# THE ANNUAL REPORT FOR 1979

GC(XXIV)/627

Printed by the
International Atomic Energy Agency
in Austria - July 1980

INTERNATIONAL ATOMIC ENERGY AGENCY

THE ANNUAL REPORT FOR 1979

CONTENTS

## LIST OF ABBREVIATIONS

| | |
|---|---|
| Agency | International Atomic Energy Agency |
| AGRIS | Agricultural Information System |
| CMEA | Council for Mutual Economic Assistance |
| EURATOM | European Atomic Energy Community |
| FAO | Food and Agriculture Organization of the United Nations |
| IAEA | International Atomic Energy Agency |
| INFCE | International Nuclear Fuel Cycle Evaluation |
| INIS | International Nuclear Information System |
| LWR | Light-water reactor |
| NDA | Non-destructive assay |
| NEA | Nuclear Energy Agency of the Organisation for Economic Co-operation and Development |
| NPT | Treaty on the Non-Proliferation of Nuclear Weapons (reproduced in document INFCIRC/140) |
| NUSS | Nuclear Safety Standards (programme) |
| OECD | Organisation for Economic Co-operation and Development |
| RCA | Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (INFCIRC/167) |
| Tlatelolco Treaty | Treaty for the Prohibition of Nuclear Weapons in Latin America |
| UNDP | United Nations Development Programme |
| UNEP | United Nations Environment Programme |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| UNICEF | United Nations Children's Fund |
| WHO | World Health Organization |

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NOTE

All sums of money are expressed in United States dollars.

## INTRODUCTION

### Nuclear power prospects

1. Energy supply problems grew worse during 1979. The FOB price of oil rose by almost 92% during the year [1], and the price of steam coal rose by an average of 40%. Political events raised questions about the long-term security of oil supplies. The difficulties involved in reversing two or three decades of decline in coal production became more apparent, as did the short and long-term effects on the environment of the burning of fossil fuels in general and of coal in particular. It became increasingly clear that renewable energy sources, such as solar energy, were not likely to make any significant contribution to the world's energy supply before the turn of the century. It also became clear that, if undue dependence on oil as the main source of energy both for developed and developing countries were to be averted in the 1990s, it was essential that there should be early and large-scale investment in nuclear power and, where possible, increased use of coal, as well as the adoption of effective conservation policies.

2. In the Socialist countries and in a few free-market and developing countries, these and other factors did, indeed, lend support to policies of continued and sometimes rapid expansion of nuclear power programmes. Nevertheless, during 1979 the total amount of nuclear power plant on order throughout the world actually decreased by about 8 000 MW; eight new orders were placed, but 14 previous orders were cancelled.

3. Doubtless, one important reason for this paradox was the accident at Three Mile Island, in the United States, on 28 March. The repercussions, in the form of public anxiety, increased regulatory uncertainty, further construction delays and cancellations of orders, were felt most strongly in the United States, but the much-publicized event attracted the attention of news media throughout the world and increased opposition to nuclear power, at least temporarily, in many countries.

4. The first months of 1980 suggest, however, that the imperatives of economic, environmental and technological factors are beginning to overcome opposition to nuclear power.

5. Also, time has lent perspective to the Three Mile Island accident. The psychological effect on the surrounding population and the material damage to the plant were significant, but, unlike other industrial accidents that have since occurred, the Three Mile Island accident caused no loss of life, either directly or indirectly. Recent re-evaluations have, moreover, tended to the conclusion that the event demonstrated the inherent safety and ruggedness of the plant in spite of mechanical failure, deficiencies in maintenance and a series of faulty decisions by the operators each of which seriously aggravated the physical damage to the reactor core. The accident has also prompted the nuclear industry to take major steps further to improve plant safety.

6. The new trend was also evident in the results of the referendum on 23 March 1980 in Sweden, where 57% of those taking part voted for the continuation of the country's nuclear power programme, in contrast with the referendum of 5 November 1978 in Austria, where a slight majority voted against the opening of Austria's first nuclear power plant. In the Federal Republic of Germany, the first orders for nuclear power plant were placed since 1975. In the United Kingdom, decisions to order new nuclear stations were taken for the first time since 1974. The nuclear power programmes of France and Japan continued to make steady progress. In the Soviet Union, the world's largest fast breeder reactor (600 MW) was brought into operation on 8 April 1980.

7. There are thus indications that in the next few years the need to deal effectively with rising energy costs and falling supplies and with their impact on inflation, employment and economic growth may, in some measure, qualify the priorities of the 1970s, although environmental protection and prevention of proliferation must continue to be of paramount concern to all countries and organizations dealing with nuclear technology.

8. In the meantime, the contribution of nuclear energy to the production of electricity is steadily growing. By the end of 1979, some 120 GW of installed nuclear power plant was producing about 8% of the world's electricity. By 1985, with the completion of plants already under construction, installed capacity will rise to 290–350 GW and its share in electricity production to about 12%. This will be the equivalent of over 400 millions tons of oil or approximately the oil production of Saudi Arabia in 1978.

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[1] From 1 January to 30 April 1980 it rose a further 10% (Note: weighted average of OPEC's official selling prices).

Nuclear safety and the environment

9. Since it began its activities, in 1958, nuclear safety has been one of the main programmes of the Agency; however, the Three Mile Island accident had an immediate and extensive impact on work in this field. In June 1979, following the recommendations of a panel of experts specially convened for the purpose of reviewing the implications of the accident for the Agency's programmes, the Board approved a significant increase in nuclear safety activities. The main effect will be an increase in the Agency's ability to provide assistance to countries that are introducing nuclear power or are at the early stage of nuclear power programmes and in its ability to provide help in emergencies. The Agency's Nuclear Safety Standards (NUSS) programme will be expanded so that new safety guides and codes may deal more fully with the technological problems and deficiencies revealed by the accident.

10. Also, Brazil, the Federal Republic of Germany and Sweden informed the Agency of the high priority they attach to the Agency's nuclear safety work and proposed various projects for its expansion. Against this background, the Agency will hold a major international conference on current nuclear power plant safety issues in Stockholm from 20 to 24 October 1980. Besides reviewing the lessons of the Three Mile Island accident and other experience connected with the safety of nuclear power plants, the conference is expected to provide the opportunity for a realistic appraisal, at the highest international level, of the safety standards applied by the nuclear industry and of the possibilities for international and regional co-operation in nuclear safety matters.

11. The Agency held international symposia in 1979 on two topical questions of considerable interest, namely the underground disposal of radioactive wastes and the radiation exposure of workers in various nuclear fuel cycle facilities. In the light of the political and technical problems that many Member States are faced with in making arrangements for the final disposal of nuclear wastes, the Agency is expanding its underground disposal programme.

Safeguards and NPT

12. In the field of safeguards, the major development during the year was the entry into force of nearly all the remaining "Facility Attachments" for nuclear power plant in the non-nuclear-weapon member States of the European Communities (Belgium, Denmark, the Federal Republic of Germany, Ireland, Italy, Luxembourg and the Netherlands).

13. There were also a number of accessions to NPT during the year, including those of Bangladesh, Indonesia, Sri Lanka, Tuvalu, the People's Democratic Republic of Yemen, and St. Lucia. The number of NPT Parties with which safeguards agreements were in force increased during 1979 from 61 to 67. A "full scope" safeguards agreement was also concluded with Colombia, in accordance with the Tlatelolco Treaty.

14. In response to requests made by the Preparatory Committee for the Second Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons (second NPT Review Conference), the Secretariat has submitted comprehensive documentation on the Agency's activities in connection with Articles III, IV and V of NPT.

15. In 1979, the Agency was applying safeguards in 11 non-nuclear-weapon States which were not party to NPT. In seven of these 11 countries, all substantial nuclear activities of which the Agency was aware were covered by a mosaic of individual safeguards agreements. In four of these 11 countries and in a fifth country, which had signed but not yet ratified NPT, unsafeguarded nuclear facilities were in operation. Reports continued to indicate that some other countries were acquiring unsafeguarded enrichment capacity. However, in only three of the 11 countries was the unsafeguarded facility significant in 1979 from the point of view of producing weapons-grade material. There were also disquieting reports of the possible explosion of a nuclear device in the South Atlantic by another Member State. These reports reflect the fears of further proliferation that are engendered by the operation of unsafeguarded sensitive nuclear facilities.

16. In 1979, as in previous years, the Secretariat, in carrying out the Agency's safeguards programme, did not detect any anomaly which would indicate the diversion of a significant amount of safeguarded nuclear material for the manufacture of any nuclear weapon, or to further any other military purpose, or for the manufacture of any other nuclear explosive device. In the light of the Safeguards Implementation Report for 1979, it is reasonable to conclude again that nuclear material under Agency safeguards remained in peaceful nuclear activities or was otherwise adequately accounted for.

17. The extent to which the Agency's safeguards responsibilities were increasing is indicated by the fact that from 1978 to 1979 the amount of plutonium (chiefly contained in spent fuel) under safeguards rose by one third to 68 t, low-enriched uranium by 12% to 11714 t and source material by 17% to 15399 t.

## International plutonium storage

18. Since 1976 the Agency has been studying means of giving practical effect to the safeguards measures foreseen in Article XII.A.5 of the Statute. The study has evolved into an International Plutonium Storage project. Considerable progress was made during 1979.

## INFCE

19. By the end of 1979, the International Nuclear Fuel Cycle Evaluation (INFCE) had almost drawn to a close (the final Plenary Conference was held from 25 to 27 February 1980). In all, 66 Member States and five international organizations participated in the evaluation. The Agency serviced the 133 INFCE meetings held at its Headquarters, printed and distributed 20 000 pages of reports, made available scientific secretaries and rapporteurs for six of the eight Working Groups and provided the Secretariat for the Technical Co-ordinating Committee (TCC) and the Plenary Conferences. It contributed substantively in many areas and assisted the Chairman of the TCC in producing the INFCE Summary and Overview report. The staff effort involved was considerable, and in some cases outside experts had to be recruited to ensure that the Agency's normal programmes would not be detrimentally affected.

20. INFCE identified a number of subjects on which international co-operation would be desirable, including two already being dealt with by the Agency (international plutonium storage and international co-operation in dealing with the long-term storage of spent fuel). Also, it became clear that the time had come for closer co-operation in relation to nuclear supplies, and in June 1980 the Board established a committee open to all Member States to consider and advise it on:

"(i) ways and means in which supplies of nuclear material, equipment and technology and fuel cycle services can be assured on a more predictable and long-term basis in accordance with mutually acceptable considerations of non-proliferation; and

(ii) the Agency's role and responsibilities in relation thereto."

## Physical protection

21. The two-year-long negotiations for the conclusion of a Convention on the Physical Protection of Nuclear Material (to diminish the risks of theft, forcible seizure, etc. and to deal with the consequences of such illegal actions) came to a successful conclusion in October in Vienna. The Convention, which is the first of its kind, represents a significant step forward in international co-operation to promote the safe use of nuclear energy for peaceful purposes.

## Technical assistance and promotion of the use of nuclear techniques

22. The total funds and resources of all kinds available for technical assistance activities increased from $15 million in 1978 to $17.5 million in 1979. The largest single component of the increase was the rise in Agency funds (derived from voluntary contributions to the target) from $7.1 million in 1978 to $8.8 million in 1979.

23. Nevertheless, the problem of assuring an adequate and predictable flow of resources for the Agency's own programmes continued to preoccupy Member States and was extensively discussed at the General Conference, in New Delhi, in December 1979.

24. It is imperative that all techniques and resources, including those provided by nuclear science, be mobilized to combat the world-wide problems of famine, malnutrition and environmental pollution. In Africa, for instance, Nagana (animal trypanosomiasis) and related diseases profoundly retard economic development. The vector of Nagana, the tsetse fly, is spread over more than seven million square kilometers, effectively denying the use of this vast area for the purpose to which it is often best suited -- namely, large-scale cattle-raising by modern methods. The project at Vom, Nigeria, which the Agency is carrying out in co-operation with the Government of Nigeria, with additional support from the Governments of the Federal Republic of Germany, Belgium and the United Kingdom, to control and, if possible, eradicate the tsetse fly by the sterile-insect technique, is now in full operation.

25. In the field of Life Sciences, special attention was given to the maintenance and quality control of nuclear medicine instruments in Latin America and Africa. Training courses in nuclear medicine techniques were held in Sri Lanka and in the Soviet Union. The biological and related health consequences of exposure to low levels of radionuclides in effluents were reviewed at a symposium, where the adequacy of the best current radiation protection practices was confirmed.

26. The Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (RCA) has successfully demonstrated the potential for regional collaboration between Governments and laboratories in introducing and using nuclear techniques. The RCA is now attracting substantial financial support from the Governments of Australia and Japan. In addition, the United Nations Development Programme is now financing preparatory assistance which is expected to lead to a major five-year UNDP-supported programme for demonstrating the uses of nuclear science and techniques in various industries.

27. In February 1979, the Board approved the revised "guiding principles and general operating rules to govern the provision of technical assistance by the Agency".

## Controlled thermonuclear fusion

28. At the end of 1979, the countries participating in the preliminary study for the International Tokamak Reactor (INTOR) project completed the "zero phase" of the project, defining possible guidelines for a sequence of designs for an international fusion reactor. The project has aroused considerable interest in the world's scientific community as well as among the authorities concerned in the co-operating countries (Japan, the Soviet Union, the United States and the member States of the European Communities). The present "definition phase", which will continue until the middle of 1981, is expected to permit a comprehensive evaluation of the potential of this project and to provide the basis for an informed decision on whether or not to proceed with the construction of an International Tokamak Reactor.

## Matters of special interest to the Agency discussed by the General Assembly of the United Nations

29. At its 34th session, the General Assembly adopted several resolutions of direct concern to the Agency. Resolution 34/11, on the Agency's report, took note with satisfaction of several of the Agency's programmes and, inter alia, urged all States to support the Agency in furthering the peaceful uses of nuclear energy, improving the effectiveness of safeguards and promoting nuclear safety.

30. By Resolution 34/63, the Assembly decided in principle to convene, by 1983, an international conference for the promotion of international co-operation in the peaceful uses of nuclear energy under the auspices of the United Nations system, with the Agency fulfilling its appropriate role. The objectives of the conference had been set out by the General Assembly in its Resolution 32/50.

31. In Resolution 32/75, the General Assembly, inter alia, demanded that South Africa submit all its nuclear installations to inspection by the Agency. It also requested the Secretary-General to prepare a comprehensive report on South Africa's plans and capabilities in the nuclear field. The Agency has provided information in this connection.

32. In Resolution 34/77, the Assembly called upon all countries in the Middle East to agree to place all their nuclear activities under the Agency's safeguards.

## The Tlatelolco Treaty

33. The General Assembly also adopted a number of resolutions calling for full implementation of the Tlatelolco Treaty. The Secretary-General of the Organization for the Prohibition of Nuclear Weapons in Latin America has continued to give the Agency valuable assistance in the negotiation of safeguards agreements with Parties to the Tlatelolco Treaty.

## Credentials of Member States

34. At the 23rd regular session of the General Conference of the Agency in New Delhi, the credentials of the delegation of South Africa were rejected by a vote of 49 to 24 with 9 abstentions.

Other matters

35. As foreseen in the annual report for 1978, the transfer of the Agency to its Permanent Headquarters at the Vienna International Centre (VIC) took place in October and November 1979.

36. The Agency has continued to face acute financial difficulties because of a further decline in the value of the United States dollar and increasing rates of inflation in almost all countries. The stringent economy measures introduced in 1978 were continued in 1979 and are reflected in the proposed budget for 1981, which foresees "zero growth" in the overall programme activities of the Agency, modest growth in certain areas being offset by cutbacks in others.

37. Finally, the Board would like to draw the General Conference's attention to the fact that a senior member of the staff of the Agency, Professor Abdus Salam, Director of the International Centre for Theoretical Physics, in Trieste, was awarded the 1979 Nobel Prize for Physics. It takes the opportunity to extend its congratulations to this distinguished scientist, who has served the world's scientific community and – for the past 16 years – the Agency so well.

## THE AGENCY'S ACTIVITIES

### TECHNICAL ASSISTANCE AND TRAINING

38. The total resources available to carry out the Agency's technical assistance activities in 1979 increased by 16.5% compared with 1978; see Figure 1 for details.

39. The main source of funds for the Agency's regular programme is the voluntary contributions of Member States to the General Fund. The target for 1979 was $8.5 million and the amount actually pledged was $8.06 million, or nearly 95%, compared with a target of $7 million and pledges of $6.45 million, or 92% in 1978. Other sources of support for Agency technical assistance activities are extrabudgetary contributions, UNDP funds, assistance in kind made available by a number of donor countries, miscellaneous income, including assessed programme costs, and funds from Member States to finance assistance for themselves. The total resources made available for 1979 programmes amounted to $17.5 million, an increase of $2.5 million over 1978. The largest rise was in the voluntary contributions of Member States ($1 608 000 more than in 1978), followed by an increase of $1 106 000 in UNDP funds. (In Figure 1 "Agency funds" include miscellaneous income amounting to, for example, $740 000 in 1979 and $670 000 in 1978; the balance consists of voluntary contributions.) Agency funds constituted one half of total available resources, a share which has remained fairly constant during recent years.

40. Of the $17.5 million available for 1979, $8.1 million was spent and $5.4 million was allocated to approved projects that had begun but where the committed funds had not yet been spent. This latter sum included unliquidated obligations totalling $3.9 million and outstanding assistance in kind valued at $1.5 million. The monetary value of the assistance provided from the resources made available for 1979 and those carried forward from prior years was, at $15.5 million, about 20% higher than the $13 million provided in 1978. The breakdown of the latter sums can be seen in Table 1.

Table 1

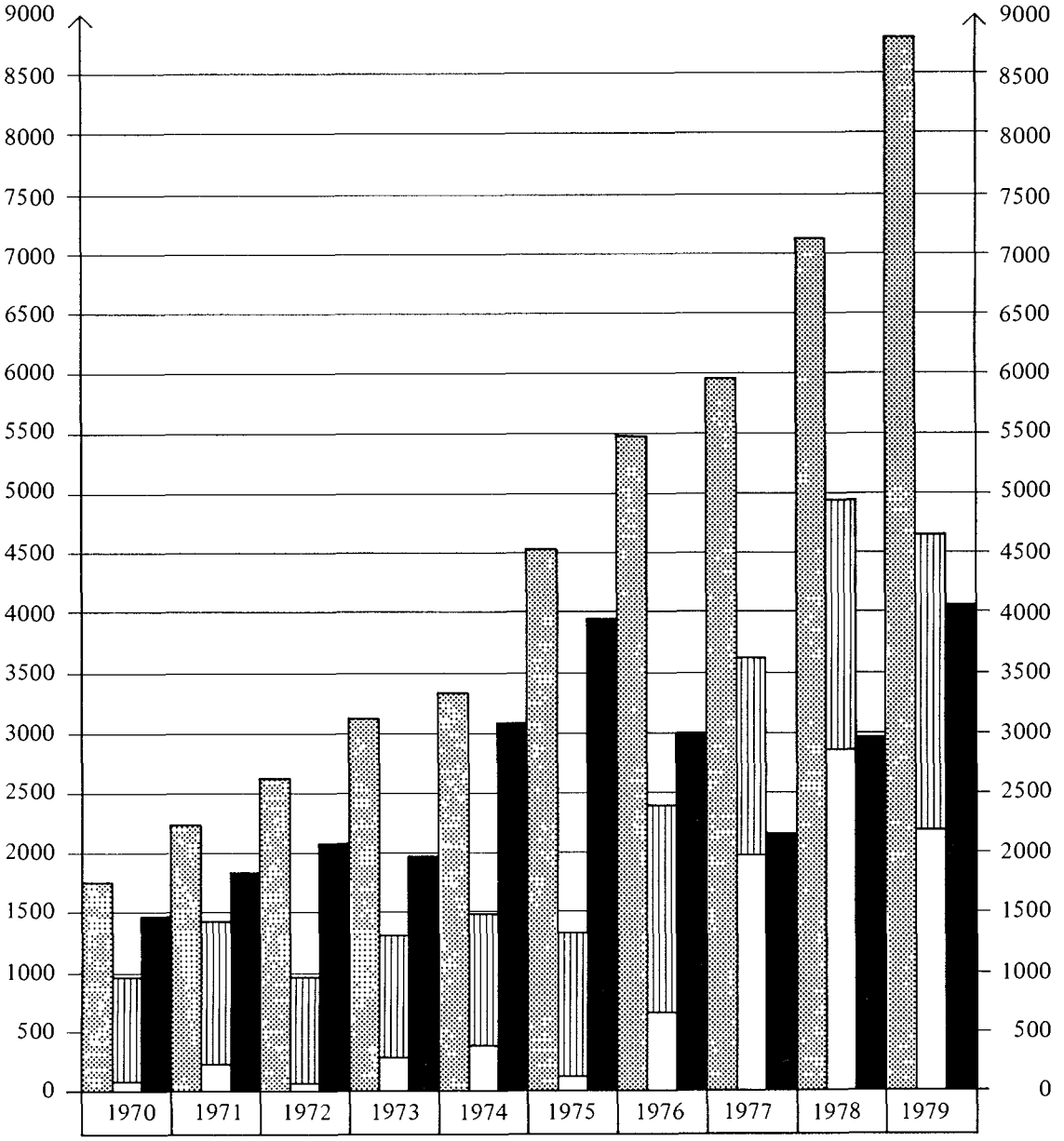
Agency technical assistance by source: 1970–1979
(in US dollars)

| Year | UNDP funds | Agency funds | Extrabudgetary funds | Assistance in kind | Total |
|---|---|---|---|---|---|
| 1970 | 1 469 200 | 1 619 300 | 75 500 | 819 100 | 3 983 100 |
| 1971 | 1 838 800 | 2 124 600 | 60 000 | 921 700 | 4 945 100 |
| 1972 | 2 072 000 | 2 556 000 | 85 700 | 779 000 | 5 492 700 |
| 1973 | 1 964 300 | 2 675 900 | 87 100 | 1 039 400 | 5 766 700 |
| 1974 | 3 081 600 | 2 413 200 | 170 300 | 1 077 400 | 6 742 500 |
| 1975 | 3 941 500 | 3 423 500 | 252 900 | 942 300 | 8 560 200 |
| 1976 | 3 002 300 | 3 954 700 | 358 800 | 1 021 500 | 8 337 300 |
| 1977 | 2 144 400 | 4 997 100 | 602 400 | 1 284 300 | 9 028 400 |
| 1978 | 2 954 000 | 6 527 500 | 1 539 200 | 1 986 800 | 13 007 500 |
| 1979 | 4 059 600 | 7 123 900 | 2 379 700 | 2 014 800 | 15 578 000 |

41. The sharpest increase, 55%, took place in assistance financed from extrabudgetary funds. These funds covered 21% of the non-UNDP-financed assistance provided by the Agency in 1979. Extrabudgetary funds, made available by Member States over and above their voluntary contributions to the target, are therefore an indispensable source of support for maintaining the total programme at its present level.

