PROGRESS WITH NUCLEAR POWER

SOME NATIONAL DEVELOPMENTS MENTIONED AT THE GENERAL CONFERENCE OF IAEA

A number of encouraging developments in the national programmes of Member States were mentioned in the course of the Agency's General Conference in September. "The development in the power reactor field", the Director General, Dr. Sigvard Eklund, told the opening session, "is best demonstrated by the fact that since September 1962 eleven power reactors with a nominal power of 650 MW(e) have become critical. At present, 50 power reactors with a total nominal output of 2800 MW(e) are in operation in ten Member States. In addition, 35 more nuclear plants with an aggregate capacity of 6900 MW(e) are under construction, and should bring the nuclear capacity to the 10 000 MW mark by the end of 1968."

The Deputy Director General for Technical Operations, Mr. P. Balligand, said that the Conference on Operating Experience with Power Reactors, held in June 1963, had reviewed the information yielded by the twenty or so nuclear power stations already in operation, and had drawn extremely encouraging conclusions. The nuclear installations had given no trouble and the utilization factor had been extremely high - in most cases above 90 per cent. The reactors had proved safe and it had been possible to increase the rated capacity of a good number without major changes in the installations; it had also been possible to reduce considerably their cost per kW installed. The experts had expressed the view that existing types of reactor could operate economically alongside the first series of breeder generators for a considerable time.

The future prospects of nuclear power plants were being viewed with increasing optimism. Rapid progress was being made in respect of fuel cycles, and the earlier estimates of the cost of producing nuclear power might be reduced in the current year by 10 per cent. The cost of fuel cycles was determined by a large number of variable factors, such as the price of uranium oxide, the fuel burn-up achieved, the cost of fabrication, processing, and the credit for plutonium; in estimating the total cost all these factors must be borne in mind. While the cost of uranium oxide, for example, might continue to be $6 per lb for a few years, it might be higher when the number of power plants under construction increased. Any increase in the price of uranium oxide might be offset by reactor improvements - for example, by changing the burn-up. Similarly, a reduction in the plutonium credit would probably result in greater efforts being made to develop breeder reactors using plutonium as fuel. Intermediate solutions between natural-uranium and enriched-uranium reactors, and between breeder and non-breeder reactors, were also being studied, as were the long-term market prospects for the various nuclear fuels, depending on the various possible fuel cycles that might be employed.

In the course of the discussions, delegates mentioned the following points, in respect of their national programmes (these, of course, are in no sense a complete survey).

United States

The United States Atomic Energy Commission, in a report to President Kennedy, predicted that economic nuclear power was so near at hand that a modest additional incentive from the Government would suffice to permit its use by United States utilities to an appreciable extent in the near future. If there were additional support for the power demonstration programme, and added emphasis in the programme on advanced converter and breeder reactors, the continuation of the US AEC's present work would enable nuclear power to compete with conventional power throughout most of the country during the 1970's, and would make breeder reactors economic by the 1980's. Thus it was estimated that, by the end of the century, nuclear power would meet most of the additional electric capacity requirements and provide about half the energy generated.

Incidentally, the United States was a low-cost power area. The report further noted that six sizeable reactors of the more highly developed type were operating on utility grids; seven small and medium-sized reactors would be completed by the end of 1967 and a few others were under construction or about to be constructed. The report suggested that seven or eight prototype power reactors - approximately half of which would be advanced converter reactors and the rest breeder reactors - might be constructed and commissioned during the next twelve years. The public utilities industry might build ten to twelve full-scale power plants. Programmes for developing more advanced reactor types - especially breeder reactors - were also suggested. The programme outlined would facilitate technological development in co-operation with other countries in the case of reactor types designed to meet power requirements throughout the world. Eleven prototype power reactors were operating in the United States, with an aggregate net electric capacity of almost 1000 MW, and the construction of eleven more with a net electric capacity of about 2800 MW had started or been decided. Plans for two more reactors with a capacity of about 1000 MW had been announced and tenders were being sought.

Thus, by the end of 1968, 4800 MW of nuclear capacity would be in operation.

Belgium

The Vulcain project was now receiving priority under the Belgian nuclear programme. It was a 20 MW spectral-shift reactor which could be used for ship propulsion or in power stations. Its economic future was very bright; it might become competitive even with smaller conventional plants, as the kWh would cost between 6 and 7 mills if the reactor went into large-scale production.

Italy

Two nuclear power stations had been put into operation during the year. The SIMEA station at Latina had become critical in December 1962. It was equipped with a graphite-moderated natural uranium reactor cooled by carbon dioxide; six heat exchangers produced the steam to feed three 70 MW turbo-alternators, which would supply the grid with 200 MW(e) at 150 and 220 kV. Approximately half of the installations had been provided by Italian industry, which had thereby acquired valuable experience. That power station had started to supply the grid with power on 30 May 1963. The Senn electro-nuclear power station situated at the mouth of the Garigliano river, near Naples, was equipped with a 150 MW(e) boiling-water reactor with enriched uranium dioxide; it had become critical on 5 June 1963.

