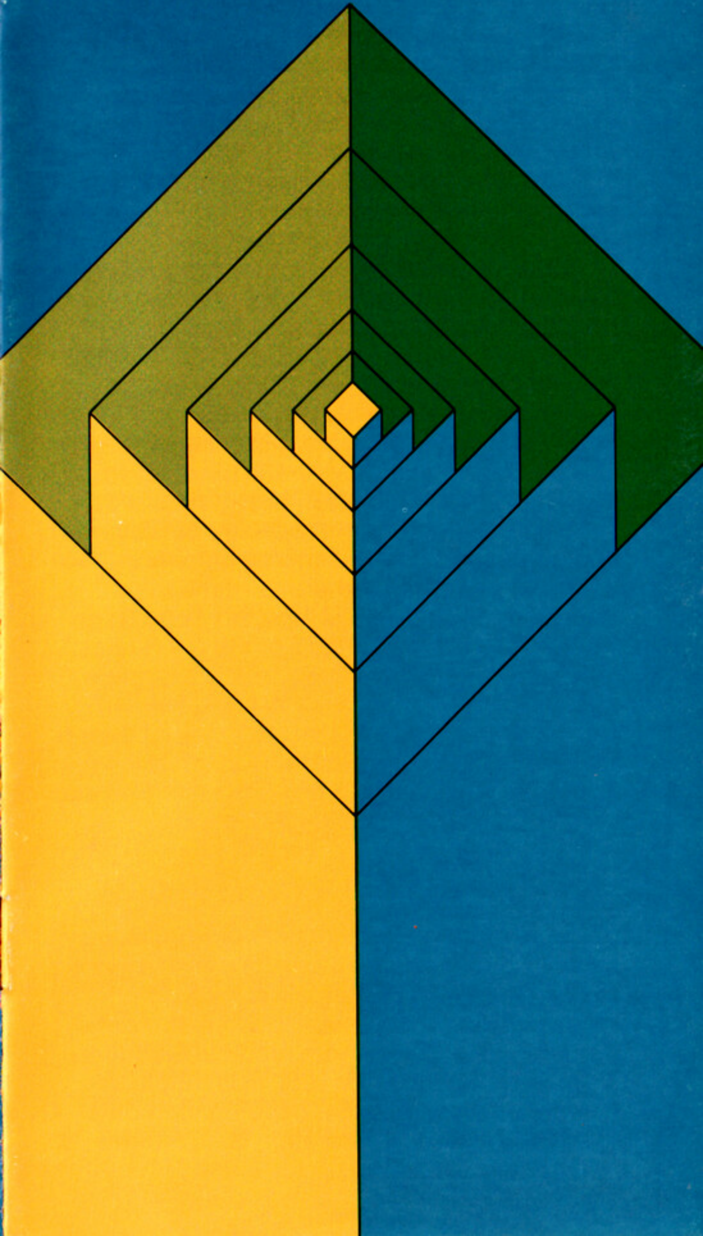
How safe is nuclear power?



The record

No human activity is absolutely safe and providing large amounts of energy from whatever source in the form of heat, light and power carries some risks. Nuclear power produces about 12% of Britain's electricity, a figure which will rise to 20% when stations under construction are completed. It is an economical, clean and very safe form of electricity generation.

There are 15 nuclear power stations in operation in Britain, comprising 32 reactors. Since 1956 when electricity was first produced from nuclear power in this country no member of the public has been killed by a radiation accident.

In any industrial activity those most at risk are employees working at the factories, mines and plants associated with the process. In 1977 the Department of Energy published statistics comparing the numbers of fatal accidents for the major energy industries over a 20 year period. In the words of the then Secretary of State for Energy, Mr Tony Benn ".... the outstanding record of the UK nuclear industry ... emerges clearly from the figures."

In 1978 and 1980 the Health and Safety Commission reviewed risks to the public from different systems of electricity production and concluded that nuclear power was as safe and probably safer than coal, oil and gas.

