cost which must be paid for the NP high safety and the possibility to use it for various power and process purposes, which will ensure force scarce kinds of organic fuel from the fuel-energy balance.

It should be noted that advantages of the modular-type plants manifest themselves at their quantity production and construction of multi-unit NP of high power, which will make it possible to reduce specific capital investments and to ensure the necessary competitiveness in the energy market.

Thus, one can believe that the suggested concept of ecologically pure modular HTGR facilitates to a great extent the problem of developing the reactor safe for population.

REFERENCES


STATUS OF THE FRENCH GCR PROGRAMMES

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1. PROGRAMMES

1.1 France has had no research and development programmes for high temperature gas-cooled reactors since 1979, when the decision was taken to end the studies carried out with the cooperation of the GAT on HTRs. The decision was taken for budgetary reasons, for it was no longer possible to develop three technologies at the same time. As it was decided in France to install PWRs in the short term and continue development of FBRs for the longer term, it was decided to abandon GCR technology. However, as the value of GCR technology is recognized in France, we have been continually monitoring developments in this field throughout the world. More particularly, a safety assessment is now being made in France of the modular concept now being developed in a number of countries. This activity forms part of a strategy of studying future reactors, including HTRs.

Furthermore, France still has a test loop in the SILOE research reactor (the Comédie loop), intended for studying fission product deposits. At the present time, a test programme for the DOE, of which MMES is in charge, is being prepared in collaboration with GA.

1.2 As concerns Magnox reactors, the CEA is carrying out, for EDF, operating and safety studies as well as the necessary studies for drawing up the dismantling files. In view of the progressive withdrawal of the Magnox reactors from service, the volume of this work is decreasing.

2. GAS-COOLED REACTOR FACILITIES

France has built 8 reactors on its own territory and one exported reactor at Vandellos in Spain. Only two reactors now remain in service.

2.1 Chinon A1 (70 MWe) was shut down in 1973 for financial reasons after ten years of operation. It has been transformed into a museum, representing an elegant solution to the
2.2 Reactors G2 and G3 at Marcoule (40 MWe each) were shut down in 1980 and 1984 respectively after 21 years and 24 years of operation. After extraction of the fuel from the cores, they are now under level 2 dismantling which consists, in an earlier stage, of removing the primary circuit, the secondary circuit and the steam generators. A graphite destruction study is in progress as part of total dismantling of the installation (level 3) which could be carried out after completion of the second stage.

2.3 Chinon A2 (210 MWe) was shut down in 1985 after 20 years of service, as planned, after having produced 23.6 TWh, corresponding to a load factor of 74%. The installation is in the process of being dismantled, the core has been emptied, the spent fuel storage pool has been removed and the primary circuit is being disassembled. The sections of the primary circuit, which are approximately 1 meter long, are to be transformed into containers for storage of various contaminated metal items in the steam generator building. On completion of this first stage, five monitored buildings will remain: the pressure vessel and the four steam generator buildings. This situation may be continued for at least about 50 years.

2.4 Saint-Laurent A1 (390 MWe) was finally shut down on 18th April 1990, in accordance with a decommissioning programme for the four remaining EDF gas-cooled reactors decided upon in March 1988.

This shutdown was preceded by optimization of fuel management during the last few months of operation, consisting in changing the number of fuel elements swapped axially in the channels, then discontinuing this re-arrangement and only renewing the elements at maximum flux positions, and finally discontinuing all renewal. The fuel savings were substantial.

Since entering service in 1969, SLA1 supplied the grid with 45.9 TWh.

2.5 Under the EDF decommissioning programme, the Chinon A3 reactor (360 MWe) was to continue operating until 1994.

When the safety authorities requested a major increase in the number of checks to be carried out on the primary circuit, EDF considered that the outage required for the work would make operation of the reactor uneconomical.

