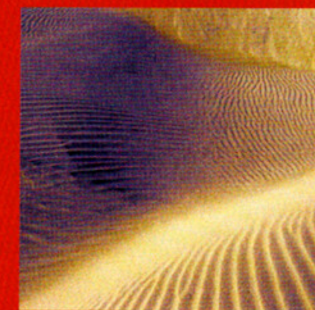
Britain is one of 160 nations which has pledged to reduce emissions of damaging gases to 1990 levels between 2008 and 2012. But the Government's commitment to a 12.5% reduction can only be achieved with a substantial contribution from nuclear energy, or other non-fossil sources.

If left unchecked, the global temperature is expected to increase by about 1°C by the year 2030. If this sounds minuscule, consider the effects it would bring. Droughts, storm surges, lowland flooding, drinking water contamination, crop failures and pestilence are but some of the consequences of a hotter world.

Cruelly, these catastrophes would be felt most in countries least able to cope with them. But everyone on the planet would be affected in some way. In our global economy, even those not directly affected by the environmental impact would not escape its economic consequences.



global warming

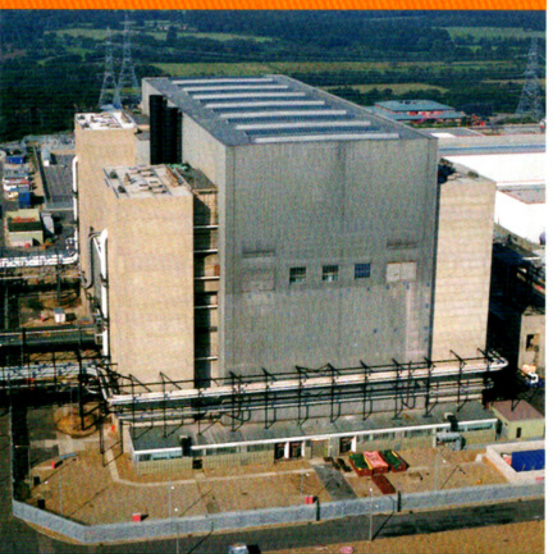


12.15

Rob Williams, arc welder, begins his shift.

Oldbury reactor hall fueling machine.

Sizewell A reactor building.



14.15

Lisa Jacob, retail manager, at The Mall on her way to a meeting with a supplier.

a jargon-free guide

Despite their different shapes and sizes, most power stations make electricity in exactly the same way.

Put simply, they convert one energy source - usually heat - into another: electricity.

Heat is used to boil water, to produce steam, to drive a turbine, to rotate a giant magnet through coils of wire. And the result, courtesy of Michael Faraday's discovery back in 1831, is electricity.

In fossil-fuelled stations, heat comes from burning coal, gas or oil.

In our nuclear reactors, we have another way of creating heat energy: it's called nuclear fission.

The anatomy of an atom

Now for a little gentle science.

Nuclear power begins with the atom. Everything in existence is made up of billions and billions of tiny particles - your home, your car, this brochure and, for that matter, you.

Each atom has a centre, the nucleus, inside which are protons and neutrons. Orbiting around the nucleus are electrons.

All atoms are different. The lightest is hydrogen, which has just one proton in its nucleus. At the other end of the scale is uranium, the heaviest of all with 92 protons and more than 100 neutrons.

We use uranium in our reactors. It is one of the most powerful elements known to man, capable of producing massive amounts of energy through fission.

It is a plentiful natural resource and, unlike fossil fuels, has few other practical uses. Coal and oil, for example, provide the fundamental chemical base for thousands of industrial and consumer products from plastics to textiles. Uranium is also uniquely recyclable.

Our mission: fission

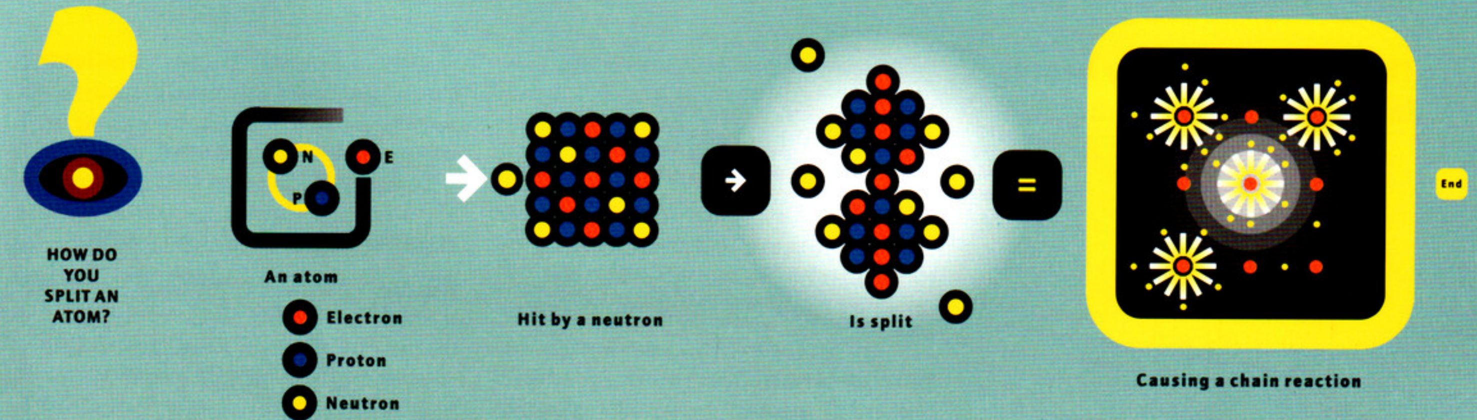
In the dictionary, you'll find that 'fission' simply means to split something.

In our case, it's atoms of uranium. Safely sealed inside a reactor, we cause a neutron to strike an atom.