Netherlands

In the Netherlands the study of the aqueous suspension reactor would be continued. In the meantime, many countries wished to obtain experience of nuclear power production, and the Netherlands fully endorsed the Agency's view that the introduction of nuclear power reactors was becoming a matter of suitable timing. Such considerations had led to the start of construction of a small 50 MW(e) power reactor in the Netherlands as a pilot plant that could be used for experimental purposes and training.

Union of Soviet Socialist Republics

Successes achieved in the practical applications of atomic energy included the operational experience obtained from the atomic-powered ice-breaker "Lenin", which had already completed three voyages and, over a three-year period, had sailed 50 000 miles, mostly under difficult ice conditions. Its reactors had operated for three years in succession (1960-61-62) without a reloading of atomic fuel. Nevertheless, it had been decided to reload the reactors before the start of the fourth voyage. During the voyages all the equipment and machinery had operated very satisfactorily. Another reason which made the present year a noteworthy one for the Soviet Union was that it marked the completion of the final preparations for the entry into operation of two large atomic power stations, one with a capacity of 210 MW and the other of 100 MW. Once they were working at these capacities, the two stations would be considerably enlarged. In addition, a number of new atomic power stations were under construction. Still another important power project in the Soviet Union was worthy of mention - namely a small atomic power plant with a total capacity of 7 - 7.5 MW. This was noteworthy because it was constructed in separate units and could easily be moved by any type of transport - railway, ship, road vehicle or aircraft. The station had already been built and tested and the operation of all its parts had proved to be satisfactory and reliable. The Soviet Union would be building that type of station in remote areas where power requirements were small. Such stations might be of interest to many countries.

Pakistan

Studies on the economic feasibility of nuclear power had shown that by 1968 power gaps in Karachi (West Pakistan) and Ruoppur (East Pakistan) would justify the establishment of a 132 MW nuclear power plant for the former and a 70 MW plant for the latter, provided that financial loans could be secured at an interest rate below 4 per cent. Nearly all Pakistan's conventional power projects had been financed through such low-interest loans from friendly countries.

France

After the Marcoule reactors, the first nuclear power station of Electricité de France had started delivering power to the network. The next two power stations were under construction and a fourth had been decided on; it, too, would have a natural uranium, graphite-moderated reactor, cooled by pressurized gas. At the same time a similar type of reactor, using heavy water as moderator, was being developed. The first prototype fast neutron reactor was under construction at Cadarache as a joint project with Euratom. France was also participating in joint undertakings concerned with the design and construction of other types of reactors.

India

Indian experience made clear that even in the under-developed countries nuclear power could be economically generated. This was shown by the estimated cost of building two nuclear power stations in India, and the cost of the electricity generated, which under certain conditions could be 10 to 15 per cent lower than that of electricity from a conventional power station. A third nuclear power station was now planned and a special committee had been set up to draft a 15-year programme for power development in India. It seemed probable that it would be necessary to start building a new nuclear power station every year from 1966 onwards. The atomic power station at Tarapur was being built by a United States firm, and the two countries had entered into a bilateral agreement which covered provision of enriched uranium fuel for the entire life of the reactor.

Spain

Spain was undertaking a series of nuclear power projects. It hoped soon to carry out three projects which were at present in preparation involving three 300 MW power stations, to be operated by the private companies Hidroeléctric Española, Empresa Sevillana de Electricidad, and Empresa Iberduero, all of which were interested in the production of nuclear power.

United Kingdom

Among outstanding developments during the past year, the Berkeley and Bradwell nuclear power stations had been officially opened in April 1963, after having been in operation for some months by then, and running smoothly and reliably from the start. The average availability of the four reactors, in terms of running hours as a percentage of possible running hours, had been over 90 per cent between the beginning of December and the end of March. The first reactor at the Hunterston station had gone critical on 14 September 1963. When the last station under the present programme, Wylfa, was completed in 1969, the United Kingdom would have a nuclear capacity of nearly 5000 MW. The Government was now considering the size of the nuclear power programme for the years following 1968. The stations in the existing programme were of the well-established Magnox type. Very good progress had been made in the past twelve months in the development of new reactor systems. The prototype Advanced Gas-cooled Reactor at Windscale had been operating at its full designed power of 28 MW(e) since February 1963. Even on conservative assumptions, large-scale power stations based on that type of reactor should be competitive under United Kingdom conditions with the most efficient of alternative conventional power stations, and furthermore, the system had substantial development potential. If the A. G. R. reactor continued to go well, and subject to Government decisions regarding the future programme, tenders would be invited in the near future for the construction of the first commercial A. G. R.

