GC

International Atomic Energy Agency

General Conference

GC(XIII)/INF/113/Add.1
11 September 1969
GENERAL Distr.
Original: ENGLISH and FRENCH

Thirteenth regular session

PROGRESS IN PEACEFUL APPLICATIONS OF NUCLEAR ENERGY DURING THE YEAR 1968/1969

Statements by Member States received between 26 and 31 August 1969

GERMANY, FEDERAL REPUBLIC OF

Advances in nuclear energy: 1968/69

INTRODUCTION

1. The first two years of the Third German Nuclear Programme (1968-1972) has brought progress in all activities connected with the peaceful use of nuclear energy and especially the rapid development of a competitive nuclear industry.

2. From its very beginning the nuclear programme in the Federal Republic has been characterized by close and efficient co-operation between Government, universities, national research centres and industry. Meanwhile industry has taken over major responsibilities in the field of nuclear applications and today nuclear energy can be regarded as an integral part of the German economy.

PUBLIC FUNDS FOR NUCLEAR RESEARCH AND DEVELOPMENT

3. Nevertheless nuclear research and development still require public support in order to ensure the continuity of recent progress. Consequently the Federal and State Governments allocated to their nuclear research and development programmes DM 965 million in 1968 and about DM 1100 million in 1969 - a 14% increase for this year. The ratio of the Federal to State contributions to the nuclear research and development budget is about 4 to 1.

4. Financial contributions to such international organizations as the Agency, the European Atomic Energy Commission (EURATOM), the European Organization for Nuclear Research (CERN), the European Nuclear Energy Agency (ENEA) and EUROCHEMIC, as well as the Franco-German Max von Laue-Paul Langevin Institute, amount to about 20% of the national expenditure on nuclear research and development.

5. There are about 23 000 employees engaged in nuclear research and industry.

NUCLEAR RESEARCH AND DEVELOPMENT AT THE NATIONAL RESEARCH CENTRES AND UNIVERSITIES

6. The two largest nuclear research centres in the Federal Republic, the Karlsruhe Nuclear Research Centre and the Jülich Nuclear Research Establishment, which are equipped for broad activities in nuclear research and development, are attaining their final stage of extension with about 3300 employees each.

7. The Plasma Physics Institute (Institut für Plasmaphysik) at München comprises about 1000 employees, the German Electron-Synchrotron (Deutsches Elektronen-Synchrotron) (DESY) at Hamburg 900, the Radiation Research Corporation (Gesellschaft für Strahlenforschung) at München-Neuherberg 600 and the Hahn-Meitner Institute at Berlin and the Corporation for Use of Nuclear Energy in Shipbuilding and Shipping (Gesellschaft für Kernenergieverwertung in Schiffbau und Schiffahrt) at Hamburg about 400.

8. Plans are under discussion for a diversification of the nuclear research centres' activities to include non-nuclear fields of interest such as information science, data processing and systems analysis, biophysics and biochemistry, ecology and health protection, materials research and low-temperature physics and technology. The work of the Radiation Research Corporation, for example, will be extended considerably for this purpose. Recently a decision was made to found a Central Institution for Solid State Physics; two institutes are being set up, one at Jülich and one at Stuttgart. The Jülich institute will mainly be concerned with the investigation of metal properties and the

dynamics of solids, and generally will be concerned with the application of nuclear methods to solid state physics. The Stuttgart institute will focus its interest on the investigation of semiconductors and insulators.

9. For basic nuclear research in the medium- and high-energy range a new type of isochron cyclotron for producing deuterons with energies between 45 and 90 MeV, designed and constructed by a German company, has been in operation at the Jülich Nuclear Research Establishment since 1968. An identical accelerator will be installed at Bonn University before the end of this year.

10. Another accelerator of the same type but giving somewhat lower particle energies has recently started operation at Hamburg University. Altogether there are now 44 particle accelerators of different types giving energies above 10 MeV in operation in the Federal Republic, 19 of them for basic research in the physical sciences and 25 for biological research and medical applications.