FIGURE 1

RESOURCES AVAILABLE FOR
AGENCY TECHNICAL ASSISTANCE PROGRAMMES: 1970–1979
(in thousands of dollars)




| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 |
|---|---|---|---|---|---|---|---|---|---|---|
| Agency funds | 1749 | 2225 | 2637 | 3125 | 3348 | 4539 | 5492 | 5962 | 7121 | 8799 |
| Extrabudgetary funds | 61 | 218 | 60 | 267 | 367 | 110 | 648 | 1966 | 2849 | 2181 |
| Assistance in kind | 894 | 1197 | 900 | 1032 | 1114 | 1212 | 1737 | 1648 | 2104 | 2462 |
| UNDP funds | 1469 | 1839 | 2072 | 1964 | 3082 | 3942 | 3002 | 2144 | 2954 | 4060 |
| TOTAL | 4173 | 5479 | 5668 | 6388 | 7911 | 9803 | 10879 | 11720 | 15028 | 17502 |

Agency funds  Extrabudgetary funds  Assistance in kind  UNDP funds

FIGURE 2

UTILIZATION OF RESOURCES: 1978, 1979 and 1970–1979
(in thousands of dollars)

| FIELD OF ACTIVITY | | Year | Experts | Equipment | Fellow-ships | Share of total programme | |
|---|---|---|---|---|---|---|---|
| | | | $ | $ | $ | $ | % |
| General atomic energy development | | 1978 | 474.5 | 766.3 | 242.6 | 1 483.4 | 11.4 |
| | | 1979 | 473.9 | 1 298.8 | 363.7 | 2 136.4 | 13.7 |
| Nuclear physics | | 1978 | 337.1 | 649.5 | 461.5 | 1 448.1 | 11.1 |
| | | 1979 | 265.3 | 700.5 | 358.8 | 1 324.6 | 8.5 |
| Nuclear chemistry | | 1978 | 39.0 | 290.5 | 212.6 | 542.1 | 4.2 |
| | | 1979 | 62.5 | 301.4 | 292.4 | 656.3 | 4.2 |
| Prospecting, mining and processing of nuclear materials | | 1978 | 663.8 | 539.7 | 209.4 | 1 412.9 | 10.9 |
| | | 1979 | 619.1 | 933.2 | 182.7 | 1 735.0 | 11.2 |
| Nuclear engineering and technology | | 1978 | 574.2 | 812.4 | 976.0 | 2 362.6 | 18.2 |
| | | 1979 | 660.3 | 958.8 | 1 233.9 | 2 853.0 | 18.3 |
| Application of isotopes and radiation in | Agriculture | 1978 | 827.4 | 1 066.2 | 550.2 | 2 443.8 | 18.8 |
| | | 1979 | 922.6 | 1 332.1 | 1 374.1 | 3 628.8 | 23.3 |
| | Medicine | 1978 | 231.5 | 376.0 | 413.9 | 1 021.4 | 7.8 |
| | | 1979 | 212.1 | 453.4 | 411.0 | 1 076.5 | 6.9 |
| | Biology | 1978 | 3.0 | 10.5 | 113.6 | 127.1 | 1.0 |
| | | 1979 | 14.1 | 198.5 | 87.9 | 300.5 | 1.9 |
| | Industry and Hydrology | 1978 | 389.6 | 643.5 | 125.0 | 1 158.1 | 8.9 |
| | | 1979 | 317.6 | 341.8 | 164.5 | 823.9 | 5.3 |
| Safety in nuclear energy | | 1978 | 344.2 | 303.6 | 360.2 | 1 008.0 | 7.7 |
| | | 1979 | 414.0 | 229.8 | 399.2 | 1 043.0 | 6.7 |
| Total assistance | | 1978 | 3 884.3 | 5 458.2 | 3 665.0 | 13 007.5 | 100.0 |
| | | 1979 | 3 961.5 | 6 748.3 | 4 868.2 | 15 578.0 | 100.0 |
| Ten-year total | | 1970-1979 | 25 918.4 | 31 048.5 | 24 474.4 | 81 441.3 | 100.0 |

| Distribution of assistance by type | | | |
|---|---|---|---|
| Type | 1978 | 1979 | 1970–1979 |
| Experts | 29.9% | 25.5% | 31.8% |
| Equipment | 41.9% | 43.2% | 38.1% |
| Fellowships | 28.2% | 31.3% | 30.1% |
| Total | 100.0% | 100.0% | 100.0% |

42. UNDP-financed assistance increased by 37%, and particularly high rates of implementation were achieved through judicious project budgeting and timely budget rephasing. Growth in aid furnished from Agency funds was a modest 9%, while the volume of the assistance provided from in-kind contributions remained at the high level attained in 1978. Comparable data on the assistance provided by field of activity and type are given in Figure 2. Information on the distribution of Agency assistance is shown in Figure 3 by region and source and in Figure 4 by field and region.

43. As can be seen in Figure 2, expenditure in 1979 on equipment grew by about 24% over 1978. The highest increase occurred in the fellowship component of the programme, which rose by almost 33%. A substantial share of the expenditure on training was for training courses and study tours.

44. The total number of expert man-months provided in 1979 declined by 104, from 918 to 814. Although this may indicate an increasing availability of national expertise in the developing countries, the problem of the timely provision of expert services remains serious as delays in project implementation occur mainly in this sector. At the end of 1979 there were still 931 man-months to be provided under the Agency's regular programme alone. The Agency repeats, therefore, its urgent appeal to Member States to assist in locating and making available the required expertise.

45. Although earmarkings for approved assistance under the regular programme which had not yet been implemented rose by $784 000, the rate of increase was lower in 1979 (16%, as compared with 20% in 1978). Of this still outstanding assistance, only 25% was in respect of approvals dating back more than two years, which indicates a decrease in "old" projects for the first time in four years.

46. The new measures introduced in 1979 to redress the imbalance between the type of currencies available among the Agency's resources for technical assistance and the type of currencies needed to implement the regular programme are proving to be successful. The co-operation of major donors of non-convertible currencies in establishing special payment arrangements and in facilitating the early identification of utilization possibilities, together with the understanding of recipient countries for the stringent measures that have to be applied in programming convertible funds, have resulted in a quite spectacular reversal of the trend towards a growing imbalance. Whereas in 1978 the deficit in convertible currency and the surplus in non-convertible currency increased by 54% and 60% respectively, they decreased by 40% and 31% respectively in 1979.

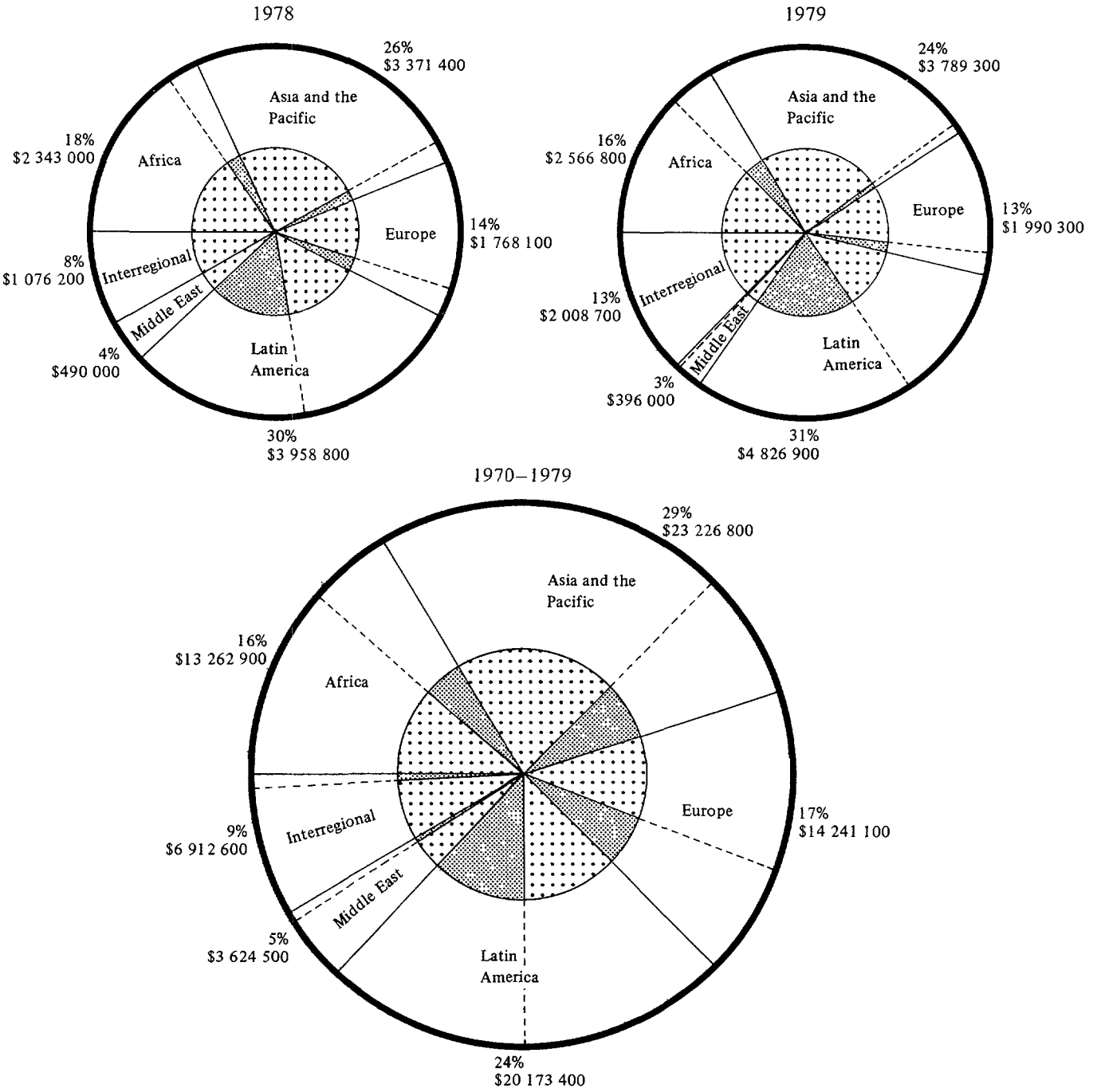
47. Notwithstanding this significant improvement in the situation, an imbalance of approximately $1.25 million still exists. It is therefore essential that the measures applied to overcome this problem should continue. Cautious programming is also required because it seems inevitable that the pro forma cost of $3800 per expert man-month used in estimating the costs under the 1980 programme will have to be increased substantially. The anticipated higher cost will exert considerable pressure on the convertible currency portion of the programme.

48. During 1979 the first step was taken in the development of a more systematic approach to the evaluation of the Agency's technical assistance activities. Simultaneously, a survey was carried out to ascertain the operational status of the equipment provided during the last five years. From the replies received it appears that, at most, 15% of the equipment supplied during this period posed maintenance problems which could not be resolved locally.

49. An important new source for the financing of technical assistance activities in the Agency's field of competence may become available through the newly created "Interim Fund for Science and Technology for Development", established as result of the United Nations Conference on Science and Technology for Development, held in Vienna in August 1979. Contact with the Interim Fund, which operates under the aegis of the Administrator of UNDP, has been established.

FIGURE 3

DISTRIBUTION OF TECHNICAL ASSISTANCE BY REGION AND SOURCE
(1978, 1979 and 1970–1979)

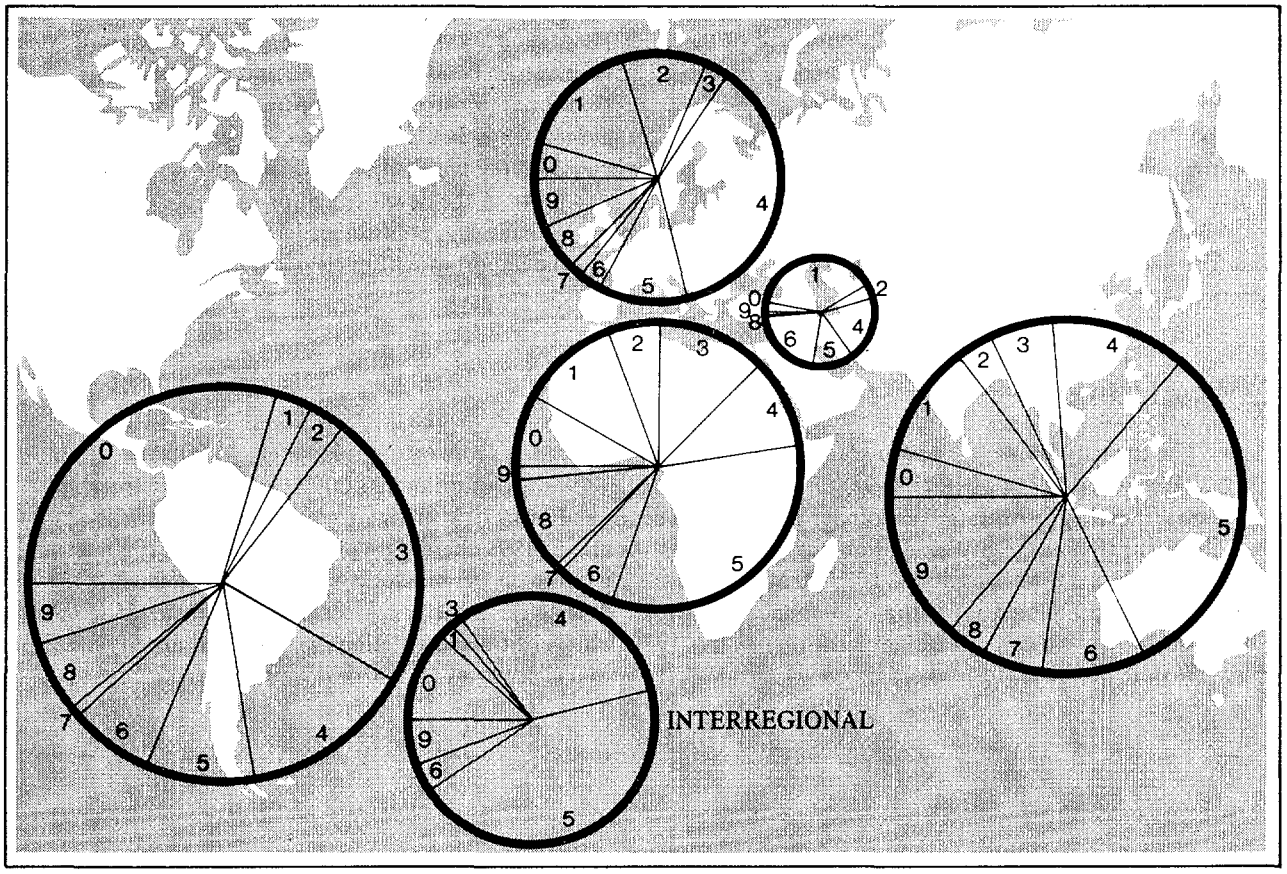



Distribution of technical assistance by source:

| | 1978 | 1979 | 1970-1979 |
|---|---|---|---|
| Agency resources | 77.3% | 73.9% | 67.2% |
| UNDP | 22.7% | 26.1% | 32.8% |

## FIGURE 4

## DISTRIBUTION OF TECHNICAL ASSISTANCE BY FIELD AND REGION: 1979[a/]




### SUMMARY

| Field of activity | Africa % | Asia and the Pacific % | Europe % | Latin America % | Middle East % | Inter-regional % | All regions % |
|---|---|---|---|---|---|---|---|
| 0 - General atomic energy development | 8 | 4 | 5 | 30 | 3 | 12 | 14 |
| 1 - Nuclear physics | 11 | 10 | 16 | 3 | 39 | 2 | 9 |
| 2 - Nuclear chemistry | 6 | 3 | 11 | 3 | 4 | – | 4 |
| 3 - Prospecting, mining and processing of nuclear materials | 12 | 6 | 3 | 22 | – | 1 | 11 |
| 4 - Nuclear engineering and technology | 10 | 13 | 36 | 14 | 20 | 31 | 18 |
| Application of isotopes and radiation in: 5 - Agriculture | 33 | 31 | 12 | 9 | 12 | 44 | 23 |
| 6 - Medicine | 7 | 9 | 3 | 7 | 21 | 4 | 7 |
| 7 - Biology | 1 | 6 | 2 | 1 | – | – | 2 |
| 8 - Industry and Hydrology | 10 | 4 | 6 | 6 | – | – | 5 |
| 9 - Safety in nuclear energy | 2 | 14 | 6 | 5 | 1 | 6 | 7 |
| | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

[a/] For each region, the relative monetary value of the technical assistance provided by the Agency is denoted by the size of the circle superimposed over the region on the map. The size of the segments in each circle indicates the share of total assistance given in the various fields of activity.

## NUCLEAR POWER AND REACTORS

### Introduction

50. The year 1979 must be viewed in the light of the Three Mile Island accident at Harrisburg, United States of America, which affected the peaceful utilization of nuclear energy in many countries besides the United States. Despite the accident and the publicity it received, nuclear power plants continued to have an excellent operating record, while the so-called "second oil crisis" clearly demonstrated the need for nuclear power in most industrialized and some developing countries. Several uncertainties – financial, economic, regulatory – and the problem of public acceptance continued in many countries to raise capital costs, stretch out lead-times and constrain the development of national nuclear programmes. Even with all the constraints which nuclear power is facing today, political leaders in the industrialized countries and in some developing countries have clearly underlined the importance of nuclear power in meeting the energy requirements of the future.

### Nuclear power growth

51. The capacity of nuclear power plant in operation in Member States rose by approximately 16 000 MW, from 103 000 MW at the end of 1978 to 119 000 MW at the end of 1979, with a further 204 000 MW under construction. The nuclear capacity in operation and under construction at the end of 1979 is summarized in Table 2, which also shows the nuclear share of electricity generation during 1979. At the end of 1979 there were plans for a further 108 nuclear power plants with a total capacity of 103 000 MW. If all the plants which were under construction or planned at the end of 1979 are completed according to announced schedules, the nuclear capacity in operation will reach 425 000 MW by the mid-1990s. However, it is significant that during 1979, while eight nuclear stations with a total capacity of 8000 MW were ordered, previous orders for 14 stations with a total capacity of 16 000 MW were cancelled.

