INFORMATION FOR MEMBERS

FROM THE

PARLIAMENTARY OFFICE OF SCIENCE AND TECHNOLOGY

BRIEFING NOTE 5

OCTOBER 1989

DECOMMISSIONING NUCLEAR POWER STATIONS

The anticipated cost of spent fuel management and decommissioning caused the Government to announce in July that Magnox stations would remain under public control, and not become part of the generating plant of National Power. Current plans envisage that it may take over 100 years to complete decommissioning; thus decisions made now will have an impact many years ahead.

This briefing note summarises the technology involved in decommissioning and addresses related issues of potential interest to Parliamentarians.

WHY DECOMMISSION?

A total of 26 Magnox reactors on 11 sites were built (Table 1)- originally with a 20 year life for depreciation purposes. As they get older, the cost of maintaining both nuclear and non-nuclear parts can rise to the point where it is un-economic to produce power from that station. Berkeley is the first to be decommissioned because of the significant expenditure required on non-nuclear components (e.g. replacement of the overhead crane) as well as the cost of complying with the results of the long-term safety review of the Nuclear Installations Inspectorate (NII).

Decommissioning is required for two basic reasons:
- to remove or contain the structure in such a way as to avoid health and environmental hazards, and to ultimately allow the land to be reused.

TABLE 1 UK Magnox Reactors

Site	Operator	Reactors	Age
Calder Hall	BNFL	4	30/32
Chaplecross	BNFL	4	29/30
Berkeley	CEGB	2	27
Bradwell	CEGB	2	27
Hunterston	SSEB	2	25
Trawsfynydd	CEGB	2	24
Dungeness A	CEGB	2	24
Hinkley Pt A	CEGB	2	24
Sizewell	CEGB	2	23
Oldbury	CEGB	2	21
Wylfa	CEGB	2	17/18

WHAT IS INVOLVED?

At closure the radioactive components of the power station are the fuel rods and the surrounding reactor materials which have become activated or contaminated during the many years of operation. Decommissioning follows three internationally-defined stages.

Stage 1 (Fig 1) - After reactor shut-down, all fuel elements are removed from the graphite core. Since the normal operation of the power station requires fuel to be continuously replaced as it is used up, defueling involves no new equipment or procedures. At Berkeley, 85,000 fuel elements will be removed over 3 years (twice the rate at which fuel is normally replaced) and returned to BNFL for re-processing in the standard transport containers. De-fueling removes **over 99.99%** of the radioactivity present in the plant at shut down.

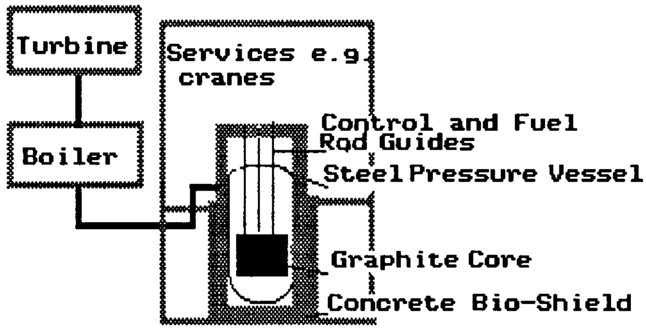

Figure 1 : Power Station at Shutdown

Stage 2 (Fig 2) - All buildings and machinery external to the reactor shields are dismantled. Most of the waste comprises uncontaminated buildings and equipment (95%), but some equipment (e.g. in the primary coolant circuit, storage ponds and fuel handling facilities) may be contaminated. Most, if not all, of this work can be carried out without developing special procedures, under the normal radiation exposure controls applied at any nuclear site.

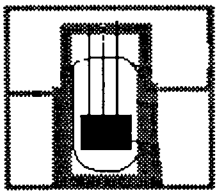

Figure 2: Completion of Stage 2

The large amounts of scrap and waste can be disposed of as follows (see footnote for waste categories):

Inactive waste	Use on site or normal disposal site
Low Level(LLW) and Intermediate Level(ILW)	Storage on site to await completion of the Nirex Repository in 2005.