11. Construction work on a new research establishment with a heavy ion accelerator of 7 MeV per nucleon has been started on a site near Darmstadt. This accelerator will be the first of its kind in the world and is expected to open up a new field of nuclear research. The high versatility of this instrument will facilitate new approaches to problems of nuclear structure, chemistry and solid state physics.

12. In 1969 the installation of a new injection linear accelerator for the 6.5-GeV electron synchrotron DESY will be completed. Construction of the 3-GeV electron positron storage rings for DESY is under way.

13. For the various purposes of low-energy nuclear research a total of 20 research reactors and critical assemblies and 10 training reactors of the Siemens-type SUR are available.

POWER REACTOR DEVELOPMENT

14. During the period of time covered by this progress report developments in the conventional light water reactor (LWR) and heavy water reactor (HWR) fields have shifted entirely into the industrial sphere. The final breakthrough to commercialization and competitiveness of these reactor lines in the Federal Republic, marking the completion of the preceding nuclear energy programmes, may be illustrated by two facts:

(a) Mergers have given rise to a notable increase in the technological and organizational efficiency of German nuclear industry; and

(b) Based on the growing experience gained with domestic nuclear power plants, export orders have been placed with German nuclear industry.

15. In 1969 Siemens and AEG-Telefunken combined their respective nuclear departments to form the Power Plant Combine (Kraftwerk Union A.G.), which now offers complete LWR power stations of the boiling or pressurized water type, as well as all nuclear and conventional components. Furthermore Siemens and NUKEM have founded the Reactor Fuel Company (Reaktor Brennelement GmbH), primarily in order to ensure the supply of LWR fuel elements, but also to provide for the continuous improvement of nuclear fuel for other types of reactors. Finally the recently established Power Plant Combine will become the major shareholder of INTERATOM via its parent companies Siemens and AEG-Telefunken. One major consequence of this arrangement will be the concentration of all industrial development of sodium-cooled fast breeder reactors at INTERATOM. This firm has already played an important role as an architect-engineer in the nuclear field.

16. Meanwhile the efforts of German nuclear industry over the past years have been recognized abroad, resulting in export orders for the construction of a 320-MW(e) pressurized HWR power station at Atucha in Argentina, the first on the South American continent, and a 400-MW(e) LWR power station at Vlissingen in the Netherlands province of Zeeland, in 1968 and 1969 respectively.

17. At present there are in the Federal Republic nuclear power plants with a total capacity of 2300 MW(e) either installed or under construction. Of these, the demonstration plants at Lingen on the Ems and Obrigheim on the Neckar, with capacities of 250 MW(e) and 300 MW(e) respectively, went into operation in 1968. The construction of two large commercial nuclear power stations at Würgassen on the Weser and Stadersand on the Elbe, with a capacity of more than 600 MW(e) each, is going on apace. Up to now German nuclear power stations have produced about 5 million MWh of electrical energy.

18. For the next few years at least six more nuclear power plants with a total capacity of 3500 MW(e) are being planned. The first of these, a 1100-MW(e) LWR station to be built at Biblis on the Middle-Rhine, has already been ordered. Furthermore, the chemical companies BASF of Ludwigshafen, Hoechst of Frankfurt, Bayer of Leverkusen and Hüls of Marl intend to set up nuclear plants for the generation of both process heat and electrical energy. As a first unit of this series, the BASF plant is designed for about 1200 MW(e). Altogether an installed nuclear capacity of about 8000 MW(e) is to be expected in the Federal Republic by 1975.

DEVELOPMENT OF ADVANCED REACTOR SYSTEMS

19. The Third German Nuclear Programme gives priority to the development of sodium-cooled fast breeder and gas-cooled high-temperature reactors. The co-ordination of activities in these fields is concentrated at the nuclear research centres of Karlsruhe and Jülich respectively, and is again characterized by close co-operation with industry.