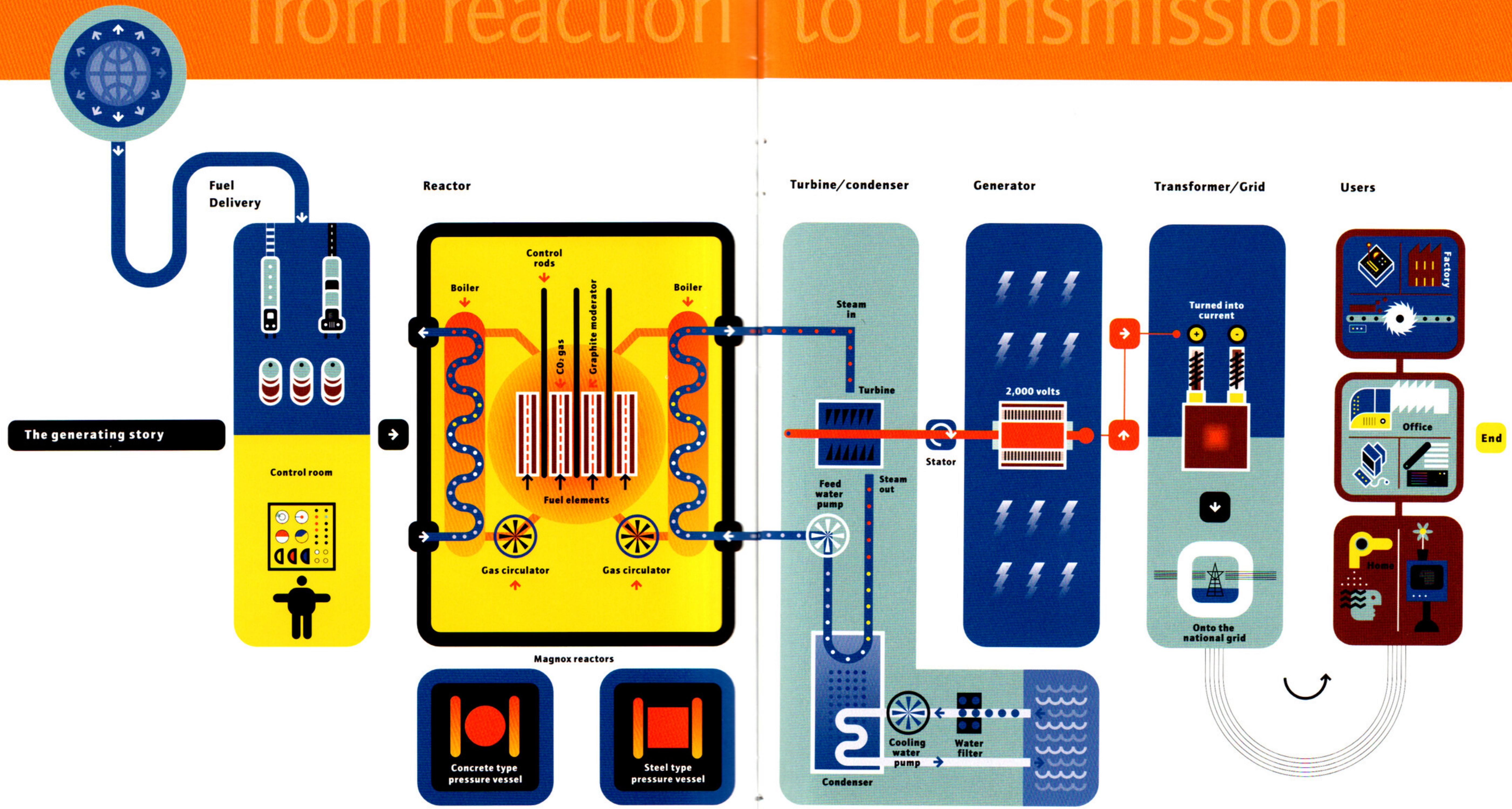
As it does so, it splits it, creating a massive release of heat energy. The split atom also releases two or three neutrons from its nucleus, which go on to split other atoms; these release more neutrons, which split more atoms, which release more neutrons, and so on. Now you know why we call it a 'chain reaction'.

Left to their own devices, these neutrons will hurtle around the reactor at speeds of more than 10,000 miles a second. But like a golf ball which has been hit too hard over a hole, this is too fast to be effective. We therefore have to slow them down, with what we call a moderator. In a Magnox reactor we use graphite.

At the right speed, fission takes place. The heat from fission produces the steam to drive the generator.



from reaction to transmission



The generating story begins inside the nuclear reactor.

Inside, there are three main components:

The moderator. Made of graphite and weighing more than 2,000 tonnes, it slows down the neutrons to the best speed for nuclear fission.

The fuel elements. Thousands of uranium rods, each sealed inside a magnesium alloy casing, are placed in vertical channels inside the core.

The control rods. These are made of boron steel and allow our engineers to stop, start and control the nuclear reaction. When lowered into the reactor, the rods actively absorb the neutrons and stop them reacting with the uranium atoms. As they're raised, the reaction steps up in intensity.

What happens where

Reactor. Inside the pressure vessel, the nuclear reaction creates a furnace-like temperature in the fuel cans of around 360°C, heating up a constant flow of carbon dioxide gas, which in turn maintains the temperature of the fuel.

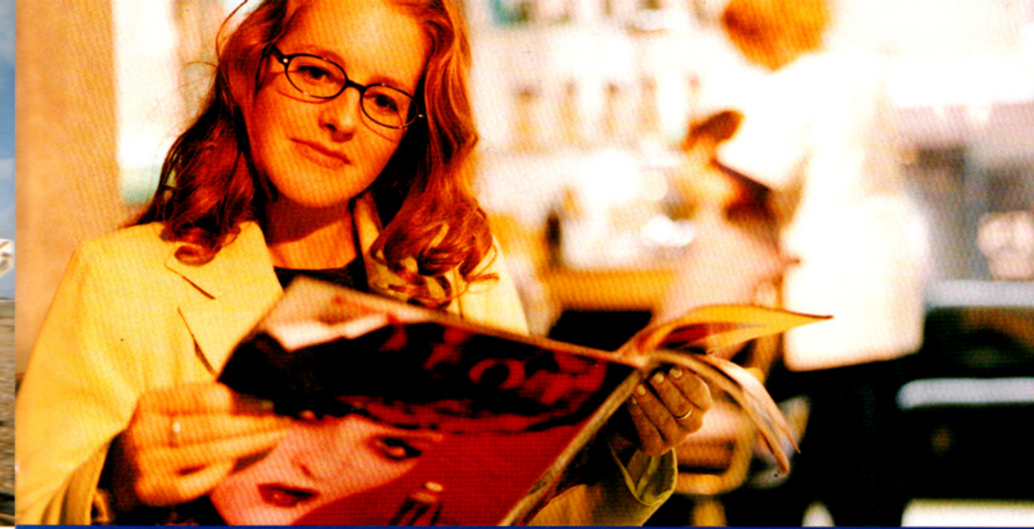
Boiler. The hot gas is pumped to the boiler, where it heats thousands of litres of very pure water, creating superheated steam.

