(reprinted from Ambio*, 3/1976)*

Nuclear Power in Britain

Britain's nuclear circumstances are in certain respects unique - historically, technologically and economically. British scientists were instrumental in the development of the atomic bomb during World War II. But immediately after the war the US passed the McMahon Act, cutting Britain off from any further access to the nuclear developments following on from the Manhattan project. Accordingly, Britain embarked on her own weapons program, which in turn led to diversification into nuclear activities quite independent of the US, and indeed of other countries with an early foothold in nuclear development. Thirty years later Britain is still ploughing a lone furrow.

THE BEGINNING OF THE PROGRAM

In 1956 Britain commissioned what was at the time called "the world's first nuclear power station" at Calder Hall in Cumbria. Calder Hall and its sister station at Chapelcross were in fact dual-purpose stations, whose primary role was the production of weapons-plutonium, with electricity as a by-product. But these two stations were the precursors of the first generation of civil nuclear power stations in Britain: gas-cooled, graphite-moderated reactors, generically labelled "Magnox" after the alloy used as cladding for the natural uranium fuel. Calder Hall and Chapelcross each incorporated four reactors, and each of the nine civil stations two, making 26 Magnox reactors in all. The Berkeley and Bradwell stations came on stream in 1962, and the others followed. Most of the Magnox stations have performed very well, although all have required derating as a result of problems with corrosion. Wylfa, the last and largest Magnox station, was started up in 1970 but has given continual trouble. It is still described as being "commissioned"; its capacity factor in 1975 was only 16 percent.

THE SECOND GENERATION

In 1965 the Government decided on a second generation of nuclear stations, and adopted the British-designed advanced gas-cooled reactor. Five twin-reactor AGR stations were ordered. The second and third of these went critical only in February 1976, more than three years late, and at the time of writing are early in the phase of power ascension and testing. The first, Dungeness B, will be at least thirteen years in construction, and is considered a potential complete write-off.

Besides the small prototype AGR at Windscale, British designers had also created another thermal design, the Steam Generating Heavy Water Reactor, of which a prototype was built at Winfrith in Dorset. In 1973-1974, after a bitter controversy, the government rejected the electricity industry's plan to buy 32 1300-megawatt Westinghouse PWRs, and opted instead for a trial program of six 660-megawatt SGHWRs in two stations, four at Sizewell in Suffolk and two at Torness near Edinburgh. Neither of these stations is yet under construction.

From 1959 onwards the UK Atomic Energy Authority (UKAEA) operated its small experimental Dounreay Fast Reactor on the north coast of Scotland. A larger Prototype Fast Reactor went critical in early 1974 but has not yet been run up to power, as a consequence of problems with turbine and steam generators. Longer-term plans, in which the fast reactor figures prominently, are at this stage no more than speculative. At one extreme the UKAEA postulate having more than 25 1000-megawatt fast reactor power stations in operation in Britain by the year 2000, in addition to thermal reactors. At the other extreme there are those who wonder whether by that time - with the Magnox stations having reached the end of their careers, and AGRs a doubtful quantity and subsequent designs even more so - Britain will have any operating nuclear power stations whatever.

Britain embarked on a civil nuclear power program in the mid-1950s as a result of an anticipated

shortfall in coal supplies. In the subsequent two decades Britain's energy situation has altered substantially for the better, with the discovery first of natural gas and then of oil in the North Sea. At the present time the electricity industry wants to augment its nuclear capacity to reduce its dependence on the revitalized coal industry. But the present Government attitude toward nuclear expansion is one of caution: in part because there is already a surplus of generating capacity, some 50 percent above peak demand, and in part because the nuclear industry is still in disorder after the AGR debacle.

SAFETY CONSIDERATIONS

British nuclear efforts received a dramatic setback in October 1957 when the Windscale Number One plutonium production reactor caught fire and was destroyed. Perhaps as a result of this accident the British civil nuclear industry has always been hyperconscious of safety considerations. With the exception of an expensive and little-publicized fuel meltdown in one of the Chapelcross reactors in 1967 there have been no major accidents to the Magnox series. Both the Magnox series and the incipient AGRs have suffered unexpected problems of corrosion, leading to derating; and a succession of design flaws and malfunctions have dogged the AGRs, in part leading to their accumulating cost and schedule overruns. At the Dounreay Fast Reactor the discovery of void formation and swelling of reactor internals from fast neutron irradiation caused unexpected delays to the fast reactor program. But none of these episodes has been in any way directly related to safety.

