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ADVANCES IN THE APPLICATION OF NUCLEAR ENERGY FOR PEACEFUL PURPOSES

Information transmitted by the Federal Republic of Germany

Note by the Director General

On 4 September the Director General received from the Federal Republic of Germany material on the advances made in the year 1973-74 in applying nuclear energy for peaceful purposes. The material in question is reproduced below for the information of the General Conference.

INTRODUCTION

1. In the Federal Republic of Germany, the application of nuclear power for the future energy supply is guided by the "Energy Programme" outlining the Federal Government's overall policy in this field. This programme, published in September 1973, assigned a leading role to nuclear energy. With the exception of a certain fraction to be met by coal-fired stations, nuclear energy is to carry the main burden of electricity generation in the future. Whereas today nuclear power stations with a total capacity of approximately 2500 MW(e) are operating in the Federal Republic of Germany, the installed nuclear capacity will reach 20 000 MW(e) in 1980 and 40 000 to 50 000 MW(e) in 1985, thus meeting approximately 40 to 45% of the overall electricity demand according to the above programme. These nuclear power stations will use ligh-water reactors (LWR) almost exclusively.

2. Research and technological development in the nuclear field proceed along the lines set out in the Fourth Nuclear Programme (1973-1976) of the Federal Republic of Germany. Priority is given to the development of advanced reactor systems (high temperature helium-cooled reactors and sodium-cooled fast breeder reactors) and to the development of the entire nuclear fuel cycle.

3. With the end of the Third Nuclear Programme in 1972, a total of more than DM 11 000 million from public funds has been spent on research and development with regard to the peaceful utilization of nuclear energy. In 1972, public funds allocated to nuclear research and development by the Federal and State Governments (85% and 15% of the total, respectively) amounted to more than DM 1500 million. About 40% of the total budget is allocated to the nuclear research centres, while another 10% is spent on scientific co-operation within international organizations.

4. The Fourth Nuclear Programme envisages a total expenditure of DM 6100 million from public funds during the years 1973-1976. About two-thirds of this budget are allocated to the development of nuclear energy, including advanced reactors, the nuclear fuel cycle, reactor safety as well as radiation protection, and controlled thermonuclear fusion. The remaining third of the budget will be spent on high-energy physics, nuclear physics, solid state physics and related disciplines.

5. At present, about 36 000 persons, 15% of whom are university graduates, are working in the nuclear field in the Federal Republic of Germany. Of these 25 000 are employed by nuclear industry and 11 000 are working in research establishments.

NUCLEAR POWER PLANTS

6. At present, some ten nuclear power stations are operating in the Federal Republic of Germany, generating about 2300 MW(e). This number includes the first two commercial power plants at Würgassen and Stade. Another ten nuclear power stations are under construction, including the first 1150 MW(e) power station at Biblis which has already become critical and is to start operating soon. Also included in this number are the two prototype power plants with a high temperature reactor (THTR 300) and a sodium-cooled fast breeder reactor (SNR 300), respectively. In order to reach the proposed nuclear capacity of 20 000 MW(e) in 1980 and 40 000 to 50 000 MW(e) in 1985, construction of some five large nuclear power stations has to start each year.

7. Although the Federal Government lays great emphasis on the promotion of the advanced reactor systems, the nuclear capacity mentioned above will have to rely almost exclusively on light water reactor technology. With Babcock-Brown-Boveri-Reaktorbau (BBR) and Kraftwerk-Union (KWU) an efficient nuclear power plant industry has been established in the Federal Republic of Germany. The total capacity of these two companies makes it possible to start construction of about 12 to 14 turnkey plants of identical design (eight to ten plants of 1300 MW(e) category and three to four smaller plants) each year. Hence about half of the constructing capacity is available for export orders.

8. Up to now, the reactor industry (KWU) has received export orders for four nuclear power stations (Atucha, Argentina; Borssele, Netherlands; Tullnerfeld, Austria; and Gösgen, Switzerland).