2.6 The two reactors remaining in service, SLA2 (480 MWe) and Bugey 1 (540 MWe) will be finally shut down in April 1992 and April 1994 respectively. For SLA2, maximum use will be made of grid demand to deplete the stock of fuel remaining, particularly after the early shutdown of Chinon A3. It will have operated for 21 years on its withdrawal from service.

Bugey 1, whose graphite reflector blocks have been the subject of special surveillance due to radiolytic corrosion problems, should nevertheless meet the 13 full equivalent power years goal in 1994. This reactor, which was commissioned in 1972, will thus have operated for 22 years when it is decommissioned.

2.7 The Franco-Spanish reactor at Vandellos (480 MWe) suffered a fire in one of the two turbine generator sets on 19th October 1989.

The cause of the fire is not known with certainty, but the most plausible sequence would appear to be the breaking of a number of blades of a turbine wheel, causing a hydrogen leak at the alternator, the explosion of which started the fire. The fire continued for a number of hours fed by a turbine lubrication oil leak caused by a pump which continued to operate.

Flooding of the auxiliaries room below the condensers, essentially due to the partial destruction by the fire of an expansion joint in a condenser feedwater pipe, resulted in the loss of a certain number of electrical pumps, some of which were involved in reactor control and last resort cooling. However, as the operating staff had a thorough knowledge of the installation, they were able to use manual control, despite the difficult conditions in the flooded facility (smoke and lack of lighting), to keep the steam generator in service to remove decay heat. This accident showed that an event in the conventional section may have unforeseen effects on reactor safety. Important operating feedback was thus obtained both for French Magnox and PWR facilities.

This reactor was therefore finally shut down on 15th June 1990, after optimizing core management in the last months of operation, having supplied the grid with 30.2 TWh since its commissioning in 1967.

Repair of the metal structures, carried out under ISIS project using robot technology, was found to be successful. Indeed, this operation proved the feasibility of carrying out work by robot in an environment of complex geometry with high precision in awkward positions, offering a fully satisfactory solution for repair work.
The scale of the damage and the political dimension of the event in Spain caused the operator to abandon the idea of repairing the installations. This decision was taken in March 1990. In 17 years of operation, the reactor had supplied 53.5 TWh, corresponding to a load factor of 73%.

3. CONCLUSIONS

In four years' time, we will thus be closing a chapter rich in 179 reactor-years of experience, that of gas-cooled graphite moderated reactors. This episode in the development of nuclear power in France will have lasted 42 years between the decision to adopt the technology in 1952 and the shutdown of Bugey 1 in 1994 if, as is desirable, nothing disturbs the planned schedule. The final balance sheet for GCRs will soon be ready, and is expected to show an overall profit, even though certain financial considerations, at times extremely flimsy, have resulted in the shutdown of some of the reactors, handicapped by their heavier operating costs than PWRs with higher power ratings.

GAS COOLED REACTOR ACTIVITIES IN THE COMMISSION OF THE EUROPEAN COMMUNITIES

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Since the last meeting of the IWGGCR the situation has not changed as far as the CEC activities on gas cooled reactors are concerned.

The Commission has no R+D programme in this field but is following and keeping herself informed regarding the developments of this line of reactors. However like it has been mentioned at the last meeting the studies on the market potential of HTRs as heat and power source in the EEC Countries have continued. A Spanish study is now available, while AEA Technology is doing the same exercise for the UK. It is expected that this latter study will be completed by the end of the year. The AEA study will be the last on the subject. All the studies on this subject which have been carried in FRG, France, Italy, Spain and the UK will be assembled into a single report which should be available by the end of 1991.

Regarding other activities of the CEC in the nuclear field the Commission has put forward a proposal to the EEC Council on a specific research and technological development programme in the field of nuclear fission safety for the period 1990-1994.

This proposal includes a continuation of Radiation Protection research, with emphasis on low dose radiation effects on human body and risk and management of radiation exposure, as well as a new action on reactor safety research.