20. As the result of a public hearing held in January 1969 by the Federal Ministry for Scientific Research, in which the responsible Parliamentary Committee participated, the steam-cooled fast breeder project, which until then had been pursued parallel to the sodium-cooled line of research, was cut down to the development of fuel elements on a small scale.

21. The construction of the 20-MW(e) compact sodium-cooled test reactor KNK at Karlsruhe will be completed before the end of 1969; the insertion of a fast core into this reactor is being prepared for 1970. Studies for a 300-MW(e) fast breeder prototype plant are under way in collaboration with the Benelux countries; an offer to build such a plant will be submitted in 1969 by the reactor building industries to the utilities of the four countries.

22. The necessity for a fast high-flux test reactor is the subject of studies. To a limited extent studies on a gas-cooled breeder are also being carried out at Karlsruhe and Jülich.

23. In the high-temperature reactor (HTR) field the 15-MW(e) AVR reactor of the pebble-bed type at Jülich continued to operate very satisfactorily. Construction plans for a 300-MW(e) uranium-thorium fuelled prototype station based on the AVR concept have been submitted by the industrial consortium BBC/Krupp and are being examined by the HKG consortium of utilities. In February 1969 the firms of Gutehoffnungshütte AG and Kernenergie-Gesellschaft Schleswig-Holstein mbH signed a contract for the construction at Geesthacht near Hamburg of a 25-MW(e) HTR experimental plant with an integrated helium gas turbine. The German HTR programme aims at the construction of a 600-MW(e) HTR power plant with an integrated helium turbine.

24. In co-operation with the Jülich Nuclear Research Establishment, a consortium of industrial firms started work on the development of a compact 20-MW(e) in-core thermionic reactor to be used as an electrical energy supply system for satellites.

NUCLEAR SHIP PROPULSION

25. Late in 1968 the nuclear cargo ship "Otto Hahn" - the first European merchant ship with nuclear propulsion - left on her maiden voyage. Since then she has proved her operational reliability and safety under the severe conditions of heavy seas and tropical climate on long voyages across the North and South Atlantic. Negotiations on the entry of the "Otto Hahn" into foreign harbours are under way.

NUCLEAR FUEL CYCLE

26. There are several German industrial firms engaged in the prospection, mining and production of natural uranium. Two companies have established contacts with firms overseas. The Uran-Gesellschaft participates in prospection projects in Canada, the United States of America and the Niger; the Uranerzbergbau-Gesellschaft has started prospection activities in Ghana and Togo. Both companies have been granted concessions in Somalia.

27. Before the end of 1969 the WAK reprocessing plant for nuclear fuel elements (with a capacity of 40 tons a year) will go into operation at Karlsruhe. The development of reprocessing methods for advanced reactor fuel elements will also be a major objective of the plant. A new laboratory for the separation of special fission products and actinides of interest in science and technology will closely co-operate with the WAF facility.

DEVELOPMENT OF NUCLEAR SAFEGUARDS METHODS

28. The programme of research and development on safeguards methods has made good progress at the Karlsruhe Nuclear Research Centre and has met with increasing international interest.

29. The programme aims at an instrumented safeguards system for the entire fuel cycle. The safeguards system is based mainly on the concept of automatic control of the flow of fissile material at certain points of the fuel cycle. Four major lines of development are being pursued: systems analyses, control experiments and direct and indirect safeguards methods. Experiments carried out at the EUROCHEMIC reprocessing plant at Mol in Belgium and at the ALKEM fuel fabrication plant at Karlsruhe have confirmed the feasibility of the control concept.

INTERNATIONAL CO-OPERATION

30. A large part of the nuclear activities of the Federal Republic are being undertaken in international co-operation, as has already been noted in the preceding paragraphs. Apart from membership of the Agency and ENEA, special importance has in the past year again been attributed to co-operation within EURATOM. The Federal Republic also participates in the work of CERN, including the preparation of its 300-GeV proton synchrotron project.

