International Atomic Energy Agency

BOARD OF GOVERNORS

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THE ANNUAL REPORT FOR 1998

1. The draft of the annual report which the Board is required to make to the General Conference under Article VI.J of the Statute is attached hereto. It covers the period 1 January to 31 December 1998.

2. The Secretariat would appreciate receiving comments on or corrections to the draft report informally before the Board considers it in June.

SUGGESTED ACTION BY THE BOARD

3. The Board's approval of the report is sought on the understanding that the draft be revised to reflect as far as possible such observations as may be made on it.

THE ANNUAL REPORT FOR 1998

(A draft of a document for the
forty-third regular session of the General Conference)

NOTE

1. The draft Annual Report aims to summarize only the significant achievements of the Agency during the year in question. Details on the degree of completion of the individual tasks set out in *The Agency's Programme and Budget for 1997 and 1998* and of monies spent can be found in the *Programme and Budgetary Performance Report for 1998.*

2. The evaluation of safeguards activities in 1998 is still in progress in the preparation of the *Safeguards Implementation Report for 1998*. Consequently, some of the statistical information given in the 'Safeguards' chapter and in the Annex must be considered provisional. If necessary, corrections will be reflected in the final version of this document.

3. All sums of money are expressed in United States dollars.

4. The designations employed and the presentation of material in this document do 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.

5. The mention of names of specific companies or products (whether or not indicated as registered) does not imply any intention to infringe proprietary rights, nor should it be construed as an endorsement or recommendation on the part of the Agency.

6. The term "non-nuclear-weapon State" is used as in the Final Document of the 1968 Conference of Non-Nuclear-Weapon States (United Nations document A/7277) and in the Treaty on the Non-Proliferation of Nuclear Weapons.

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THE YEAR IN REVIEW

In 1998, there were a number of developments in the international environment relating to the Agency's overall programme: the international dimension of nuclear safety became increasingly recognized; the need for sustainable development continued to be a priority; the requirements for electricity generation without the emission of environmental pollutants, and especially the emission of greenhouse gases, grew in urgency; and the importance of worldwide moves towards a strengthened non-proliferation regime was heightened. Against this background, the Agency set in motion a re-examination and redirection of its functioning in order better to meet the needs and interests of its Member States.

During the year, the Agency operated on a regular budget of $226 million and also used slightly more than $30.1 million in extrabudgetary funds for important activities in support of programmes. The target for contributions to the Technical Co-operation Fund for 1998 was set at $71.5 million, of which $53.4 million was pledged by Member States.

At the end of 1998, there were 2133 staff members of the Secretariat — 847 in the Professional and higher categories and 1286 in the General Service category. These figures represent 1676 regular, 278 temporary assistance and 179 extrabudgetary staff. Ninety-five nationalities were represented among the 684 staff members in posts subject to geographical distribution.

This review highlights some of the achievements of the Agency in 1998 against the background of worldwide developments.

Nuclear technology and energy for sustainable development

Nuclear technology

The importance of water

Water — its quantity and quality — continued to be a critical global issue. One particular expression of this concern was the growing interest expressed by Member States in nuclear technology for desalination. A joint pre-project study by Morocco and China was completed in October with the assistance of the Agency under a technical co-operation project. Morocco selected a 10 MW(th) nuclear reactor from China for a desalination plant to be built in Tan-Tan. A co-operation agreement was signed between the two Governments in December.

Another sign of heightened interest in the problem of water was the decision by the United Nations to declare 1998 the 'International Year of the Ocean'. The overall objective was to focus the attention of the public, governments and decision makers on the importance of the oceans and the marine environment as resources for sustainable development in the light of the increasing threats of pollution, population pressure, excessive fishing, coastal zone degradation and climate variability. The Agency and other international organizations involved in ocean related studies contributed jointly to this endeavour. The interagency co-operation programmes included a contribution to EXPO '98 in Lisbon, and joint conferences, co-ordination meetings and regional assessments. The most important event in which the Agency played a leading role was a symposium on marine pollution, organized in co-operation with the IOC of UNESCO, UNEP, IMO and the Commission Internationale pour l'Exploration Scientifique de la Mer Méditerranée, held in Monaco in October. The symposium was a timely opportunity for scientists to share the latest knowledge on the sources, behaviour and impact of marine contaminants in the world's oceans. During the same week the new premises of the Agency's Marine Environment Laboratory were inaugurated.