Looking further ahead, the experimental fast reactor at Dounreay had reached its full capacity of 60 MW(t) in July 1963, and now provided an irradiation facility for fast reactor fuel which was at present unique. Construction of a prototype steam-generating heavy water reactor of 100 MW(e) had begun in May 1963 at Winfrith Heath. The Dragon project of the European Nuclear Energy Agency, involving the construction of a high-temperature gas-cooled reactor, had been extended for three years to March 1967; the reactor was expected to go into operation during the summer of 1964. The Government was consulting the shipping and shipbuilding industries about the possibility of building the first British nuclear merchant ship. As regards the marine propulsion reactor, the United Kingdom had concentrated during the year on the Vulcain system (being developed in collaboration with Belgium) and on an integral boiling reactor; other possibilities were being kept in mind.

Sweden

The complicated technical problems involved in the integration of nuclear power into existing power systems had been extensively studied. The combination of hydro and nuclear power had great economic advantages, and most of the new demand for power in the seventies was expected to be met by the installation of some 4000 MW of nuclear power. The Ågesta-R 3 power station had gone critical on 17 July 1963; it provided electric power and hot water for district heating, but Swedish studies showed that nuclear power was not yet competitive with conventional fuels for district heating. The extensive development work on smaller reactors now taking place might change the picture, but generation of cheap electricity by very large power reactors might on the other hand make electric domestic heating a more attractive proposal. Sweden's first large power reactor, the Marviken boiling heavy water reactor, with a maximum capacity of 200 MW, was now under construction. Very large reactors with an electrical capacity of about 1000 MW were being studied in Sweden to explore the potentialities of the heavy water type.

Canada

Very satisfactory results had been achieved with the first small nuclear power plant, with a capacity of 20 000 kW, which had just completed its first year of operation and had been available for 78 per cent of the period. There had been some minor problems such as a small heavy water loss. The major difficulty, however, had occurred with a stand-by Diesel generator, which had been out of operation for 50 per cent of the period. The use of the dousing system as a safety mechanism was very successful. The CANDU 200 MW reactor would be completed in 1964 and the actual cost would be a little lower than had been estimated. It was intended to construct a 2000 MW plant consisting of four 500 MW reactors of the CANDU type. The construction of a heavy water plant would start shortly and the heavy water produced would be available for export and domestic use at a cost of about $20 per pound. The Canadian programme, which was not so broad as the programmes of the United Kingdom and the United States, intended to concentrate on one type of plant, using heavy water as the moderator. A demonstration plant using organic coolants would be operating in 1965. Other coolants such as light water in the form of steam - which would offer considerable advantages - were also being carefully studied for use in heavy water pressure-tube reactors.

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INTERNATIONAL SEMINAR FOR RESEARCH AND EDUCATION IN PHYSICS

A one-year course will be held at the Institute of Physics, Uppsala. It is being sponsored by the Swedish Agency for International Assistance, the International Atomic Energy Agency and the United Nations Educational, Scientific and Cultural Organization. The course will start on 1 September 1964 and finish about 1 July 1965.

A. The aim of the International Seminar is:

1. To provide possibilities for individual participation in qualified experimental research work in one of various fields of physics (e.g. solid state physics, nuclear physics, atomic physics, etc.) under the guidance of experienced scientists. An introductory course in the operation of, and the coding for, a modern computer, IBM 1620, will be given.
2. To inform the participants of the organization of research projects, physics laboratories and teaching of graduate and undergraduate students.
3. To demonstrate to the participants how Sweden and some other European countries have organized schools, universities, other scientific institutions and industrial laboratories.

B. The Seminar will be open to non-European students and scientists, mainly from developing countries, who are interested in the above-mentioned combination of subjects and who are connected with the teaching and/or research of a university or national laboratory. Applicants should not be less than 20 years and not more than 40 years old. Applicants without earlier research experience outside their home countries are preferred.

C. The official language of the Seminar will be English.

D. The course is given yearly.

E. After satisfactory completion of the course a special diploma will be issued to each participant.

F. All applicants accepted for the Seminar will be given fellowships, covering the total cost of participation, i.e. travel expenses by air, tourist class, round trip from home country and a monthly stipend of Sw.Cr.700.- (about US $135.-) during ten months plus a book allowance.

G. Application forms for attending the 1964-65 course as well as further information can be obtained upon request from

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The complete application should arrive at the Seminar office not later than 15 April 1964.

H. The applicants will be informed before 1 June 1964 if they have been accepted to participate in the 1964-65 course.