Turbine. The steam is blasted onto the blades of turbines which rotate at speeds of up to 3,000rpm. The used steam, meanwhile, is cooled and turned back into water for re-use in the boiler. This cooling process demands millions of litres of ordinary water, which are taken from and returned to the sea in a separate water circuit.

Generator. The turbines drive a shaft which is connected to the generator – a single, cylindrical electromagnet weighing an average of 4 tonnes, which is rotated inside the stator. This is surrounded by 25kms of coiled copper wire some 30mm thick, and it is here that the electricity is generated.

Transformer. The electricity is routed to the transformer, which steps up the voltage, from where it is fed directly along the 7,000kms of power lines of the National Grid – to your town, your home, and your toaster.

Our workers, plant and the surrounding environment are routinely monitored.



16.30

Zoë Read in her favourite salon, planning some retail therapy.

If you weren't aware that nuclear electricity contributes to your everyday life, you certainly won't know that it has been doing so safely and reliably for more than 40 years.

safety, first and last

In all that time, there has never been an incident at a commercial nuclear power station that posed a danger to the general public; nor, indeed, one which even approached internationally agreed safety limits.

In short, nuclear generation in the UK has an excellent safety record, and we work to the world's most stringent standards to ensure that's how it will stay.

No consideration, whether practical or commercial, is ever allowed to compromise our standards. And to ensure that this is so, every nuclear business must be licensed.

Everything that goes on inside a nuclear power station is subject to the approval of the Government, through the Nuclear Installations Inspectorate (NII). Their inspectors have right of access to any part of the plant, and any record, at any time. If they are not entirely satisfied with what they observe, they have the power to close a plant down.

At Magnox Generation, we work closely with the NII, as well as the Environment Agency and the Scottish Environment Protection Agency concerning safety and discharges.

In almost every case, our own rules for nuclear, radiological, industrial and environmental safety are actually more stringent than even the law demands.

But our performance is continuously checked by specialists; both our own and those of the authorities. Our workers, our plants and the surrounding environment are carefully monitored for radioactivity. We regularly sample the air, water and soil, the vegetation, animal and marine life within a 20 mile radius of our power stations.

The safety of our people

Radiation doses are very strictly controlled. Under a company practice known as ALARP 'as low as reasonably practicable', every worker's exposure is both minimised and constantly monitored, with the aid of film badges and personal dosemeters.

The law allows a dose limit of 50 millisieverts a year. At Magnox Generation power stations, however, our company guideline lowers this to just 15mSv. Even then, the highest dose any worker has actually received in recent years was just 10 mSv. For certain workers, those who work in controlled radiological areas, we reinforce these very conservative limits with regular health screening and medical checks. Although they receive slightly higher doses than other staff, interestingly, they still receive less than some non-nuclear workers, for example airline crews.

Our plant: safety built-in

Simple, well-built and well-engineered, Magnox plant is reliable, robust and, above all, safe.

The design of each plant is based on four fundamental safety principles.

The redundancy principle. If one component should fail, there are two or more back-ups to perform the same function.

The diversity principle. This is applied to complete systems or sub-systems, giving the operators more than one alternative with which to achieve the same end result.

The separation principle. Take the scenario of a fire destroying a vital system; another, able to take its place, will be available in a separately-located area.

The fail-safe principle. Should a key component fail, it will always do so in its safest state.

This is the approach of defence in depth; a school of thought which imagines the unimaginable, and assumes that the improbable is entirely possible. Its record speaks for itself.