31. Provisions for the implementation of the memorandum on Belgian-Netherlands-German co-operation in the field of fast reactors, now extended to Luxembourg, have been put into effect. Thereby, close co-ordination of research and development work undertaken in the research centres as well as in the industries of the four countries is ensured. By the end of 1969 industry is to submit a detailed design, together with a firm offer for a 300-MW(e) fast reactor prototype, to the utilities of the four countries.[1] They are to be organized as a single company for which the status of a Joint Enterprise under the EURATOM Treaty could be envisaged.

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[1] See para. 21 above.

32. Towards the end of 1968 the Governments of the Netherlands, the United Kingdom of Great Britain and Northern Ireland and the Federal Republic started negotiations for an agreement for co-operation in the development and exploitation of the gas-ultracentrifuge process for enriching uranium, in order to cover the growing demand of nuclear power stations. The establishment of two international industrial enterprises is envisaged, one to be responsible for the design and manufacture of centrifuges, and the other to be entrusted with the commercial operation of enrichment plants. During a first phase, two enrichment plants are to be constructed in the Netherlands and in the United Kingdom. The aim of the three Governments is to conclude the necessary agreements as early as possible. Collaboration with other countries, in particular European countries, is envisaged once the project has been established.

33. The joint Franco-German very high-flux reactor project of the Institute Max von Laue-Paul Langevin at Grenoble has made good progress. The reactor is being set up according to schedule, and an increasing number of scientists are preparing experiments to be executed at this facility.

34. Apart from its long-established co-operation with France and the other EURATOM countries, as well as with Canada, the United Kingdom, the United States and other European countries, the Federal Republic has extended its bilateral relations in respect of the peaceful uses of atomic energy to a growing number of countries, among them Argentina, Brazil, India, Japan, Pakistan, Romania, Spain and Turkey.

MONACO

Activities of the Applied Radioactivity Laboratory of the Scientific Centre in peaceful applications of nuclear energy

1. The Laboratory is completing the tenth year of its existence. It has issued some fifteen specialized publications, and there does not seem to be any slowing down in the rate at which these publications are appearing.

2. Forming an integral part of the Oceanographic Museum, it enjoys the advantages, as an eminent expert put it, of "a favourable atmosphere for scientific work", thanks to the proximity of other laboratories, such as the International Laboratory of Marine Radioactivity of the Agency and the scientific infrastructure of the museum.

3. Supported and stimulated in its efforts by the Commissariat à l'énergie atomique, the Laboratory of the Scientific Centre has been able to attain its initial objective during these ten years, carrying out purely analytical work for the benefit of other laboratories. It hopes in the near future to widen the scope of its basic activities.

4. Set up for the purpose of promoting the use of radionuclides in the marine sciences and assisting in the technology of their application, the Laboratory has not pursued this objective owing to the lack of research contracts. The efforts made to develop methods for the measurement of low-level radioactivity have nevertheless enabled it to strike out in two directions:

(a) Monitoring the radioactive contamination of fall-out and its effects on the marine environment;

(b) Analytical measurement of ^{14}C for dating purposes, on behalf of numerous investigators, who are mainly but not exclusively concerned with Mediterranean studies in the fields of archaeology, geology or palaeogeography.

5. Co-operation with the Agency Laboratory in Monaco started immediately after its establishment and is still continuing. This collaboration relates mainly to matters of instrumentation: the Laboratory of the Scientific Centre maintains all the Agency Laboratory's electronic and measuring equipment, from pH meters to radiation detectors. It often happens that the Laboratory of the Scientific Centre is called upon to construct apparatus or modify existing equipment to meet the special needs of Agency research workers. For example, it has recently constructed a large variable high-voltage unit for electrophoresis, and a gamma radiation detector has been mounted on a chromatography unit. Mention should also be made of numerous gamma spectrometry measurements carried out by the Laboratory of the Scientific Centre for investigators and scientists under training, the testing of radionuclides used by the Agency Laboratory, etc. The advisory role which the Laboratory of the Scientific Centre fulfils for the radionuclide users of the Agency Laboratory, while not perhaps vital, does allow them to avoid costly errors.

