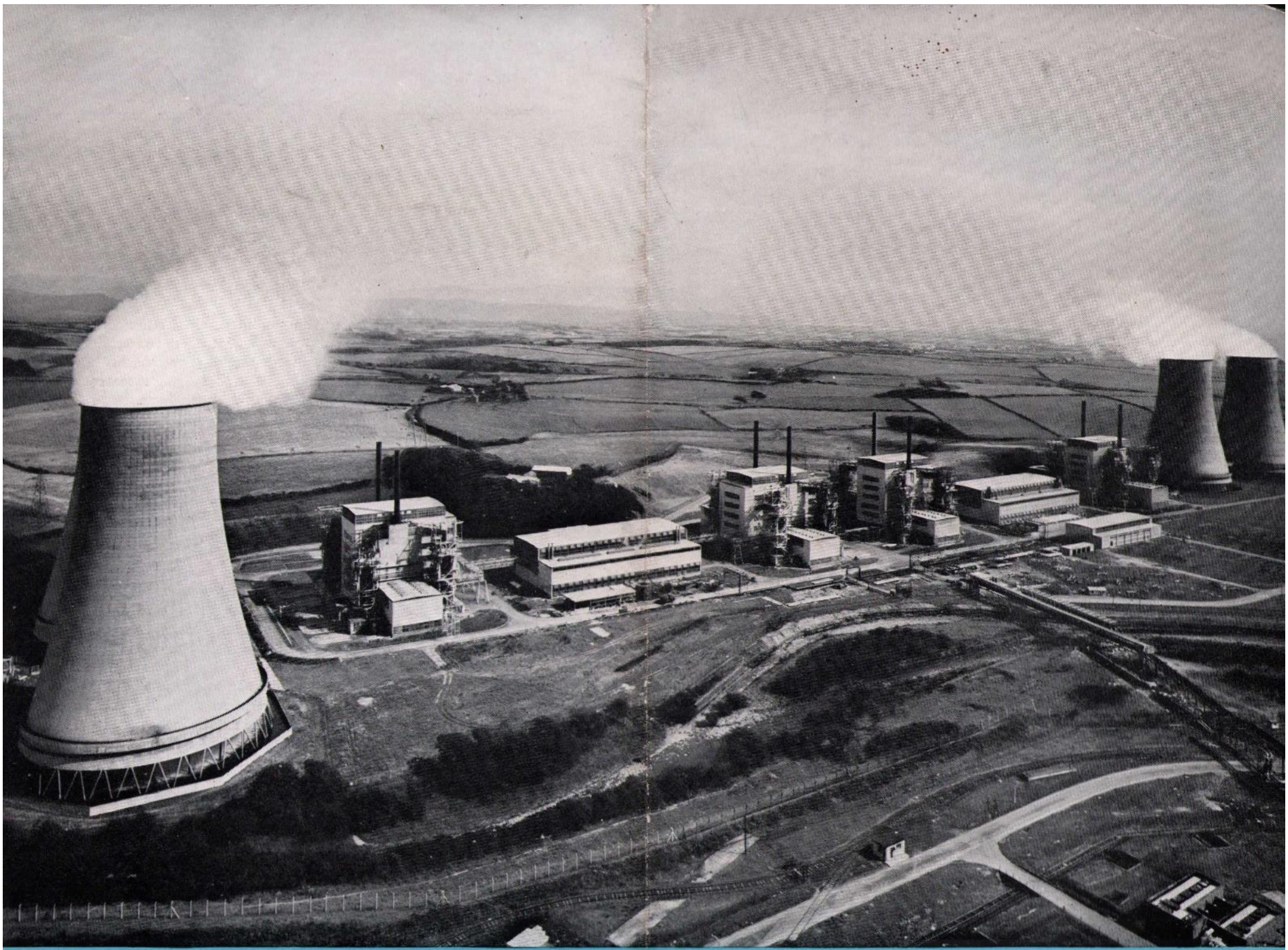
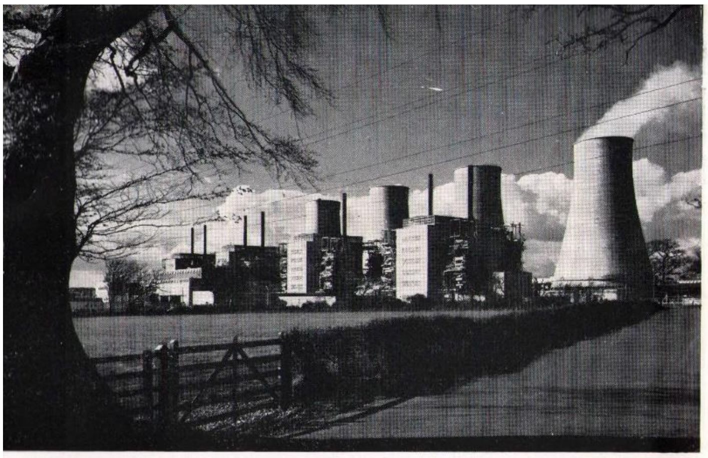