Greater efforts were made to initiate joint programmes and collaboration with other United Nations agencies in the area of water resources development and management. For example, a Memorandum of Understanding was signed between the Agency and WMO to further enhance collaboration in operating the Global Network for Isotopes in Precipitation. The joint efforts are aimed at a wider use of the isotope data.

The Agency's work in isotope hydrology in Africa was given special recognition by being included in a United Nations system-wide initiative (see Box 1). The Agency was also invited to participate in a new United Nations project being launched to characterize and develop mitigation strategies for contaminated drinking water. The initial focus of this work will be on the arsenic contamination of drinking water in Bangladesh, which has affected millions of people and is a major public health issue.

BOX 1

Water resources in Africa

A number of countries in Africa are currently facing a crucial shortage of freshwater that threatens public health and impedes social and economic development. This situation has prompted the United Nations to include water among the set of priorities of the 'System-wide Initiative on Africa', with the aim of assuring sustainable use of and equitable access to freshwater. The Agency contributes to this initiative with two large technical co-operation Model Projects aimed at solving specific practical problems related to the assessment and management of water resources using isotope techniques in combination with other hydrological studies. The first project started in 1995 and involves nine countries in northern Africa: Algeria, Egypt, Ethiopia, Mali, Morocco, Niger, Nigeria, Senegal and Sudan. The second Model Project started this year with seven countries from southern and eastern Africa, namely Kenya, Madagascar, Namibia, South Africa, the United Republic of Tanzania, Uganda and Zimbabwe. In 1998 the first phase of the northern Africa project was completed.

Senegal, in common with other Sahel countries south of the Sahara desert, has faced a significant decline in rainfall over the last four decades, coupled with increasing demands on its water resources, principally groundwater. The metropolitan area of Dakar, with a population of more than 1.5 million and 70% of its water drawn from aquifers located in the coastal zone, is an example of human settlement and development that depend mainly on (over-used) local groundwater. The water demand is 221 000 m^3 per day and chronic shortages reaching 25–30% are experienced. The increasing exploitation of the three major aquifers in this area, the Cap Verde Peninsula, combined with the effect of the drought, has led to a continuous decline in the groundwater level of this aquifer system and advancing seawater intrusion in several parts of it. In order to avoid further decline and degradation of the groundwater resources, the water authorities need to better understand the natural replenishment of the aquifers and the interrelationships between the different aquifers under exploitation. Through the integration of isotope investigations into ongoing hydrological studies and groundwater modelling, this goal was reached. In particular, isotopes demonstrated that in one of the aquifers the groundwater uptake is presently still compensated by natural replenishment (rainfall infiltration). One of the other aquifers, however, is being over-exploited, and in the third one the groundwater quality is deteriorating owing to infiltration of domestic waste water. The results of the project have encouraged the local water authorities to embark on studies for alternative sources of water.

Food and health

The increasing acceptance of food irradiation and the strengthened support given to the issue of food quality and safety through the newly established FAO/IAEA Training and Reference Centre at Seibersdorf (see Box 2) made a contribution to trade enhancement and improved food control systems. In this connection, it was agreed by member countries at a meeting in October to extend the mandate of the International Consultative Group on Food Irradiation, which expires in May 1999, for another three years, with a refocused work programme.

In Latin America, a five year study was completed on the development and validation of a diagnostic assay to distinguish animals vaccinated against brucellosis from those naturally infected, an essential prerequisite to the slaughter of animals carrying the disease. This was the largest serological study ever undertaken with regard to brucellosis — considered to be one of the most important diseases affecting animals and, through the consumption of milk and dairy products, one of the most dangerous diseases affecting humans. Through the support provided by the Agency, an essential tool now exists that will significantly assist Member States in the future control and eradication of brucellosis.

From a figure of approximately 6% in the 1980s, the proportion of deaths in developing countries due to cancer rose to 9% by 1998. The Agency has accorded greater priority to cancer treatment using radiotherapy. During 1998, 18 national and regional training courses targeted at radiation oncologists, technologists operating machines and nurses caring for brachytherapy patients were held to help improve clinical practice. In addition, regional projects, particularly in Africa, resulted in a significant upgrading of equipment used in cancer control and an enhancement of the skills of medical personnel. A radiation centre was set up in Ghana, in addition to establishments in Namibia and Ethiopia. As a result of Agency assistance, these centres now offer full teletherapy and brachytherapy cancer services.