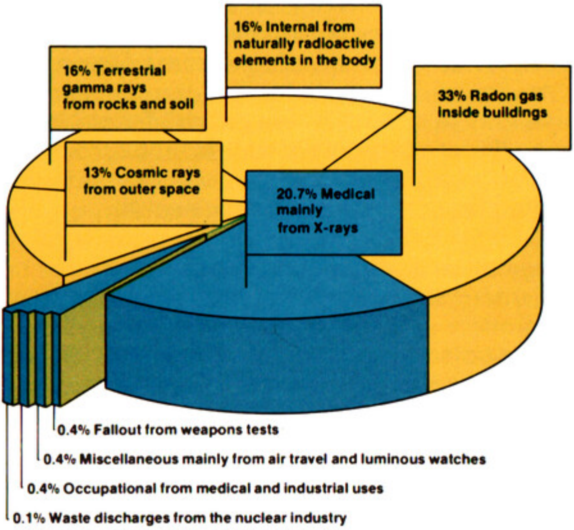
Radiation

The main hazard associated with nuclear power is radiation. However, mankind has evolved in a radioactive environment, exposed to cosmic rays from space, the radioactivity in rocks, soil and the human body itself. Today, radiation also comes from medical diagnosis and treatment, from TV sets, from nuclear power and even from the building materials used in our houses. Radiation is all around us and the average contribution from the nuclear industry is very small indeed.

Radiation was discovered in 1895. Exposure to very high levels can cause death through the destruction of body tissues. It can cause cancer and produce genetic defects in subsequent generations, although no excess genetic defects in the children of people exposed to high levels of radiation have been detected, even among the children of the survivors of Nagasaki and Hiroshima.

The effects of radiation on the human body have been widely studied throughout this century. Exposure limits for workers and members of the public are recommended by the International Commission on Radiological Protection (ICRP), based on periodic reviews of the scientific evidence. The ICRP,

The components of the radiation dose to which, on average, each person in the UK is exposed



composed of eminent scientists and physicians elected by their peers and independent of governments, was established in 1928 - long before the nuclear industry was born - to advise the medical profession. In the UK, expert advice on ICRP recommendations is given by the National Radiological Protection Board and other bodies. The Health and Safety Commission draws on this advice to prepare the regulations, which are approved by Parliament and enforced by the Health and Safety Executive.

Risks from radiation are probably better researched and understood than those associated with other methods of energy production. Based on this knowledge the nuclear industry uses a wide range of safety measures to protect employees and the public. As a result, the average radiation dose to the public from the activities of the nuclear industry is 500 times less than that arising from natural sources. It is less than the extra radiation dose arising from taking a holiday in the granite regions of Cornwall or Scotland, where the natural background radiation is above average; or on a flight from London to Glasgow due to the enhanced cosmic ray intensity at altitude. It is a hundred times less than the variation of the natural background radiation within Britain. This variation is itself of no practical significance to health.

Regulation and control

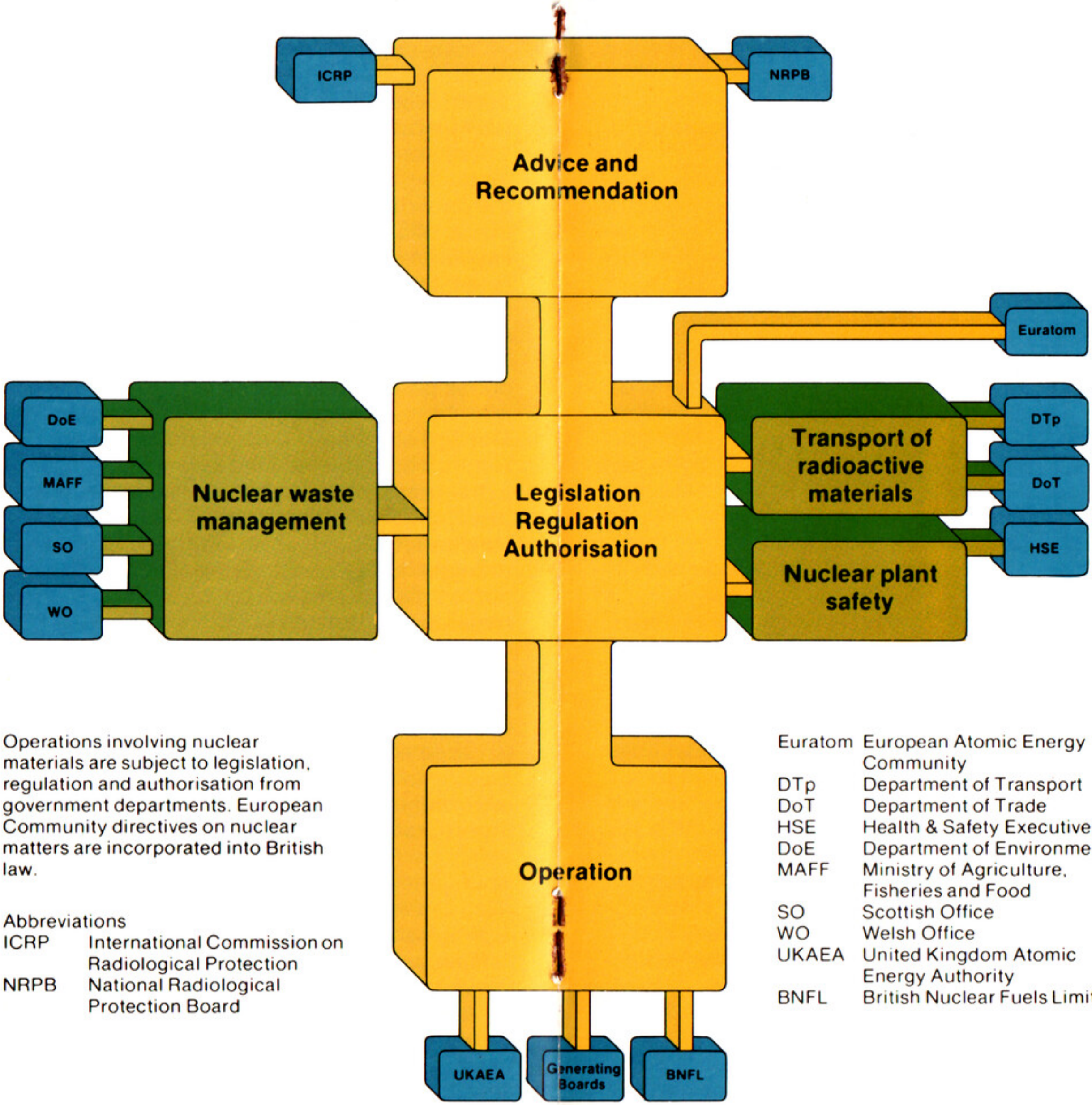
In Britain, the safety of nuclear plant and its operation is the responsibility of the operator. In general, the Health and Safety Executive (HSE) lay down safety conditions in a nuclear site licence and exercise close supervision over the operator. The HSE's Nuclear Installations Inspectorate monitor the safety of the plant from initial design through its construction and operating lifetime to

