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NUCLEAR ENERGY AND THE NUCLEAR INDUSTRY

These notes have been prepared by the Department of Energy to provide information and to answer questions often raised about nuclear energy and the nuclear industry. It is hoped that these will contribute to the public debate about the future of nuclear energy in the UK.

NUCLEAR ENERGY AND THE NUCLEAR INDUSTRY

Contribution of Nuclear Power

1 Experience of nuclear power in the UK extends over more than two decades. Calder Hall, the world's first full scale commercial sized nuclear power station, was opened in 1956. Since then, ten further Magnox stations with 22 reactors and two Advanced Gas-cooled Reactor (AGR) stations with two reactors each have been built and three further AGRs are nearing completion. Construction work on two more AGRs has recently begun.

2 Nuclear power already provides 12% of the electricity generated in the UK and by the early 1980s, when the three AGRs nearing completion are due to come onstream, this is expected to increase to 20% or about 6% of total UK energy requirements.

3 To generate the electricity produced each year by our present nuclear capacity would require the equivalent of 7m tonnes of oil. With the increased capacity in the early 1980s, this should rise to some 14m tonnes, an amount equivalent to the annual output of a large North Sea oilfield like Piper or twice that of a coal mine like Selby.

Energy Forecasts

4 On present prospects, UK indigenous oil production will be in decline by the 1990s and natural gas production may begin to decline a few years later. The Department of Energy's recently published projections for the year 2000 suggest a gap between energy demand and indigenous supply. This is after making allowance for substantial savings from energy conservation and for major investment in long life economic coal production capacity, as well as assuming a major expansion in nuclear power and a contribution from alternative energy sources. The UK energy import requirement could by then be over 100 million tonnes of coal equivalent (mtce) at a time when oil supplies in international markets are expected to become increasingly scarce and expensive. The projections suggest the following energy balances for 1990 and 2000:

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UK PRIMARY ENERGY BALANCE

mtce

	1977	1990	2000
DEMAND			
Energy	332	370-390	400-460
Petrochemical Feedstock*	28	40- 45	45- 55
TOTAL	360	410-435	445-510
INDIGENOUS SUPPLY			
Coal	122	127-138	137-155
Gas	60	68- 71	62- 65
Oil	65	153	100
Nuclear and Hydro	16	34- 35	88- 95
TOTAL	263	380-395	390-410
Net Fuel Imports	97	15- 50	35-120

* Includes gas and bunkers
NB Figures do not add vertically

It should be noted that these energy projections are necessarily based on certain long term assumptions which are liable to change. The projections do not imply Government commitment to particular levels or sources of energy production.

5 Without a major contribution from nuclear power, net dependence on imported fossil fuels from the 1990's onwards is likely to increase substantially and it may not be possible to ensure adequate and secure energy supplies at tolerable prices. With lead times of about a decade for most forms of energy investment, including conservation, it is necessary, in spite of the inevitable uncertainties, to look ahead now to the end of the century in considering energy policy.

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Nuclear Fuel and Reactor Types

6 The splitting, or fission, of an atom produces heat. The atoms of most substances can be split by bombarding them with neutrons, but this usually requires more energy than is given out. If you want to produce heat in a nuclear reactor, you need to find a substance in which the atoms can be made to go on splitting by themselves - and giving out heat in the process. Uranium, and in particular a variety or "isotope" of uranium called Uranium 235, is the only naturally occurring substance that will do this. This is because when a uranium atom is split, it gives out a number of neutrons. These neutrons can be made to split other uranium atoms, which give out more neutrons, and so start a self sustaining chain reaction. This chain reaction can provide a large and continuous source of heat.

7 Uranium 235 makes up only 0.7% of naturally occuring uranium. Another isotope, U238, makes up 99% of the rest. In most reactors, the fuel is either made from natural uranium or the percentage of U235 it contains is slightly increased by a process known as "enrichment".