Partnerships in the transfer of technology

A special effort was made during 1998 to work with and through partners in the implementation of the Agency's technical co-operation programme. The resulting synergy both helped to bring extra financial resources to projects and encouraged regional collaboration. One example was a project in Eastern Europe on medical education for nuclear accident preparedness, co-ordinated through the Boston University Medical Center. The approach used was a major departure from tradition, involving outsourcing that brought together ten international centres. Some $3 million will have been spent by the end of the

BOX 2

FAO/IAEA Training and Reference Centre for Food and Pesticide Control

Extrabudgetary funds from the Governments of Austria and Sweden facilitated completion of the construction and equipping of the Centre at the Agency's Laboratories in Seibersdorf, near Vienna. The main objective is to strengthen the analytical capacities of Member States to fulfil the requirements for implementing international standards and agreements relevant to food quality and safety, particularly those covered by the 'Agreement on the Application of Sanitary and Phytosanitary (SPS) Measures' being enforced by the WTO.

The activities of the Centre focus on training, standardization of analytical methods and the provision of information to national food control laboratories relevant to determining pesticides, veterinary drug residues, radionuclides and other contaminants in food and feed covered by the FAO/WHO Codex Alimentarius Food Standards.

project, with only 40% contributed by the Agency. Another innovative, cost saving, feature was the organization of courses using teleconferencing systems to connect various centres during training sessions. The project has trained more than 100 medical doctors, developed a curriculum and a train-the-trainers programme, and has helped emergency centres in six countries become capable of delivering the curriculum.

Nuclear energy

Contribution of nuclear power

In 1998, there was a rise in world electricity consumption by about 3% over the figure for 1997. Nuclear energy continued to contribute about 16% to the overall total. If the nuclear generated energy had been produced by the current mix of fossil fuels, total energy related carbon emissions would have been increased by some 8%.

According to data reported to the Agency's Power Reactor Information System, there were 434 nuclear power plants in operation at the end of 1998: 151 in Western Europe, 70 in Eastern Europe, 118 in North America, 5 in Latin America, 11 in the Middle East and South Asia, 2 in Africa and 77 in the Far East. Four new nuclear plants were connected to electricity grids, three in the Republic of Korea and one in Slovakia, representing 2958 MW(e) of capacity. Construction started on two plants in China and one in Japan, bringing the total number of plants under construction around the world to 36, equivalent to a total generating capacity of 27 536 MW(e). Seven reactors were shut down during the year (equivalent to 5776 MW(e)), including two Canadian reactors which are expected to restart in the future. Accumulated operating experience reached approximately 9010 reactor-years.

The largest contributor to the world installed nuclear capacity remained the USA (28%), followed by France (18%) and Japan (12.5%). Germany's contribution was 6.4%, followed by the Russian Federation with 5.7%, Ukraine with about 3.9%, the United Kingdom with 3.7%, the Republic of Korea with 3.5%, and Sweden and Canada with about 2.9%.

Lithuania continued to be the country with the highest contribution of nuclear power to national electricity production (77%), followed by France (76%), Belgium (55%), Sweden (46%), Ukraine (45%), Slovakia (44%), Slovenia (44%), Bulgaria (42%), and the Republic of Korea and Switzerland (41%). In an additional eight countries, more than 25% of the electricity was produced by nuclear power.

In the European Union, the most likely scenario for nuclear power is that capacity will remain at about its present level in the coming years, with life extension programmes implemented whenever needed. However, at the policy level a number of important developments took place during the year. Most important in this respect were events in Germany. After elections in September the coalition agreement for the new Government stated that the use of nuclear power would be stopped and invitations issued for talks concerning a new energy consensus. In France, a final decision on Superphénix, the 1200 MW(e) demonstration fast breeder reactor, was taken in early 1998: it will be shut down and dismantled. The partially burnt and the unburned newly fabricated cores will be reprocessed. With the completion of Civaux 2 in France, planned to be connected to the grid in mid-1999, there were no reactors under construction in the European Union. Utilities in Finland were seeking Government approval to build a fifth reactor.

In Turkey, bids by three international consortia for the first nuclear power plant, being planned at Akkuyu on the eastern Mediterranean coast, were being evaluated.

In Asia, planning for the expansion of nuclear power continued, particularly in China, India, Japan and the Republic of Korea. However, the financial crisis in this region slowed down the expected growth in energy demand.

South Africa continued with the development of the 100 MW(e) Pebble Bed Modular Gas Cooled Reactor, with the Agency assisting in its assessment.