Table 2

Power reactors in the world
(at the end of December 1979)

| Country | Operating | | Under construction | | Electricity supplied by nuclear plants during 1979 | |
|---|---|---|---|---|---|---|
| | Number of units | Total MW(e) | Number of units | Total MW(e) | TWh(e) | Percentage of total electricity production |
| **OECD Europe** | | | | | | |
| Belgium | 3 | 1666 | 4 | 3811 | 11.4 | 22 |
| Finland | 2 | 1080 | 1 | 420 | 6.7 | 19 |
| France | 16 | 8163 | 21 | 20290 | 39.9 | 18 |
| Germany, Fed. Rep. of | 15 | 8782 | 10 | 10638 | 40.4 | 11 |
| Italy | 3 | 542 | 3 | 1966 | 2.6 | 1.5 |
| Netherlands | 2 | 499 | – | – | 3.5 | 6 |
| Spain | 3 | 1073 | 7 | 6302 | 6.7 | 6 |
| Sweden | 6 | 3700 | 5 | 4682 | 21.0 | 23 |
| Switzerland | 4 | 1926 | 1 | 942 | 11.8 | 26 |
| United Kingdom | 33 | 6982 | 6 | 3714 | 38.6 | 13 |
| **OECD North America** | | | | | | |
| Canada | 11 | 5495 | 14 | 9751 | 38.4 | 11 |
| USA | 69 | 49989 | 89 | 97558 | 279.7 | 12 |
| **OECD Pacific** | | | | | | |
| Japan | 23 | 14466 | 10 | 8341 | 61.0 | 10 |
| **CMEA** | | | | | | |
| Bulgaria | 2 | 816 | 2 | 828 | 6.2 | 19 |
| Cuba | – | – | 1 | 408 | – | – |
| Czechoslovakia | 1 | 381 | 7 | 2940 | 1.8 | 2.5 |
| German Democratic Republic | 4 | 1287 | 5 | 2040 | 9.0*/ | 9 |
| Hungary | – | – | 2 | 816 | – | – |
| USSR | 30 | 10616 | 16 | 14380 | 54.0*/ | 4 |
| **Developing countries** | | | | | | |
| Argentina | 1 | 345 | 1 | 600 | 2.9 | 7.5 |
| Brazil | – | – | 3 | 3116 | – | – |
| India | 3 | 602 | 5 | 1087 | 2.9 | 2.5 |
| Korea, Republic of | 1 | 564 | 6 | 4954 | 3.0*/ | 8 |
| Mexico | – | – | 2 | 1308 | – | – |
| Pakistan | 1 | 125 | – | – | 0.03 | 0.3 |
| Philippines | – | – | 1 | 621 | – | – |
| Yugoslavia | – | – | 1 | 632 | – | – |
| **Others** | | | | | | |
| South Africa | – | – | 2 | 1843 | – | – |
| Total | 233 | 119000 | 225 | 204000 | 643 | 10 |

*/ Estimates.

Reference: Power reactors in Member States, IAEA, 1979 Edition.
Note: Nuclear programmes in Austria and in Iran have been interrupted and the plants are not included.

52. The uncertainties mentioned above make it very difficult to forecast growth rates for either electricity consumption or nuclear power. INFCE Working Group 1's projections for 1985 and 2000 are presented in Table 3, together with Agency statistical data through 1980.

Table 3

Installed total electric and nuclear capacity
(in thousands of MW(e))

| | 1978[a/] | 1979[a/] | 1980[a/] | 1985[b/] | 2000[b/] |
|---|---|---|---|---|---|
| Electric | 1830 | 1900 | 2030 | 2450–2850 | 5230–6200 |
| Nuclear | 103[c/] | 119 | 149 | 290– 350 | 1080–1650 |
| Share of nuclear (%) | 5.8 | 6.4 | 7.3 | 12 | 20– 27 |

a/ Figures based on Agency data.
b/ Figures based on INFCE Working Group 1 projections.
c/ In commercial operation.

53. It will be seen that nuclear power's share of the world's total electrical generating capacity may treble or quadruple by the end of the century.

Nuclear power costs

54. Recent increases in the price of oil, now approximately US $30 per barrel, have considerably improved the competitive position of nuclear power. It is expected that the improved competitive position will be maintained as long as uranium and enrichment prices remain stable in constant money terms and the capital investment costs of nuclear power plants do not rise faster than those of conventional plants.

55. In recent years, the costs of nuclear and conventional plants have risen in roughly the same proportions, largely because increasingly stringent environmental standards are being applied to both types. The Agency will issue a report on this subject in 1980.

Table 4[a]

Reasonably assured and estimated additional uranium resources[b]
(thousands tonnes U)

| | Reasonably Assured | | Estimated Additional | |
|---|---|---|---|---|
| | $80/kg U ($30/lb $U_3O_8$) | $130/kg U[c] ($50/lb $U_3O_8$) | $80/kg U ($30/lb $U_3O_8$) | $130/kg U[c] ($50/lb $U_3O_8$) |
| **North America** | **752** | 976 | **1145** | **1904** |
| USA | 531 | 708 | 773 | 1158 |
| Canada | 215 | 235 | 370 | 728 |
| Mexico | 6 | 6 | 2.4 | 2.4 |
| Greenland | 0 | 27 | 0 | 16 |
| **Africa** | 609 | 776 | 139 | 263 |
| South Africa | 247 | 391 | 54 | 139 |
| Niger | 160 | 160 | 53 | 53 |
| Namibia | 117 | 133 | 30 | 53 |
| Algeria | 28 | 28 | 0 | 5.5 |
| Gabon | 37 | 37 | 0 | 0 |
| Central African Republic | 18 | 18 | 0 | 0 |
| Zaire | 1.8 | 1.8 | 1.7 | 1.7 |
| Somalia | 0 | 6.6 | 0 | 3.4 |
| Egypt | 0 | 0 | 0 | 5 |
| Madagascar | 0 | 0 | 0 | 2 |
| Botswana | 0 | 0.4 | 0 | 0 |
| **Australia** | **290** | **299** | 47 | 53 |
| **Europe** | 66 | **391** | 49 | 98 |
| France | 39.6 | 55.3 | 26.2 | 46.2 |
| Spain | 9.8 | 9.8 | 8.5 | 8.5 |
| Portugal | 6.7 | 8.2 | 2.5 | 2.5 |
| Yugoslavia | 4.5 | 6.5 | 5 | 20.5 |
| Turkey | 2.4 | 3.9 | 0 | 0 |
| UK | 0 | 0 | 0 | 7.4 |
| Germany, Federal Republic of | 4 | 4.5 | 7 | 7.5 |
| Italy | 0 | 1.2 | 0 | 2 |
| Austria | 1.8 | 1.8 | 0 | 0 |
| Sweden | 0 | 301 | 0 | 3 |
| Finland | 0 | 2.7 | 0 | 0.5 |
| **Asia** | **40** | **46** | **1** | **24** |
| India | 29.8 | 29.8 | 0.9 | 23.7 |
| Japan | 7.7 | 7.7 | 0 | 0 |
| Korea, Republic of | 0 | 4.4 | 0 | 0 |
| Philippines | 0.3 | 0.3 | 0 | 0 |
| **South America** | 97 | **102** | 99 | **105** |
| Brazil | 74.2 | 74.2 | 90.1 | 90.1 |
| Argentina | 23 | 28.1 | 3.8 | 9.1 |
| Chile | 0 | 0 | 5.1 | 5.1 |
| Bolivia | 0 | 0 | 0 | 0.5 |
| Total (rounded) | 1850 | 2590 | 1480 | 2450 |

[a] This table does not give figures for countries with centrally planned economies.
[b] Data available on 1 January 1979.
[c] Includes resources at $80/kg U level.

56. The economic and technical status and prospects for the use of small and medium-sized power reactors, especially for the production of electricity and process heat, was reviewed at an advisory group meeting held in October at Cadarache, France.

57. In 1979, the Agency provided training in the planning of electrical power system expansion and in the economic evaluation of different nuclear power plant types. The Agency is steadily improving two of the analytical tools which can help Member States in this regard – namely, the energy and economic data bank and a set of computer programs for the planning of power system expansion.

58. As part of its contribution to the International Nuclear Fuel Cycle Evaluation (INFCE), the Agency developed a comprehensive computer model of the nuclear fuel cycle which will permit assessment of the impact of future nuclear power growth, with different combinations of reactor type and fuel cycle, on the demand for nuclear raw materials and fuel cycle services.

## Uranium resources

59. The joint NEA/IAEA Steering Group and Working Party on Uranium Resources completed their work on the latest issue of the report "Uranium Resources, Production and Demand", which was published early this year.

60. Table 4 shows reasonably assured and estimated additional resources as at 1 January 1979 and Figure 5 shows the relative growth of low-cost reasonably assured resources, as reported in "Uranium Resources, Production and Demand", since 1965. As indicated in Figure 6, peak production from known resources should occur in the mid-1990s. In view of the long lead-times for establishing new production centres (often up to 15 years), efforts to expand the known resource base should be undertaken as soon as possible.

61. In 1979, the Agency established a computerized data base containing regional geology, uranium exploration, uranium deposit and national uranium statistics; the data base is known as the International Uranium Geology Information System (INTURGEO). The Agency sponsors six continuing working groups on uranium geology to obtain up-to-date information on the source, genesis and deposition of uranium. In addition, the Agency sponsors, jointly with NEA, eight research and development working groups with a view to improving the methodologies, geological concepts and equipment used in uranium exploration.

62. For the past four years, the help that the Agency is giving to Member States in uranium prospecting, production and ore processing has steadily expanded; in 1979, the Agency was carrying out 40 projects in 27 countries under various technical assistance programmes.

## Fuel element technology and performance

63. Several Latin American countries are engaged in or plan to begin the fabrication of nuclear fuel. To help them, the Agency held a regional seminar in Buenos Aires in November 1979. The seminar focused on basic quality assurance and quality control and reviewed the present international requirements in these areas. The Agency also held three specialist meetings during the year to help plan its activities and to identify the need for research and development work on the internal chemistry of fuel rods, power ramping and cycling and the behaviour of defective fuel.

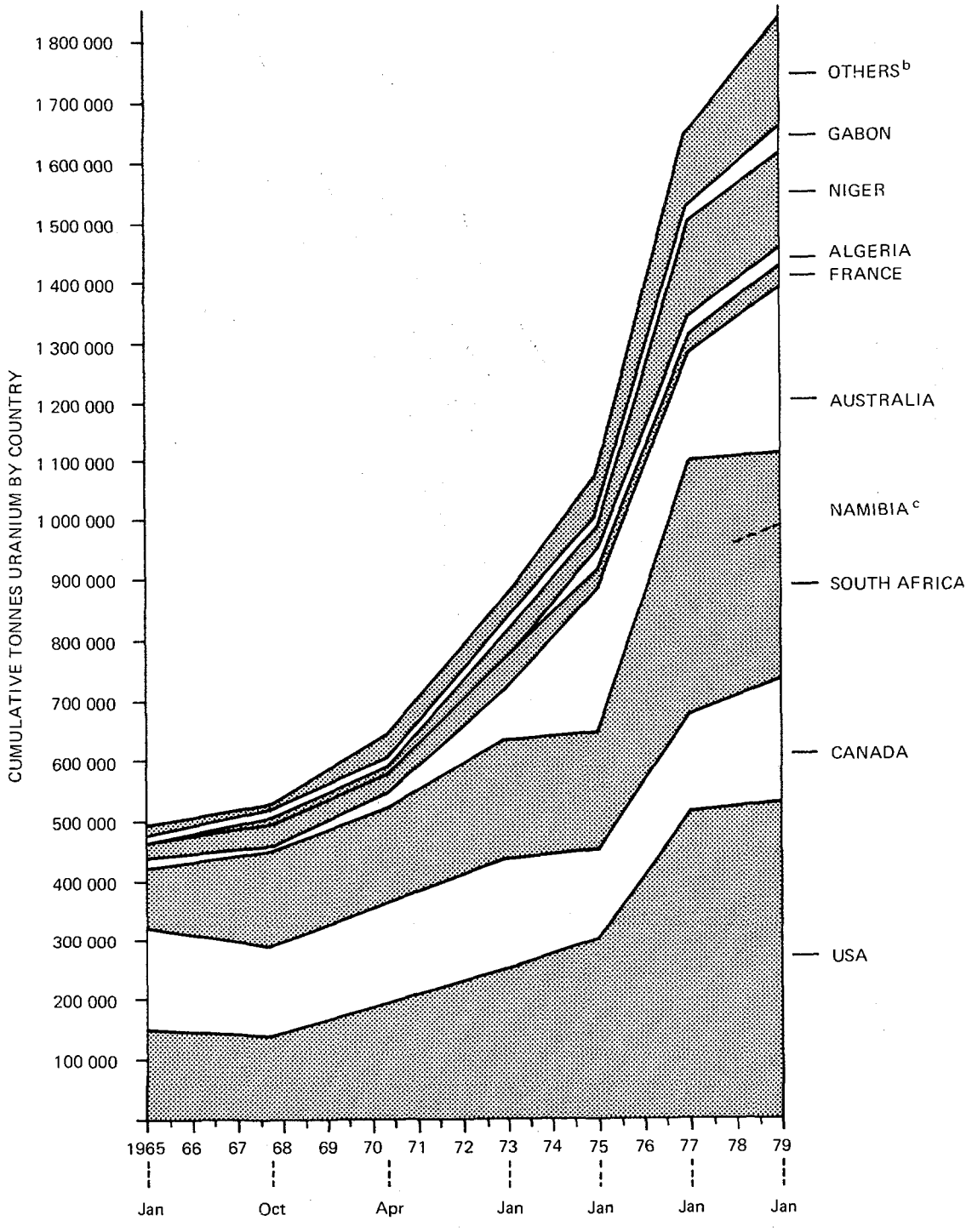
64. The Agency also gave assistance to Argentina, Brazil, Indonesia and several other Member States in developing the capacity to manufacture nuclear fuel and in defining and launching technical assistance projects in this field.

## Spent fuel storage

65. Besides the study which the Agency is making of the legal and institutional problems of international co-operation in spent fuel storage, the Agency and NEA have begun a joint research project on the behaviour of spent fuel and support equipment when stored for long periods in water-filled pools.

FIGURE 5

GROWTH OF REASONABLY ASSURED URANIUM RESOURCES [a]
(NEA/IAEA JOINT WORKING PARTY ON URANIUM RESOURCES)



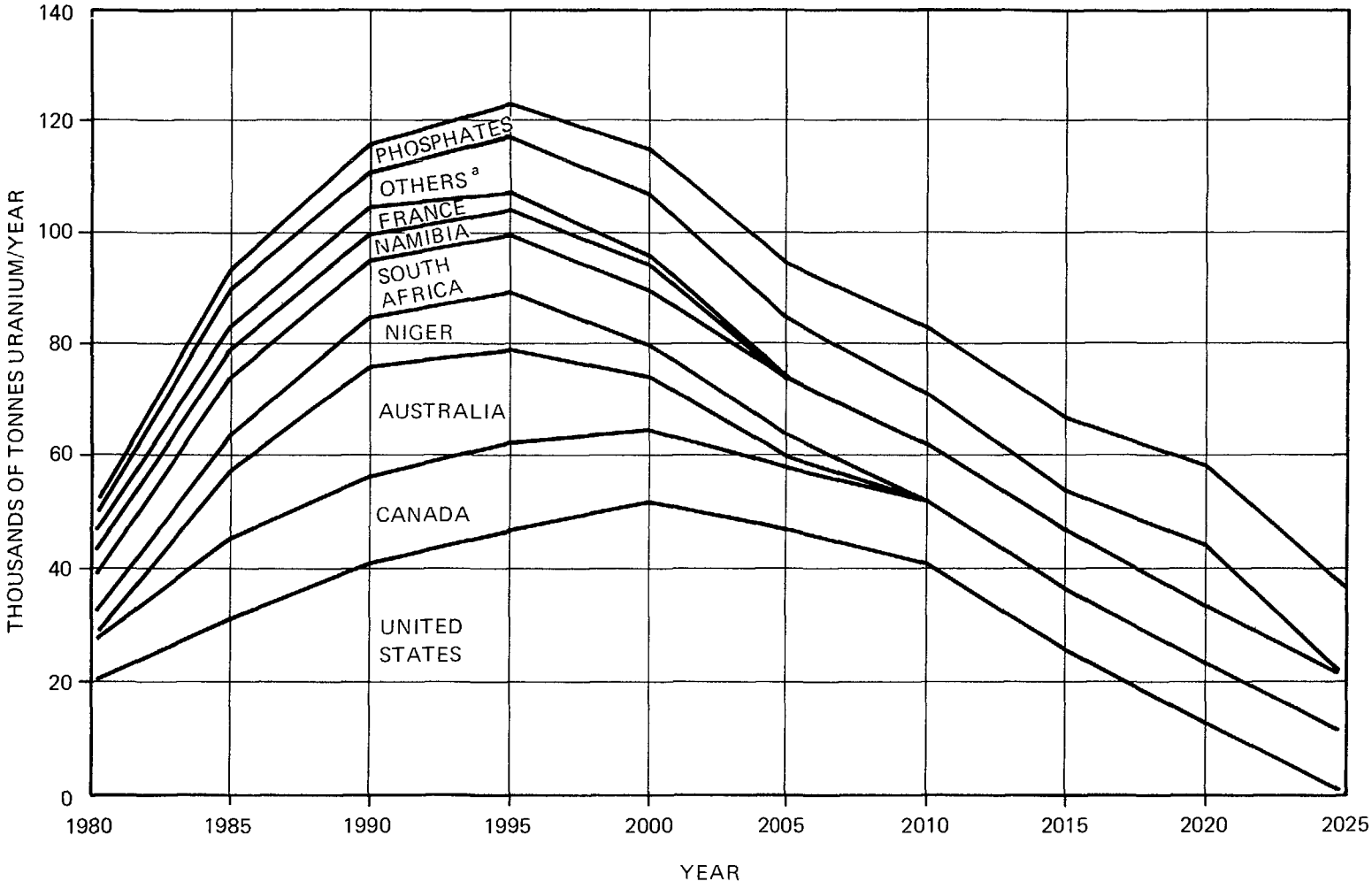

[a] In following production cost categories: 1965, 1967, 1970 at \$10/lb $U_3O_8$ (\$26/kg U), 1975 at \$15/lb $U_3O_8$ (\$39/kg U) and 1977 and 1979 at \$30/lb $U_3O_8$ (\$80/kg U).

[b] Others: Argentina, Austria, Brazil, Central African Republic, Federal Republic of Germany, India, Italy, Japan, Mexico, Morocco, the Philippines, Portugal, Spain, Turkey, Yugoslavia, Zaire.

[c] Namibia's reserves are distinguished from South Africa's in the reporting period indicated.

FIGURE 6

PROJECTION OF MAXIMUM ANNUAL PRODUCTION FROM KNOWN RESOURCES: 1980–2025




[a] Others: countries (plus Algeria and Gabon) listed in footnote [b] to Figure 5.

Manpower development

66. Developing countries introducing nuclear power usually need substantial numbers of trained personnel to cope with an advanced and demanding technology, and it has been an important responsibility of the Agency to help meet this need. During 1979, the Agency held seven interregional training courses – in France, the Federal Republic of Germany, Spain and the United States of America. Two hundred participants from developing countries took part in the courses, and by the end of 1979 a total of 730 persons had taken part over the years in the Agency's training courses in the field of nuclear power. Six of the seven 1979 courses focused on special aspects of nuclear power plant safety such as the siting of plants, safety analyses, quality assurance, operational safety and reliability.

67. The Agency completed work on a guidebook – to be published this year – on manpower requirements for nuclear power programmes. The guidebook drew considerably on the information presented at an international symposium which the Agency held on this subject at Saclay, France, in April 1979.

68. Participants in a seminar on nuclear power plant operation and maintenance in developing countries, held in November 1979 at Kalpakkam, India, were able to exchange information about their experience in this field and discuss staffing and other problems.

Improvements in reliability

69. The 1978 Annual Report on Operating Experience with Nuclear Power Plants showed that the average load factor for 156 nuclear power plants during that year was 67%.

70. During 1979, the Agency held working groups on the reliability of reactor pressure components and on nuclear power plant control and instrumentation; a guidebook is being prepared on the latter subject. The Agency published, under the NUSS programme, a code of practice for quality assurance.