At this stage other conventional problems must also be dealt with, particularly those associated with asbestos cladding and moving large loads.

Stage 3 (Fig 3) - The remaining reactor core and shield structure are dismantled and the waste removed to leave a clear site. Wastes at this stage include the activated steel, concrete and graphite of the reactor and its shields, and will contain a significant proportion of ILW. This stage involves the creation of a securely contained and shielded work area in which remote-controlled cutting equipment dismantles sections of the inner core and removes them from the reactor into the adjoining shielded area. Here they can be set in concrete in large (50 tonne) containers prior to disposal (Fig 3) .

CURRENT ISSUES

Is a Delay between Stages 2 and 3 the best Option?

In the UK, two major variants in decommissioning procedures have been considered. One would proceed

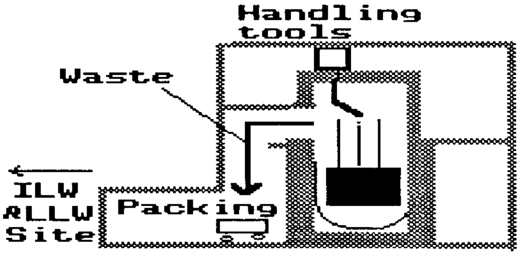

Figure 3: Stage 3 Dismantling

straight through stages 1 and 2 (which may nevertheless take 10-15 years) to stage 3; the other would maintain the reactor building in a sealed, weather-tight condition, allowing radiation levels to decay naturally before tackling stage 3. The debate on the relative merits of these approaches includes technical/safety considerations, economic factors and other issues.

Technical and Safety Considerations

After fuel removal, the radioactivity remaining on the power station site continues to decay. CEGB have calculated that the radiation exposure of workers using the same stage 3 dismantling procedures declines substantially over the first 100 years, after which further falls are slow (Fig 4). In decommissioning plans put to the NII for Magnox stations, the CEGB have proposed that stage 3 be delayed to about 100 years after shutdown, in order to gain the maximum benefit from this process. It is claimed that these proposals are consistent with the ALARP (as low as reasonably practicable) philosophy underlying radiation protection in the UK, and may also reduce the amount of radioactive waste.

Early stage 3 decommissioning could increase the level of worker exposure. However a greater reliance on remote operations would keep this within industry safety limits. While it is generally accepted that stage 3 dismantling will be technically simpler after 100 years, it is acknowledged in the Government's response to the Select Committee on Energy, that it is technically possible to dismantle a reactor almost immediately after stage 2.

Economic Factors

Government and CEGB policy is that the costs of decommissioning a power station should be borne by those benefitting from its production. Consequently, consumers are charged during the operating life of the station to provide capital at closure which, if invested, would grow to the sums needed for decommissioning. These were estimated at £300m ('86 prices) per station, but recent reviews by CEGB have raised this to £550m ('89 prices)- primarily due to increased costs of waste disposal. This estimate includes a contingency of around 20% and makes no assumptions on technical improve-

Footnote : Definitions of Waste

Inactive (Free Release) Waste	*<400 Bq/kg*
Low Level Waste	*>400 and <12,000,000 Bq/kg*
Intermediate Level Waste	*between LLW and HLW*
High Level Waste	*capable of self-heating*