In Brazil, it was announced that the Angra-2 nuclear power plant would be inaugurated in 1999. A feasibility study concluded in March 1998 that it would take five years to complete Angra-3.

Energy from nuclear fusion

Six years of international collaborative work under the auspices of the Agency on the International Thermonuclear Experimental Reactor (ITER) Engineering Design Activities (EDA) were completed, culminating in a final design report which was

approved by the ITER Council in June. Following completion of the report, the Council agreed on guidelines for a new work programme. A priority task is the design of reduced cost options which would still meet the overall objective of demonstrating the scientific and technological feasibility of fusion energy for peaceful purposes. An Amendment to the ITER Agreement extending the EDA for three years was signed by the European Union, Japan and the Russian Federation. In September, the USA agreed to continue its participation in the extended EDA until July 1999.

Reducing greenhouse gases

The Annex I Parties to the United Nations Framework Convention on Climate Change (i.e. the industrialized countries and the economies in transition) gave binding commitments under a Protocol adopted in Kyoto in December 1997 to reduce by about 5% their emissions of greenhouse gases (GHG) by the year 2010 as compared with the 1990 levels. They confirmed this pledge at a further meeting in Buenos Aires in November. Although the Kyoto Protocol does not impose any such commitments on the non-Annex-I countries (i.e. developing countries), it is certain that unless concerted efforts are made to check the growth of GHG in these countries as well, the stabilization of concentrations of these gases in the global atmosphere at an acceptable level cannot be achieved. One of the flexible mechanisms envisaged under the Kyoto Protocol is the 'Clean Development Mechanism'. This creates a means for transferring credits obtained for reducing emissions from projects in developing countries to the Annex I sponsors of those projects. It combines the objectives of assisting developing countries in achieving sustainable development (through technology transfer and financial assistance) with assisting Annex I Parties in complying with their commitments under the Protocol in a cost effective manner.

Fuel cycle and radioactive waste

Supply of nuclear fuel

World uranium demand increased moderately in 1998 to some 61 000 tonnes and was met by supplies of about 38 000 tonnes from mining and milling (60% of the total requirement). The remaining material needed to fuel reactors came primarily from stockpiles, from the use of mixed oxide (MOX) fuel, and from reprocessed uranium and the dilution of high enriched uranium. The number of nuclear power plants loaded with MOX fuel reached 32 (with about 50 more licensed or undergoing licensing) in Belgium, France, Germany, Japan and Switzerland. In Belgium and Switzerland, a batch average burnup of MOX fuel similar to that of uranium fuel was attained.

Back end of the fuel cycle and waste management

Annual spent fuel arisings amounted to about 10 500 tonnes of heavy metal, with some 130 000 tonnes in storage facilities around the world. The inventory of separated civil plutonium was estimated to be about 200 tonnes — the highest figure since reprocessing began. The Agency held a symposium on the storage of spent fuel from power reactors in November (see Box 3).

Site selection and characterization studies for high level long lived radioactive waste and spent fuel disposal facilities continued to be the main focus of many national programmes. Important developments occured in several of these programmes. Sweden moved to the second phase of development of the Hard Rock Laboratory in Aspö, implementing a full scale prototype experiment. After a four year siting study, the French Government decided in December to authorize the construction and operation of two underground laboratories in clay and granite formations for research on the possibilities of a reversible or non-reversible repository in a deep geological formation. The first laboratory will be built in eastern France (Meuse site), while the granite formation laboratory requires the selection of a new site, for which preparations will start in 1999.

The US Department of Energy is responsible for an estimated 140 000 m^3 of transuranic (TRU) waste left from the production of nuclear weapons and the dismantling and cleanup of weapons production sites. This waste is dispersed in various sites in temporary retrievable storage. The construction and testing of the underground Waste Isolation Pilot Plant (WIPP) facility at Carlsbad, New Mexico, as well as the facilities and equipment required to safely transport, receive, handle and dispose of TRU wastes, were essentially completed in the last decade. The Agency, together with the OECD/NEA, conducted an international review of the safety documents required under US regulations. In May 1998, the Environmental Protection Agency

certified that WIPP complies with all applicable environmental radiation protection standards.

At a meeting in Murmansk in November, the Contact Expert Group for International Co-operation in Radioactive Waste Management with the Russian Federation approved a list of highest priority projects covering spent fuel and radioactive waste resulting from the decommissioning of nuclear submarines. Most of the tasks to be undertaken under these projects require the construction of new facilities, the acquisition of equipment, and multimillion-dollar funding.