Advanced reactors

71. In comparison with thermal reactors, fast breeders will utilize available uranium resources better by a factor of 100 and high-temperature reactors allow the use of nuclear energy in steel-making, coal gasification and coal liquefaction and also offer some improvement in fuel economy. Agency Member States that have experience with advanced nuclear power reactors exchange information through the Agency's International Working Group on Fast Reactors (IWGFR) and International Working Group on High-Temperature Reactors (IWGHTR). From reports given at meetings of these working groups it is clear that experience in operating experimental fast breeder plants continues to be quite satisfactory. The Prototype Fast Reactor (PFR) in the United Kingdom has operated at an overall availability of 71% since it reached criticality in 1974. In France, the Super-Phénix (1200 MW) FBR is nearing completion and is expected to go on line in 1983. The SNR plant (300 MW) in the Federal Republic of Germany and the BN-600 fast breeder reactor in the Soviet Union are expected to be completed in 1984 and 1980, respectively. Progress in the fast breeder field has been influenced not so much by the rate at which it has been possible to solve technological problems as by political factors.

72. In the area of high-temperature reactors, the THTR-300 plant in the Federal Republic of Germany was 70% complete by the end of 1979 and is expected to start operation in 1983. The Fort Saint Vrain reactor (330 MW) in the United States was modified in 1979 and full-power operation is expected in 1980. The IWGHTR paid particular attention during the year to critical heat exchanger technology in relation to the use of process heat in industry. The group plans to give special consideration in future to the safety of HTRs.

Nuclear explosions for peaceful purposes (PNE)

73. Work is in progress on an English-French-Russian-Spanish glossary of PNE terms to be published in 1980. Also, work continued on a PNE bibliography for the period 1969–1979.

Nuclear power plant safety

74. The accident at the Three Mile Island nuclear power plant underscored the importance of the Agency's work in nuclear power reactor safety. All documentation on the accident which the Agency has received has been collated to facilitate its distribution to the regulatory bodies in developing and other countries engaging in nuclear power programmes.

75. Shortly after the accident, the Director General invited ten leading experts in industrial and nuclear power plant safety to make a preliminary evaluation of the accident's implications for the Agency's programme. The experts' main recommendation was that the Agency should play an increasingly important role in nuclear power plant safety, principally through:

- The active sponsorship of, and participation in, symposia and specialized meetings related to the consequences of the accident;
- The preparation of additional specialized safety guides within the framework of the NUSS programme;
- A more active role in safety research and development activities, particularly the collection, review, evaluation and distribution of information;
- A general increase in the advisory and technical assistance activities relating to nuclear safety; and
- An increase in the Agency's ability to provide emergency help in the event of nuclear accidents.

76. To implement the experts' recommendations the Board subsequently approved a supplementary nuclear power safety programme, to be supported by voluntary contributions from Member States until its integration with the regular nuclear safety programme in 1981; also, the first steps were taken in preparing an international conference on current nuclear power plant safety issues to be held in Stockholm in October 1980. The Agency established an advisory group on emergency preparedness and issued a preliminary document on planning for off-site response to radiation accidents at nuclear facilities.

77. The expert group also recommended that Member States:

- Adopt policies to ensure that results of safety research are made available more freely and quickly to other Member States;
- Require that an adequate accident emergency plan exist before permitting the sale or purchase of a nuclear power plant;
- Enter into bilateral, multilateral or regional agreements to facilitate mutual assistance in the event of an emergency;
- Test periodically their own emergency plans; and
- Request the Agency to check their safety activities more routinely and take action on the recommendations that are made by the Agency.

78. The group considered that the Agency had shown foresight in establishing the NUSS programme, which provides a sound basis for guidance in the field of safety. In the six years of this programme, five codes of practice and ten safety guides have been published. In addition, 39 of the 45 safety guides originally envisaged have either been completed or are being prepared. Plans were made during the year for future activities within the framework of the NUSS programme: the preparation of additional safety guides (six to eight), the revision at an appropriate time of certain codes and guides, and a programme to assist Member States in implementing the NUSS documents. Consideration was also given to the development of codes and guides for other fuel cycle facilities and for fast breeder reactors.

Advisory services and training

79. The Agency assisted in the safety evaluation of the Lemoniz nuclear power plant in Spain and siting evaluations for nuclear power plants in Egypt and Malaysia; also, it sent advisory missions to research reactor centres in Indonesia and Zaire. The Agency gave advice to Niger on radiation protection in respect of uranium mining and milling and helped in formulating national regulations.

80. A training course devoted entirely to the safety evaluation of nuclear plants was held in the Republic of Korea. Medical and radiological aspects of emergency preparedness for radiological accidents were covered in lectures presented at a training school in Hungary.

Radiological safety

81. The Agency continued work on revising its Basic Safety Standards for Radiation Protection (Safety Series No.9) in accordance with the 1977 recommendations of the International Commission on Radiological Protection (ICRP). The standards cover fundamental legal requirements and give guidance on limiting radiation doses. A seminar was held to collect information on the practical implications of the new ICRP recommendations and to review a draft revised version of the Basic Safety Standards, which was subsequently sent to Member States for further comment.

82. The Agency continued preparatory work on a comprehensive review of the Agency's Regulations for the Safe Transport of Radioactive Materials, which have been adopted in most parts of the world. The basic radiation protection and safety principles on which the regulations are based were reviewed and re-evaluated in an effort to determine the degree of safety which they provide. In response to an invitation from the Agency, Member States submitted more than 100 separate proposals for changes in the Regulations, which are to be re-issued in 1983. Work began on the collection of information on the global volume of traffic in radioactive materials by all modes of transport and on accidents which may have occurred. Other activities included the convening of an advisory group on transport package test standards.

83. The Agency and NEA held a symposium, at Los Angeles, on occupational radiation exposure in nuclear fuel cycle facilities. The participants paid particular attention to those activities in which exposure is highest and to techniques which have been successfully used in minimizing both individual and collective doses. Information was presented on changes in occupational exposure during the life-time of individual nuclear power plants. One report showed that the exposure of personnel to radiation in fuel reprocessing plants is similar to that in nuclear power plants. Relevant documents issued during the year included the following:

(a) Radiological Surveillance of Airborne Contaminants in the Working Environment;

(b) Code of Practice on Basic Requirements for Personnel Monitoring; and

(c) Manual on Decontamination of Surfaces.

Waste management and disposal

84. The Agency continued to review technologies for the safe handling and treatment of radioactive waste and effluents, in particular by holding expert meetings on:

(a) The retention of gaseous radionuclides at nuclear power plants under normal and accident conditions;

(b) Techniques for the conditioning of low- and intermediate-level waste concentrates and the treatment of solid waste; and

(c) Practices for the stabilization of uranium mill tailings.

85. In March, the Agency and NEA held a symposium, at Zürich, on the on-site management of power reactor wastes.

86. Technical reports on the following subjects were published or prepared for publication:

(a) Characteristics of solidified high-level waste products;

(b) Handling and storage of high-level radioactive liquid waste requiring cooling;

(c) Storage, handling and movement of fuel and related components at nuclear power plants;

(d) Safe handling of radioactive waste at nuclear power stations;

(e) Handling of tritium-bearing waste;

(f) Techniques for radioiodine removal from nuclear facilities; and

(g) Removal and storage of krypton-85.

87. Under a comprehensive programme on the underground disposal of radioactive waste launched in 1977, a series of documents is being prepared on generic, regulatory, and safety assessment activities, waste repository siting, waste acceptance, the design and construction of repositories, and the operation and shut-down of repositories for the various underground disposal methods of interest. During 1979, the work concentrated on site investigations and safety assessment methods. Reports are in preparation on:

(a) Basic guidance for underground disposal;

(b) Guidance for disposal in shallow ground;

(c) Regulatory procedures for deep geological disposal;

(d) Site investigations for deep geological disposal and disposal in shallow ground; and

(e) Safety assessment methods.

88. The Agency and NEA held an international symposium on the underground disposal of radioactive waste at Otaniemi, Finland, in July. It resulted in an authoritative account of the status of underground disposal programmes throughout the world.

89. The Agency prepared guidelines for selecting, managing and surveying ocean dumping sites and reviewed the packaging requirements for deep ocean dumping. It also studied the problems arising in the establishment of exemption limits below which small ("de minimis") quantities of radioactive material may be dumped at sea without a special permit. The Agency recommended to the Contracting Parties to the Convention for the Protection of the Mediterranean Sea against Pollution (the Barcelona Convention) that they adopt the Agency's Revised Recommendations of 1978 as a basis for implementing the Protocol for the Prevention of Pollution of the Mediterranean Sea by Dumping from Ships and Aircraft; the Agency's Revised Recommendations were prepared for the purposes of the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (the London Dumping Convention).

## Environmental protection

90. Work in 1979 centred on the comparison, in co-operation with UNEP, of environmental impacts of nuclear energy with those of other energy sources.

91. A draft report on generic models and data for predicting environmental transfer of radionuclides to man was prepared and a report issued on methodology for assessing impacts of radioactivity on aquatic ecosystems. The Agency's environmental protection programme was reviewed by an advisory group, which recommended that further emphasis be placed on environmental aspects of radioactive waste disposal and the release of radioactive effluents.

Risk assessment

92. During 1979, the Secretariat tested a questionnaire designed to provide a detailed analysis of public attitudes towards nuclear power and other sources of energy. The tests, made with the co-operation of authorities and institutes in Brazil, the Federal Republic of Germany, Japan and the Philippines, showed the usefulness of the questionnaire in very different circumstances, and preparations were made for using it on a large scale in 1980 and 1981.

93. The Agency's work on the comparative risks of various energy sources has been presented in several publications and international conferences. One of the main problems has been uncertainties in the data on the risks entailed in the use of fossil fuel, about which far less is known than about the effects of using nuclear energy; the Agency is studying ways of dealing with such uncertainties. A new method has been developed for evaluating the cost-effectiveness of measures to reduce risks in such a way that one can avoid defining cost-effectiveness in monetary terms (for example, the United States dollar cost of each reduction by one man-rem).

## FOOD AND AGRICULTURE

### General

94. The joint FAO/IAEA programme on food and agriculture is designed to help developing Member States to apply isotope and radiation techniques in research and development in order to increase agricultural production, improve food quality, reduce post-harvest losses and minimize pollution of food and the environment. The activities under this programme embrace: plant breeding and genetics; soil fertility, irrigation and crop production; insect and pest control; chemical residues and pollution; animal production and health; and food preservation.

95. In 1979 over 80 technical assistance projects were supported in more than 40 developing Member States, and more than 200 laboratories and other institutes participated in 25 co-ordinated research programmes sponsored by the Agency.

### Insect control

96. The Mediterranean fruit fly (medfly) has established itself in Guatemala and, during the past year, invaded the southern part of Mexico [2]. The Agency has continued to assist Mexico in its campaign against the medfly, furnishing expert help in mass-rearing, sterilization, packaging, insect release and quality control, and providing training. Mass-rearing facilities that make use of techniques developed at the Agency's Laboratory are now operational at Tapachula, Mexico.

97. The Vom project in Nigeria [3], aimed at controlling/eradicating a riverine species of the tsetse fly by means of the sterile-insect technique, has continued to receive support from Belgium, the Federal Republic of Germany and the United Kingdom.

### Improving crop production

98. The co-ordinated research programme on micronutrients in rice production has been completed [4]. The principal results include the evaluation of the residual effects of zinc fertilizers on successive rice crops and an assessment of optimum rates of application, the most efficient source and the most efficient placement technique for zinc fertilizers in the case of flooded rice.

99. The Agency has sponsored a new co-ordinated research programme on isotope and radiation techniques for the efficient use of water and fertilizer in semi-arid regions. Research contracts and agreements have been awarded to 12 Member States for the implementation of this programme.

100. The co-ordinated research programme started in 1978 with Swedish support, and dealing with the biological fixation of atmospheric nitrogen by crops is now being carried out by laboratories in 19 Member States.

101. The Agency has also started a new co-ordinated research programme on multiple cropping systems. It is designed to determine the most efficient use of nitrogen and phosphorus fertilizer in combined non-legume and legume cropping systems.

102. A research co-ordination meeting was held in Kuala Lumpur for workers involved in projects aimed at increasing the production of pulses by the genetic improvement of grain legume varieties. A number of such projects are being carried out in South East Asia, where pulses constitute a very important part of the diet, under the Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (RCA).

103. To familiarize agricultural researchers from the developing countries with the use of nuclear techniques and of induced mutations in plant genetics and breeding, the Agency organized a study tour in Czechoslovakia, the German Democratic Republic and Poland. Also, it conducted a regional training course, in Jakarta, on the use of induced mutations in plant breeding.

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[2] GC(XXIII)/610, para.101.
[3] Ibid, para.102.
[4] Ibid, para.105.

Animal production and health

104. The Agency and FAO are endeavouring to improve animal production through co-ordinated research programmes on the detection of mineral imbalances in livestock, on the measurement of hormone (particularly progesterone) patterns in cattle and other ruminants by radioimmunoassay in plasma and milk, and on the nutritive value of low-quality roughages and agro-industrial by-products for cattle.

105. The co-ordinated research programme on the water needs of grass-eating animals in the tropics has been completed [5]. It focussed on water use in relation to the production of meat and milk in cattle, sheep and goats, elucidating many of the mechanisms by which grazing ruminants conserve water, and on the relationships between food intake, temperature regulation and water use. The programme was supported by Sweden.

106. To study and control parasitic diseases the Agency began co-ordinated research programmes on:

(i) the pathological and immunological effects of tick-borne diseases and the vaccination potential of irradiated infective red cells; and

(ii) some parasitic diseases of buffalo suspected of causing mortality in new-born and young calves (for example, Neoascaris vitulorum).

107. The interaction between breed or strain of animal and resistance or tolerance to parasitic infection and the influence of nutrition on this interaction are of particular importance in this sector of animal health.

Protection of the environment

108. Work continued in 1979 on the use of nuclear techniques in protecting food and the environment against chemical and radioactive contaminants [6].

109. The Agency started three co-ordinated research programmes: on the problems created by "bound" pesticide residues; on improving the utilization of agricultural residues; and on the use of herbicides and related chemicals in achieving the best use of the nitrogen in the soil.

Food preservation

110. By the end of last year, 28 irradiated foods had been given public health clearance (limited or unlimited) in 20 countries. At the International Facility for Food Irradiation Technology (IFFIT) in Wageningen, the Netherlands, training was given in food irradiation and technological and economic feasibility studies were carried out on a pilot scale.

111. The Agency, supported by the Government of Japan, held an RCA workshop at five Japanese institutes engaged in food irradiation research. A meeting was held at Wageningen on technological and economic aspects of irradiating various fruits and vegetables; an earlier co-ordinated research programme had helped to develop methods for inhibiting sprouting in potatoes, onions and garlic and for delaying the ripening of sub-tropical fruits.

112. The Codex Alimentarius Commission of the Joint FAO/WHO Food Standards Programme adopted the "Recommended General Standard for Irradiated Foods and the Code of Practice for the Operation of Radiation Facilities Used for the Treatment of Foods". This standard is based on work previously done by the Agency, FAO and WHO.

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[5] Ibid, para. 114.

[6] Ibid, para. 116.

## General

113. The Agency's work in this area is aimed at (i) promoting practical applications of radiation and radioisotopes of benefit to human health and an understanding of the associated biological hazards, and (ii) co-ordinating the efforts of scientists concerned with such applications in Member States. More specifically, the Agency is supporting the development of techniques which can be applied in medicine, biology and health-related environmental research and promoting improved reliability and accuracy in radiation dosimetry. Close collaboration with WHO is maintained in much of this work.

## Medical applications of radionuclides

114. The Agency undertook a six-month survey of the state of maintenance of nuclear medicine instruments in about 100 nuclear medicine laboratories in ten countries of Latin America, and a similar survey was started in seven countries in Africa. The Agency launched, under the Regional Co-operative Agreement (RCA), a project to improve maintenance procedures for nuclear instruments in eight countries of South East Asia.

115. The use of improved radioimmunoassay and related procedures for the in vitro assay of biologically active substances has been encouraged through the Agency's research contract and technical assistance programmes. The preparation of reference materials for a co-ordinated research programme on quality control in assays of thyroid-related hormones is almost complete. The Agency held a training course on in vitro assay techniques in Sri Lanka.

116. Efforts were made to up-grade procedures used in the in vivo application of radionuclides in developing countries. The Agency held a training course and study tour on such applications in the Soviet Union.

117. The use of nuclear techniques in the study of biologically important trace substances continued to receive support. Under a joint IAEA/WHO research programme, eight laboratories in seven Member States are applying such techniques in studies on the role of trace elements in human nutrition, with special reference to human milk.

## Dosimetry for radiation applications

118. The IAEA/WHO network of secondary standard dosimetry laboratories (SSDLs) has become an internationally recognized institution. In this network a total of 42 member laboratories, mainly in developing countries, are supported by twelve national standardizing laboratories and five international organizations. Visiting experts and Agency staff carried out dose calibration intercomparisons at six SSDLs in Latin America and four SSDLs in the Far East.

119. Some 120 dose intercomparisons were performed under the IAEA/WHO cobalt-60 postal dose intercomparison programme. In addition, trial intercomparisons were conducted in respect of medium-energy X-rays and high-energy photon and electron radiations.

120. The Agency plans to organize a high-dose intercomparison service for industrial radiation plants. In preparation for this, a pilot study was undertaken to select a suitable dosimetry system.

## Radiation biology

121. The biological implications of radionuclides released from nuclear industries were reviewed at a symposium held in Vienna in March 1979. The data presented at the symposium indicated that, with current radiation protection standards and practices, the biological impacts of potential exposure to low levels of radionuclides in effluents from nuclear industries are unlikely to result in measurable harm.

122. On the basis of the results of an earlier co-ordination research programme, which showed that irradiated vaccines offer promise in the treatment of some parasitic diseases, a new programme was started in 1979; an advisory group reviewed the status of work on developing irradiated vaccines.

123. The co-ordinated research programme on the use of modifying agents, especially anoxic sensitizers, in cancer therapy [7] was reviewed at a meeting of participating laboratories. A few radiosensitizers which showed promise in clinical trials were reported on; the collection of further data is in progress.

Health-related environmental research

124. The Agency continued its support of research on the use of nuclear techniques in monitoring human exposure to toxic trace elements. A co-ordinated research programme on the development of nuclear techniques for the analysis of trace elements in human hair was replaced in 1979 by a programme under which these techniques are being tested in a number of Member States.

125. A pilot project, organized under RCA and involving the study of human contamination with potentially toxic trace elements, continued with the Agency's support.

[7] GC(XXIII)/610, para.132.

## Physics

126. The International Tokamak Reactor (INTOR) workshop group, which met four times in Vienna, produced a thorough assessment of the data base for the tokamak approach to controlled fusion reactors. The INTOR project was organized, on the recommendation of the International Fusion Research Council (IFRC), to enable a response to be made to a proposal from the Soviet Union that the next significant advance in tokamak research be made through international co-operation under the aegis of the Agency. The group defined a set of parameters as guidelines for a continuing sequence of conceptual and preliminary designs.

127. Four technical committee meetings concerning the most important areas of fusion research were held and such topics as disruptive instabilities in tokamaks, the plasma physics of intense neutral beam heating in tokamaks, advances in inertial confinement systems, and sources and effects of impurities in fusion reactors were discussed. A consultants' meeting on the exchange of computer codes for fusion research was also convened. A co-ordinated research programme involving laboratories in both advanced and developing countries in an investigation of materials for fusion reactors was brought to a successful close; the results were discussed at a meeting held in April this year, in conjunction with an international meeting in the Federal Republic of Germany on plasma surface interactions.

128. Recent advances made in basic research on fission processes and mechanisms were summarized at the fourth Symposium on the Physics and Chemistry of Fission, sponsored by the Agency. Work on the development and application of nuclear techniques suitable for laboratories in developing countries continued.

129. Activities relating to research reactors focused on two main subjects: (i) improved approaches to research reactor utilization; and (ii) research reactor core conversion from highly enriched to low-enriched nuclear fuel. A guidebook on core conversion has been prepared.

## Industrial applications and chemistry

130. Under the Regional Cooperative Agreement (RCA) the Agency will carry out a large-scale UNDP project in a number of Asian and Pacific countries to demonstrate the industrial uses of radioisotopes in major industries (for example, the rubber, plastics, paper, steel, tin-mining and wood industries). Preparation of this project began in 1979. In the field of chemistry, work concentrated on methods for producing and separating high-priority isotopes, chemical thermodynamics, chemical standards, and nuclear analytical techniques for the analysis of nuclear materials (including training in the use of such techniques in safeguards). The Agency also studied means whereby stable isotopes and cyclotron products could be made more readily available at economic prices and in accordance with specifications.