8 During reactor operation, some of the Uranium 238 captures neutrons and is subsequently converted into plutonium. Like Uranium 235, plutonium is a good nuclear fuel because it will sustain a chain reaction. About one-third of the energy released while uranium fuel is being fissioned comes from fission of the plutonium that is formed by the conversion of U238. When the spent fuel is discharged from the reactor, typically after about five years, only a small amount of the uranium and derived plutonium has been consumed. The unused uranium and plutonium can be extracted from the spent fuel by chemical "reprocessing". Then either the uranium or plutonium, or both, can be made into new fuel elements.

9 For the current generation of reactors to operate successfully, the fast moving neutrons produced by the chain reaction must be slowed down by a substance called a "moderator". Reactors of this type - using slow moving neutrons - are called "thermal reactors". The heat produced is removed from the reactor core by a "coolant", which transfers the heat to the electricity

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generating equipment. In some cases, it is possible for the same substance to act both as moderator and coolant.

10 The first generation of reactors in the UK was the Magnox, which was fuelled with natural uranium, and used a graphite moderator and pressurised carbon dioxide gas as a coolant. A development of this, in which heat resisting steels were used to enable operation at higher temperatures to improve economy are the "Advanced Gas Cooled" Reactors, which are the base for our second reactor programme.

11 Worldwide, the most common reactor uses ordinary water as both a moderator and coolant. These are called "light water reactors" (LWRs). The coolant is kept under pressure; and in some reactors it may boil, as in the Boiling Water Reactor (BWR), or be circulated without boiling as in the Pressurised Water Reactor (PWR). With some design changes, heavy water may be used as a moderator, as in our own prototype Steam Generating Heavy Water Reactor (SGHWR) at Winfrith or in the Canadian CANDU reactors. It was decided in 1978 not to develop the SGHWR system further in the UK.

12 Another type of reactor which has been under development in the UK and some other countries for several decades has no moderator. The neutrons in the core are not slowed down but move fast. These are called "fast reactors". The UK has a 250 megawatt prototype (PFR) in operation at Dounreay, Caithness. Fast reactors are fuelled by plutonium. The plutonium core is surrounded by a blanket of a type of uranium which cannot be burned in thermal reactors but which, during the fission process, is turned into more plutonium. Fast reactors can be operated either to produce more plutonium than they consume, to produce as much plutonium as they consume or to burn up plutonium produced in thermal reactors. How they are operated would depend on forecasts of electricity demand. Because they can be used to breed plutonium, they are also known as "breeder reactors" or "fast breeder reactors", although they do not "breed fast". Their development would make it possible to increase the energy available from uranium by 50 to 60 times.

/ Cost ...

Cost

13 The following table gives the generation costs, including capital costs in 1978/79 for the CEGB's six Magnox nuclear stations, 13 coal-fired stations and two oil-fired stations commissioned after 1 April 1965, as published in the CEGB's Annual Report for 1978/79:-

	per/kwh
Nuclear (Magnox)	1.02
Coal - fired	1.29
oil - fired	1.31

The cost of nuclear stations include provision for reprocessing and vitrification of residues from nuclear fuels, and for the ultimate decommissioning of the stations. Although Hinkley Point B, the one AGR station operating, was not fully commissioned for that year, its costs on a comparable basis were about 1.3 p/kwh. However, these figures are historic costs and are not suitable as a basis for future investment decisions.

14 In considering investment in new generating capacity, the CEGB assess future capital and operating costs, including expected future increases in fuel costs, as well as the cost of eventual decommissioning. They also take into account such strategic considerations as the availability of oil and coal. When ordering a power station, a major consideration is the assurance of adequate and economic fuel supplies over the life - about 35 years - of the station. On the best available estimates of capital costs and future fuel prices that can be made, the CEGB believe that the development of nuclear plant will be the most economic, besides its value in forestalling possible energy shortages. They consider it essential that the options for both coal and nuclear plant should be fully maintained: 70% of current capacity is coal fired.