THE FUTURE

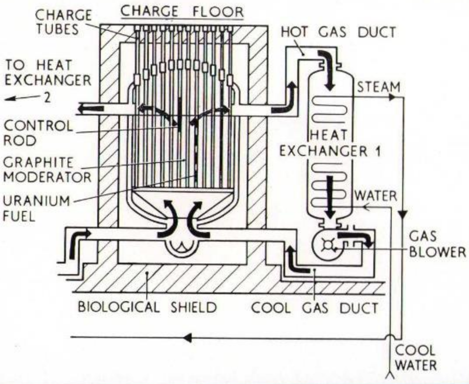
The pattern of the British nuclear power structure in the 1970's is now emerging. There will be a number of Calder-type stations working on high load factors and more advanced reactors (possibly advanced gas-cooled reactors) working on lower load factors. Then there may well be an increasing number of fast reactors fuelled with plutonium coming from the earlier reactor systems. Finally, there may be a number of high temperature gas-cooled reactors. However, the numbers of each of the different types of reactors and their rate of installation will be very dependent on the success of the research and development on them as well as on the availability and price of conventional fuel.

NUCLEAR POWER IN BRITAIN

UNITED KINGDOM ATOMIC ENERGY AUTHORITY



Chapelcross nuclear power station.



The gas-cooled reactor

Britain's nuclear power programme is based on the gas-cooled reactor. As its name suggests, it uses a gas under pressure, pumped through a nuclear "furnace" or core containing hot uranium metal, to remove the heat and transfer it to water boilers. In turn, these supply steam to turbo-alternators which make electricity.

This, then, is the way in which heat is removed. It is nothing very new. The novelty lies in the way the heat is produced in the core; by bringing together enough uranium metal rods to make what is known as a "critical mass" so that fission, or splitting, of the uranium-235 atoms in the natural uranium can take place. When this is done, the rods become very hot and radioactive.

These design features impose certain conditions on the builders of such reactors. They must provide vessels to withstand the pressure of the circulating coolant gas, thick concrete shielding to contain the radioactivity of the uranium rods and metal cans around these rods to protect the uranium metal and contain the fission products.

The earliest reactor in Britain was GLEEP, built at Harwell in 1947. It was air-cooled and the heat was wasted. In 1948, a much larger unit called BEPO went into operation and some of the heat removed by the coolant air was recovered. The Windscale plutonium-producing reactors were air-cooled, the heat being discharged to the atmosphere.

When the possibility of large-scale production of nuclear power in Britain was being considered at the beginning of the 1950's, it was realised that the gas-cooled reactor was the best type which, having regard to local conditions, could be developed as a power producer within a reasonable time. It was also a type using mostly conventional techniques and not too expensive materials. From 1951 to 1953, a design study of a plant to produce plutonium and electric power using natural uranium as fuel and carbon dioxide as coolant gas was undertaken at Harwell. Detailed design and construction of the plant—a 200 megawatt (heat) reactor and steam equipment to generate 37 megawatts (net) of electric power—was then entrusted to the Production Establishment at Risley. Work began on the selected site in August, 1953.