REACTOR SAFETY

9. At the end of 1972, responsibilities within the Federal Government with respect to nuclear energy were reallocated. In order to secure and to demonstrate greater independence, the responsibilities for research and development on the one side and for licensing, safety and radiation protection on the other, have been assigned separately to the Ministry for Research and Technology and the Ministry of the Interior, respectively.

10. With regard to the proposed large-scale use of LWR power plants, work on reactor safety research and development is concentrating on this technology almost exclusively, while safety questions concerning advanced reactor lines are still treated as part of the overall development projects. The most important projects under the reactor safety programme are:

(a) The design of emergency core-cooling systems;

(b) Research on core melt-down phenomena and core catcher;

(c) Development of engineering safeguards against pressure vessel rupture; and

(d) Study of the effectiveness of containment, including experiments using prototype plants which are to be closed down in the near future, e.g. the Grosswelzheim power plant.

Additional work is carried out in radiation prctection and the environmental effects of energy conversion.

11. While the need for nuclear energy is more obvious than ever before, there is growing public concern about the utilization of nuclear energy in the Federal Republic of Germany. Therefore, authorities and industry assign great importance to all initiatives toward increasing public understanding of the need for nuclear energy.

NUCLEAR SHIP PROPULSION

12. Since it was launched in October 1968, the prototype merchant vessel "Otto Hahn" has completed approximately 75 voyages covering more than 250 000 nautical miles. Encouraged by her excellent performance, the continuation and extension of the nuclear ship propulsion programme is proposed in the Fourth Nuclear Programme. Using a second advanced core, the "Otto Hahn" presently operating as an ore freighter, provides further experience for the development of larger pressurized water ship reactors for ship propulsion.

13. As a further step along the path towards the commercial application of nuclear ship propulsion, complete specifications are being worked out for the design and construction of a large nuclear container vessel with a capacity of 80 000 shaft horse power. As a consequence of the rise in oil prices, increasing importance is attributed to the application of nuclear power for ship propulsion.

REACTOR DEVELOPMENT

High temperature reactors

14. The development of the high temperature reactor system is one of the most important projects in the nuclear energy programme of the Federal Republic of Germany. The use of high temperature reactors in nuclear power stations is considered a substantial advantage as far as ecological and economic aspects are concerned, since the high temperature reactor promises to become an economic heat source for industrial processes.

15. A prototype high temperature reactor power plant (THTR 300) of 280 MW(e) is under construction at Schmehausen in the Ruhr district. This type of reactor is based on development work carried out at the Jülich Research Centre (KFA) and applies the pebble-bed principle. It is being constructed by Hochtemperatur-Reaktorbau GmbH (HRB), a subsidiary of BBC and General Atomic.

16. At present, utilities are considering ordering a high temperature reactor power plant of about 1100 MW(e) within the next few years. This power station, as offered by HRB, will employ prisma-type fuel elements. The increased interest in the further application of high temperature reactors is demonstrated by the establishment of an additional company, the Gesellschaft für Hochtemperatur-Reaktortechnik (GHT), as a subsidiary of KWU.

17. For the development of single circuit HTR power plants using helium turbines in direct loops, a so-called HHT project is being carried out jointly by BBC, HRB, the KFA, the Swiss Eidgenössisches Institut für Reaktorforschung, the Nukem company and the utility of the city of Oberhausen.

18. Another project is aimed at the development of further applications of high temperature reactors in industrial processes. In particular, the conversion of fossil fuels into gaseous energy carriers promises to be a technique suitable for industrial processes and for transportation systems which have to rely on direct consumption of thermal energy. There are also strong arguments in favour of using nuclear process heat in steel production. The project is carried out by the KFA in co-operation with the nuclear industry.