Thermal Reactor Strategy

15 The UK has been developing gas -cooled reactor technology for 25 years, first with the Magnox stations and then through the AGRs. However, the UK is alone in basing all its commercial reactors on the gas -cooled design: the major design adopted in other countries is the water-cooled PWR. The construction costs of a PWR are less than an AGR. The CEGB estimate the costs to be about £750,000 per MW for an AGR and £680,000 per MW for a PWR (1979 price levels). In order not to be dependent solely on one reactor design, the last Government endorsed the intention of the CEGB to order a PWR station. Together with the building of the two latest AGRs at Heysham and Torness this should enable us to continue to exploit our experience with gas -cooled technology while also ensuring that the PWR is available and its technology understood in the UK. As with all reactors, no PWR can be built until the stringent safety and licensing requirements have been satisfied.

Planning Margin

16 The Generating Boards work to a standard of security of supply of meeting the winter peak demand in full in all except 24 winters per century and of avoiding disconnections at the winter peak in all except three winters per century. To achieve this standard, the Boards include an element of additional generating capacity, called the planning margin. The current value of the planning margin in England and Wales is 28%; that is to say the total generating capacity is 28% above the forecast (made for planning purposes) of future winter peak demand in average cold spell weather conditions. The planning margin provides cover against unavailability of generating plant, increase in demand due to unusually bad weather, and increase in demand above the forecast level. That such a margin is necessary was shown in 1978/79 when the peak demand in England and Wales was

44.1 GW and 46.1 GW of plant was available for service, thus coming within 2 GW of an interruption in supply.

17 The present power station ordering programme, including nuclear stations, is required in order to meet the estimated demand for electricity in the mid and late 1980's with no increase in the size of the planning margin.

Safety

18 During 23 years of operation, no accidents have occurred at commercial nuclear power stations in the UK that have given rise to significant public hazard. This is the result of the way in which nuclear power stations are designed, licensed, constructed and operated. Probably in no other industrial activity is such a wealth of time, expertise and resources devoted to the supervision of safety.

19 The principal risk from the development of nuclear power is that of an escape of radioactivity. However there is no evidence that any injury has been caused by radiation from a nuclear power station in the UK. The number of industrial accidents from non-nuclear causes has been relatively low compared to many other industries. This is shown by the following table, published by the Health and Safety Executive in 1977. It sets out the incidence rates for 1975 for injuries per 100,000 employees at risk in different industries.

Industry	Fatal accidents	Total accidents
Shipping (Merchant seamen)	120	1560*
Coalmining	24.7	20900
Coal & petroleum products	22.4	6570
Construction	17.7	3460
Railways	18.7	2920
Shipbuilding & marine engineering	14.0	6180
Agriculture**	11.7	1800
Metal manufacture	10.0	6350
Bricks, pottery, glass & cement	7.2	4750
Chemicals	6.7	3640
Timber & furniture	5.5	3200
Mechanical engineering	3.4	4110
Paper, printing & publishing	2.9	2270
Electrical engineering	1.8	2320
Food, drink & tobacco	1.7	4370
Textiles	1.7	2750
Nuclear Power generation †	0.0	2897***

* excludes fatal accidents
** excluding farmers and their families
*** from non-nuclear causes
⌿ frequency rates are based on the number of CEGB staff employed at nuclear power stations

20 A small number of workers involved in research, fuel fabrication and reprocessing, but not the operation of commercial power stations, have been restricted from work involving contact with radiation sources. This is because their bodies have retained plutonium in excess of internationally agreed safety limits. Exceeding these limits does not mean that disease will necessarily occur.