Three years later, on October 17, 1956, H.M. the Queen opened this first industrial-scale nuclear power station, at Calder Hall.

THE NUCLEAR POWER PROGRAMME

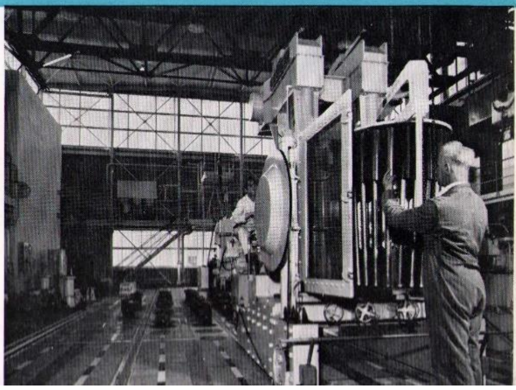
The Government decided, in 1955, to base a civilian nuclear power programme on the physics and technology of Calder Hall. A White Paper published in February that year announced that at least 12 stations would be built to give a nuclear generating capacity of 1,500 to 2,000 megawatts by 1965. In the meantime, the Atomic Energy Authority began training the design staffs of the consortia—the four groups of private companies which had banded together to build the new power stations.

The first designs showed such an advance over conditions obtaining in Calder, that a great expansion in the power programme was possible.

Since 1956, contracts have been awarded for eight natural-uranium, gas-cooled, graphite-moderated twin reactor stations. They are being constructed for the electricity generating authorities and will provide over 3,500 megawatts of installed capacity by 1967. One of these stations is in Scotland, one in Wales and the other six are in England. A further station will be constructed at Wylfa, Anglesey.

The Government has decided that new orders for nuclear stations should be placed at the rate of roughly one a year which shoud provide about 5,000 megawatts of nuclear capacity in 1968.

Calder Hall

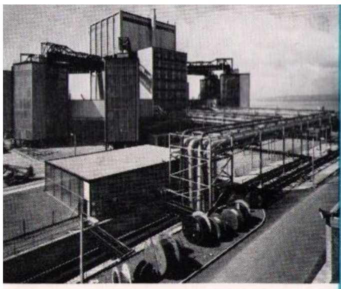


Calder Hall reactor charging floor showing fuel elements and a charge machine.

From its inception, Calder Hall was planned to give the best conditions for the production of plutonium, production of electric power taking only second place. However, its designers knew that the problem could be tackled the other way round and that electricity-producing reactors of this type could be built to supply power at reasonable prices.

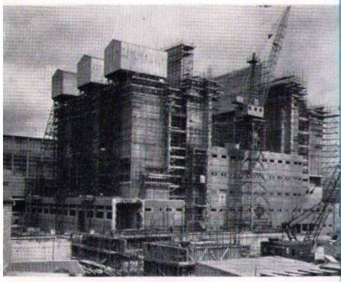
Calder consists of two stations both containing two reactors, each of which is now operating at 45 megawatts nett electrical output—an increase of 28% above the original design figure. While Calder Hall was still under construction, a second Calder-type station containing four almost identical reactors was planned for Chapelcross in Scotland.

The first of the Chapelcross reactors began producing electricity in February, 1959, the fourth began feeding electricity into the national grid in March, 1960.



Bradwell
A 300 megawatt station being built by the Nuclear Power Group for the Central Electricity Generating Board on the Essex coast. The first reactor went critical on the 19th August, 1961.

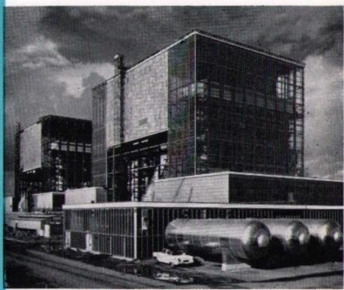
Hinkley Point
A 500 megawatt station being built by the English Electric-Babcock and Wilcox-Taylor Woodrow Atomic Power Group in Somerset on the Bristol Channel for the Central Electricity Generating Board. It is scheduled to be producing power in 1963.