Safety issues in the use of nuclear energy and technology

The issues shaping the global safety agenda were illustrated by the topics covered at an Agency conference in Vienna: safety management; occupational radiation protection; backfitting, upgrading and modernization of nuclear power plants; chronic exposure to residual materials; long term waste disposal; and regulatory strategies.

Legal instruments

An important component of the global safety agenda is represented by the binding legal instruments developed over recent years. By the end of 1998, 49 States had become Contracting Parties to the Convention on Nuclear Safety and 37 States had signed the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, though only 5 had ratified it.

In addition to these binding legal instruments, an important step forward was the review of the Agency's document INFCIRC/225/Rev. 3, *The Physical Protection of Nuclear Material*. This review resulted in recommendations to improve the structure and clarity of the document and to take account of improved technology and current practices.

Nuclear regulation

A strengthening of relations between nuclear regulators was apparent in 1998. The first meeting of the 'Network of Regulators of Countries with Small Nuclear Programmes' was held in Vienna in September.

BOX 3

Symposium on Storage of Spent Fuel from Power Reactors

An opportunity for representatives of governmental authorities, utilities, industry and research organizations to exchange information on the latest technologies and policies for spent fuel storage was provided by an international symposium which was held in Vienna from 9 to 13 November in co-operation with the OECD/NEA. The participants discussed the current situation and the major factors influencing national policies in this field, and identified the most important directions for national efforts and international co-operation:

- The interim storage of spent fuel will be longer than initially anticipated and extended operation of existing facilities will therefore be required;
- Additional fuel storage capacity is needed;
- The design of spent fuel storage facilities should in the future take into account spent fuel originating from advanced fuel cycle practices (high burnup and the use of MOX fuels);
- An integrated approach to spent fuel storage that would address the transport, storage and disposal of spent fuel, while at the same time using flexible multipurpose systems, is required.

Nuclear regulatory authorities in the States of the European Union that have nuclear power plants announced their intention in December to form a new Western European Nuclear Regulators Association.

Safety missions and advice

A landmark was reached in 1998 with the organization of the one hundredth mission under the Agency's Operational Safety Assessment Review Team programme (see Box 4). A special Agency extrabudgetary programme on the safety of WWER and RBMK reactors ended in 1998 (see Box 5).

The startup in June of the first unit of the Mochovce nuclear power plant in Slovakia — a WWER-440/213 reactor with extensive safety upgrades — was accompanied by discussions on safety matters in which the Agency also participated. They focused on the status of the reactor pressure vessel, the design modifications and the seismic safety of the plant.

Safety in transport

In May, the transport of spent fuel in France, Germany and Switzerland was stopped after inspections by the French regulator found that for a number of years a high percentage of the flasks and wagons arriving at the rail terminal used by the reprocessing plant at La Hague had levels of non-fixed contamination exceeding 4 Bq/cm^2 beta–gamma activity — a level specified in the Agency's Transport Regulations and in many national regulations as a 'clean' level for shipments. Further measurements and consultation of records indicated the presence of such contamination on a significant fraction of empty flasks arriving at nuclear power plants in France, Germany and Switzerland, and full flasks arriving at La Hague and at Sellafield in the United Kingdom. Although studies showed that radiation exposure of rail workers or the public had been extremely low, the authorities in France, Germany and Switzerland required the introduction of improved technical procedures, monitoring, documentation and information flow. Transports were resumed in France in

BOX 4

100 OSART missions: A milestone in ensuring the operational safety of nuclear power plants

The Operational Safety Assessment Review Team (OSART) programme was created in 1982 as a service to the Agency's Member States whereby an international team of experts conducts a three week in-depth review of operational safety performance at a power plant at the request of a Member State. The first OSART mission took place at the Kori nuclear power plant in the Republic of Korea in August 1983, and the hundredth mission was carried out at the Golfech plant in France.

The one hundred OSARTs were conducted at 73 different plant sites, in 29 countries on all continents that have nuclear power plants. Over 1100 team members participated in these missions. More than 800 of these were provided by the nuclear industry worldwide in support of the Agency's own staff.

OSART missions focus on the performance of management processes and plant personnel in achieving safe operation, and usually review performance in eight areas: management, organization and administration; training and qualifications; operations; maintenance; radiation protection; chemistry; and emergency planning and preparedness.