## Isotope hydrology

131. Consultancy and isotope analysis services were provided to the United Nations Department of Technical Co-operation for Development, FAO and UNICEF in connection with large-scale groundwater projects carried out under sub-contracts and focusing on estimations of the origin and mechanism of groundwater recharge in Afghanistan, Argentina, Greece, the Libyan Arab Jamahiriya, Qatar and Turkey. Similar assistance was furnished directly by the Agency to Cyprus, Italy, Mexico, Sri Lanka and the United Republic of Tanzania.

132. Advances made in methods of measuring natural levels of tritium in water and the applicability of new isotope-based methods in dating very old groundwater were reviewed; the latter subject is of particular importance in assessing the suitability of sites for the long-term storage of radioactive waste.

## Nuclear data

133. The Agency continued to provide nuclear data services to developing countries; in response to 246 requests for nuclear data and documents received in 1979, it distributed over 36 800 numerical data sets, comprising 7 700 000 data records and 182 documents and reports, to scientists in 25 Member States. In support of nuclear data measurements in developing countries, the Agency concluded two new contracts for the supply of targets and samples to scientists in

Egypt and Pakistan. Also, it continued its support of four other projects – in Bangladesh, Hungary and Romania – related to the collection of data important in reactor design and safeguards.

134. The requirements for and status of delayed-neutron data important for reactor operation and safety and of transactinium isotope nuclear data important for safe nuclear waste management were reviewed at two specialist meetings. The Agency co-operated in the Fifth International Conference on Nuclear Cross-Sections for Technology, organized by the United States Department of Energy and held in Knoxville, Tennessee, in October.

135. The Agency continued its support of two co-ordinated research programmes aimed at improving actinide nuclear physics data needed for the calculation of actinide build-up in nuclear fuel, for safeguards and for the preparation of radioisotope standards.

136. A cumulative issue of CINDA (the basic international index of all measured, calculated and evaluated neutron reaction data) covering the years 1935–76 was published. The latest version of the world request list (WRENDA 79–80), which contains in condensed form a total of 1780 requests for specific measurements and evaluations of nuclear data required for fission and fusion reactor development and for nuclear material safeguards, was also published.

137. In addition to issuing the quarterly periodical "International Bulletin on Atomic and Molecular Data for Fusion", the Agency prepared "CIAMDA", a computerized index to the literature on atomic and molecular collision data relevant to fusion, for publication this year; the index contains approximately 13 000 literature references and covers the years 1950–79.

## THE LABORATORIES

### Seibersdorf Laboratory

#### Agriculture

138. The Laboratory's activities consisted chiefly of analytical services and research in support of research contracts and technical assistance, and programmes of training in the efficient use of fertilizers, plant breeding and entomology. Wheat lines having a high protein content were selected and are being tested in the field. Fertilizer application practices which entail a minimum loss of fertilizers in the soil and maximum uptake by crops were demonstrated. A field method was developed for testing cultivation practices which may lead to better biological fixation of atmospheric nitrogen by peas and beans. The Laboratory developed improved methods for mass-rearing the Mediterranean fruit fly (medfly), in support of a large-scale technical assistance project in Mexico, and also supported the tsetse fly project being carried out at Vom, Nigeria. In particular, it perfected handling techniques to facilitate mass-rearing and artificial feeding techniques using freeze-dried blood.

#### Medical Applications Laboratory

139. The Medical Applications Laboratory moved to new premises in the recently completed Dosimetry and Medicine Annex of the Seibersdorf Laboratory. In support of a programme on instrumentation for nuclear medicine, an automatic well-type scintillation counter with a sophisticated data processing capability was constructed and transferred to a laboratory in a developing country for field testing. Two WHO/IAEA co-ordinated research programmes in which neutron activation analysis and other techniques are being applied in the determination of trace elements in bio-medical samples were supported; the Medical Applications Laboratory serves as a receiving and distribution centre for such samples and is also responsible for data collection and analytical quality control. In addition, the Laboratory provided various other analytical quality control services in response to some 50 requests.

#### Chemistry

140. During 1979 the Laboratory distributed 613 sub-samples of reference materials and 204 sub-samples of inter-comparison materials to 307 institutes in 56 Member States participating in the Analytical Quality Control programme. It carried out a total of 529 determinations on 270 samples, mainly uranium and low-level plutonium.

#### Metrology

141. The Laboratory is evaluating the advantages and disadvantages of various computer codes for neutron flux unfolding used in the interpretation of experimental data. Also, it participated in an intercomparison of high-precision germanium-lithium gamma spectrometry and associated computer evaluation programmes involving 78 laboratories in Member States.

#### Safeguards Analytical Laboratory (SAL)

142. The Agency installed and tested the facilities needed for the full use of SAL in analyzing all fuel samples collected at safeguarded facilities. It is hoped that full operation under an agreement with Austria will start this year.

143. SAL analyzed 430 uranium-product samples, some plutonium samples of various types and 103 samples originating from spent fuels, waste streams and plutonium-product solutions. A set of 450 mixed $^{233}U/^{242}Pu$ spikes was prepared and characterized for the 103 isotopic dilution analyses performed.

144. SAL continued its efforts to improve analytical techniques, particularly those for spent fuels and plutonium; this included the preparation of sources for alpha spectrometry and the development of software for gamma spectrometry and of routine procedures for determining impurities in uranium-bearing materials by emission spectroscopy.

145. The measurement of transuranic elements in Mediterranean seawater and biota continued. The results permitted an estimation of the mean residence time of plutonium and americium in the mixed layer (approximately 12 years for plutonium and three years for americium), thus demonstrating the different behaviour of these two elements in the water column.

146. The Laboratory studied the behaviour of transuranic radionuclides (including those characteristic of deep-sea disposal sites) in a variety of marine food chains. Transuranic elements appear to be more available for uptake from water and food than from sediments; once incorporated in tissues, their subsequent fate depends predominantly on species and to a lesser extent on environmental factors.

147. A comprehensive study of the behaviour of polonium-210 in the marine biosphere is being undertaken. Early data have confirmed that polonium-210 accounts for the major radiation dose to marine organisms. The most significant finding so far is that the hepatopancreas appears to be the organ receiving the highest dose. The results of this study are expected to be important with regard to the relative radiation hazards posed by natural and man-made radioactivity in the marine biosphere.

148. The behaviour of non-nuclear pollutants in the marine environment were studied with the financial support of UNEP and UNESCO. Contrary to earlier expectations, it was observed that heavy metal and chlorinated hydrocarbon levels in pelagic species in the open Mediterranean were similar to those in pelagic species from other oceanic regions. Biokinetic uptake and depuration experiments were performed for certain metals and chlorinated hydrocarbons. The results indicate the importance of the correct simulation of natural conditions so as to ensure the applicability of laboratory data in the natural environment.

149. During the year the main fields of research and training-for-research were as follows:

(a) Physics and energy (non-conventional energy, plasma physics and fusion);
(b) Physics and the frontiers of knowledge (elementary particles, fundamental theory and relativity);
(c) Physics and technology (atomic and molecular physics, quantum optics and condensed matter physics);
(d) Applicable mathematics (solitons, partial differential equations, spectral methods and evolution equations); and
(d) Regional activities in Asia, Europe and Latin America, organized for the benefit of scientists from developing countries.

Physics and energy

150. In 1979, the main theme of the energy programme was non-conventional energy.

151. An Autumn College on Plasma Physics, from 16 October to 23 November, dealt with important aspects of plasma physics relating to fusion, space research and astrophysics.

Physics and the frontiers of knowledge

152. Research activities relating to elementary particles, fundamental theory and relativity continued. A highlight of the year was the second Marcel Grossmann meeting, on Recent Developments in General Relativity, held in honour of the centenary of Albert Einstein's birth. In addition, in late November the Centre organized a topical meeting on confinement in field theory to bring elementary particle physicists up to date on new developments in this area.

Physics and technology

153. A Winter College on Atomic and Molecular Physics and Quantum Optics was held from 23 January to 30 March. It was divided into two parts, the first devoted to atomic and molecular physics, with emphasis on laser physics, and the second to quantum and statistical optics.

154. Research in condensed matter physics continued. In addition, two meetings were held: (i) a seminar on phase transitions and critical phenomena in solids and liquids; and (ii) a symposium on core and surface processes in condensed matter.

Applicable mathematics

155. In conjunction with a summer workshop on theoretical physics, a study group on solitons, partial differential equations and spectral methods met in July. In November a mathematics workshop was held on recent advances in evolution equation theory.

Regional activities

156. The Centre again provided guidance with regard to the annual summer college on physics and contemporary needs, held each year since 1976 in Nathiagali, Pakistan. In addition, it co-sponsored the following regional activities organized for the benefit of scientists from developing countries:

(a) Physics symposium (Dacca, Bangladesh);
(b) Seminar on Sobolev spaces and applications in fluid dynamics (Surat, India);
(c) Summer college on physics teaching at university level (Grenoble, France);
(d) Summer school on differential geometric methods in mathematical physics (Clausthal, Federal Republic of Germany); and
(e) Einstein centennial symposium on fundamental physics (Bogotá, Colombia).

157. Over 1000 scientists visited the Centre in 1979. A large proportion came from developing Member States, and some 70% of the financial resources available for scientific activities were used to support the Centre's work on behalf of scientists from these countries.

158. The Centre continued to receive financial support from the Danish Energy Agency, the Swedish Agency for Research Co-operation, the Italian National Research Council, the Italian National Institute for Nuclear Physics, King's College (London), the People's Committee of Al-Fateh University (Libyan Arab Jamahiriya), the University of Rome, the University Grants Commission of India and the Organization of American States. Also, the Centre continued to work closely with the Institute of Theoretical Physics and the Advanced School of Physics in Trieste and with the "Consorzio per l'incremento degli studi e delle ricerche" of the University of Trieste.

## SAFEGUARDS

### General

159. In 1979, as in the previous years, the Secretariat, in carrying out the safeguards programme of the Agency, did not detect any anomaly which would indicate the diversion of a significant amount of safeguarded nuclear material for the manufacture of any nuclear weapon, or to further any other military purpose, or for the manufacture of any other nuclear explosive device. In the light of the report which the Director General submitted to the Board on the implementation of safeguards in 1979, it is reasonable to conclude that nuclear material under Agency safeguards remained in peaceful nuclear activities or was otherwise adequately accounted for.

160. The considerations which led to this conclusion and certain observations to which it is subject are set forth in the Safeguards Implementation Report for 1979.

161. In addition to the extensive experience which has been gained by the Agency in safeguarding power reactors (particularly light-water reactors) the Agency is now acquiring experience in safeguarding fuel conversion and fabrication plants and in safeguarding fast breeder reactors and reprocessing plants. The Agency is testing various approaches for safeguarding the storage and the feed and withdrawal areas of enrichment plants. The practices that the Agency follows in implementing safeguards continued to improve during 1979; new techniques and approaches are being applied in order to increase the effectiveness of safeguards and the Agency is constantly endeavouring to make more efficient use of the resources available to it.

162. The Standing Advisory Group on Safeguards Implementation (SAGSI) held two meetings in 1979, during which it discussed mainly the safeguarding of fast breeder reactors and the question of a glossary of safeguards terms. At its last meeting, SAGSI reviewed its previous methods of work and made a series of recommendations concerning the manner in which it would proceed in future and the subjects which should be given priority.

### Increased safeguards coverage

163. By the end of 1979, 109 non-nuclear-weapon States were party to NPT. For 67 of these States the required safeguards agreements had been concluded and had entered into force. Of the remaining 42 parties to the Treaty, three had significant nuclear activities. Of these three parties, two (Indonesia and Venezuela) had initiated but not yet completed the procedures for bringing their agreements with the Agency into force [8].

164. In 1979, the Agency was applying safeguards in 11 non-nuclear-weapon States which were not party to NPT – namely, Argentina, Brazil, Chile, Colombia, the Democratic People's Republic of Korea, India, Israel, Pakistan, South Africa, Spain and Turkey. In seven of these 11 countries all substantial nuclear activities of which the Agency was aware were covered by a mosaic of individual safeguards agreements. In four of these 11 countries and in a fifth country, which had signed but not yet ratified NPT, unsafeguarded nuclear facilities were in operation [9]. As is indicated in the Introduction, there continued to be reports that the number of countries operating unsafeguarded facilities might increase in the near future. However, in 1979 in only three of the 11 countries was the unsafeguarded facility capable of producing weapons-grade material.

165. During 1979, as in 1978, safeguards were applied in France, the United Kingdom and the United States of America to nuclear material which was subject to safeguards under agreements with third countries and which had been returned or transferred to those three States [10]. As the Board reported last year, the agreement with the United Kingdom and EURATOM under which the Agency may apply safeguards to any material in civilian nuclear plants in the United Kingdom is in force, but the subsidiary arrangements had not been completed by the end of the year. The similar agreement with the United States of America and the agreement with France, which were approved by the Board in September 1976 and February 1978, respectively, are in the process of ratification by the States in question.

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[ 8] The third party was the "Republic of China".
[ 9] See GC(XXIII)/610, para 183.
[10] See GC(XXIII)/610, para 185.

166. By far the major part (90% of the total for plutonium and 95% of the total for uranium) of the nuclear material under safeguards was in States that had submitted all their peaceful nuclear activities to safeguards as a consequence of their being parties to NPT or the Tlatelolco Treaty. Safeguards were also being applied outside the scope of these treaties to significant facilities and material in 11 non-nuclear-weapon States, as indicated in paragraph 115 above.

167. The number of plants under safeguards increased during 1979 (see Table 5); the plants included certain facilities for which very frequent or continuous inspection was needed. The quantity of plutonium under safeguards rose by 33% to 68 t, the quantity of highly enriched uranium under safeguards increased by 1% to 11.4 t; safeguarded low-enriched uranium and source material rose by 12% and 17% respectively, to 11 714 t and 15 399 t (see Table 6).

168. These changes were reflected in a significant increase in the amount of information contained in accountancy reports submitted by States and in the work involved in processing the information. The amount of information handled was over 50% higher in 1979 than in 1978, with more than 300 000 entries concerning nuclear material movements, physical inventory details, etc. being processed.

Safeguards development and technical support

169. Safeguards approaches for sensitive facilities handling and processing plutonium and highly enriched uranium were further developed and improved. Progress was made in developing alternative safeguards approaches for uranium enrichment facilities.

170. There was also progress in developing the methodology for evaluating the effectiveness of safeguards and in working out guidelines on the design of nuclear facilities to make safeguards easier and more effective.

171. The Agency continued to assist Member States in establishing and maintaining their national systems of accounting for and control of nuclear material by conducting training courses and by giving advice in specific cases. Guidelines for States' systems of accounting for and control of nuclear material were drafted with the assistance of experts from Member States.

172. The Agency increased its support to safeguards inspectors through the provision of properly maintained and calibrated instruments for the non-destructive analysis of nuclear materials and for the application of containment/surveillance measures.

173. In December 1979, metallic safeguards seals were being fingerprinted and issued at a rate of about 600 per month. Photo developing services and photo and video unit maintenance were being provided for surveillance systems which collectively took pictures at a rate of 10 000 per day.

174. During 1979, the reliability of surveillance equipment was recognized as being of paramount importance, and a programme for its improvement was initiated with positive results.

175. NDA equipment developed for inspector use was continuously being received and in-field tested by the Agency and distributed to inspectors after training.

176. Advisory group meetings on safeguarding fuel element fabrication plants, on isotopic correlation and on spent fuel NDA assay were held at the Agency's Headquarters.

177. Progress was achieved in development programmes on the following: software for NDA data reduction; a new stabilized assay meter; advanced optical surveillance systems; a semi-automatic super 8 mm film scanner; and optical instruments for verifying the integrity of LWR spent fuel.

178. Development support programmes of Member States have continued to provide valuable help in increasing the effectiveness of safeguards.

Safeguards information treatment

179. The Advanced Safeguards Information Treatment System, based on the ADABAS data base management system, began routine test operations in parallel with the current system.

180. Over 600 000 records on nuclear material accounting, facility design and inspection data had been loaded into the data base by the end of 1979. During the year about 300 000 new records were processed and added to the data base, and over 20 000 queries were put to the system and the answers distributed to inspectors, to management and to the Safeguards Evaluation Section for incorporation in the Safeguards Implementation Report. Terminals provided as gifts in kind were installed in all regional sections in order to give inspectors direct access to the data base in respect of all data relevant to their work.

181. The computerization of inspection data was expanded to include the plans and summaries of inspection reports, the updating of book inventories, inspectors' working papers and analytical results. New inspection report formats and the associated definitions were developed, and their computerization started early this year.

182. Numerous data evaluation services were provided to inspectors in connection with tank calibration and the calibration of standards, the preparation of inspection sampling plans, evaluations of the quality of destructive and non-destructive measurements performed by inspectors, evaluations of physical inventory verification data and the application of isotopic correlation techniques.

183. An annual workshop seminar was held in order to assist Member States in preparing and transmitting to the Agency accurate and timely safeguards accounting reports; participants from over 20 countries attended. In addition, considerable effort was expended in training inspectors and personnel from States' systems of accounting for and control of nuclear material. Two advisory groups reviewed the quality of safeguards data obtained by destructive and non-destructive measurements.

Table 5

Nuclear installations under Agency safeguards or containing safeguarded material

| Nuclear installations[a] | End of 1979 | | |
|---|---|---|---|
| | NPT | Non-NPT | Total[b] |
| Facilities | | | |
| Power reactors | 94 | 23 | 117 (113) |
| Research reactors and critical assemblies | 140 | 31 | 171 (168) |
| Conversion plants | 4 | 0 | 4 ( 4) |
| Fuel fabrication plants | 28 | 5 | 33 ( 33) |
| Reprocessing plants | 4 | 1 | 5 ( 5) |
| Enrichment plants | 4 | 0 | 4 ( 3) |
| Separate storage facilities | 14 | 5 | 19 ( 15) |
| Other facilities | 40 | 0 | 40 ( 42) |
| | 328 | 65 | 393 (383) |
| Other locations | 289 | 18 | 307 (290) |
| Total | 617 | 83 | 700 (673) |

a A standardized categorization of nuclear installations under safeguards or containing safeguarded material was introduced in 1979.

b The figures in brackets indicate the status at the end of 1978. They have been adjusted on the basis of the new categorization.

Table 6

Quantities (in tonnes) of nuclear material under Agency safeguards in non-nuclear-weapon States

| | 1974 | 1975 | 1976 | 1977 | 1978[b] | 1979 |
|---|---|---|---|---|---|---|
| Plutonium[a] | 11 | 17 | 26 | 36 | 51 | 68 |
| Uranium enriched to 20% or more | 3.6 | 4.2 | 5.0 | 11.2 | 11.3 | 11.4 |
| Uranium enriched to less than 20% | 2 301 | 3 091 | 3 613 | 7 849 | 10 495 | 11 714 |
| Source materials (natural or depleted uranium and thorium) | 3 901 | 4 440 | 5 336 | 12 934 | 13 150 | 15 399 |

a These figures represent the sum of the amount of plutonium reported by Member States and the amount of plutonium in some reactor cores and cooling ponds, which is not required to be reported to the Agency. The amount of non-reported plutonium is estimated roughly on the basis of published information. The non-reported plutonium is contained in fuel elements to which item accountancy and containment and surveillance measures are applied.

b These figures are somewhat less than the figures indicated in the annual report for 1978, because in that report some nuclear material reported by nuclear-weapon States was included in the total amount of material under Agency safeguards.