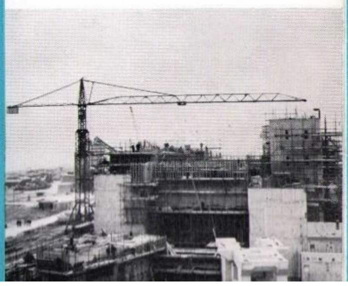
Dungeness
A 550 megawatt station being built in Kent on the south coast for the Central Electricity Generating Board. by the Nuclear Power Group. It is scheduled for completion in 1964.

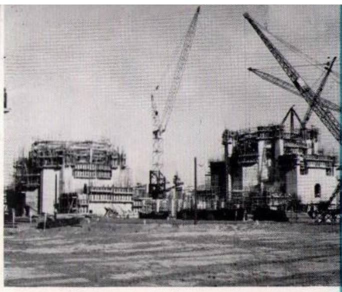
Berkeley
A 275 megawatt station being built on the River Severn for the Central Electricity Generating Board by the Nuclear Power Group. The first reactor went critical on the 27th August, 1961.

Hunterston
A 300 megawatt station for the South of Scotland Electricity Board being built in Ayrshire by the United Power Corporation. Start-up date is scheduled for 1964.



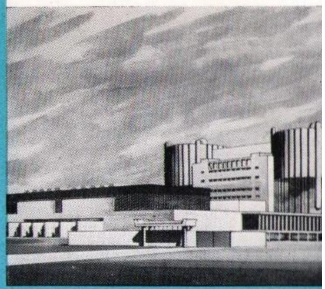
Trawsfynydd
A 500 megawatt station under construction for the Central Electricity Generating Board in North Wales. Scheduled for completion in 1964 it is being built by the United Power Corporation.





Oldbury
A 560 megawatt station being built in Gloucestershire by The Nuclear Power Group for the Central Electricity Generating Board. The first reactor is expected to go into commercial operation in 1966.

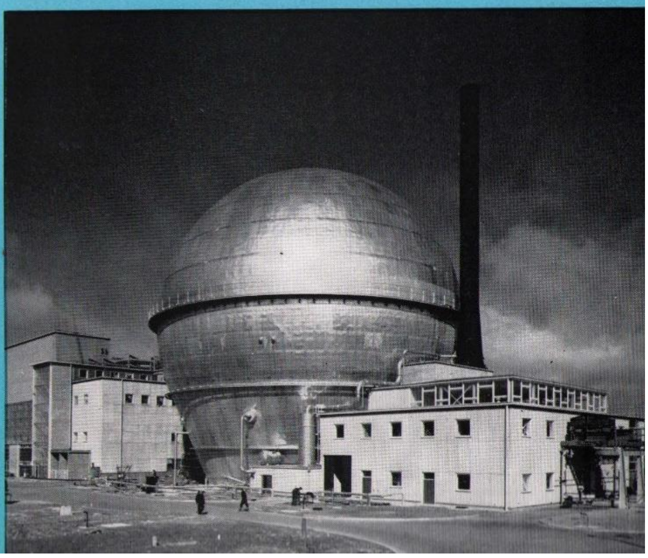
Sizewell
A 580 megawatt station under construction in Suffolk for the Central Electricity Generating Board. It is being built by the English Electric-Babcock and Wilcox-Taylor Woodrow Atomic Power Group and is to be completed in 1966.