Fast breeder reactors

19. The focal point of the fast breeder reactor programme is the construction of a 300 MW(e) prototype sodium-cooled FBR (SNR 300). The project is jointly financed by Belgium, the Netherlands and the Federal Republic of Germany - with a ratio of 15:15:70. The SNR 300 is the largest project under the Fourth Nuclear Programme. The total costs will be approximately DM 1700 million, not including additional developments in nuclear research centres. The power station will be built by the Internationale Natrium-Brutreaktor-Baugesellschaft mbH which has been founded by Belgonucléaire, Interatom and Neratoom. The owner and operator will be the Schnell-Brüter-Kernkraftwerks-gesellschaft mbH, the shares of which are held by three national utilities (RWE, SEP and Synatom). Construction at Kalkar on the Lower Rhine started in spring 1973.

20. Further development of the liquid-metal fast breeder reactor concept, such as the design of a 1000 to 2000 MW(e) FBR power plant, will rely on the experience gained by constructing and operating the SNR 300. It will be based on extended European co-operation, especially with France, Italy and the United Kingdom. At present, the utilities of these countries are planning to order two fast breeder reactors of 1200 MW(e) each. Alternative solutions for the fast breeder are being sought in close co-operation between industry and the research centres concerning other coolant systems such as steam and gas, but only on a very moderate scale.

FUEL CYCLE

21. The large-scale use of nuclear power in the Federal Republic of Germany calls for the development of all phases of the nuclear fuel cycle in accordance with economic and ecological requirements. In this respect, the "second part" of the fuel cycle (re-processing of irradiated fuel and waste management) is gaining an importance comparable to the supply of nuclear fuel.

Natural uranium supply

22. In order to secure a sufficient supply of natural uranium at low and stable prices for the near future, two industrial companies in the Federal Republic of Germany pursue activities in the field of uranium prospection and exploration in various parts of the world with governmental support.

Uranium enrichment

23. The largest project under the fuel cycle programme is the development of the gas ultra-centrifuge process for uranium enrichment. This programme is carried out jointly by the United Kingdom, the Netherlands and the Federal Republic of Germany, according to the Treaty of Almelo. The international firms CENTEC and URENCO are responsible for the further development of the technology and for the construction and operation of future plants. Two prototype plants are under construction at Almelo and Capenhurst. The first cascades have started operation.

24. According to the plans of URENCO, the capacity will be increased to 2000 tUSW/a in 1980 and to 10 000 tUSW/a in 1985 in order to be able to cover a major part of the demand in Europe. Recently, the Federal Government has decided to secure, in co-operation with industry the financing of the proposed capacity until 1982. With this decision, the centrifuge technique has now entered the stage of industrial application.

25. On a relatively small basis, research on the separation nozzle technique is being carried out by the GfK at Karlsruhe in co-operation with Steag.

Reprocessing

26. The interests of the major European partners (BNFL, United Kingdom; CEA, France; and KEWA, Federal Republic of Germany) are concentrated in a single company, United Reprocessors (URG) GmbH. URG will make use of the existing plants as long as their capacities are sufficient to serve the market. Within URG, KEWA has the option to build the next large plant, which will then become part of the pool. This plant, with an annual capacity of 1500 t of spent UO_2 fuel, is expected to be operating in 1984. Research and development activities in the Federal Republic of Germany are concentrated on the improvement of existing technologies, making use of the prototype plant WAK at Karlsruhe.

Radioactive waste management

27. Finding a solution to the problems involved in the safe storage of radioactive waste produced by nuclear reactors is one of the prerequisites of the large-scale utilization of nuclear energy. In the Federal Republic of Germany, the nuclear research centres GSF, GfK and KFA are working on the most promising solution to the problem. Special attention is given to processes for the treatment of highly radioactive waste. Prototype plants for the calcination and vitrification of highly active waste solutions are under construction at Karlsruhe. In addition, intensive research is under way to study the ultimate storage of this material, especially in salt mines. The salt mine Asse II already serves as an experimental facility for the storage of wastes of low and intermediate activity. Experimental storage of highly active waste is scheduled for 1977. The experience gained so far is highly promising.