Benefits to the plant from an OSART mission stem from the preparation and self-assessment before the visit, as well as the exchange of experience and good practices with the experts. The OSART report, sent to the government and the regulatory body, also promotes openness and transparency.

July 1998 following the implementation of some measures and subject to others being carried out. As of the end of 1998, transports in Germany and Switzerland remained suspended.

Several States and non-governmental organizations continued to voice more general concerns about the international transport of spent fuel and radioactive waste. A resolution adopted by the Agency's General Conference in September invited States shipping radioactive materials "to provide, as appropriate, assurances to potentially affected States upon their request that their national regulations take into account the Agency's Transport Regulations; and to provide them with relevant information relating to shipments of radioactive materials. The information provided should in no case be contradictory to the measures of physical security and safety."

Radiation sources not under regulatory control

Radiation sources not under regulatory control ('orphan' sources) continued to pose a problem (see Box 6). In July, three caesium-137 sources were found in Georgia, apparently from a former Soviet civil defence base. The dose rates close to the largest of the sources were up to about one hundred million times natural background levels. At the request of Georgia, the Agency assisted in the recovery operation and, with the help of the Government of France, undertook biological dosimetry of the potentially affected population. Two other sources — both strontium-90 — were discovered in October near Khaishi. The Agency sent a mission to assess the situation.

In June, very low concentrations of caesium-137 were detected in air samples at a number of places in Europe. Investigations determined that the cause was a source apparently delivered in a load of scrap metal and melted in a steel plant in Algeciras in southern Spain. Although the incident did not require invocation of the Convention on Early Notification of a Nuclear Accident, the mechanisms established under the Convention allowed the Agency to rapidly disseminate information to Member States.

Radiological assessment

In 1996, following a request from the Government of France, the Agency embarked on a study of the

BOX 5

Safety evaluation of WWER and RBMK plants

In response to requests from Member States operating Soviet designed WWER model 230 nuclear power plants, the Agency launched a major international programme in 1990 to evaluate this first generation of Soviet designed reactors and provide safety assistance to plant operators and regulators. The programme was undertaken as a complement to existing national, bilateral and international activities and was extended in 1992 to other types of WWERs and to RBMKs. It was financed primarily by voluntary contributions as an extrabudgetary programme (EBP), with some activities being funded through the Agency's regular budget or through national and regional technical co-operation projects. Steering committees provided independent advice on the conduct of this EBP.

A significant achievement of the programme was the preparation of 'Safety Issue Books' detailing design and operational safety issues and their importance for the plants under consideration. International consensus was reached on safety issues related to WWERs and RBMKs and on the priority measures required. The programme findings and associated publications are being widely used as a technical basis for the development of safety upgrades, reviews by national regulatory authorities, and the establishment of safety priorities in national, bilateral and international programmes.

radiological situation at the Atolls of Mururoa and Fangataufa, in French Polynesia, where France conducted 193 'expériences nucléaires' (nuclear experiments) between 1966 and 1996. The study was designed to assess the residual radiological conditions at the atolls after the end of all the experiments and also the future radiological situation. It concluded that: there will be no radiation health effects which could be either medically diagnosed in an individual or epidemiologically discerned in a group of people; the expected radiation dose rates and modes of exposure are such that no effects on biota population groups could arise; no remedial action at the atolls is needed on radiological protection grounds, either now or in the future; no further monitoring at Mururoa and Fangataufa Atolls is needed for purposes of radiological protection; and the expected extent of changes in the conclusions due to uncertainties in the parameters used in the modelling is slight. The findings, conclusions and recommendations of the study were presented in June in the Fiji Islands to high level officials and selected representatives of member countries of the South Pacific Forum, and in Tahiti to authorities of French Polynesia, the French Government, and various other organizations and authorities. The results were also issued in a nine volume set, together with the

BOX 6

Conference on the Safety of Radiation Sources and Security of Radioactive Materials

The first ever major international conference devoted to the safety of radiation sources and security of radioactive materials was held in Dijon, France, in September. It was organized by the Agency and co-sponsored by the European Commission, INTERPOL, WCO and the Atomic Energy Commission of France.

The 10 technical sessions reviewed 12 major topics:

- *The safety of radiation sources* — regulatory control, safety assessment techniques, engineering and managerial measures, lessons from experience, international co-operation through reporting systems and databases, verification of safety through inspection and the use of performance indicators for a regulatory programme;
- *The security of radioactive materials* — measures to prevent breaches in the security of radioactive materials, detection and identification techniques for illicit trafficking, response to detected cases and seized radioactive materials, strengthening awareness, training and information exchange.