Table 7

Agreements in force in connection with NPT, the Tlatelolco Treaty and voluntary offers made by nuclear-weapon States[a,c]

| | |
|---|---|
| NPT | 50 |
| NPT and Tlatelolco Treaty | 12 |
| NPT and Additional Protocol I of Tlatelolco Treaty | 1 |
| Tlatelolco Treaty | 1 |
| Agreements concluded with nuclear-weapon States on basis of voluntary offers | 1 |
| | 65 |

Table 8

Agreements in force other than those included in Table 5[b,c]

| | |
|---|---|
| Project agreements | 25 |
| Unilateral submissions | 13 |
| Trilateral agreements | 31 |
| | 69 |

a The total number of agreements in force for non-nuclear-weapon States in connection with NPT or with NPT and the Tlatelolco Treaty was 63. The total number of States involved (see paragraph 114) was, however, 67 as the seven non-nuclear-weapon States members of EURATOM had concluded one single agreement covering all seven of them. Furthermore, two of these States had concluded outside the agreement with EURATOM one agreement each which was still in force (see Table 8, Footnotes c and d). In addition, one agreement was in force pursuant to the Tlatelolco Treaty (see also footnote b) and one agreement was in force for one nuclear-weapon State on the basis of a voluntary offer.

b Pursuant to the entry into force of safeguards agreements in connection with NPT, the application of Agency safeguards had been suspended in the case of 29 of the above agreements: 15 project agreements, one agreement concluded in connection with the Tlatelolco Treaty and 13 trilateral agreements (in the last category of agreements, the suspension applied to both parties in two cases and to only one party in 11 cases).

c In view of the suspensions mentioned in footnote b and the fact that 34 of the non-nuclear-weapon States for which safeguards agreements were in force under NPT or under NPT and the Tlatelolco Treaty had no significant nuclear activities, the Agency was applying safeguards in:

| | |
|---|---|
| 29 non-nuclear-weapon States | pursuant to agreements concluded in connection with NPT or with NPT and the Tlatelolco Treaty |
| 14 non-nuclear-weapon States | pursuant to other agreements |
| 4 non-nuclear-weapon States | pursuant to agreements pertaining to the first and the second category |
| 3 nuclear-weapon States | pursuant to agreements involving other countries |

Table 9

Non-nuclear-weapon States party to NPT which by 31 December 1979 had not yet complied with Article III.4 of the Treaty stipulating the deadline for the entry into force of the relevant safeguards agreements to be concluded with the Agency[a]

| | |
|---|---|
| Bahamas | Libyan Arab Jamahiriya |
| Benin | Mali |
| Bolivia | Malta |
| Botswana | Nigeria |
| Burundi | Panama |
| Central African Republic | Rwanda |
| Chad | San Marino |
| Democratic Kampuchea | Senegal[b] |
| Gabon | Sierra Leone |
| Grenada | Somalia |
| Guatemala | Syrian Arab Republic |
| Guinea-Bissau | Togo |
| Haiti | Tonga |
| Ivory Coast | Tunisia |
| Kenya | United Republic of Cameroon |
| Lao People's Democratic Republic | Upper Volta |
| Liberia | Venezuela |

a For 42 non-nuclear-weapon States party to NPT on 31 December 1979 the relevant safeguards had not yet entered into force. Thirty four of these States had not met the stipulated deadline. Seven States (Bangladesh, Congo, Democratic Yemen, Indonesia, St. Lucia, Sri Lanka and Tuvalu) were still within the period prescribed for the entry into force of the agreement. The eighth party was "the Republic of China".

b The safeguards agreement with Senegal entered into force on 14 January 1980.

## Table 10

Situation on 31 December 1979 with respect to the signing of, the ratification of, or accession to NPT by non-nuclear-weapon States and to the conclusion of safeguards agreements between the Agency and these States in connection with NPT

| Non-nuclear-weapon States which have signed, ratified or acceded to NPT[a] (1) | Date of ratification or accession[a] (2) | Safeguards agreement with the Agency (3) | INFCIRC (4) |
|---|---|---|---|
| Afghanistan | 4 February 1970 | In force: 20 February 1978 | 257 |
| Australia | 23 January 1973 | In force: 10 July 1974 | 217 |
| Austria | 27 June 1969 | In force: 23 July 1972 | 156 |
| Bahamas | 10 July 1973 | | |
| Bangladesh | 27 September 1979 | | |
| Barbados[g] | | | |
| Belgium | 2 May 1975 | In force: 21 February 1977 | 193 |
| Benin | 31 October 1972 | | |
| Bolivia[b] | 26 May 1970 | Signed: 23 August 1974 | |
| Botswana | 28 April 1969 | | |
| Bulgaria | 5 September 1969 | In force: 29 February 1972 | 178 |
| Burundi | 19 March 1971 | | |
| Canada | 8 January 1969 | In force: 21 February 1972 | 164 |
| Central African Republic | 25 October 1970 | | |
| Chad | 10 March 1971 | | |
| China, Republic of | 27 January 1970 | | |
| Colombia[f] | | | |
| Congo | 23 October 1978 | | |
| Costa Rica[b] | 3 March 1970 | In force: 22 November 1979 | |
| Cyprus | 10 February 1970 | In force: 26 January 1973 | 189 |
| Czechoslovakia | 22 July 1969 | In force: 3 March 1972 | 173 |
| Democratic Kampuchea | 2 June 1972 | | |
| Democratic Yemen | 1 June 1979 | | |
| Denmark[c] | 3 January 1969 | In force: 21 February 1977 | 193 |
| Dominican Republic[b] | 24 July 1971 | In force: 11 October 1973 | 201 |
| Ecuador[b] | 7 March 1969 | In force: 10 March 1975 | 231 |
| Egypt[f] | | | |
| El Salvador[b] | 11 July 1972 | In force: 22 April 1975 | 232 |
| Ethiopia | 5 February 1970 | In force: 2 December 1977 | 261 |
| Fiji | 14 July 1972 | In force: 22 March 1973 | 192 |
| Finland | 5 February 1969 | In force: 9 February 1972 | 155 |
| Gabon | 19 February 1974 | Signed. 3 December 1979 | |
| Gambia | 12 May 1975 | In force: 8 August 1978 | 277 |
| German Democratic Republic | 31 October 1969 | In force: 7 March 1972 | 181 |
| Germany, Federal Republic of | 2 May 1975 | In force: 21 February 1977 | 193 |
| Ghana | 5 May 1970 | In force: 17 February 1975 | 226 |
| Greece | 11 March 1970 | Provisionally in force: 1 March 1972 | 166 |
| Grenada | 19 August 1974 | | |
| Guatemala[b] | 22 September 1970 | Signed: 20 July 1978 | |
| Guinea-Bissau | 20 August 1976 | | |
| Haiti[b] | 2 June 1970 | Signed: 6 January 1975 | |
| Holy See | 25 February 1971 | In force: 1 August 1972 | 187 |
| Honduras[b] | 16 May 1973 | In force: 18 April 1975 | 235 |
| Hungary | 27 May 1969 | In force. 30 March 1972 | 174 |
| Iceland | 18 July 1969 | In force: 16 October 1974 | 215 |
| Indonesia[h] | 12 July 1979 | | |
| Iran | 2 February 1970 | In force. 15 May 1974 | 214 |
| Iraq | 29 October 1969 | In force. 29 February 1972 | 172 |
| Ireland | 1 July 1968 | In force: 21 February 1977 | 193 |
| Italy | 2 May 1975 | In force· 21 February 1977 | 193 |
| Ivory Coast | 6 March 1973 | | |
| Jamaica[b] | 5 March 1970 | In force: 6 November 1978 | 265 |
| Japan | 8 June 1976 | In force: 2 December 1977 | 255 |
| Jordan | 11 February 1970 | In force. 21 February 1978 | 258 |
| Kenya | 11 June 1970 | | |
| Korea, Republic of | 23 April 1975 | In force: 14 November 1975 | 236 |
| Kuwait[f] | | | |
| Lao People's Democratic Republic | 20 February 1970 | | |
| Lebanon | 15 July 1970 | In force: 5 March 1973 | 191 |
| Lesotho | 20 May 1970 | In force: 12 June 1973 | 199 |

| (1) | (2) | (3) | (4) |
|---|---|---|---|
| Liberia | 5 March 1970 | | |
| Libyan Arab Jamahiriya | 26 May 1975 | Approved by the Board, Dec. 1979 | |
| Liechtenstein | 20 April 1978 | In force: 4 October 1979 | 275 |
| Luxembourg | 2 May 1975 | In force: 21 February 1977 | 193 |
| Madagascar | 8 October 1970 | In force: 14 June 1973 | 200 |
| Malaysia | 5 March 1970 | In force: 29 February 1972 | 182 |
| Maldives | 7 April 1970 | In force: 2 October 1977 | 253 |
| Mali | 10 February 1970 | | |
| Malta | 6 February 1970 | | |
| Mauritius | 25 April 1969 | In force: 31 January 1973 | 190 |
| Mexico[b] | 21 January 1969 | In force: 14 September 1973 | 197 |
| Mongolia | 14 May 1969 | In force: 5 September 1972 | 188 |
| Morocco | 27 November 1970 | In force: 18 February 1975 | 228 |
| Nepal | 5 January 1970 | In force: 22 June 1972 | 186 |
| Netherlands[d] | 2 May 1975 | In force: 21 February 1977 | 193 |
| New Zealand | 10 September 1969 | In force: 29 February 1972 | 185 |
| Nicaragua[b] | 6 March 1973 | In force: 29 December 1976 | 246 |
| Nigeria | 27 September 1968 | | |
| Norway | 5 February 1969 | In force: 1 March 1972 | 177 |
| Panama | 13 January 1977 | | |
| Paraguay[b] | 4 February 1970 | In force: 20 March 1979 | |
| Peru[b] | 3 March 1970 | In force: 1 August 1979 | 273 |
| Philippines | 5 October 1972 | In force: 16 October 1974 | 216 |
| Poland | 12 June 1969 | In force. 11 October 1972 | 179 |
| Portugal | 15 December 1977 | In force: 14 June 1979 | 272 |
| Romania | 4 February 1970 | In force: 27 October 1972 | 180 |
| Rwanda | 20 May 1975 | | |
| St. Lucia | 28 December 1979 | | |
| Samoa | 17 March 1975 | In force: 22 January 1979 | 268 |
| San Marino | 10 August 1970 | Approved by the Board, Feb. 1977 | |
| Senegal[i] | 17 December 1970 | Approved by the Board, Feb. 1977 | |
| Sierra Leone | 26 February 1975 | Signed: 10 November 1977 | |
| Singapore | 10 March 1976 | In force: 18 October 1977 | 259 |
| Somalia | 5 March 1970 | | |
| Sri Lanka[j] | 5 March 1979 | | |
| Sudan | 31 October 1973 | In force: 7 January 1977 | 245 |
| Suriname[b] | 30 June 1976 | In force: 2 February 1979 | 269 |
| Swaziland | 11 December 1969 | In force: 28 July 1975 | 227 |
| Sweden | 9 January 1970 | In force: 14 April 1975 | 234 |
| Switzerland | 9 March 1977 | In force: 6 September 1978 | 264 |
| Syrian Arab Republic | 24 September 1969 | | |
| Thailand | 7 December 1972 | In force: 16 May 1974 | 241 |
| Togo | 26 February 1970 | | |
| Tonga | 7 July 1971 | Approved by the Board, Feb. 1975 | |
| Trinidad and Tobago[f] | | | |
| Tunisia | 26 February 1970 | | |
| Turkey[k] | | | |
| Tuvalu | 19 January 1979 | | |
| United Republic of Cameroon | 8 January 1969 | | |
| Upper Volta | 3 March 1970 | | |
| Uruguay[b] | 31 August 1970 | In force: 17 September 1976 | 157 |
| Venezuela[b] | 26 September 1975 | Signed: 23 June 1978 | |
| Viet Nam[e] | 10 September 1971 | In force. 9 January 1974 | 219 |
| Yemen Arab Republic[f] | | | |
| Yugoslavia | 3 March 1970 | In force 28 December 1973 | 204 |
| Zaire | 4 August 1970 | In force. 9 November 1972 | 183 |

[a] The information reproduced in columns (1) and (2) was provided to the Agency by the depositary Governments of NPT, and an entry in column (1) does not imply the expression of any opinion on the part of the Secretariat concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers. On the basis of a communication received from the Permanent Mission of the USSR to the Agency certain ratification and accession dates have been changed and the accession of Guinea-Bissau added.

[b] The relevant safeguards agreement was concluded in connection with both NPT and the Tlatelolco Treaty.

[c] The NPT safeguards agreement with Denmark (INFCIRC/176), in force since 1 March 1972, has been replaced by the agreement of 5 April 1973 between the seven non-nuclear weapon States of EURATOM, EURATOM and the Agency (INFCIRC/193) but still applies to the Faroe Islands.

[d] An agreement had also been concluded in respect of the Netherlands Antilles (INFCIRC/229). This agreement entered into force on 5 June 1975.

[e] Viet Nam is reconsidering adherence to the commitments of the former Administration under international agreements.

[f] The following States had signed NPT but not yet ratified it: Colombia, on 1 July 1968; Egypt, on 1 July 1968; Kuwait, on 15 August 1968; Trinidad and Tobago, on 22 August 1968; and the Yemen Arab Republic, on 23 September 1968.

[g] Barbados ratified NPT on 21 February 1980.

[h] Agreement approved by the Board in June 1980.

[i] Agreement in force as of 14 January 1980.

[j] Agreement approved by the Board in March 1980

[k] Turkey ratified NPT on 17 April 1980.

Table 11

Agreements providing for safeguards, other than those
in connection with NPT,
approved by the Board as of 31 December 1979

| Party(ies)[a] | Subject | Entry into force | INFCIRC |
|---|---|---|---|
| Bilateral Agreements | | | |
| (a) Project Agreements | | | |
| Argentina | Siemens SUR-100 | 13 March 1970 | 143 |
| | RAEP Reactor | 2 December 1964 | 62 |
| Chile | Herald Reactor | 19 December 1969 | 137 |
| Finland[b] | FiR-1 Reactor | 30 December 1960 | 24 |
| | FINN sub-critical assembly | 30 July 1963 | 53 |
| Greece[b] | GRR-1 Reactor | 1 March 1972 | 163 |
| Indonesia | Additional core-load for Triga Reactor | 19 December 1969 | 136 |
| Iran[b] | UTRR Reactor | 10 May 1967 | 97 |
| Japan[b] | JRR-3 | 24 March 1959 | 3 |
| Mexico[b] | TRIGA-III Reactor | 18 December 1963 | 52 |
| | Siemens SUR-100 | 21 December 1971 | 162 |
| | Laguna Verde Nuclear Power Plant | 12 February 1974 | 203 |
| Pakistan | PRR Reactor | 5 March 1962 | 34 |
| | Booster rods for KANUPP | 17 June 1968 | 116 |
| Peru[c] | Research Reactor and fuel therefor | 9 May 1978 | 266 |
| Philippines[b] | PRR-1 Reactor | 28 September 1966 | 88 |
| Romania[b] | TRIGA Reactor | 30 March 1973 | 206 |
| Spain | Coral I Reactor | 23 June 1967 | 99 |
| Turkey | Sub-critical assembly | 17 May 1974 | 212 |
| Uruguay[b] | URR Reactor | 24 September 1965 | 67 |
| Venezuela | RV-1 Reactor | 7 November 1975 | 238 |
| Viet Nam[b] | VNR-1 Reactor | 16 October 1967 | 106 |
| Yugoslavia[b] | TRIGA-II | 4 October 1961 | 32 |
| | KRSKO Nuclear Power Plant | 14 June 1974 | 213 |
| Zaire[b] | TRICO Reactor | 27 June 1962 | 37 |
| (b) Unilateral submissions | | | |
| Argentina | Atucha Power Reactor Facility | 3 October 1972 | 168 |
| | Nuclear material | 23 October 1973 | 202 |
| | Embalse Power Reactor Facility | 6 December 1974 | 224 |
| | Equipment | 22 July 1977 | 250 |
| | Nuclear material, material, equipment and facilities | 22 July 1977 | 251 |
| Chile | Nuclear material | 31 December 1974 | 256 |
| China, Republic of | Taiwan Research Reactor Facility | 13 October 1969 | 133 |
| Democratic People's Republic of Korea | Research Reactor and nuclear material for this reactor | 20 July 1977 | 252 |
| India | Nuclear material, material and facilities | 17 November 1977 | 260 |
| Pakistan | Nuclear material | 2 March 1977 | 248 |
| Spain | Nuclear material | 19 November 1974 | 218 |
| | Nuclear material | 18 June 1975 | 221 |
| United Kingdom | Nuclear material | 14 December 1972 | 175 |

| Party(ies)[a] | Subject | Entry into force | INFCIRC |
|---|---|---|---|
| (c) Tlatelolco Treaty | | | |
| Colombia | All nuclear material | | |
| Mexico[b] | All nuclear material, equipment and facilities | 6 September 1968 | 118 |
| Panama | All nuclear material | | |
| (d) Agreements concluded with nuclear-weapon States on the basis of voluntary offers | | | |
| France | Nuclear material in facilities submitted to safeguards | | |
| United Kingdom | Nuclear material in facilities designated by the Agency | 14 August 1978 | 263 |
| United States | Nuclear material in facilities designated by the Agency | | |

Trilateral Agreements

(While the Agency is a party to each of the following agreements, the list only mentions the States party to them.)

| | | |
|---|---|---|
| Argentina/United States of America | 25 July 1969 | 130 |
| Australia[b]/United States of America | 26 September 1966 | 91 |
| Austria[b]/United States of America | 24 January 1970 | 152 |
| Brazil/Germany, Federal Republic of[b] | 26 February 1976 | 237 |
| Brazil/United States of America | 20 September 1972 | 110 |
| China, Republic of/United States of America | 6 Decemter 1971 | 158 |
| Colombia/United States of America | 9 December 1979 | 144 |
| India/Canada[b] | 30 September 1971 | 211 |
| India/United States of America | 27 January 1971 | 154 |
| Indonesia/United States of America | 6 December 1967 | 109 |
| Iran[b]/United States of America | 20 August 1969 | 127 |
| Israel/United States of America | 4 April 1975 | 249 |
| Japan[b]/Canada[b] | 12 November 1969 | 85 |
| Japan[b]/France | 22 September 1972 | 171 |
| Japan/United States of America | 10 July 1968 | 119 |
| Japan[b]/United Kingdom | 15 October 1968 | 125 |
| Japan[b]/Australia[b] | 28 July 1972 | 170 |
| Korea, Republic of/United States of America | 19 March 1973 | 111 |
| Korea, Republic of[b]/France | 22 September 1975 | 233 |
| Pakistan/Canada | 17 October 1969 | 135 |
| Pakistan/France | 18 March 1976 | 239 |
| Philippines[b]/United States of America | 19 July 1968 | 120 |
| Portugal/United States of America | 19 July 1969 | 131 |
| South Africa/United States of America | 26 July 1967 | 98 |
| South Africa/France | 5 January 1977 | 244 |

Table 11 (cont.)

| Party(ies)[a] | Entry into force | INFCIRC |
|---|---|---|
| Spain/United States of America | 9 December 1966 | 92 |
| Spain/Canada[b] | 10 February 1977 | 247 |
| Sweden[b]/United States of America | 1 March 1972 | 165 |
| Switzerland/United States of America | 28 February 1972 | 161 |
| Turkey/United States of America | 5 June 1969 | 123 |
| Venezuela/United States of America | 27 March 1968 | 122 |

a An entry in this column does not imply the expression of any opinion whatsoever on the part of the Secretariat concerning the legal status of any country or territory or of its authorities or concerning the delimitation of its frontiers. The Socialist Republic of Viet Nam is reconsidering adherence to the commitments of the former Administration under international agreements.

b Application of Agency safeguards under this agreement has been suspended as the State has concluded an agreement in connection with NPT (see also footnote e to Table 10).

c The requirement for the application of safeguards under this agreement was satisfied by the application of safeguards pursuant to the agreement concluded by Peru in connection with NPT.