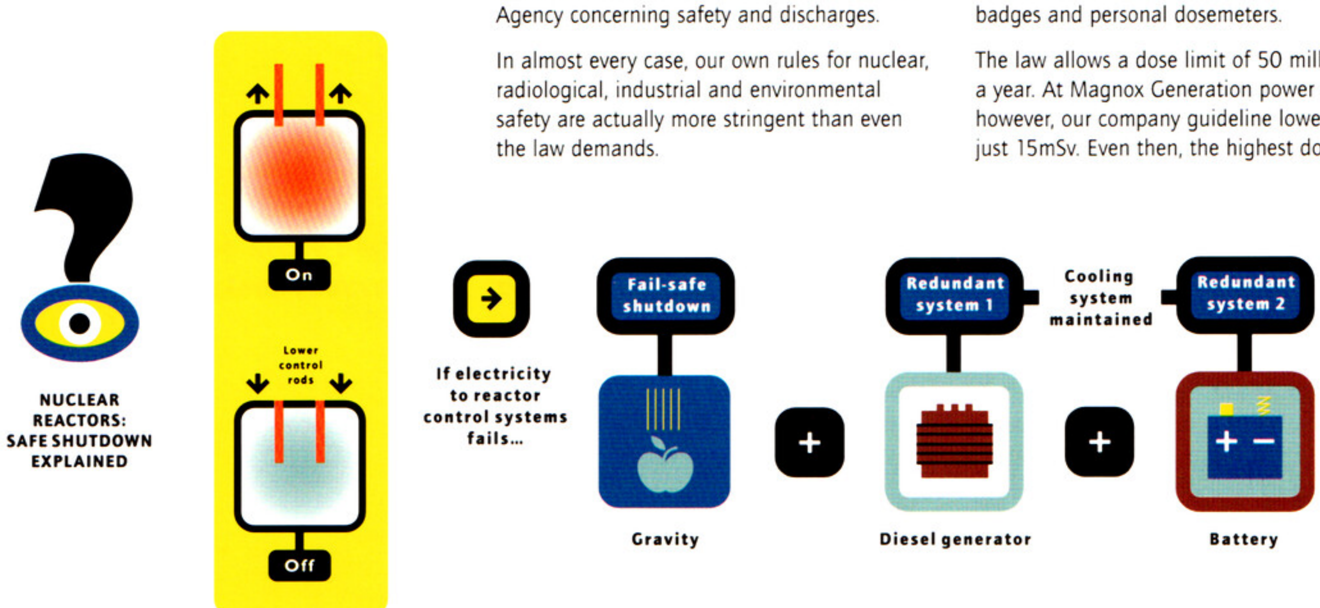
A commitment to openness

Any incident with a bearing on safety, no matter how trivial, is reported.

This information is made public, directly to local community groups, the media and via public libraries for all to see.

In addition, Magnox Generation subscribes to the International Nuclear Event Scale (INES) reporting code.

INES categorises the seriousness, or otherwise, of incidents from Level Zero (an incident with no safety or radiological significance) to Level 7 (a major release of radioactivity with widespread health and environmental effects).



radiation: the force is with you

17.00

Abby Thompson, 7, on her dad's computer, studying recreational sciences.

Much as we'd love to take the credit, radiation was not the invention of the nuclear industry.

In fact, it is as old as the earth itself and as natural a phenomenon as, for example, gravity.

Like gravity, you can't see it, smell it or touch it, but it is all around us.

We all live in a sea of radiation, receiving it day and night from natural sources: the earth, the sun, the stars, food and drink. Just how much you personally receive depends on how and where you live and work.

If you live in Cornwall, for example, you'll receive more than someone in Norfolk; much of the south-west is built on the radioactive rock of granite.

If you're partial to coffee or bread, you'll receive more than those who aren't. And if you work as an airline pilot, you'll receive more radiation than a nuclear worker on the ground.

Radiation is a natural occurrence in our daily lives, and normal levels are quite harmless.

On average, around 85% of the radiation we all receive comes from entirely natural sources. A further 14-15% comes from medical treatments such as X-rays. And we receive small amounts from such everyday things as computers, smoke alarms and TVs.

The nuclear industry also contributes to the radiation you receive. But only to the tune of less than 0.1%. That's about the same as you'd receive from a luminous bedside clock.

Radiation as an asset

Although radiation can be harmful, it can, in the right hands, do a power of good.

The very fact that it can be dangerous to human cells, for example, is put to good use by killing cancerous ones too.

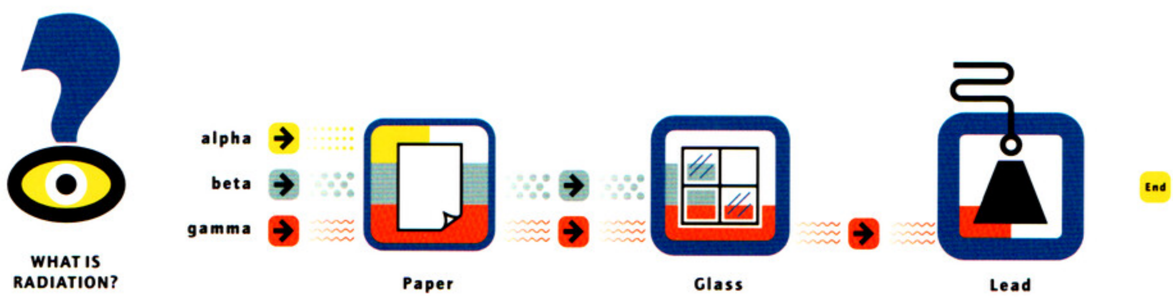
Radiation helps save lives with X-rays and smoke detectors; gamma ray photography is used to inspect aircraft engines; it is used in pest control, and in the creation of drought-resistant crops in Third World countries.

In fact, there's not a person in Britain who doesn't derive some benefit from the harnessing of this remarkable force.

The different types of radiation

Not all radiation is the same. Its strengths, characteristics, harmful effects and usefulness depend on its type.

Some can be stopped by a simple sheet of paper; others require more robust shielding such as concrete or water.



Alpha particles. Alpha particles are tiny atomic particles (helium nuclei). They're slow, heavy and cannot penetrate paper or skin. They can be harmful to living beings if materials which emit them are taken into the body through, for example, a cut in the skin or by swallowing. They can also be useful: radium, a natural mineral used in the treatment of cancer, is alpha-emitting.

Beta particles. These particles, which are actually electrons, are smaller, travel at higher speed and have more penetrating power. Nevertheless, they can be stopped by quite thin layers of water, glass or metal. For a source of beta particles, look no further than yourself – you contain them, and emit them.

X-rays, gamma rays. Like light, these are electromagnetic waves. Both are very penetrating; gamma rays, in particular, are only stopped by dense, heavy shielding such as lead, steel or concrete. Gamma rays are routinely emitted by the earth itself and by natural building products such as stone.

From radioactive to radiopassive

From the day of its creation, the world's natural radioactivity has been decaying. It is less radioactive than it was a billion years ago. And, by the time you reach the end of this sentence, it will be a little less radioactive than when you started it.

LLW can be handled. HLW is stored in heavily shielded steel containers and remotely handled.

Fuel transport flasks have been subjected to the most stringent safety tests.

radioactive waste: disposing of the myths

Nuclear generation may be one of the cleanest forms of large-scale electricity production we have. But doesn't it leave behind hazardous by-products at the same time?

The simple answer is yes. Like all manufacturing processes, waste products do result, and some of ours must be handled with great care and shielded from man and the environment.

But unlike many other toxic metals and chemicals, the behaviour of nuclear wastes is predictable and fully understood. And unlike many other industries, the nuclear industry takes full responsibility, financial and managerial, for its waste.

Waste in context

The treatment and storage of radioactive waste poses no technical or safety problem to either nuclear workers or the general public, because:

It decays naturally. Radioactivity fades away over time. Some toxic substances, for example mercury, remain toxic forever.