ultimate decommissioning.
No radioactive material can be discharged to the environment without authorisations from the appropriate Government department. These are based on exposure limits which give a large margin of safety to members of the public who live and work near nuclear plants. Steps must also be taken to keep exposure as far below the authorised levels as is reasonably achievable. Radiation levels in the environment near nuclear plants are regularly checked and published annually. They show that the radiation dose to the public is negligible.

Mining
No uranium is mined in Britain, but the extraction of uranium in source countries involves both radiation and physical hazards. However, the number of deaths from mining uranium is only about one-tenth of those from mining the quantity of coal required to generate the same amount of electricity.

Reactor operations
A reactor cannot explode like an atomic bomb; the fuel is too dilute. What has to be guarded against is a series of malfunctions leading to a release of radioactivity to the environment. Nuclear power stations incorporate in their design a number of major safety barriers to prevent substantial amounts of radiation escaping to the environment, even in the event of a severe accident. The fuel, which has to withstand high temperatures without melting, is sealed in fuel pins or cans, which provide initial protection. Water-cooled and some gas-cooled reactors are contained in steel pressure vessels, surrounded by massive concrete shielding. Advanced gas-cooled reactors are placed in steel-lined concrete pressure vessels, several

Organisations involved in Nuclear Safety in the UK



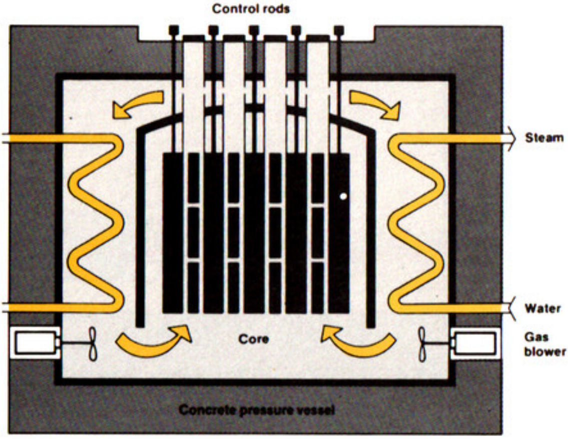
Operations involving nuclear materials are subject to legislation, regulation and authorisation from government departments. European Community directives on nuclear matters are incorporated into British law.