***Note:** 1Bq = 1 disintegration per second (Coffee has around 1,600 Bq/kg; garden soil around 800 Bq/kg)*

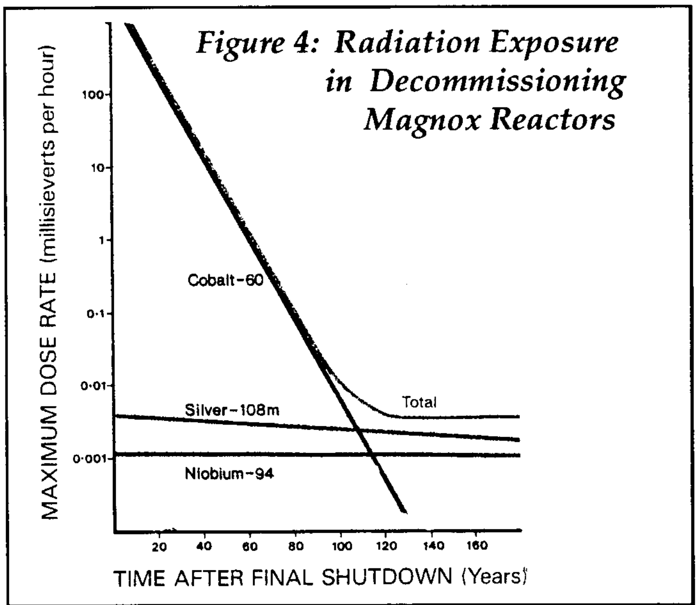

Figure 4: Radiation Exposure in Decommissioning Magnox Reactors

ments in dismantling techniques over the next 100 years.

Deciding how much should be saved now to pay for work extending over 100 years requires assumptions on the rate of interest earned. CEGB assumes that capital will earn a real (net of inflation) rate of 2% which provides for a 7-fold real growth over 100 years. If these assumptions hold, then amounts put aside during the Magnox stations' life should provide for stage 1 and 2 dismantling, the surveillance, maintenance and monitoring costs after stage 2, and final stage 3 removal after 100 years. As of 31 March 1989, CEGB had made provisions of £1300m in their accounts towards the ultimate costs of decommissioning all their current Magnox and AGR stations.

This approach has been criticised on the grounds that nuclear power industry costs tend to rise at above the average inflation rate. Funds accumulating over 100 years may therefore prove to be inadequate to pay for stage 3 removal - necessitating either a further delay to allow more interest to accrue, or the provision of funds from another (e.g. public) source.

Similar difficulties would arise if earlier stage 3 dismantling were to be required for political or other reasons. In this case, costs would increase due to both the extra difficulties of early stage 3 dismantling (up 25%) and the "loss" of interest through there being no extended delay period. In 1986, when costs were £300m per station, CEGB estimated that early stage 3 removal would require them to set aside an **extra** £200m (1986 prices) per year for 10 years.

A further economic issue relates to the mechanism of saving decommissioning capital. Worldwide, methods range from placing contributions from power bills into a totally independent trust fund, to planning to bear the costs at the time of decommissioning. Some argue that the possibility of insolvency in the private sector supports the establishment of an independent trust fund during the life of the station adequate to cover anticipated decommissioning costs.

Other Factors

Surveillance and monitoring of the reactor during any stage 2/3 delay is required by the NII to prevent public access and detect any breach of containment. Hypothetical scenarios have nevertheless been considered to quantify the consequences of these controls failing. One extreme case involved a "salvage digger" penetrating the 2m thick reinforced concrete bioshield to reach the pressure vessel inside (Fig 1). US and CEGB calculations based on gaining entry after 100 years showed that such an intruder could not exceed the current worker safety limits.

Another scenario assumed complete collapse of the reactor remains at a site over an aquifer used for drinking water. CEGB calculated that even this "worst case" would give rise to negligible extra dose rates to the local population (<0.11% of background levels).

A further question raised by some is over the ethics of leaving the remains of current power stations for future generations to deal with - particularly since any unforeseen costs would be borne by latter-day consumers or tax-payers who had not benefitted from the power generated. A final consideration arises from the inability to reuse the land area affected for long periods - though most areas affected are likely to remain on sites used for electricity generation.

Policy Options

Both general and station specific decommissioning plans must be submitted to the regulatory authorities (NII and HMIP) for approval, which requires a minimum of two years notice prior to the commencement of operations pertaining to each stage. Since it takes 10-15 years to complete stages 1 and 2, an irrevocable decision on whether to proceed to stage 3 will not need to be taken for some years yet.

The outcome of debate on the above issues will determine whether delays are authorised between decommissioning stages for all Magnox stations, for none, or on the basis of factors specific to each station. Such site-specific factors could include costs of site security (presumed to be highest on isolated sites which do not remain generating sites) and local pressures to reclaim or reuse the site as soon as possible.