It is predictable. We know exactly how long radioactivity takes to decay into a safe state.

It is storable. Even the small amount of High Level Waste in existence is fully containable using existing materials and technology.

It is low in volume. A single tonne of uranium, the nuclear fuel, will deliver as much electricity as 15,000 tonnes of coal. It follows, then, that there is very little radioactive waste left behind to manage. And, its volume is further reduced by reprocessing.

Britain's waste. By volume, by radioactivity

Radioactive waste must, by law, be divided into one of three categories.

Approx. 90% = Low Level Waste (LLW). This comprises routine items such as nuclear workers' gloves and overalls, paper towels and certain plant equipment. Almost all is actually less radioactive than naturally radioactive substances, such as your morning cup of coffee. It is compacted, incinerated, and the ash sealed in drums at the BNFL stores at Drigg in Cumbria. LLW accounts for less than 10% of radioactivity in waste.

Approx. 10% = Intermediate Level Waste (ILW). This includes fuel can debris, filter sludges and ion exchange resins. It must be handled using remotely operated tools and shielding, and is housed at power stations in concrete vaults.

Approx. 0.1% = High Level Waste (HLW). This accounts for 90% of all radioactivity in waste, yet less than 0.1% of its volume. HLW comes only from fuel, which is reprocessed at Sellafield. After some forty years of nuclear generation, Britain's total HLW would fill the equivalent of just four double decker buses.

Transporting spent fuel

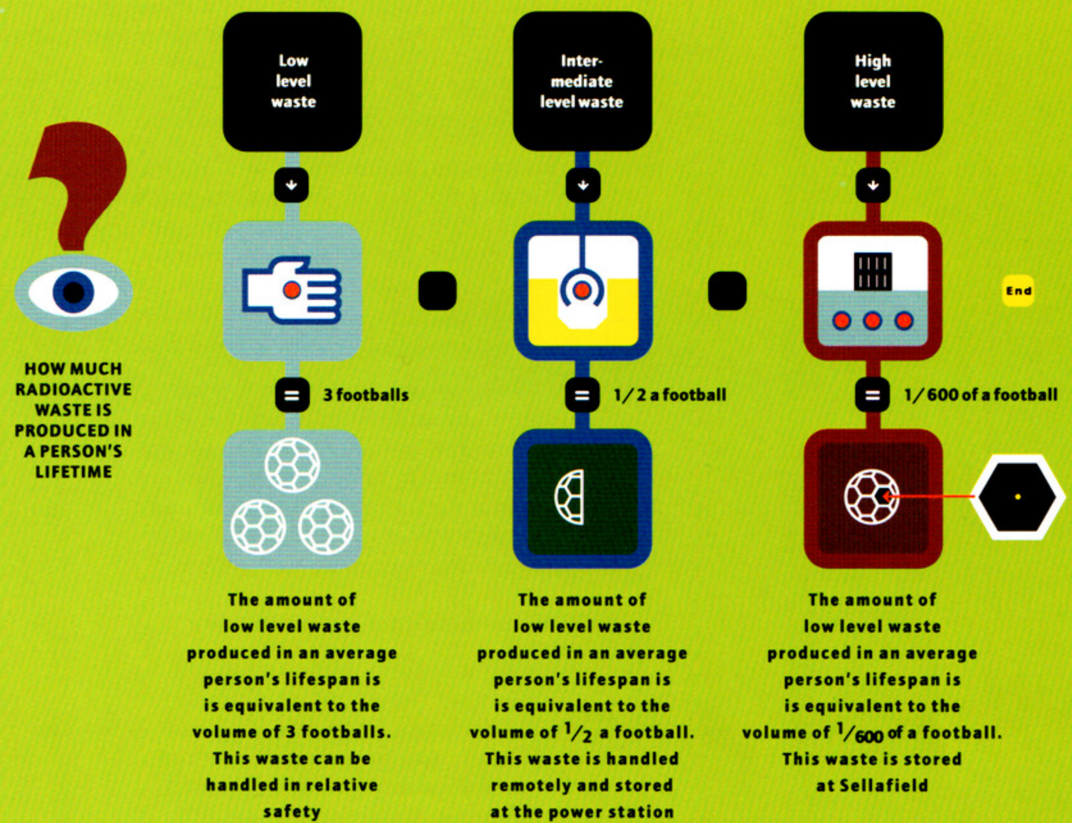
Nuclear fuel is remarkably recyclable.

Ninety nine percent of Magnox fuel can be recovered, which is why spent fuel is sent from our power stations to the BNFL reprocessing facility in Cumbria.