21 In three cases, financial settlements have been reached with relatives of former British Nuclear Fuels employees who died of cancer. These cases were settled out of court on the basis of expert medical advice as to the balance of probability of the fatal disease having been radiation - induced. These settlements reflect the positio under the Nuclear Installations Act 1965 by which where a plaintiff establishes that a death or injury is attributable to radiation from a defendant's premises, the defendant becomes liable to pay compensation. In fact, in none of these cases was it completely established that the deaths were attributable to radiation. There are also a number of claims pending concerning employees and ex-employees of BNFL and one case is outstanding against the AEA.

22 In 1957 a release of radioactivity from an early nuclear reactor, of a type never repeated for commercial nuclear stations, engaged in defence -related operations at Windscale led to a precautionary ban on the consumption of milk within a radius of some miles. The Himsworth Committee, set up by the Medical Research Council to report on the heath and safety aspects of the accident, concluded that "it is in the highest degree unlikely that any harm has been done to the health of anybody, whether a worker in the Windscale plant or a member of the general public."

23 As a comparison, the Health and Safety Executive have estimated the number of deaths due to accidents per Gigawatt year of electricity sent out. The results, published in 1978 were: coal 1.8, oil and gas 0.3, nuclear 0.25. None of the deaths from nuclear generation was from radiation. The nuclear figure included the HSE's estimate of the fatalities in uranium mining even though this is carried out outside the UK.

Nuclear Licensing

24 No commercial nuclear installation may be built or operated in this country without a licence granted by the Health and Safety Executive (HSE) under the Nuclear Installations Act 1965. Operators have to comply with legally binding licence conditions imposed by the HSE on the advice of its Nuclear Installations Inspectorate (NII) and a licence is not issued until the NII is satisfied with the safety standards to be achieved. The HSE and the NII are completely independent of the nuclear industry and the Inspectorate make rigorous safety checks at all stages of the design, siting, construction and operation of a nuclear installation.