Abbreviations

ICRP	International Commission on Radiological Protection
NRPB	National Radiological Protection Board
Euratom	European Atomic Energy Community
DTp	Department of Transport
DoT	Department of Trade
HSE	Health & Safety Executive
DoE	Department of Environment
MAFF	Ministry of Agriculture, Fisheries and Food
SO	Scottish Office
WO	Welsh Office
UKAEA	United Kingdom Atomic Energy Authority
BNFL	British Nuclear Fuels Limited

Fuel is encased in stainless steel cans to contain all the fission products. The whole reactor is inside a steel lined concrete pressure vessel more than five metres thick. This vessel contains the pressure of the coolant gas, and provides shielding from radiation. Strength is provided by many pre-stressing cables which can easily be inspected and replaced if they show signs of fatigue.

Advanced Gas-cooled Reactor (AGR)



metres thick. In the worst accident at a nuclear power station (at Three Mile Island, Harrisburg, USA, in 1979) these safety barriers ensured that no employee or member of the public was injured.

Great care is taken to reduce the risk of major malfunction leading to a serious accident. This includes a high standard of design, manufacture and operation and a multiplicity of protective systems, which are duplicated or triplicated. Such systems are designed to detect unsafe conditions and restore the plant automatically to a safe condition.

Extensive studies have been carried out in several countries into the likelihood of major accidents at nuclear power stations using sophisticated techniques of safety analysis which are now being adopted to study risks in other major industrial activities. These show that the likelihood of a nuclear accident leading to members of the public being killed or injured is very remote indeed. For example, the risk to someone living in the vicinity of a nuclear power station is less than one in a million per year of operation. Major hazards to the public from nuclear power are less than those arising from other industrial processes and natural catastrophies.

Over 2000 reactor-years of operating experience have been accumulated by nuclear power stations throughout the world without known harm to the public. The radioactivity released at Three Mile Island was, in the words of the Presidential Commission of Inquiry, "so small that there will be no detectable additional cases of cancer, development of abnormalities, or genetic ill health as a consequence." The Commission considered that even if the core had melted the protection provided by the containment building would probably have prevented a serious release. The lessons learnt from that accident have been carefully studied and incorporated into existing safety arrangements.

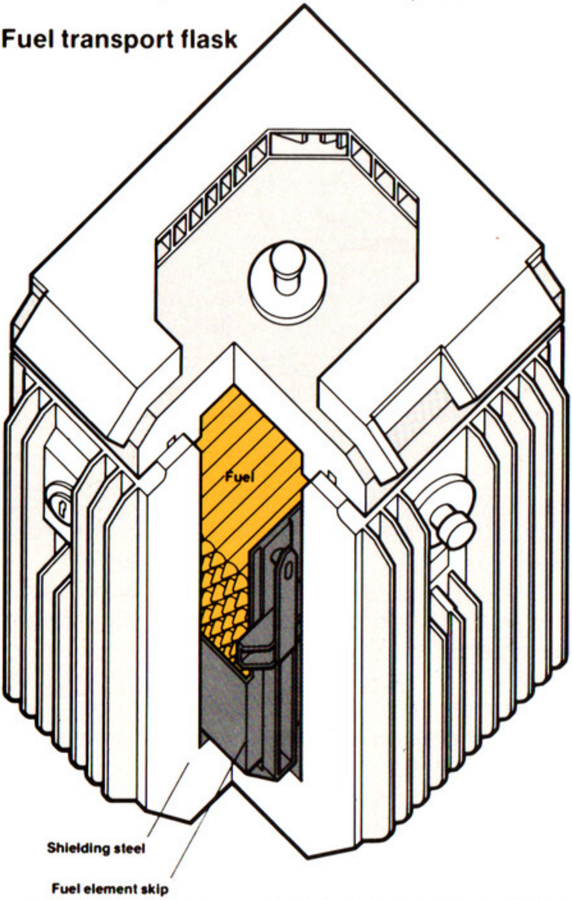
Transport

After a few years in the reactor of a nuclear power station spent fuel is removed and replaced with fresh fuel. It is then stored under water, which both cools the physically hot fuel and acts as a radiation shield. After a few months during which much of the intense initial radioactivity has died down, the fuel is transported in heavily shielded flasks weighing 50 tons or more to the Windscale reprocessing plant in Cumbria.

The flasks are designed and tested to comply with stringent international regulations. The tests include nine-metre drops onto a unyielding surface and onto a steel punch so as to cause maximum damage. This is followed by an engulfing fire test, where all surfaces are exposed to at least 800 degrees Celsius and by immersion in 15 metres of

In the UK the main traffic is that of magnox clad irradiated fuel. The flasks used are made of steel more than 350mm thick. Measuring about two metres high, two and a half metres long and two metres wide, they weigh 50 tonnes and can contain up to 200 fuel rods. The flasks are filled with water, which disperses the heat of the rods to the flask walls, and thence to the atmosphere.