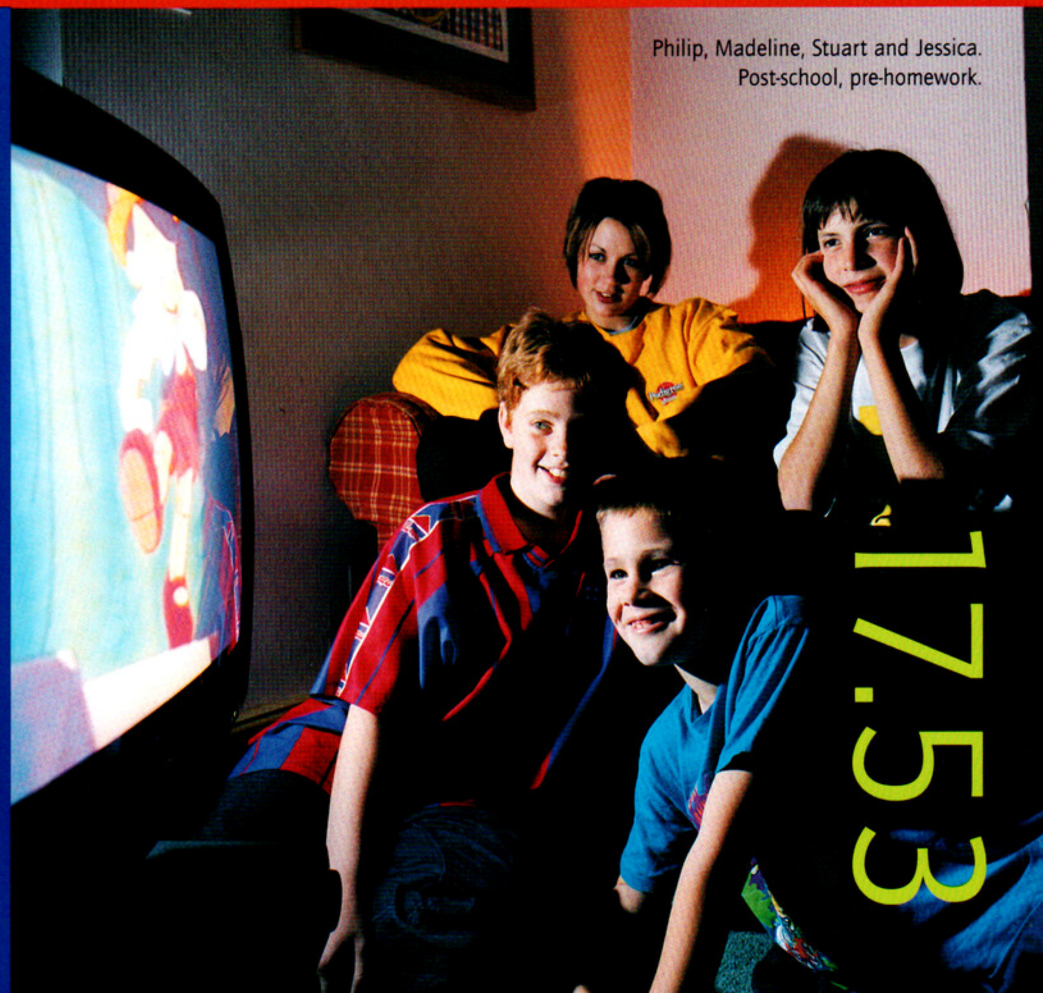
Its transport is highly regulated and rigid safety guidelines dictate how it is moved.

The fuel is transported in specially designed nuclear 'flasks', each weighing some 50 tonnes and made in forged steel at least 35cm thick. These flasks have passed a battery of tests to meet the requirements of the International Atomic Energy Agency. The Magnox M2 flask has been shown to withstand fire at a temperature of 800°C, and is unaffected by water pressure at a depth of 200 metres. They have also survived drop testing and, in one spectacular case, a head-on collision test with a 100mph locomotive. The train was written off; the flask sustained nothing more than scratches and dents.

Since 1962, nuclear flask movements have covered more than 6 million miles on Britain's roads and rails. Not one hazardous incident has ever taken place.

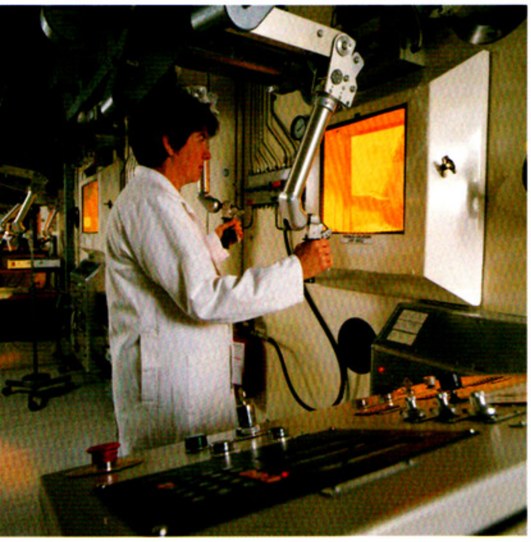


Philip, Madeline, Stuart and Jessica. Post-school, pre-homework.



our robot army

Our excellent record of safety and reliability is no coincidence: all our reactors receive exceptional levels of care.