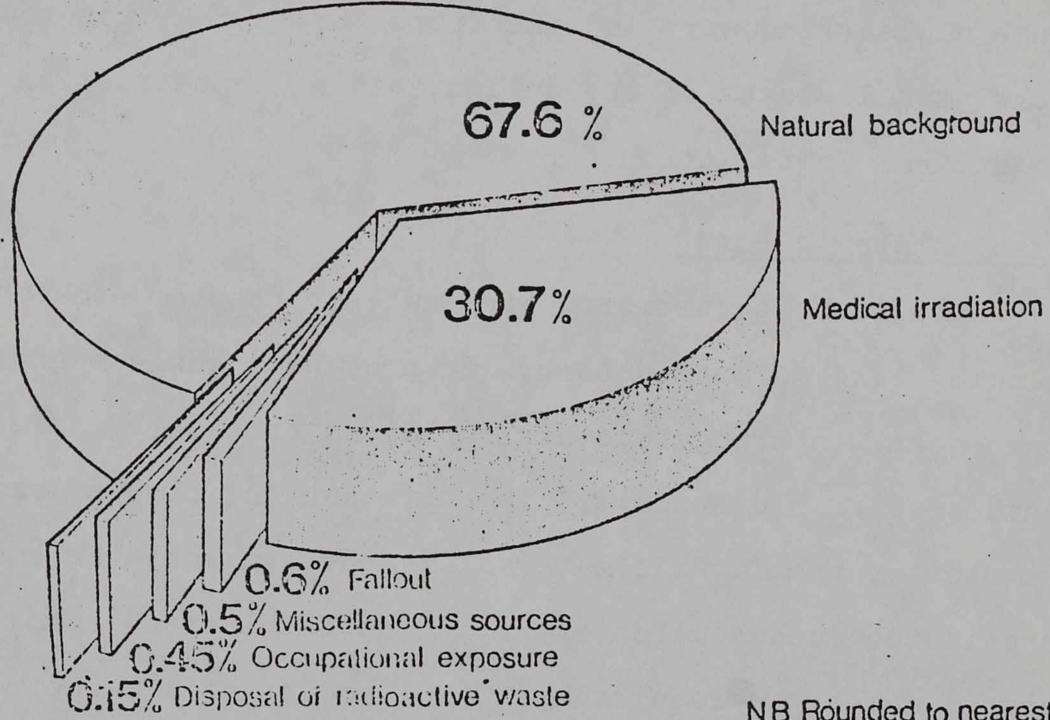
Unlike an Atomic Bomb

25 There is no possibility of a nuclear reactor -thermal or fast - exploding like an atomic bomb. To produce a nuclear explosion, it is necessary to bring together rapidly a critical mass of almost pure uranium 235 or plutonium 239 in a precise and compact shape. However in a reactor the fissile material is not concentrated enough to explode, there is too much neutron absorbing material present and there is no means by which the required critical amount of fissile material could be assembled and held together while the general reaction spreads through it.

Radiation

26 Considerable research has been and continues to be undertaken in the UK and in many other countries to identify all the possible effects of exposure to radiation, including not only the high doses which may be received in a short time as in an accident, but also the doses which may be accumulated slowly over long periods of time. As a result, the Health and Safety Executive consider that radiation is perhaps better understood than the possible effects of conventional energy sources.

27 Everything and everybody is irradiated to some extent. Most of the radiation occurs naturally, either from the earth or the sun, as is shown by the following diagram:



Annual effective dose equivalent to the UK population

NB Rounded to nearest 0.05%

National Radiological Protection Board

28 International recommendations for the protection from man -made radiation are made by the International Commission on Radiological Protection (ICRP). Formed in 1928, the ICRP is made up of scientists elected each year on the basis of their individual reputations and their independence and as such, it is independent of governments. Its recommendations are accepted by all major countries, including the UK. In the UK, the National Radiological Protection Board is responsible for advising the Government and industry on the standards recommended by the ICRP and is an authoritative point of reference on radiological protection.

29 The effects of radiation on man are counted by a unit of radiation dose called a rem or a millirem (mrem), one thousandth of a rem. The two main radiation dose limits are: for radiation workers 5 rems in a year; and for members of the public 0.5 rems in a year, with a long term restriction to an average of 0.1 rems in a year. These limits are in addition to background radiation which exceeds
per year 0.5 rems/in some parts of the world. Other examples of radiation doses received by the public are:

one chest X ray	50 - 200 mrem
natural background radiation for a person living in the UK per year	105 mrem
additional natural radiation from granite buildings received by a person living in Aberdeen per year	40 mrem
the average radiation dose received by a person resulting from the activities of the nuclear industry per year	0.2 mrem

Operators are obliged to reduce exposure to radiation to the lowest possible level. As a result the average radiation dose received by radiation workers is for example 0.3 rems a year at the CEGB and is just over 1 rem a year at BNFL, compared to the maximum upper limit of 5 rems for each year of a full working life.

Waste Disposal

30 The burning of nuclear fuel in power stations and the reprocessing of spent fuel gives rise to three broad levels of activity of nuclear waste: low, intermediate and high. Within each broad category however, there are short and long lived isotopes. Low level wastes are discharged from nuclear power stations and from BNFL establishments into the atomosphere, the sea or, in the case of Trawsfynydd power station, into a fresh water lake. These and all other discharges are subject to strict control and are carefully monitored. Stringent limits for the radioactivity that may be discharged are based on the ICRP recommendations that the maximum radiation dose to any member of the public from all man made sources shall be as low as reasonably achievable and shall not exceed a maximum of 0.5 rem per year regardless of cost. Some low level solid wastes are packed in concrete filled steel drums and sunk in the deep ocean under international supervision while intermediate level solid wastes are stored, under supervision, at nuclear sites.

31 Only 3% of the waste remaining after the reprocessing of spent fuel is highly active. Since reprocessing began in 1952, BNFL has reprocessed over 19,000 tonnes of spent fuel, resulting in less than 800 cubic metres of highly active wastes - about the size of a four - bedroomed house. These are safely stored in high integrity stainless steel cooling tanks.