Table 12

## Nuclear facilities under Agency safeguards or containing safeguarded material under agreements in force as of 31 December 1979

### A. Research reactors and critical assemblies

| State[a] | Abbreviated name | Location | Type | Capacity MW(th) | In operation | Subsidiary arrangements in force |
|---|---|---|---|---|---|---|
| Argentina | RA-1 | Constituyentes | Tank | 0.07 | x | x |
| | RA-2 | Constituyentes | MTR | 0.00 | x | x |
| | RA-3 | Ezeiza | MTR | 5.00 | x | x |
| | RA-4 | Rosario | SUR-100 | 0.00 | x | x |
| Australia[b] | HIFAR | Lucas Heights, N.S.W. | Tank | 11.00 | x | x |
| | MOATA | Lucas Heights, N.S.W. | Argonaut | 0.01 | x | x |
| | CF | Lucas Heights, N.S.W. | Critical assembly | 0.00 | x | x |
| Austria[b] | SAR | Graz | Argonaut | 0.01 | x | x |
| | Triga II | Vienna | Pool | 0.25 | x | x |
| | ASTRA | Seibersdorf | Pool | 12.00 | x | x |
| Belgium[b] | BR1-CEN | Mol | Tank | 4.00 | x | x |
| | BR2-CEN | Mol | Tank | 100.00 | x | x |
| | Thetis | Gent | Pool | 0.15 | x | x |
| | BRO2 | Mol | Tank | 0.00 | x | x |
| | CEN-Venus | Mol | Tank | 0.00 | x | x |
| Brazil | IEAR-1 | São Paulo | MTR | 5.00 | x | x |
| | UMG | Belo Horizonte | Triga I | 0.10 | x | x |
| | RIEN-1 | Rio de Janeiro | Argonaut | 0.01 | x | x |
| Bulgaria[b] | IRT-2000 | Sofia | Pool | 2.00 | x | x |
| Canada[b] | NRX | Chalk River, Ont. | NRX | 30.00 | x | x |
| | NRU | Chalk River, Ont. | NRU | 125.00 | x | x |
| | WR-1 | Pinawa, Manitoba | Organic-cooled | 60.00 | x | x |
| | McMaster | Hamilton, Ont. | Pool-type | 2.5 | x | x |
| | Slowpoke - Toronto | Univ. of Toronto | Pool-type | 0.02 | x | x |
| | AECL, Chem. Comp. | Ottawa, Ont. | Pool-type | 0.02 | x | x |
| | PTR | Chalk River, Ont. | Pool-type | 0.00 | x | x |
| | ZED-2 | Chalk River, Ont. | Pool-type | 0.00 | x | x |
| | ZEEP[*] | Chalk River, Ont. | Tank | 0.00 | x | x |
| | Slowpoke - Halifax | Dalhousie Univ. | Pool-type | 0.02 | x | - [i] |
| | Ecole Polytechnique | Montreal | Pool-type | 0.02 | x | x |
| | Slowpoke - Edmonton | Univ. of Alberta | Pool-type | 0.02 | x | - [i] |
| Chile | La Reina | Santiago | Herald | 5.00 | x | x |
| | Lo Aguirre | Santiago | MTR | 10.00 | x | x |
| China, Republic of | THOR | Hsin-chu | Pool | 1.00 | x | x |
| | TRR | Huaitzupu | NRX | 40.00 | x | x |
| | ZPRL | Lung-Tan | Pool | 0.01 | x | x |
| | THAR | Hsin-chu | Argonaut | 0.01 | x | x |
| | MER | Hsin-chu | Mobile Educational Reactor | 0.00 | x | x |
| | WBRL | Lung-Tan | Tank | 0.1 | - | x |
| Colombia | IAN-R1 | Bogotá | MTR | 0.02 | x | x |
| Czechoslovakia[b] | SR-OD | Vochov | Critical assembly | 0.00 | x | x |
| | SR-OB | Vochov | Exponential assembly | 0.00 | x | x |
| | VVR-S | Rez | Tank | 4.5 | x | x |
| | TR-O | Rez | Critical assembly | 0.00 | x | x |
| Democratic People's Republic of Korea | IRT-DPRK | Nyonpyon | Pool | 4.00 | x | x |
| | Critical assembly | Nyonpyon | Pool | 0.10 | x | x |

[*] Decommissioned.

| State[a] | Abbreviated name | Location | Type | Capacity MW(th) | In operation | Subsidiary arrangements in force |
|---|---|---|---|---|---|---|
| Denmark[c] | DR-1 | Roskilde | Homogeneous | 0.00 | x | x |
| | DR-3 | Roskilde | Tank | 10.00 | x | x |
| Finland[b] | Triga II | Otaniemi | Tank | 0.25 | x | x |
| German Democratic Republic[b] | WWR-S(M) | Rossendorf | Tank | 10.00 | x | x |
| | RRR | Rossendorf | Tank | 0.00 | x | x |
| | RAKE | Rossendorf | Tank | 0.00 | x | x |
| | Training Reactor AKR | Dresden | Tank | 0.00 | x | x |
| | Training and research reactor | Zittau | Tank | 0.00 | x | - [i] |
| Germany, Federal Republic of[b] | FRM | Garching | Pool | 4.00 | x | x |
| | GKSS-FRG1 | Geesthacht | Pool | 5.00 | x | x |
| | GKSS-FRG2 | Geesthacht | Pool | 15.00 | x | x |
| | GFK-FR-2 | Karlsruhe | Tank | 45.00 | x | x |
| | KFA-FRJ1 | Jülich | Pool | 10.00 | x | x |
| | KFA-FRJ2 | Jülich | Tank | 43.00 | x | x |
| | Triga | Mainz | Triga I | 0.10 | x | x |
| | Triga II | Heidelberg | Triga II | 0.25 | x | x |
| | FMRB | Braunschweig | Tank | 1.00 | x | x |
| | Triga | Hanover | Triga II | 0.25 | x | x |
| | Triga | Neuherberg | Triga II | 1.00 | x | x |
| | GFK-SNEAK | Karlsruhe | Critical assembly | 0.00 | x | x |
| | SUR 100 | Garching | Solid-homogeneous | 0.10 | x | x |
| | SUR 100 | Darmstadt | Solid-homogeneous | 0.10 | x | x |
| | SUR 100 | Stuttgart | Solid-homogeneous | 0.10 | x | x |
| | SUR 100 | Hamburg | Solid-homogeneous | 0.10 | x | x |
| | SUR 100 | Kiel | Solid-homogeneous | 0.10 | x | x |
| | SUR 100 | Ulm | Solid-homogeneous | 0.10 | x | x |
| | SUR 100 | Karlsruhe | Solid-homogeneous | 0.10 | x | x |
| | SUR 100 | Bremen | Solid-homogeneous | 0.10 | x | x |
| | SUR 100 | Furtwang | Solid-homogeneous | 0.10 | x | x |
| | SUR 100 | Aachen | Solid-homogeneous | 0.10 | x | x |
| | KFA-ITR | Jülich | Critical assembly | 0.00 | x | x |
| | FRF-2 | Frankfurt | Triga | 1.0 | x | x |
| | SUR 100 | Hanover | Solid-homogeneous | 0.1 | x | x |
| | KFA-NEA | Julich | Critical assembly | 0.00 | x | x |
| | BER-2 | Berlin (West) | Aqueous Homogeneous | 5.00 | x | x |
| | SUR 100 | Berlin (West) | Solid-homogeneous | 0.10 | x | x |
| Greece[b] | GRR-1 | Athens | Pool | 5.00 | x | x |
| | N.T.U. | Athens | Graphite | 0.00 | x | x |
| Hungary[b] | WWR-S(M) | Budapest | Tank | 5.00 | x | x |
| | ZR-4 | Budapest | Critical assembly | 0.00 | x | x |
| | ZR-6 | Budapest | Critical assembly | 0.00 | x | x |
| | Training reactor | Budapest | Tank | 0.01 | x | x |
| Indonesia | PRAB | Bandung | Triga II | 1.00 | x | x |
| | Gama | Yogjakarta | Triga II | 0.25 | x | x |
| Iran[b] | TSPRR | Teheran | Pool | 5.00 | x | x |
| Iraq[b] | IRT-2000 | Baghdad Tuwaitha | Pool | 2.00 | x | x |
| Israel | IRR-1 | Soreq | Pool | 5.00 | x | x |
| Italy[b] | Triga 1-RC1 | Casaccia | Triga I | 1.00 | x | x |
| | AGN-201 | Palermo | Solid-homogeneous | 0.00 | x | x |
| | CESNEF-L54 | Milan | Aqueous Homogeneous | 0.01 | x | x |
| | ESSOR | Ispra | Tank | 40.00 | x | x |
| | RTS-1-S.PI.A GR | Pisa | Pool | 5.00 | x | - [h] |
| | RANA | Casaccia | Pool | 0.01 | x | x |
| | RB-2 | Montecuccolino | Argonaut | 0.01 | x | - [h] |
| | RITMO | Casaccia | Pool | 0.00 | x | x |
| | TAPIRO | Casaccia | Fast neutron | 0.00 | x | x |
| | Triga-2 | Pavia | Triga II | 0.25 | x | x |
| | RB-1 | Montecuccolino | Graphite | 0.00 | x | x |
| | RB-3 | Montecuccolino | Tank($D_2O$) | 0.01 | x | x |
| Japan[b] | DCA | Oarai-Machi | Critical assembly | 0.00 | x | x |
| | FCA | Tokai-Mura | Critical assembly | 0.00 | x | x |
| | HTR | Kawasaki-shi | Pool | 0.10 | x | x |
| | JMTR | Oarai-Machi | Tank | 50.00 | x | x |
| | JMTR-CA | Oarai-Machi | Critical assembly | 0.00 | x | x |

| State[a] | Abbreviated name | Location | Type | Capacity MW(th) | In operation | Subsidiary arrangements in force |
|---|---|---|---|---|---|---|
| | JOYO | Oarai-Machi | EBR | 50.00 | x | x |
| | JRR-2 | Tokai-Mura | Tank | 10.00 | x | x |
| | JRR-3 | Tokai-Mura | Tank | 10.00 | x | x |
| | JRR-4 | Tokai-Mura | Pool | 3.50 | x | x |
| | Kinki University | Kowake | UTR-B | 0.00 | x | x |
| | KUR | Kumatori-cho | Pool | 5.00 | x | x |
| | KUCA | Kumatori-cho | Critical assembly | 0.00 | x | x |
| | NSRR | Tokai-Mura | Triga (pulse) | 0.30 | x | x |
| | Musashi College of Technology | Kawasaki | Triga II | 0.10 | x | x |
| | NAIG-CA | Kawasaki-ku | Critical assembly | 0.00 | x | x |
| | Rikkyo University | Nagasaka | Triga II | 0.10 | x | x |
| | SHE | Tokai-Mura | Critical assembly | 0.00 | x | x |
| | TCA | Tokai-Mura | Critical assembly | 0.00 | x | x |
| | TODAI | Tokai-Mura | Fast Neutron Source Reactor | 0.00 | x | x |
| | TTR | Kawasaki-shi | Pool | 0.10 | x | x |
| | KUCA | Kumatori-cho | Critical assembly | 0.00 | x | x |
| | KUCA | Kumatori-cho | Critical assembly | 0.00 | x | x |
| Korea, Republic of[b] | KRR - TRIGA II | Seoul | Triga II | 0.10 | x | x |
| | KRR - TRIGA III | Seoul | Triga III | 2.00 | x | x |
| Mexico[d] | Centro Nuclear de Mexico | Ocoyoacac | Triga III | 1.00 | x | x |
| | Training reactor facility | Mexico City | SUR 100 | 0.00 | x | x |
| Netherlands[b] | LFR | Petten | Argonaut | 0.01 | x | x |
| | HOR-THS | Delft | Pool | 2.00 | x | x |
| | BARN | Wageningen | Graphite | 0.10 | x | x |
| | HFR | Petten | Tank | 45.00 | x | x |
| Norway[b] | JEEP-II | Kjeller | Tank | 2.00 | x | x |
| | HBWR | Halden | HBWR | 25.00 | x | x |
| Pakistan | PARR | Rawalpindi | Pool | 5.00 | x | x |
| Peru[d] | RP-O | Lima | Tank | 0.00 | x | x |
| Philippines[b] | PRR-1 | Diliman, Quezon City | Pool | 1.00 | x | x |
| Poland[b] | EWA | Świerk | Tank | 8.00 | x | x |
| | Maryla | Świerk | Critical assembly | 0.00 | x | x |
| | Anna | Świerk | Critical assembly | 0.00 | x | x |
| | Agata | Świerk | Critical assembly | 0.00 | x | x |
| | Maria | Świerk | Tank | 30.00 | x | x |
| Portugal[b] | RPI | Sacavem | Tank | 1.00 | x | x |
| Romania[b] | VVR-S | Margurele | Tank | 10.00 | x | x |
| | Triga II | Pitesti-Colibasi | Tank | 0.25 | x | x |
| South Africa | SAFARI-1 | Pelindaba | Tank | 20.00 | x | - [f] |
| Spain | JEN-1 and JEN-2 | Madrid | Pool | 3.00 | x | x |
| | CORAL-1 | Madrid | Fast cricital assembly | 0.00 | x | x |
| | ARBI | Bilbao | Argonaut | 0.01 | x | x |
| | ARGOS | Barcelona | Argonaut | 0.01 | x | x |
| Sweden[b] | R2 | Studsvik | Tank | 50.00 | x | x |
| | R2-O | Studsvik | Pool | 0.00 | x | x |
| | R-O | Studsvik | Pool | 0.00 | x | x |
| Switzerland[b] | Proteus | Würenlingen | Fast thermal critical assembly | 0.00 | x | x [j] |
| | Saphir | Würenlingen | Pool | 5.00 | x | x |
| | Crocus | Lausanne | Pool | 0.00 | x | x |
| | AGN201P | Geneva | Solid-homogeneous | 0.00 | x | x |
| | AGN211P | Basel | Pool | 0.00 | x | x |
| Thailand[b] | TRR-1 | Bangkok | Pool | 2.00 | x | x |
| Turkey | TR-1 | Istanbul | Pool | 1.00 | x | x |
| | TR-2 | Istanbul | Triga II | 0.25 | x | x |

| State[a/] | Abbreviated name | Location | Type | Capacity MW(th) | In operation | Subsidiary arrangements in force |
|---|---|---|---|---|---|---|
| United Kingdom | Zebra | Winfrith | Critical assembly | 0.00 | x | x |
| Uruguay[d/] | RU-1 | Montevideo | Lockheed | 0.10 | x | x |
| Venezuela | RV1 | Altos de Pipe | Pool | 3.00 | x | x |
| Yugoslavia[b/] | Triga II | Ljubljana | Triga II | 0.25 | x | x |
| | Boris Kidric R. | Vinča | Tank | 6.50 | x | x |
| | RB | Vinča | Critical assembly | 0.00 | x | x |
| Zaire[b/] | Triga-Zaire | Kinshasa | Triga II | 1.00 | x | x |

## B. Nuclear power reactors

| State[a] | Name of power reactor | Location | Type | Capacity MW(e) | In operation | Subsidiary arrangements in force |
|---|---|---|---|---|---|---|
| Argentina | Atucha NPS | Atucha | PHWR | 319 | x | x |
| | Embalse PR | Cordoba | Candu | 600 | - | x |
| Austria[b] | Tullnerfeld | Zwentendorf | PWR | 700 | - | x |
| Belgium[b] | BR-3-CEN | Mol | PWR | 11 | x | x |
| | DOEL-1 | Antwerp | PWR | 412 | x | x |
| | DOEL-2 | Antwerp | PWR | 412 | x | x |
| | SEMO | Tihange | PWR | 920 | x | x |
| Brazil | Angra-1 | Angra dos Reis | PWR | 626 | - | x |
| Bulgaria[b] | Kozloduy-1 | Kozloduy | PWR | 440 | x | x |
| | Kozloduy-2 | Kozloduy | PWR | 440 | x | x |
| Canada[b] | Bruce-1 | Tiverton, Ontario | Candu | 788 | x | x |
| | Bruce-2 | Tiverton, Ontario | Candu | 788 | x | x |
| | Bruce-3 | Tiverton, Ontario | Candu | 788 | x | x |
| | Bruce-4 | Tiverton, Ontario | Candu | 788 | x | x |
| | DPGS | Kincardine, Ontario | Candu | 208 | x | x |
| | Gentilly-1 | Gentilly, Quebec | Candu | 250 | x | x |
| | Gentilly-2 | Gentilly, Quebec | Candu | 600 | - | - g/ |
| | NPD | Rolphton, Ontario | Candu | 22 | x | x |
| | Pickering-1 | Pickering, Ontario | Candu | 540 | x | x |
| | Pickering-2 | Pickering, Ontario | Candu | 540 | x | x |
| | Pickering-3 | Pickering, Ontario | Candu | 540 | x | x |
| | Pickering-4 | Pickering, Ontario | Candu | 540 | x | x |
| | Point Lepreau | New Brunswick | Candu | 600 | - | - g/ |
| China, Republic of | FNPS-1 | Ching-San | BWR | 636 | x | x |
| | FNPS-2 | Ching-San | BWR | 636 | x | x |
| | SNPS-1 | Kuosheng Tsun | BWR | 985 | - | x |
| | SNPS-2 | Kuosheng Tsun | BWR | 985 | - | x |
| Czechoslovakia[b] | A1 | Bohunice | HWGC | 143 | x | x |
| | V.1 Bohunice-1 | Bohunice | PWR | 440 | x | x |
| Finland[b] | Loviisa-1 | Loviisa | PWR | 420 | x | x |
| | Loviisa-2 | Loviisa | PWR | 420 | - | x |
| | TVO-1 | Olkiluoto | BWR | 660 | x | x |
| | TVO-2 | Olkiluoto | BWR | 660 | - | x |
| German Democratic Republic[b] | Rheinsberg PWR | Rheinsberg | PWR | 80 | x | x |
| | Bruno Leuschner-1 | Greifswald | PWR | 440 | x | x |
| | Bruno Leuschner-2 | Greifswald | PWR | 440 | x | x |
| | Bruno Leuschner-3 | Greifswald | PWR | 440 | x | x |
| | Bruno Leuschner-4 | Greifswald | PWR | 440 | x | x |
| Germany, Federal Republic of[b] | KRB-1 | Gundremmingen | BWR | 250 | x | x |
| | GFK-MZFR | Karlsruhe | HWR | 58 | x | x |
| | VAK-KAHL | Grosswelzheim | BWR | 16 | x | x |
| | AVR | Jülich | HTGR | 15 | x | - i/ |
| | KWL-1 | Lingen | BWR | 267 | x | x |
| | KNK | Karlsruhe | SZR | 21 | x | x |
| | KWW | Wurgassen | BWR | 670 | x | x |
| | KKS-1-HAM | Stade | PWR | 662 | x | x |
| | KWO | Obrigheim | PWR | 345 | x | x |
| | KKB | Brunsbuttel | BWR | 805 | x | x |
| | RWE-BIBLIS-A | Biblis | PWR | 1204 | x | x |
| | RWE-BIBLIS-B | Biblis | PWR | 1300 | x | x |
| | GKN | Neckarwestheim | PWR | 805 | x | x |
| | KKU | Unterweser | PWR | 1300 | x | x |
| | KKI-ISAR | Ohu | BWR | 907 | x | x |
| | KKP | Philippsburg | BWR | 907 | x | x |
| India | Tarapur-1 | Tarapur | BWR | 190 | x | x |
| | Tarapur-2 | Tarapur | BWR | 190 | x | x |
| | Rajasthan-1 | Rajasthan | Candu | 200 | x | x |
| | Rajasthan-2 | Rajasthan | Candu | 200 | - | x |
| Italy[b] | E.N.E.L. | Latina | GCR | 160 | x | - g/ |
| | E.N.E.L. | Garigliano | BWR | 160 | x | x |
| | FERMI | Turin | PWR | 256 | x | x |
| | E.N.E.L. | Caorso | BWR | 920 | x | x |

| State[a] | Name of power reactor | Location | Type | Capacity MW(e) | In operation | Subsidiary arrangements in force |
|---|---|---|---|---|---|---|
| Japan[b] | Fugen | Tsuruga-Fukui | ATR | 165 | x | x |
| | Fukushima-1 | Okuma-Fukushima | BWR | 460 | x | x |
| | Fukushima-2 | Okuma-Fukushima | BWR | 784 | x | x |
| | Fukushima-3 | Okuma-Fukushima | BWR | 784 | x | x |
| | Fukushima-4 | Okuma-Fukushima | BWR | 784 | x | x |
| | Fukushima-5 | Okuma-Fukushima | BWR | 784 | x | x |
| | Fukushima-6 | Okuma-Fukushima | BWR | 1100 | x | x |
| | Genkai-1 | Kyushu | PWR | 559 | x | x |
| | Hamaoka-1 | Hamaoka-cho | BWR | 540 | x | x |
| | Hamaoka-2 | Hamaoka-cho | BWR | 840 | x | x |
| | Ikata-1 | Nishiuwagun | PWR | 566 | x | x |
| | Mihama-1 | Mihama-Fukui | PWR | 340 | x | x |
| | Mihama-2 | Mihama-Fukui | PWR | 500 | x | x |
| | Mihama-3 | Mihama-Fukui | PWR | 826 | x | x |
| | Ohi-1 | Ohi-cho, Fukai-ken | PWR | 1175 | x | x |
| | Ohi-2 | Ohi-cho, Fukai-ken | PWR | 1175 | x | x |
| | Shimane | Kashima-cho | BWR | 460 | x | x |
| | Takahama-1 | Takahama | PWR | 826 | x | x |
| | Takahama-2 | Takahama | PWR | 826 | x | x |
| | Tokai-1 | Tokai-Mura | Magnox | 166 | x | x |
| | Tokai-2 | Tokai-Mura | BWR | 1100 | x | x |
| | Tsuruga | Tsuruga | BWR | 357 | x | x |
| | JPDR | Tokai-Mura | BWR | 90 | - | x |
| | Mutsu nuclear ship | Minato-Machi Mutsu | PWR | 36 | - | x |
| Korea, Republic of[b] | Kori-1 | Pusan | PWR | 564 | x | x |
| Mexico[d] | Laguna Verde PS | Laguna Verde, Vera Cruz | BWR | 650 | - | - i/ |
| Netherlands[b] | GKN | Dodewaard | BWR | 54 | x | x |
| | PZEM | Borssele | PWR | 468 | x | x |
| Pakistan | KANUPP | Karachi | Candu | 125 | x | x |
| South Africa | Koeberg-1 | Cape Town | PWR | 922 | - | x |
| | Koeberg-2 | Cape Town | PWR | 922 | - | x |
| Spain | Almaraz-1 | Province of Caceres | PWR | 930 | - | - e/ |
| | Almaraz-2 | Province of Caceres | PWR | 930 | - | - e/ |
| | Asco-1 | Province of Tarragona | PWR | 930 | - | - e/ |
| | Asco-2 | Province of Tarragona | PWR | 930 | - | - e/ |
| | Cofrentes | Province of Valencia | BWR | 975 | - | - e/ |
| | José Cabrera | Almonacid de Zorita | PWR | 153 | x | x |
| | Lemoniz-1 | Province of Viscaya | PWR | 930 | - | - e/ |
| | Lemoniz-2 | Province of Viscaya | PWR | 930 | - | - e/ |
| | Santa Maria de Garona | Province of Burgos | BWR | 440 | x | x |
| Sweden[b] | Barseback-1 | Near Malmö | BWR | 580 | x | x |
| | Barsebäck-2 | Near Malmö | BWR | 580 | x | - i/ |
| | Forsmark-1 | Near Uppsala | BWR | 900 | - | - i/ |
| | Oskarshamn-1 | Oskarshamn | BWR | 440 | x | x |
| | Oskarshamn-2 | Oskarshamn | BWR | 580 | x | x |
| | Ringhals-1 | Near Göteborg | BWR | 760 | x | x |
| | Ringhals-2 | Near Göteborg | PWR | 830 | x | x |
| | Ringhals-3 | Near Göteborg | PWR | 912 | - | - i/ |
| | Ringhals-4 | Near Goteborg | PWR | 912 | - | - i/ |
| | Forsmark-2 | Uppsala | BWR | 900 | - | - i/ |
| Switzerland[b] | KKM | Mühleberg | BWR | 320 | x | x |
| | KKB-1 | Beznau | PWR | 350 | x | x |
| | KKB-2 | Beznau | PWR | 350 | x | x |
| | KKG | Gösgen-Däniken | PWR | 970 | x | x |
| Yugoslavia[b] | Krsko | Krsko | PWR | 632 | - | x |