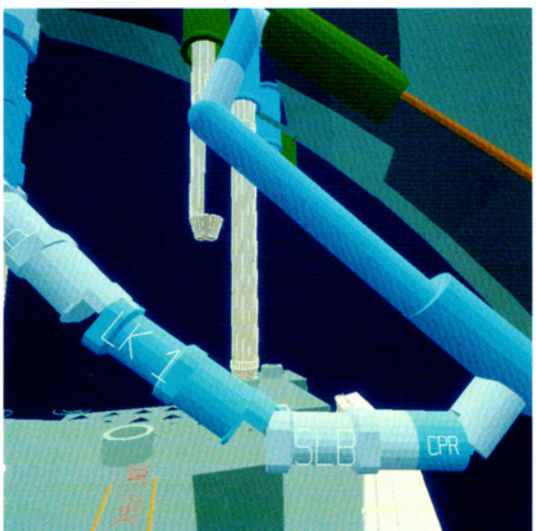


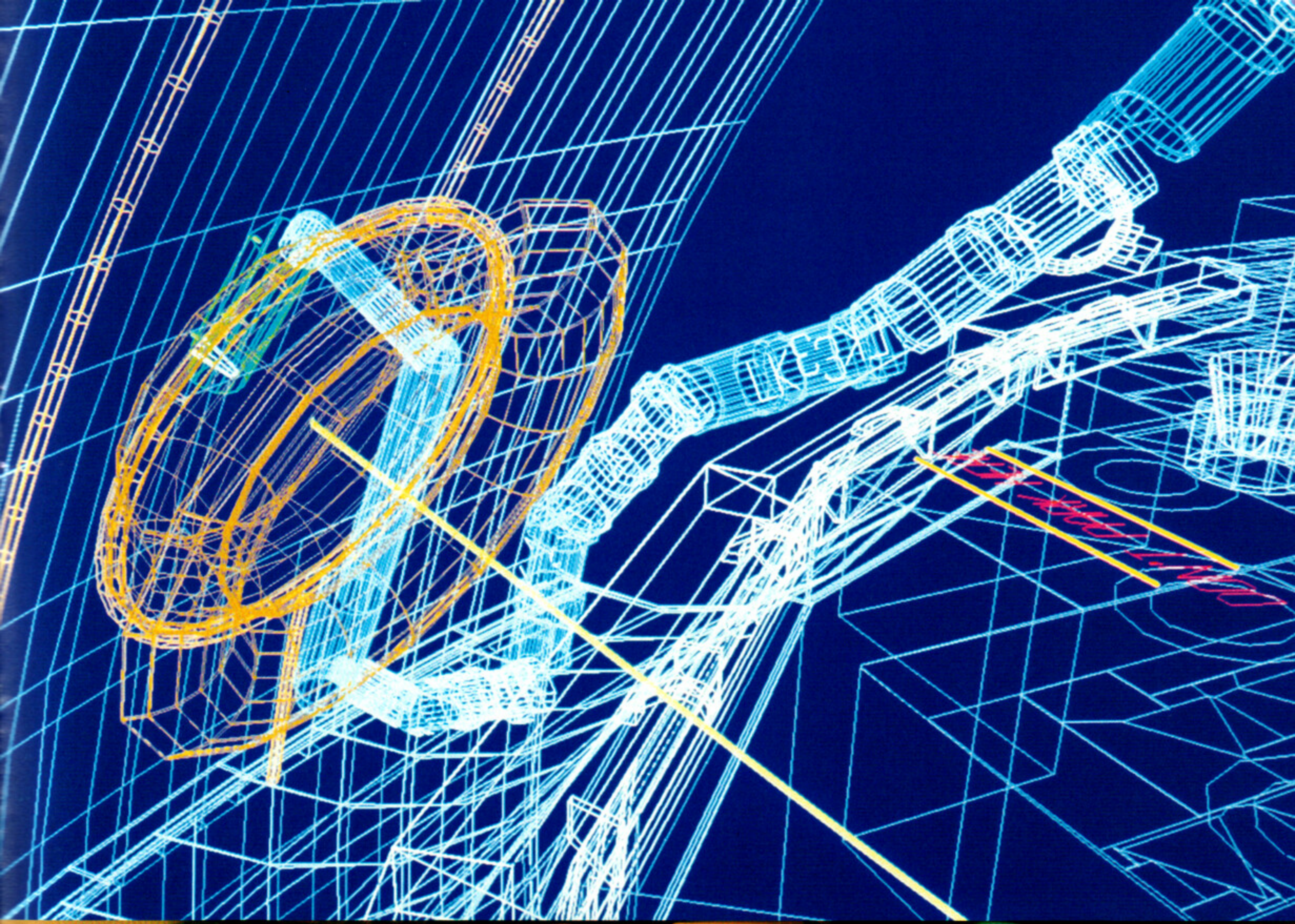
The expertise and technology applied to the inspection, assessment, maintenance and repair of Magnox plant is, literally, world class. We are acknowledged leaders in areas such as structural integrity, remote operations and advanced robotics.

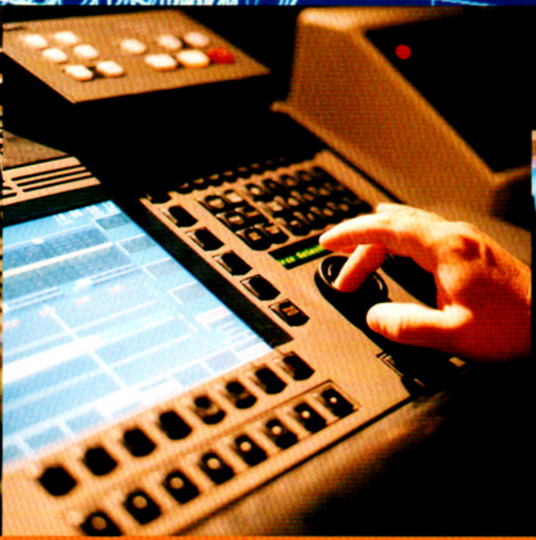
Our robot army allows us to work inside reactors. Built to withstand the hostile environment and navigate the complex internal structures with millimetre precision, they can assess welds, take metal samples, make repairs and modifications.

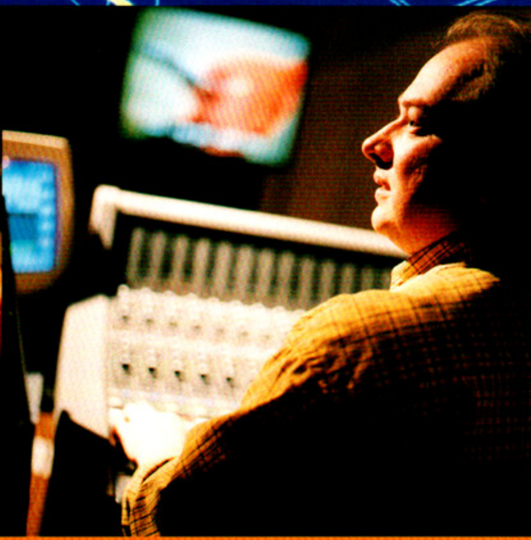
Hydraulic or electrically driven manipulator arms and remote controlled vehicles can carry inspection and viewing equipment including optics, electro-optics, infrared and lasers, as well as photographic and radiation tolerant high resolution TV. They can then carry out specific work equipped with tools that can perform cutting, drilling, grinding, welding and bolting.

In our laboratories and shielded facilities, we study and measure the behaviour and chemistry of materials, including the examination of highly radioactive materials. Our radio chemistry and electron microscopy facilities can analyse fuel, metal samples and other substances to microscopic and atomic levels.









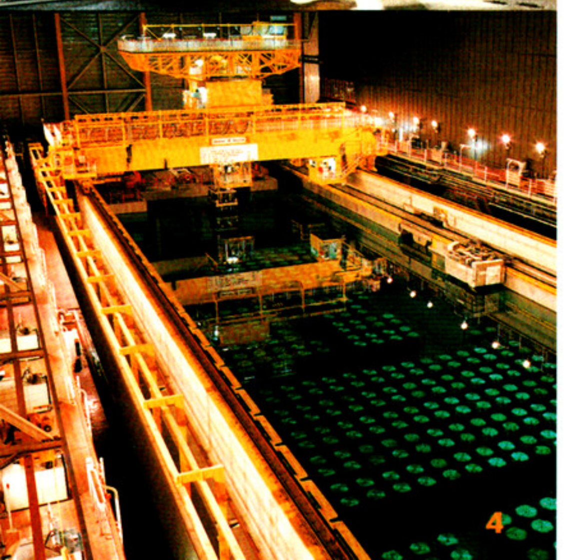
20.55

Martyn Harries, sound engineer, puts the finishing touches to a wildlife documentary.