PUBLIC DEBATE

For this and other reasons there has until recently been little public debate about nuclear power in Britain. However, the controversy over the planned order of Westinghouse PWRs in 1973-4 stirred public attention, and involved many different interest groups, including Members of Parliament, nuclear scientists and engineers, trades unions, the environmental organizations Friends of the Earth and the Conservation Society, and press, radio and television. Later in 1974 a Lancaster group called Half-Life joined the growing opposition. The critics, from various perspectives, are concerned about the economics of nuclear power in the context of overall energy policy; about operating safety of nuclear facilities in the event of accident or sabotage; about the management of plant at Windscale; and about the security of fissile materials.

Until late 1974 there was little apparent Parliamentary concern about such matters. But a front-page story (less than scrupulously accurate) in the national *Daily Mirror* in October 1974 triggered a wave of public concern about plans to expand reprocessing at Windscale. In response the Secretary of State for Energy asked British Nuclear Fuels to arrange a public debate in London between their senior executives and the critics, which took place in January 1976 and was widely reported. Even so, the extent of real public awareness of nuclear issues in Britain is only now being investigated. It does not thus far seem particularly high, but has undoubtedly grown considerably in the past two years.

ENRICHMENT AND FUEL REPROCESSING

Britain has engaged in uranium enrichment and fuel reprocessing since the heyday of the weapons program in the 1950s. The gaseous diffusion enrichment plant at Capenhurst was largely mothballed in the early 1960s; but the site is now the home of a new gas-centrifuge plant, being erected as part of the program of the tripartite URENCO-CENTEC Anglo-Dutch-German consortium of which British Nuclear Fuels are one-third partners. BNFL is contracting to supply separative work not only to the British electricity industry but also to overseas customers. At their Windscale site BNFL have an operating reprocessing plant for uranium metal fuel. But the head-end plant for oxide fuel experienced an accidental leak of radioactivity in 1973, and has been shut down since that time for extensive rebuilding. BNFL now propose to build two further plants for reprocessing oxide fuel at

Windscale; these plans are the subject of the controversy aforementioned.

HIGH LEVEL WASTES

High level waste produced by the present plant is stored in liquid form in stainless steel tanks on the Windscale site. It is proposed to equip the present and proposed plants with facilities for glassification of the high level wastes; but the glassification process is still in the laboratory stage, and has yet to be demonstrated on a commercial scale. Overseas reprocessing contracts now being negotiated by BNFL include a clause requiring the customer country to accept return of the glassified high level wastes. No firm plans have yet been developed for longer-term management of radioactive wastes in Britain.

SAFEGUARDS

Britain, as a nuclear weapons power, is not required to accept safeguards under the Non-Proliferation Treaty (NPT). Like the US, Britain has offered to place all her civil nuclear facilities under International Atomic Energy Agency safeguards. However, the British Government does not anticipate an increase in British contribution to the IAEA for this purpose, which casts some doubt on the scope of possible IAEA supervision of the very extensive British nuclear establishment. Britain has exported only two reactors, to Japan and Italy in the early 1960s, with little likelihood of further exports in the foreseeable future. Both the above exports involved lifetime fuel services, including reprocessing. As far as is known Britain has returned to Japan and Italy the plutonium recovered from Japanese and Italian spent fuel, under bilateral safeguards. However, Japan has at the time of writing still not ratified the Non-Proliferation Treaty, and is accordingly not yet subject to NPT safeguards. A heated disagreement has persisted for more than a year between Friends of the Earth, who claim that Britain is violating Article III, Section 2 of the NPT by providing such services to Japan, and the British Government who deny any such violation. Britain is of course one of the group of nuclear exporters referred to as the “secret seven”, who have recently concluded top-level agreements about the conditions under which they will undertake nuclear exports, to reduce the threat of weapons-proliferation. Britain has never been notably interested in peaceful nuclear explosives, except insofar as they remain ambiguous and an embarrassment to weapons-control agreements.

PROJECTIONS

Britain’s Department of Energy has not committed itself to any very explicitly defined projections of energy-source proportions in 1985 or 2000. Heavily qualified projections for 1990 propose that the proportions might, by inference, be some 20 percent coal, 40 percent oil, 13 percent natural gas, and the rest nuclear electricity with a trace of hydroelectricity. The same projections for 2000 imply perhaps 40 percent nuclear electricity. However, the error limits on these projections are so wide as to make them of limited significance. Many observers remain profoundly skeptical both of the demand forecasts and of the means officially proposed to meet them. Very little serious consideration has been given officially to alternative energy sources. The Government funding available for research in these directions is less than one percent of the devoted to nuclear energy.

The British nuclear establishment has had 25 years of comparative privacy, abundant funding and whole-hearted Government support for its civil activities. The privacy is now being invaded by increasing numbers of the unconvinced, who feel that the performance and prospects of the nuclear establishment do not warrant its virtual monopoly of the official energy future of the country.