32 A method of converting highly active wastes into a glass solid has been developed and proven on a pilot scale in the UK. A full scale demonstration plant is expected to be operational in the late 1980s. In France, glassification has already reached the stage where it is being operated on a semi-industrial scale. Glassification reduces many of the problems of radioactive waste management. It substantially reduces the bulk of waste and makes it safer and easier to handle. Also there can be no danger of the waste itself leaking while in storage.

33 A large scale research programme is in progress to find an acceptable way to dispose of these wastes permanently. Three options for the disposal of containers of the glassified waste are being considered: in deep underground stable formations on land; on the bed of the deep ocean; and under the ocean bed. All three are technically feasible. No particular option is preferred at this stage and research into all three is being carried out in this country and abroad. Any decision to dispose of highly active waste by any of these routes would be taken only after the fullest consideration of all the safety and environmental issues and the results of the extensive research programmes. It is not expected that actual disposal will commence until the beginning of the next century at the earliest. Until then the high level wastes, in glass form, will be placed in cooled stores under appropriate supervision.

34 Radioactive wastes have a finite half life and in time decay away. Some non-radioactive wastes which may be toxic and dangerous, for example those containing metals such as cadmium and lead, do not break down as such, although they may change their chemical form.

Transport of Nuclear Materials

35 Nuclear fuel assemblies, irradiated fuel elements and nuclear materials are carried, whether by land, sea or air, in specially designed containers. The containers are designed, assessed, certified and transported in accordance with stringent internationally accepted safety standards laid down by the International Atomic Energy Agency. These standards ensure that the containers would withstand a severe accident, for example, a high speed collision followed by a prolonged fire, without posing a significant hazard to the public. For instance, the flasks used by the UK Generating Boards to carry irradiated fuel are massively constructed of steel some 14" thick. They weigh around 50 tons each. The Generating Boards have been moving this fuel mainly by rail for some 17 years and over 9,000 tons have been moved to

Windscale in this way. Although there have been a few minor instances of derailment, none of these has resulted in damage to a flask and release of radioactivity. However, detailed national emergency procedures exist in case of accidents involving the transport of all radioactive materials. These procedures encompass the police and the emergency services. The Generating Boards operate, in conjunction with British Railways, a national emergency plan tailored to fuel flask movements.

Emergency Arrangements at Nuclear Sites

36 The possibility of a serious accident involving a release of radioactivity capable of affecting the nearby population is considered extremely remote. Nevertheless, it is prudent to have measures for the protection of the local community ready against such an eventuality. The operators of nuclear installations are therefore required by the conditions of the nuclear site licences to make preparations for dealing with emergencies. Sites operated by the AEA and by Government departments are required to meet the same standards as are imposed on the operators of licensed sites.

37 Emergency arrangements are set out in a site emergency plan which each licensed operator is required to submit to the Health and Safety Executive. The plan covers: (a) on site organisation and arrangements; (b) off site arrangements in an emergency, for example, the evacuation of the neighbouring pipulation, and the monitoring of radioactive levels; and (c) arrangements with outside bodies, such as local authorities, emergency services and Government departments. The local emergency services would be able to call on such national bodies as the National Radiological Protection Board and the Health and Safety Executive for help and advice. Naturally, as in the case of any other emergency, assistance would be forthcoming from wider national resources, if circumstances required it.

38 Details of these plans are discussed with the Local Liaison Committee and are made available to the local communities, for instance, through public libraries. These Committees comprise representatives from the local community, local authorities and other public bodies including Government departments and emergency services. The Committees provide a channel through which local people are kept in touch with emergency arrangements and provide general information about the operation of nuclear installations.