6. The scientific results obtained in the last few years by the Laboratory of the Scientific Centre will be discussed further in the following paragraphs.

7. As far as monitoring radioactive contamination of the atmosphere is concerned, the results of routine measurements of air and precipitation, although they have not been compiled in a comprehensive report, have been incorporated as and when they were obtained in the general body of data collected by numerous other stations of various national territories and published by large international organizations, such as the European Nuclear Energy Agency and the Organisation for Economic Co-operation and Development.

8. Work concerning the uptake of radionuclides by marine organisms has formed the subject of several publications, certain of which were produced in collaboration with Agency research workers. Among the latter category the following titles may be mentioned:

In 1961: Test analyses of the radioactivity of the "Hircinia variabilis" sponge;

In 1963: Aspects of research by the Scientific Centre on pollution of the sea;

In 1964: Future of the direct, in situ method of detecting radioactivity in sea-water;

In 1968: Manganese content and presence of ^{54}Mn from fall-out in certain Mediterranean marine biotopes.

9. Carbon dating, however, appears to be the field which has contributed most to the scientific reputation of the applied radioactivity section. In this connection, it is perhaps worth while to make the following points:

(a) As each analytical measurement of ^{14}C has its own special characteristics, which cannot be separated entirely from the nature and history of the sample to be measured, the operator is almost forced to work together with the investigator who provides it. It is for this reason that the Laboratory of the Scientific Centre has so often acted in association with other laboratories of different disciplines, such as palaeogeography, archaeology or sedimentology, in the various publications which have been issued, but it has specialized more particularly in measuring marine sediment uptake rates and in the chronology of the deposits characteristic of Quaternary sea levels;

(b) The titles of the main publications are as follows:

(The first three refer to articles which appeared in the American Journal "Radiocarbon")

In 1964: Monaco radiocarbon measurements I

In 1966: Monaco radiocarbon measurements II

In 1963: Monaco radiocarbon measurements III

In 1964: Validity of the dating of recent Quaternary sediments by analysis of the ^{14}C content of sea shells

In 1965: The radiocarbon content of deep and surface water in the Indian Ocean (Sea of Oman)

Some limitations of the ^{14}C method of dating shells

In 1967: The distribution of natural ^{14}C content in the various constituents of the biophase of a surface sediment in the western Mediterranean

In 1968: Radiocarbon dating of certain submarine sediments of the Nice area

The counting and automatic printing unit used for dating by the ^{14}C method

The absolute chronology and sequence of prehistoric civilizations in North Africa

In 1969: The age of the rock outcrops of the Roussillon continental plateau

Tests on the determination of sedimentation rates in the eastern Mediterranean by means of ^{14}C measurements

(c) The results of the ^{14}C measurements of the Laboratory of the Scientific Centre have also been used to support a thesis for a doctorate (B. Chassefière, 1968) and have also been incorporated in other publications

In 1966: The use of vermetus in the determination of former sea levels

In 1967: The possibility of dating Quaternary levels by means of vermetus

In 1968: Note on the marine environment of Wreck M 1 (Malta) in "Gallia Préhistoire"

(d) The large number of requests for analyses means long waiting periods. The waiting periods are currently more than a year. The project for trebling of the ^{14}C measurement facilities, which has been under study for many years and is currently being implemented, should in principle allow us to resolve this problem. By increasing the number of our dating projects the new scientific problems which are almost invariably raised by current measurements, which are of necessity limited in number, will allow us to deal more thoroughly with the subjects studied and even to tackle subjects of wider scope, such as the movement of sea-water masses.

10. Dating by ^{14}C does not allow us to go back further than 35 000 years. At the request of other establishments, in particular the Museum of Prehistoric Anthropology of Monaco, the Laboratory of the Scientific Centre is considering the application in the near future of other methods, for which it has the equipment.

11. Finally, in the field of the medical applications of radioactivity, the Laboratory of the Scientific Centre intends to collaborate in the maintenance of the equipment used by the medical service of the Principality at the Princess Grace Clinic.