Fuel transport flask



water. These tests are designed to ensure that even in the most severe accident conditions the flasks do not fail. In America as part of a research programme to evaluate test procedures, experimental crashes at over 80 mph have been carried out without rupturing the flasks. Although different in design both British and American flasks have to meet the same international standards.

Throughout the world, several million packages of radioactive materials are shipped each year - 300,000 of them in the UK - and no significant radiation hazard has been caused. About 500 packages of highly radioactive spent fuel from nuclear stations are sent to Windscale each year. The design of packages for all but small quantities of radioactive materials have to be approved by the appropriate Government departments.

Wastes

Nuclear power produces radioactive wastes, mainly during reprocessing.

The treatment of spent fuel to remove uranium for re-use and plutonium for later use in fast reactors is a chemical process based on solvent extraction. After extraction of the uranium and plutonium, a small amount - about two per cent - of highly radioactive waste remains. This is stored at Windscale in stainless steel tanks, surrounded by concrete and cooled with water. Other radioactive waste from nuclear power includes the fuel element cans and general scrap from production and laboratory activities, some of which is stored. Most low level solid waste is either buried in special trenches or packaged for disposal in the deep Atlantic Ocean under international surveillance. Low level liquid waste is discharged to the sea. Low level gases are discharged to the atmosphere.

All these practices are subject to Government authorisation and regulations. There is a comprehensive programme of environmental monitoring, involving the sampling of many foodstuffs, soil, marine organisms and drinking water.

For over 25 years high level waste has been stored safely as a liquid but there are advantages in solidifying the waste by incorporating it into glass blocks in corrosion-resistant canisters.

A plant to convert liquid high level waste to glass is planned to be in operation at

Windscale by 1990. A plant of this type is already operating in France. The glass blocks can be easily stored in air-cooled vaults or under water. This is a safe and practicable option for isolating the wastes for very long periods under retrievable conditions requiring minimum supervision. After storage for several decades to allow cooling, the glass blocks could be disposed of in deep geological strata or on or under the sea bed away from man's immediate environment. Research into the feasibility of these disposal methods is being conducted in the UK and other countries.

Fast reactors and plutonium

Today's nuclear power stations use thermal reactors, fuelled with uranium. However, supplies of uranium are limited. A different type of reactor now under development - the 'fast' reactor - can enable about 60 times as much electricity to be generated from the same amount of uranium by first converting it to plutonium.

Plutonium is a valuable nuclear fuel produced in thermal reactors as a by-product. Some of it undergoes fission in those reactors but the remainder is separated out when the spent fuel is reprocessed. Fast reactors depend on this plutonium to provide their initial fuel. During fission they can breed more plutonium from a surrounding blanket of non-fissile uranium and, if necessary, produce a surplus. This in turn can contribute to a stock of fuel for later fast reactors.

Plutonium is a very hazardous material but a number of chemical and biological substances are more toxic. As far as toxicity arising from radioactivity is concerned, two forms of radium are a hundred times more toxic. The main hazard from plutonium is inhalation and special safe handling techniques such as the use of leak-proof "glove boxes" have been developed. These techniques have been used routinely for over a quarter of a century.

Insurance

British law makes the operator of a nuclear site absolutely liable for damage or injury caused by radiation. There is no need to prove negligence and compensation can be claimed up to 30 years after an incident. Each operator has to provide insurance cover for up to £5,000,000 per incident and central funds are available for up to £50,000,000 per incident under international agreement. Claims beyond this figure would be settled as Parliament decided. It is the existence of these special provisions which leads to the exclusion of nuclear risks from insurance policies.

Summary

About 12% of Britain's electricity comes from nuclear power and this will shortly rise to about 20%. Unlike coal and oil which have many other essential uses, uranium can only be used commercially for electricity production. Nuclear power is producing electricity cheaper than coal and oil.

The industry has an excellent safety record. In a quarter of a century of nuclear electricity generation in Britain, no member of the public has been killed by a radiation accident.

The main hazard from nuclear power - radiation - is well understood and nuclear power plants are designed and operated to very high standards to reduce the risks of accidents to a minimum.

The chance of an accident serious enough to put a member of the public living in the vicinity of a nuclear power station at risk is less than one in a million per year of operation.

Further information on atomic energy and its applications can be obtained from:

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United Kingdom Atomic Energy Authority
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The Electricity Council
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