Relevant Research and Exploitation

There are a number of international activities on decommissioning. The EEC is in its third 5-year programme of research and part-funds a number of decommissioning projects. The International Atomic Energy Agency has been sharing information on decommissioning and producing guidelines.

Nationally, the CEGB has an internal research expenditure of around £1m per year. BNFL also has its own internal decommissioning R&D projects and acquired experience in decommissioning redundant reprocessing plant - some of it relevant to stage 2 procedures. A stage 3 research project is underway at the Atomic Energy Authority's (AEA) prototype (33 MW) Windscale advanced gas-cooled reactor (WAGR), funded mainly by the Department of Energy with some EEC support (CEGB formerly contributed to this project but withdrew funding in 1988). This demonstration project will cost £60m from 1986 to 1996 and will involve developing remote-controlled cutting and removal equipment; it aims to extend UK skills in decommissioning technology and allow more accurate cost estimates to be prepared.

Other pilot projects are underway elsewhere. Japan is decommissioning a 90 MW PWR by 1993. France, Germany and the USA also have stage 3 decommissioning projects underway on PWR's, and information on these is shared via the Nuclear Energy Agency of the OECD.

Worldwide, many power stations are reaching the end of their useful life; by the year 2000 over 150 will be over twenty-five years old and a few more than forty years. Expertise gained through UK research could thus be applied through consultancies and project management to decommissioning projects overseas as well as in the UK, and ways of exploiting such expertise within CEGB, BNFL and AEA are being examined. Other contractors with experience in decommissioning other nuclear facilities (e.g. laboratories) may also seek to offer decommissioning services for power stations. Future options for the management of the Magnox stations might include opening up decommissioning contracts to more competition. In such a situation, it is likely that contractors from other countries (eg USA) may also compete in the UK market.

The prospects of increasing use of contractors raises the issue of what controls are appropriate for ensuring the quality of the work carried out. In the UK this is currently the responsibility of the site operator, under the conditions of the operating license from the NII. The NII also exercises direct quality control through the safety plans required before work is started and via inspection and audit during the project.

Can we Deal with the Waste?

Wastes from decommissioning will add significantly to the quantity of radioactive wastes for disposal. Nirex estimate that planned facilities will be adequate to deal with the ILW and LLW generated by stage 1 to 3 decommissioning whether or not a delay is introduced between stage 2 and 3. However, this assumes that the planned Nirex deep repository becomes operational in 2005- since until then, LLW and ILW must be safely stored on the original site.

One option favoured by some would involve disposal of the larger, slightly contaminated, structures by dumping in the deep sea, since they could be loaded directly onto vessels at coastal or estuary stations. Candidates would include the heat exchangers and boilers which would otherwise require cutting up into sections small enough to be transported to the Nirex repository. At present this option is not available since dumping at sea is subject to a moratorium under the London Dumping Convention, pending the results of scientific and legal studies.

Implications for AGR's

The Advanced Gas-cooled Reactors remain part of the portfolio of generating capacity being privatised, and questions have also been raised as to the costs of decommissioning these reactors. Unlike the Magnox design, detailed studies of AGR decommissioning costs have not been reported. However, it is currently believed that they would be of a comparable order to those of Magnox stations, which would translate to a lower cost per kilowatt because of the larger size of the AGR.

An additional factor is that, given a station life of 25 years or more, the first decommissioning decisions on AGR's are not expected until 2005 or later, by which time it will be possible to make more precise estimates of costs, having benefitted from the results of the Dept of Energy-funded WAGR project already described.

Funding mechanisms for AGR decommissioning have yet to be finalised. One proposal is for the owners to purchase Government bonds. Some are concerned at the possibility of the privatised companies encountering financial problems during the extended period of decommissioning envisaged, and favour the creation of a wholly separate and independent decommissioning trust fund along the lines of that required in the USA. These mechanisms could also deal with future reactors such as the PWR's.

FURTHER INFORMATION

Additional details and background information are available from POST, 16 Great College Street, Westminster; Tel 222-7085/3912.