Siting of Nuclear Stations

39 Planning applications for power station sites are made by the Electricity Boards to the Government. These applications are decided by the Government rather than by local planning authorities, but normal planning procedures apply. Everything is done to take into account the views of those concerned, whether local authorities or residents or other objectors, and public inquiries are held when necessary.

40 The main safeguard for the public from any hazard arising from nuclear installations is provided by high standards of design, construction and operation. But it is also prudent to site them in such a way as to limit the extent of the emergency on the public in the unlikely event of an escape of radioactivity.

41 Early nuclear power stations in this country were built on remote sites. But in 1968, after a review by the Nuclear Safety Advisory Committee (NSAC), it was found possible to relax this policy to some extent, and the AGRs were cleared for construction on semi-urban sites such as Heysham and Hartlepool. The Nuclear Installation Inspectorate would, however, still require the first few stations of any type of reactor new to commercial operation in the UK to be built on remote sites.

Security of Nuclear Installations

42 Because of the special security needs of nuclear installations the Atomic Energy Authority operates a Constabulary to guard certain sites and to protect certain nuclear material in transit. The Constabulary was established under the Atomic Energy Act 1954 and organised as a disciplined police force along lines similar to

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regular police forces, with a Chief Constable responsible to the UKAEA. In common with other police forces, AEA police have access to firearms, which are only carried when the officers concerned are on duties directly related to guarding fissile materials. Their Standing Orders, which are closely modelled on those of other police forces, set out clearly the circumstances in which firearms may be used. The Constabulary numbers about 500 at present. Security surveillance precautions are taken at all UK nuclear power stations.

World Nuclear Programmes

43 In 1978, the members of the International Energy Agency - which includes all the developed Western countries except France - consumed 33 million barrels of oil a day, of which two-thirds, 23 million barrels a day, was imported. By 1990, projected oil consumption could have increased to some 45 million barrels a day of which about two-thirds would still be imported. Even if sufficient oil supplies exist, it cannot be assumed, as the situation in Iran has shown, that the oil will in fact be available to import. The need for substantial and secure sources of energy other than oil is appreciated by all countries dependent on oil imports.

44 Nuclear power already makes a significant contribution to world energy supplies. Total installed nuclear capacity throughout the non-Communist world in 1978 was over 110 GW, compared with 10 GW ten years before. For the future, nuclear power occupies a key role in the long term energy plans of most industrialised, and several developing, countries. Thus, minimum nuclear requirements for IEA countries for 1985 and 1990 have been estimated at 201 GW and 332 GW (6 and 10 million barrels of oil a day) respectively. At present, 23 countries have nuclear generating capacity and by 1985 it is expected to increase to 34.

45 The Commission of the European Communities has made the following assessment of current and projected nuclear capacity for those Member States with major nuclear programmes:

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	GW at end 1977	at end 1985
Belgium	1.4	5.1
France	4.6	38.5
Italy	0.6	7.4
West Germany	5.6	24.0
U.K.	5.9	9.4

46 World leaders at both the Tokyo summit and in the European Council have endorsed the development of nuclear energy under conditions guaranteeing the safety of the population. Without further growth of nuclear capacity, the European Council considers that no economic growth will be possible.

International Regulation and Non-Proliferation

47 It has been recognised, since the earliest days of nuclear power, that the spread of nuclear technology might increase the possibilities for other countries to obtain nuclear weapons. The proliferation of nuclear weapons is a risk that should be balanced against the benefits of the peaceful use of nuclear power. The aim of the international community is to reduce these risks to the minimum. They cannot, however, be completely eliminated even if there were to be no nuclear power. Considerable international effort has been and continues to be devoted to minimising the risks of proliferation, and to finding ways to reduce them. The UK continues to play a full part in these efforts.