## C. Conversion plants, fuel fabrication plants, enrichment plants and chemical reprocessing plants including pilot plants with an annual throughput or inventory exceeding one effective kilogram

| State[a] | Abbreviated name | Location | Type | Subsidiary arrangements in force |
|---|---|---|---|---|
| Argentina | Pilot Fuel Fabrication Plant (natural uranium) | Constituyentes | Fuel fabrication | x |
| | Pilot Fuel Fabrication Plant (HEU) | Constituyentes | Fuel fabrication | x |
| Belgium[b] | FBFC | Dessel | Fuel fabrication | x |
| | Belgonucleaire-BN-MOX | Dessel | Fuel fabrication | x |
| Canada[b] | ENL Port Hope | Port Hope | Conversion | x |
| | ENL Port Hope | Port Hope | Conversion | x |
| | CGE Peterborough | Peterborough | Fuel fabrication | x |
| | Westinghouse Fuel Fabrication Plant | Varennes | Fuel fabrication | x |
| | Combustion Engineering Superheat | Moncton, New Brunswick | Fuel fabrication | x |
| | WCL Port Hope | Port Hope | Fuel fabrication | x |
| | CGE Toronto | Toronto | Fuel fabrication | x |
| | Noranda Met. Ind. Ltd. | Montreal | Fuel fabrication | x |
| | ENL Port Hope | Port Hope | Fuel fabrication | x |
| | CRNL Fuel Fabrication Plant | Chalk River | Fuel fabrication | x |
| | Metallurgy | Chalk River | Fuel fabrication | x |
| China, Republic of | INER Fuel Fabrication Plant | Lung Ton | Fuel fabrication | x |
| Denmark[c] | Metallurgy Department | Risø | Fuel fabrication | x |
| Germany, Federal Republic of[b] | ALKEM | Wolfgang, Hanau | Fuel fabrication | - i/ |
| | NUKEM | Wolfgang, Hanau | Fuel fabrication | x |
| | RBU-1 | Wolfgang, Hanau | Fuel fabrication | x |
| | RBU-2 | Karlstein | Fuel fabrication | x |
| | GWK-WAK | Leopoldshafen, Karlsruhe | Reprocessing | x |
| | Exxon | Lingen | Fuel fabrication | - h/ |
| | Uranit | Jülich | Enrichment | - i/ |
| India | Nuclear Fuel Complex | Hyderabad | Fuel fabrication | x |
| Italy[b] | Fabnuc-Bosco Marengo | Alessandria | Fuel fabrication | - g/ |
| | COREN | Saluggia | Fuel fabrication | - g/ |
| | EUREX | Saluggia | Reprocessing | x |
| | IFEC | Saluggia | Fuel fabrication | - h/ |
| | ITREC-Trisaia | Rotondella | Reprocessing | x |
| | Comb. Nuc. | Rotondella | Fuel fabrication | - g/ |
| Japan[b] | PNC Reprocessing Plant | Tokai-Mura | Reprocessing | x |
| | NFI (Kumatori-1) | Kumatori, Osaka | Fuel fabrication | x |
| | SMM (Tokai-1) | Tokai-Mura | Conversion | x |
| | JNF | Yokosuka | Fuel fabrication | x |
| | MNF | Tokai-Mura | Fuel fabrication | x |

| State[a/] | Abbreviated name | Location | Type | Subsidiary arrangements in force |
|---|---|---|---|---|
| | PPFF | Tokai-Mura | Fuel fabrication | x |
| | MAPI | Ohmiya | Fuel fabrication | x |
| | NFI (Kumatori-2) | Kumatori, Osaka | Fuel fabrication | x |
| | NFI (Takayama-R&D) | Takayama | Conversion | x |
| | PNC Pilot Enrichment Plant | Ningyo | Enrichment | - i/ |
| Netherlands[b/] | URENCO | Almelo | Enrichment | - i/ |
| | Ultra-Centrifuge | Almelo | Enrichment | - i/ |
| Spain | Metallurgical Plant<br>Juan Vigon Research Centre | Madrid | Fuel fabrication | x |
| | Juan Vigon Research Centre | Madrid | Reprocessing | x |
| Sweden[b/] | ASEA - ATOM | Västeras | Fuel fabrication | x |

## D. Separate storage facilities and other facilities

| State[a] | Abbreviated name | Location | Type | Subsidiary arrangements in force |
|---|---|---|---|---|
| Australia[b] | Research Laboratory | Lucas Heights | Other facilities | x |
| Belgium[b] | CEN-Labo | Mol | Other facilities | x |
| | BCMN | Geel | Other facilities | x |
| | Overpelt | Olen | Separate storage | x |
| | Eurochemic | Mol | Separate storage | x |
| | BN-Mol | Mol | Other facilities | - i/ |
| | PULAB | Mol | Other facilities | - g/ |
| Canada[b] | Fuel Engineering | Chalk River | Other facilities | x |
| | WNRE | Pinawa, Manitoba | Other facilities | x |
| | Workshops | Chalk River | Other facilities | x |
| | WNRE | Pinawa, Manitoba | Separate storage | x |
| | Pickering G.S. | Pickering | Separate storage | x |
| | CRNL | Chalk River | Separate storage | x |
| | Bruce G.S. | Tiverton | Separate storage | x |
| Czechoslovakia[b] | Research Laboratories | Rez | Other facilities | x |
| | Nuclear Fuel Inst. (UJB) | Prague | Other facilities | x |
| | A1 | Bohunice | Separate storage | x |
| Denmark[c] | FAB.STO. | Risø | Separate storage | x |
| | Hotcell Plant | Roskilde | Other facilities | x |
| France | COGEMA | Cap de la Hague | Separate storage | x |
| German Democratic Republic[b] | Staatl. Amt f. Atomsicherheit | Berlin-Karlshorst | Other facilities | x |
| | VEB Geophysik Leipzig | Gommern | Other facilities | x |
| Germany, Federal Republic of[b] | Urananlage | Ellweiler | Separate storage | x |
| | Braunkohle | Wesseling | Separate storage | x |
| | KWU-Hotcell | Karlsruhe | Other facilities | x |
| | KFA-Lab | Julich | Other facilities | - i/ |
| | Transuran | Karlsruhe | Other facilities | x |
| | GFK-Hotcell | Karlsruhe | Other facilities | x |
| | GFK/IHCH | Karlsruhe | Other facilities | x |
| | GFK/IMF3 | Karlsruhe | Other facilities | x |
| Hungary[b] | Institute of Isotopes | Budapest | Other facilities | x |
| Italy[b] | CNEN-LAB. TEC | Casaccia | Other facilities | x |
| | CNEN. LAB. PU. | Casaccia | Other facilities | x |
| | CCRM-Ispra | Ispra | Separate storage | x |
| | Research Centre | Ispra | Other facilities | - i/ |
| | AGIP Bosco-Marengo | Alessandria | Separate storage | - h/ |

| State[a] | Abbreviated name | Location | Type | Subsidiary arrangements in force |
|---|---|---|---|---|
| Japan[b] | JAERI-Oarai R&D | Oarai-Machi | Other facilities | x |
| | JAERI-Tokai R&D | Tokai-Mura | Other facilities | x |
| | NERL, University of Tokyo | Tokai-Mura | Other facilities | x |
| | NFD | Oarai-Machi | Other facilities | x |
| | NRF | Tokyo | Other facilities | x |
| | PNC Tokai R&D (development facility) | Tokai-Mura | Other facilities | x |
| | PNC-Oarai R&D | Oarai-Machi | Other facilities | x |
| Netherlands[b] | ECN+JRC | Petten | Other facilities | x |
| | Kema Lab. | Arnheim | Other facilities | x |
| Norway[b] | Research laboratories | Kjeller | Other facilities | x |
| Pakistan | Storage at Government depot | Karachi | Separate storage | x |
| Poland[b] | Institute of Nuclear Research | Świerk | Other facilities | x |
| | Miscellaneous locations combined in one material balance area | Various | Other facilities | x |
| Portugal[b] | Instalacao de Armazenagem | Armazenagem | Separate storage | x |
| Romania[b] | Helen | Margurele | Other facilities | x |
| | Demfuel | Pitesti, Colibasi | Other facilities | x |
| Sweden[b] | Central storage fresh fuel | Studsvik | Other facilities | x |
| | Central Hot Laboratory | Studsvik | Other facilities | x |
| Switzerland[b] | Diorit | Würenlingen | Separate storage | x |
| | Federal Institute of Reactor Research | Würenlingen | Other facilities | x |
| United Kingdom | Windscale PU-storage | Windscale | Separate storage | x |
| | Zebra storage facility | Winfrith | Separate storage | x |
| USA | Argonne National Laboratory | Argonne | Separate storage | x |

a/ An entry in this column does not imply the expression of any opinion whatsoever on the part of the Secretariat concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.

b/ NPT safeguards agreement.

c/ Prior to the entry into force on 21 February 1977 of the safeguards agreement between the seven non-nuclear-weapon States of EURATOM, EURATOM and the Agency, NPT safeguards were applied in Denmark under the NPT agreement with Denmark which entered into force on 1 March 1972.

d/ Safeguards agreement in connection with the Treaty for the Prohibition of Nuclear Weapons in Latin America (Tlatelolco Treaty) and NPT.

e/ In force on 12 February 1980.

f/ Proposal made by the Agency in October 1979.

g/ In force on 1 January 1980.

h/ In force on 1 February 1980.

i/ Under negotiation.

j/ Concluded pursuant to the Switzerland/USA/Agency safeguards agreement (INFCIRC/161).

## INIS

184. During 1979 two further Member States joined INIS, bringing the total number of participants to 62 countries and 13 international organizations. More than 75 000 references were processed. By the end of the year the file of information had grown to almost 500 000 items, more than three quarters of which could be reached directly via on-line search. The microfiche collection was expanded and now contains almost 120 000 documents.

185. In order to make the INIS and AGRIS data bases more easily available for on-line searches, the Agency concluded agreements during 1979 with the European Space Agency, the International Institute for Applied Systems Analysis (IIASA) and the Time-Sharing Network (TYMNET).

186. During a time of strong public concern over nuclear safety, over 8000 relevant documents were retrieved as a result of an on-line search of the INIS data base. INIS is to-day the only system that provides such depth of coverage; in fact, since "Nuclear Science Abstracts" ceased publication in 1976 INIS is the only system that provides a worldwide coverage of nuclear literature.

187. Under the INIS training programme the Agency held special on-line workshops at information centres in France and the Soviet Union.

## Computer services

188. At the end of 1979 the Agency assumed responsibility for providing computer services to all organizations located at the Vienna International Centre. As the work-load increased in 1979, the number of on-line terminals was more than doubled, reaching nearly 70, and the main computer memory was increased by 50%.

## ADMINISTRATION

### External and legal affairs

#### Physical protection

189. Negotiation of a Convention on the Physical Protection of Nuclear Material was concluded on 26 October at the Agency's Headquarters. The Convention, the first multilateral agreement on the physical protection of nuclear material, took over two years to negotiate. [11].

190. The Convention establishes standard measures of physical protection to be applied to nuclear material during transport from one country to another. Parties will be required to provide for the prosecution or extradition of persons committing any of a number of defined serious criminal offences involving nuclear material and to co-operate in preventive measures and information exchange with regard to acts such as theft, sabotage and extortion involving nuclear material.

191. A high degree of interest continued to be shown in training courses on the physical protection of nuclear facilities and material. The second such course organized by the Agency in co-operation with the United States of America was held at Albuquerque, New Mexico.

#### Nuclear law

192. An international seminar on nuclear law and nuclear safety regulations was held in Istanbul, Turkey, in September. Various legislative and regulatory aspects of nuclear safety control, reactor licensing, quality assurance, emergency response planning, third-party liability and insurance, and nuclear export control were discussed.

193. Advisory services in nuclear law were provided to Indonesia, Malaysia and Yugoslavia.

#### International spent fuel management

194. In 1978 the Director General circulated to all Member States the results of a study, carried out by the Secretariat, on the international management and storage of plutonium and spent fuel. An expert group on international spent fuel management was convened in 1979 to follow up the spent fuel portion of the Secretariat study. Its purpose is to examine the possibilities for international co-operation in spent fuel management and to assist the Agency in defining the role it might play in solving problems created by the accumulation of spent fuel. Two meetings of the expert group were held in Vienna; fundamental issues were identified and discussed and the ground was laid for a further study of this topic.

#### International plutonium storage

195. Meetings of the expert group on international plutonium storage, which is preparing proposals for an international plutonium storage system in implementation of Article XII.A.5 of the Agency's Statute, were held in May and November. The group made good progress and agreed to continue its work in 1980 by considering drafts of the legal instruments needed to establish a scheme.

#### Privileges and immunities

196. By the end of the year, 49 Member States had accepted the Agreement on the Privileges and Immunities of the Agency. [12].

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[11] It was opened for signature on 3 March 1980.

[12] Reproduced in document INFCIRC/9/Rev.2.

197. A number of agreements concerning the new Headquarters buildings at the Vienna International Centre (VIC) were under negotiation with the Austrian Government throughout the year. One agreement, concerning the delineation of the area of the VIC, was concluded.

## Vienna International Centre

198. At an inauguration ceremony on 23 August, the buildings comprising the Vienna International Centre were formally transferred to the United Nations and the International Atomic Energy Agency by the Austrian Government. The Agency's move to its new Headquarters buildings began in October and was completed within one month.

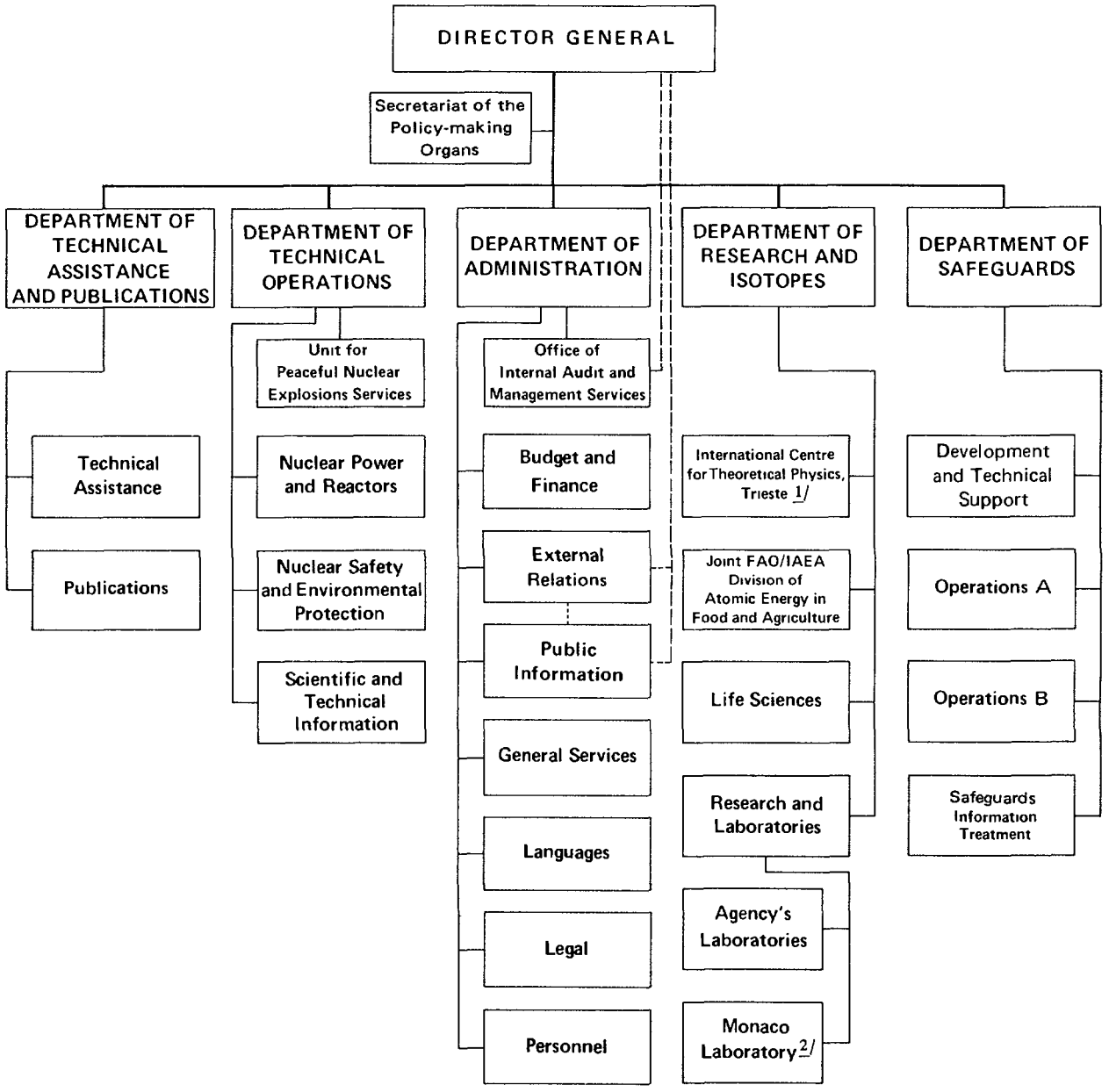
## Personnel

199. In 1979 a total of 305 staff members left the Agency and 281 were appointed. Of the new staff members, 100 were in the Professional category.

200. At the end of the year, the Secretariat had 524 staff members in the Professional and higher categories, 830 in the General Service category and 177 in the Maintenance and Operatives Service category.

201. The following organizational chart shows the structure of the Secretariat as at the end of 1979.

## ORGANIZATIONAL CHART




1/ Jointly operated by the Agency and UNESCO.
2/ With the participation of UNESCO and UNEP.