1

2

3



4

In January 1998, Magnox Electric plc merged with British Nuclear Fuels plc.

It was a move which brought a major generating capability to BNFL, completing its business portfolio across the nuclear fuel cycle and consolidating its position as a world class nuclear services company.

Every phase of the nuclear generating process is served within the BNFL group.

1 We manufacture nuclear fuel

BNFL is one of the world's leading manufacturers of specialist nuclear fuels, designed for all types of commercial reactor such as Magnox, AGR and PWR. The Springfields site in Lancashire also has the world's most modern plant for the production of uranium hexafluoride, the material used in nuclear fuel enrichment.

2 We generate nuclear electricity

BNFL's original two Magnox reactors, Calder Hall at Sellafield and Chapelcross in Scotland, have been joined by the six operating power stations from the original Magnox Electric plc. This gives the group a market share of some 8% of the electricity generation market.

3 We transport nuclear materials

BNFL has moved radioactive cargoes more than 15 million miles by sea, road and rail. Through subsidiary companies, BNFL offers specialist fuel transport services on sea routes between the UK, Europe and the Far East, as well as dedicated rail services in Britain.

4 We recycle nuclear fuel

Since 1964, BNFL has reprocessed spent Magnox fuel, recovering 99% of the uranium. The group also operates THORP, opened in 1994, for the reprocessing of fuel from Light Water and Advanced Gas-cooled reactors. It currently has orders worth in excess of £12 billion, 50% from overseas.

5 We manage nuclear waste

BNFL is a world leader in waste treatment and storage, with purpose-built stores for Low Level Waste at Drigg; an encapsulation plant for Intermediate Level Waste; and a vitrification plant for High Level Waste at Sellafield.

6 We decommission and clean up nuclear plant

BNFL has extensive experience of decommissioning; the safe closure and ultimate dismantling of nuclear plant. Indeed, BNFL were the first to return a site, cleaned and decontaminated, for re-use.

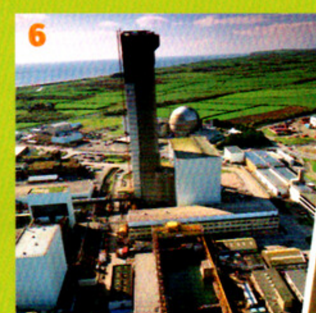
23.47

Keith Yeates, investment analyst, about to check the closing prices in New York.

completing the cycle at BNFL

5

6



00.30

Dennis Huxley, shift charge engineer, starts his shift in the control room.

Maentwrog power station the hardware

water source	
Source	Trawsfynydd reservoir
Capacity	33 million cubic metres
Site area	506 hectares (1,274 acres)
Fed by	Afon Prysor & Ardudwy leat (9.7km) Llennyrch leat (2.4km)
Catchment	93.5km^2 200-862m OD
Rainfall	178-279cm per year

maentwrog dam	
Constructed	1988-1991
Type	S-shaped gravity dam
length	219m
Height	38.8m (foundations to crest)
Crest	200m OD
Gates	hydraulically-operated control gate winch-operated emergency gate
Additional dams	Gyfynys Hendre Mur Trawsfynydd
Water head	185m

tunnels and pipelines	
Low pressure tunnel	3m diameter x 534m long Driven through rock, concrete lined
Riveted steel pressure pipe	3m diameter x 1817m long
Second tunnel	3m diameter x 421m long incl. 6m diameter surge shaft at highest point
Pressure pipelines	2 (1.5 + 1.8m diameter)
Water delivery	1.26 million litres/min
Water pressure	19bar at full head

turbo generator

turbine	
Number	2
Type	Francis reaction
Speed	600rpm
Commissioned	December 1991
Runners	2, each 1120mm diameter 2,250kg 17 blades

generator	
Number	2
Output each	15MW

station output	
Volts	11,000 transformed to 33,000 for distribution 30MW (nominal)

British Nuclear Fuels plc
Magnox Generation

Maentwrog power station
Blaenau Ffestiniog
Gwynedd
LL41 4HY

Tel: 01766 590280
Fax: 01766 590639

Electricity has been produced here since 1928 when the North Wales Power Company opened the station with three turbo generators. At the time, its output of 18 megawatts was more than the local area could actually consume.

Maentwrog employs seven people and can produce a valuable 30MW of electricity.

Maentwrog power station

BNFL power stations

- Operating stations
- Decommissioning stations
- Hydroelectric station

	Visitor centres	Station tours	Nature trail	Classroom	Picnic area	Refreshments
1 Berkeley ☎ 01453 810431		◇→				
2 Bradwell ☎ 01621 873395	V	→	✓	✓	✓	✓
3 Calder Hall ☎ 01946 785829	◇V	◇→	✓	✓	✓	✓
4 Chapelcross ☎ 01461 208329	V	◇→		✓		✓
5 Dungeness A ☎ 01797 321815	V	→	✓	✓	✓	✓
6 Hinkley Point A ☎ 01278 654700	(V)	→	✓	✓	✓	✓
7 Hunterston A ☎ 01294 824000	V					
8 Maentwrog ☎ 01766 590280	V					
9 Oldbury ☎ 01454 419899	V	→	✓	✓	✓	✓
10 Sizewell A ☎ 01766 540622	(V)	→	✓	✓	✓	✓
11 Trawsfynydd ☎ 01766 540622	V	→	✓	✓	✓	✓
12 Wylfa ☎ 01407 711400	V	→	✓	✓	✓	✓

(V) *Visitor centres managed by British Energy*

◇V *Sellafield visitor centre*

◇→ *Station tour by appointment only*

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