Plutonium handling and recycling

28. As large amounts of plutonium will be produced in the future, research and development are conducted in order to ensure safe handling of this material and to allow a higher amount of plutonium to be used as fuel in light water reactors.

Flow control of fissile material

29. For the flow control of fissile material in all sections of the fuel cycle, effective and practicable systems are being further developed and tested in order to meet the requirements of the international safeguards systems. This work is focused in a special project at the GfK.

CONTROLLED THERMONUCLEAR FUSION

30. With the growing size of the experimental devices required for attempts to achieve fusion conditions, plasma physics research is concentrated in the Institut für Plasmaphysik at Munich and KFA Jülich. Although most plasma research still belongs to fundamental science, work will also commence on technological problems of the fusion reactor. As a basis for these investigations, a memorandum has been worked out jointly by several German plasma physics research institutions.

31. A large part of plasma physics research is performed in the relevant EURATOM association. At present, a Joint European Tokamak Experiment is under consideration.

NUCLEAR RESEARCH ESTABLISHMENTS

32. At present, about 11 000 persons are employed in the seven nuclear research establishments in the Federal Republic of Germany. This number has remained almost constant during the past few years.

33. With the main burden of the further development of nuclear technology shifting to industry, the fields of activity of the research centres are varying and widening. Efforts designed to maintain their scientific capacity and to diversify the activities carried out have yielded the first results.

34. The GfK at Karlsruhe, which was formerly engaged mainly in the development of the fast breeder, is now focusing on the problems of reprocessing techniques and radioactive waste management, as well as safeguarding and the physical protection of fissile material.

35. The KFA at Jülich has used its links with coal technology, developed during the work on the high-temperature reactor, to further engage in research and development work on fossil sources of energy, ranging from coal gasification to oil exploration techniques.

36. The Gesellschaft für Kernenergieverwertung in Schiffbau und Schiffahrt at Geesthacht, while concentrating on nuclear ship propulsion, also works on different marine technologies.

37. In the other research establishments, this process of diversification, however, has not yet started, either because of the fact that possible applications are far ahead e.g. in plasma physics, or because they are working in the field of pure research.

PURE RESEARCH

38. As already indicated, a considerable amount of the budget for nuclear research and development is still being spent on pure research. This scientific work is mainly conducted in connection with large experimental facilities which are, in general, owned and operated by the nuclear research establishments.

39. At present, there are no plans for the construction of new facilities, such as accelerators. By means of the reorganization of scientific co-operation, the Federal Government has ensured that best use be made of the existing facilities for all sectors of scientific work.

High-energy physics

40. At the German Electron Synchrotron DESY at Hamburg, construction on the electron-positron storage rings "DORIS" has been completed. This facility allows collision between electrons and positrons of 3 GeV each. Other high energy electron accelerators are operating at the universities of Bonn (2.3 GeV) and Mainz (500 MeV).

41. A number of high-energy physics research teams is making use of the facilities of CERN in order to prepare experiments at the large CERN II accelerator.

Heavy ion and nuclear physics

42. Construction of the UNILAC heavy ion accelerator of the Gesellschaft für Schwerionenforschung at Darmstadt is progressing satisfactorily. The machine is expected to start operation at the beginning of 1975.

43. At the Hahn-Meitner-Institut in Berlin, construction of a heavy ion accelerating cyclotron, of medium size, combined with an existing Van de Graaff accelerator, is under way.

Solid state physics

44. The two large laboratories devoted to solid state physics at Jülich and Stuttgart are operating at their full capacity.

INTERNATIONAL CO-OPERATION

45. As already pointed out in the preceding paragraphs, an important part of the nuclear activities is pursued in close international co-operation. This holds true in particular for the large projects, e.g. the fast breeder prototype, the centrifuge enrichment technology and high-energy physics research.

46. The current energy problems have led to fresh initiatives to intensify international co-operation in existing programmes and also to extend this co-operation to new national programmes on energy research and development. The Federal Republic of Germany is participating actively in these efforts.