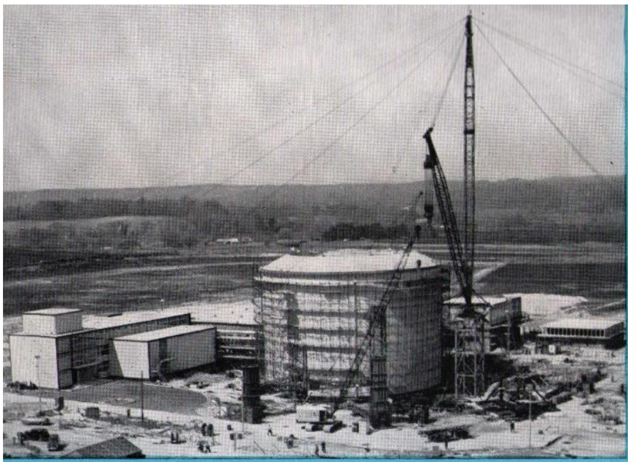


The advanced gas-cooled reactor

The next phase of development of the graphite-moderated gas-cooled reactor concept beyond the basic Calder Hall type is represented by the advanced gas-cooled reactor. An experimental version of this reactor has been constructed at Windscale and development work will follow the initial operation of the reactor. The main objective of the A.G.R. is to reduce the capital costs of the reactor installation. This is done by raising the steam temperature and thus the thermal efficiency and by increasing the heat generation rate from a given size of reactor. It is possible to reach the necessary high temperature by using uranium oxide instead of uranium metal as fuel. This also has the advantage of giving a longer life to the fuel elements which are, themselves, sub-divided into clusters of small rods. The uranium is slightly enriched. The fuel elements are canned in stainless steel; beryllium canning is also being investigated.

The advanced gas-cooled reactor nearing completion.





The DRAGON reactor under construction.

The high temperature gas-cooled reactor

The next step in the development of the Calder Hall-type reactor beyond the A.G.R. stage is to increase temperatures still further—to about 800°C. At this temperature it might be possible to operate a gas turbine, doing away with heat losses incurred in heat-exchangers.

The production of these high temperatures is the aim of the research and development now in progress, in co-operation with O.E.E.C. countries, at the A.E.E. Winfrith in an international research project known as DRAGON.

The reactor under study could use helium as a coolant and a fuel element encased in graphite, a new departure in fuel element design. The fuel itself would consist of uranium oxide enriched in uranium-235, thorium oxide (in which uranium-233—another nuclear fuel—is formed under irradiation) and graphite. This reactor system might come into service for power generation in the 1970's; the system may well be economic in small sizes.

The O.E.E.C. collaborative project aims to develop an H.T.G.C. system to the reactor experiment stage. A zero energy reactor, ZENITH, has already been built by the Authority and this reactor will initially be used by the DRAGON project to study the nuclear physics problems involved.

The DRAGON reactor experiment will generate about 20 megawatts (thermal) and construction began during 1960.

The fast reactor

In producing heat for conversion into electric power, the reactors of the C.E.G.B. and S.S.E.B., both Calder Hall and A.G.R. types, will also transform some of their uranium fuel into plutonium. This material, like uranium-235, can form a critical mass, but unlike uranium-235, it does not exist in nature.

Reactor physicists have found that the best way of using up this plutonium is to burn it in a fast reactor which has the attractive property of "breeding" at least as much fuel as it consumes. A large experimental reactor of this type is operating at Dounreay in the north of Scotland. Initially, it will use as fuel uranium with a high concentration of uranium-235 to produce the heat and radiation to breed plutonium in a "blanket" of ordinary uranium surrounding the fuel charge. Later, this plutonium will be used in the core to breed still more plutonium.

The main interest of this reactor is that eventually it may make it possible to extract much more of the potential energy in natural uranium. This is extremely high; one ton of it could produce theoretically as much heat as 3,000,000 tons of coal. (The first gas-cooled stations now being built will extract from each ton of uranium the heat content of 10,000 to 20,000 tons of coal.)

Further features are that the capital costs of the breeder reactor could be kept low and that it promises to be a very economical power producer. On the other side of the balance sheet, however, is the fact that it presents some arduous engineering problems which will require years of intensive research work to solve.

The Dounreay fast reactor.