48 Principal among the international organisations working in this field is the International Atomic Energy Agency. The Agency was set up in 1957 to assist less developed countries to acquire the benefits of nuclear power and, through a detailed system of inspection called "safeguards", to detect the misuse of nuclear facilities or materials. The safeguards system applies to all signatories of the Non-Proliferation Treaty and to those countries which have otherwise accepted them. Safeguards are designed to monitor, through accounting of all nuclear materials and other means, the use of such materials in all civil fuel cycle activities. The aim of safeguards is to rapidly detect the diversion of any materials from their declared use and to notify any such diversion to the United Nations. The ability of safeguards to give the international community timely warning of any diversion provides

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an effective deterrent against any misuse. Safeguards are administered by an international team of IAEA inspectors.

49 The Non-Proliferation Treaty was agreed in 1968 and came into force in 1970. It has now been signed and ratified by over 100 states. Nuclear Weapons States agree not to transfer, and Non-Nuclear Weapons States agree not to develop or acquire nuclear explosives. Parties also agree to work towards nuclear disarmament, to promote the exchange of nuclear equipment and technology for peaceful purposes, and to accept and promote IAEA safeguards.

50 The Nuclear Suppliers Group was set up in 1975 by the principal suppliers of nuclear materials and technology and is chaired by the UK. It has established guidelines placing controls on the export of sensitive nuclear materials and technology.

51 When the UK entered the EEC, it also became a member of Euratom, which operates a system of safeguards similar to that of the IAEA. Euratom inspectors have the right of access to all places, data and persons concerned with management of nuclear material to the extent necessary to ensure that the material is not diverted from its intended use.

IAEA Safeguards Arrangements in the UK

52 Although the UK is a nuclear weapon state and therefore under no international obligation to accept safeguards, we have voluntarily submitted all our civil facilities to international safeguards. Our reason for doing this was to avoid putting the nuclear industries in non-nuclear weapons states at a commercial disadvantage. Safeguards impose a significant cost on the industry, and to encourage all countries to submit to them, we are prepared to accept a similar cost burden on our own industry. The Americans also accept this principle.

53 All civil nuclear activities in the UK are therefore subject to both Euratom safeguards arrangements and, in the very near future, to IAEA safeguards as well. The procedures require that all users of these materials for civil purposes must maintain and produce for the safeguards authorities detailed operating and accounting records, submit reports of movements, stocks and use

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of materials on a monthly basis, and allow both Euratom and IAEA inspectors to verify compliance. IAEA inspectors will be present continuously at large facilities holding plutonium.

INFCE

54 The International Nuclear Fuel Cycle Evaluation (INFCE) was launched in October 1977. 56 countries and 8 international organisations are participating. The programme of work is due to be completed in February 1980. The evaluation covers every stage of the fuel cycle from uranium mining right through to waste disposal, and assesses the economic and environmental aspects of various different fuel cycles. It also examines the risks of misuse of civil fuel cycles to manufacture nuclear weapons and the ways in which those risks can be reduced. The INFCE reports are expected to be released at the end of February.

Uranium Supplies

55 As with other sources of fuel, there are uncertainties in the long term projections of uranium supply and demand. There will be political and environmental constraints on the availability of uranium as well as physical constraints. Demand will be affected by the future size and type of world civil nuclear reactor programmes and by the price of uranium. However, it seems likely that there is sufficient uranium in the ground in currently known low extraction cost deposits (i.e. below $130 per kgU or $50 per lb U_3O_8) to meet the lifetime requirements of all nuclear reactors likely to be installed in the non-Communist world by the end of the century (provided that planned reprocessing and recycling of recovered uranium take place). Estimates of non-Communist world production capacity vary around 80,000 to 130,000 tonnes of uranium per annum in 1990 and 120,000 to 200,000 tonnes of uranium per annum in 2000. Total UK requirements are currently about 2,000 tonnes of uranium per annum; these could rise to some 4,000 tonnes per annum in 1990 and might reach around 10,000 tonnes per annum by the end of the century. There are also exploration and development programmes in many parts of the world which, with more fuel efficient reactor designs, should add to known reserves.

11 December 1979