The conference discussed:

- The need for Member States to ensure effective systems of control and for preventing, detecting and responding to illicit trafficking in radioactive materials;
- Major problems related to human errors, caused by a lack of training, insufficient commitment of managers, and the absence of procedures and supervision;
- Problems in developing countries connected with the import and use of radiation sources without effective maintenance and the lack of expertise of regulatory authorities in ensuring the safety of the imported equipment, as well as inadequate resources;
- The problem of 'orphan' sources ending up in the public domain.

proceedings of a specially convened international conference held in Vienna in June–July.

Remediation

The Emu site in South Australia, used by the United Kingdom for two atmospheric nuclear weapons tests in 1953, was returned to its Aboriginal owners at the end of March 1998, following remediation work. The criterion applied was that individuals should not receive more than about twice the global average background dose per year from permanent occupancy of the site.

Verification of the peaceful uses of nuclear energy

In 1998, the Agency continued the development and implementation of measures to strengthen its safeguards system. Environmental sampling started to become a routine safeguards measure, and the necessary infrastructure for using remote monitoring as a safeguards tool was being set up. As a result of the strengthening measures of recent years, the Agency's information base has become broader and this process will accelerate when States submit information under the Protocol Additional to Safeguards Agreements. A

BOX 7

Additional Protocols: Dates of signing

Australia	23 September 1997	Ireland	22 September 1998
Armenia	29 September 1997	Italy	22 September 1998
Georgia	29 September 1997	Luxembourg	22 September 1998
Uruguay	29 September 1997	Netherlands	22 September 1998
Philippines	30 September 1997	Portugal	22 September 1998
Poland	30 September 1997	Spain	22 September 1998
Lithuania	11 March 1998	Sweden	22 September 1998
Ghana	12 June 1998	United Kingdom	22 September 1998
USA	12 June 1998	Uzbekistan	22 September 1998
Jordan	28 July 1998	Bulgaria	24 September 1998
Austria	22 September 1998	Canada	24 September 1998
Belgium	22 September 1998	Holy See	24 September 1998
Croatia	22 September 1998	New Zealand	24 September 1998
Denmark	22 September 1998	Hungary	26 November 1998
Finland	22 September 1998	Slovenia	26 November 1998
France	22 September 1998	Japan	4 December 1998
Germany	22 September 1998	China	31 December 1998
Greece	22 September 1998		

- Four Additional Protocols entered into force in 1998: the Additional Protocols concluded by the Holy See, Jordan and New Zealand entered into force upon signature; and the Protocol concluded with Uzbekistan entered into force on 21 December. As of 31 December 1998, a total of 5 Additional Protocols were in force (Australia's Additional Protocol entered into force on 12 December 1997).
- In addition, the Board of Governors approved Additional Protocols with Cyprus, Monaco and Slovakia. As of 31 December 1998, the Board had approved Additional Protocols for 38 States.

model for such an Additional Protocol was adopted in 1997. During 1998, the number of signatories to such Protocols increased from 6 to 35 (see Box 7). Under the new Protocol, inspector access will be broader than before, and during the year guidelines for such complementary access were developed.

Particular challenges remained with regard to the Agency's mandates in the Democratic People's Republic of Korea (DPRK) and in Iraq. The Agency was still unable to verify the correctness and completeness of the initial declaration of nuclear material made by the DPRK, and in Iraq the implementation of the Agency's ongoing monitoring and verification (OMV) plan faced particular difficulties during the year.

Democratic People's Republic of Korea

Because the Agency is still unable to verify the correctness and the completeness of the initial declaration of nuclear material made by the DPRK, it is unable to conclude that there has been no diversion of nuclear material in the DRPK.

The safeguards agreement between the DPRK and the Agency remains binding and in force, and the Agency is continuing to implement safeguards measures in the DPRK. These measure include monitoring the "freeze" on the DPRK's graphite moderated reactors and related facilities, as requested by the United Nations Security Council and as foreseen in the "Agreed

BOX 8

Senior Management Conference

At a Senior Management Conference held in January, the Director General, Department Heads and Division Directors reviewed internal management processes and identified a number of issues that need to be addressed. As a follow-up to the Conference, an Action Plan was developed and a number of initiatives were taken in the course of the year:

- A Programme Co-ordination Committee and an Office of Programme Support and Evaluation were established to ensure the coherence and co-ordination of all Agency programmes.
- A new Office of Information Management was tasked with rationalizing information processing and documentation flow and dissemination within and outside the Secretariat.
- A study of the feasibility of a fully biennial Agency programme cycle was prepared and a report submitted to Member States for discussion.
- Current procedures and processes for the preparation by the Secretariat of reports on its activities were reviewed and clarified to achieve more concise reporting on programme and financial performance in a reduced number of documents.
- A number of actions were initiated in the area of human resource management to ensure that human resources are better matched to programme requirements.
- A new policy framework for an integrated training curriculum for 1998 and beyond was approved, with emphasis on management training.
- Recruitment procedures were simplified to expedite the process while preserving the requirement for excellence in the candidates selected.

Framework" concluded in October 1994 between the DPRK and the USA.

Certain issues relevant to the monitoring of the "freeze" remain unresolved. In addition, at three technical meetings held during 1998 between DPRK representatives and the Agency, no progress was made regarding the preservation by the DPRK of information required by the Agency for the verification of the correctness and completeness of the DPRK's initial inventory.

BOX 9

Report of the Senior Expert Group

The Senior Expert Group made the following general recommendations:

- The Agency should continue to be guided and motivated by its mission "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world", recognizing that an important prerequisite of achieving this mission is to improve confidence in nuclear technology in many Member States. In fulfilling its mission, the Agency should pursue three strategic objectives that are complementary and of equal importance:
  - — Promote the safe use of nuclear technology;
  - — Ensure that undertakings related to the peaceful use of nuclear energy are implemented;
  - — Assist Member States, particularly developing Member States, in the peaceful uses of nuclear technology.
- The Agency should continue to be guided by the principle that its credibility is based on its scientific and technical competence. This can be maintained only if the Agency keeps itself at the forefront of nuclear science and technology.
- The Agency should remain scientifically objective in all its work.
- The Agency, through effective management and integrated programmes, should continue to pursue synergies between its various programmes, including its technical co-operation programme.
- The Agency should strive to enhance its co-operation with other organizations and with private enterprise in order to maximize the value of its programmes while achieving all possible economies; this co-operation should take the form of formal agreements wherever possible and the Agency should ensure that the results of such co-operation are equally accessible to all Member States.
- The Agency should continue critical reviews of its programmes, amongst other ways by strengthening the Programme Performance Assessment System and applying it more widely as a fundamental management tool.
- Concerted efforts should be made to ensure that core activities are funded mainly through the regular budget, thereby reducing dependence on extrabudgetary resources. Nevertheless, innovative cost sharing or cost allocating mechanisms should be explored where necessary to achieve priority goals.

The DPRK remains in non-compliance with its safeguards agreement.

Iraq

Continuing difficulties experienced by the United Nations Special Commission (UNSCOM) and the Agency in gaining access to sites described by Iraq as "sensitive" were resolved by a Memorandum of Understanding signed on 23 February by the Secretary-General of the United Nations and the Deputy Prime Minister of Iraq.

On 25 March, Iraq provided the Agency with a consolidated version of its 'Full, Final and Complete Disclosure', and on 25 April it issued a 'Summary of Technical Achievements' of its clandestine nuclear programme. The Agency accepted both documents as being consistent with its technically coherent picture of Iraq's clandestine nuclear programme.

On 5 August, Iraq announced that it was suspending co-operation with UNSCOM and the Agency. The restrictions that Iraq placed on Agency inspections resulted in significantly reduced assurances of Iraq's compliance with its obligations under United Nations Security Council resolutions.

On 31 October, Iraq ceased all co-operation with UNSCOM. Although Iraq placed no additional restrictions on the Agency's ongoing limited implementation of its OMV plan, the escalating situation caused the Director General to temporarily relocate Agency personnel from Baghdad to Bahrain, on 11 November, after which Agency inspection activities were interrupted during a seven day period. For similar reasons, the Director General again withdrew Action Team personnel on 16 December. Since that time the Agency has been unable to implement its mandate in Iraq and, as a consequence, to provide any assurance that Iraq is in compliance with its obligations.

Fissile material treaty

In 1995, the United Nations General Assembly adopted a resolution outlining the elements of a mandate for the negotiation of a treaty banning the production of fissile material for nuclear weapons and other explosive devices. That resolution requested "the IAEA to provide assistance for examination of verification requirements for such a treaty as required." After long delay, the Conference on Disarmament in Geneva reached agreement in August 1998 to create an ad hoc committee to begin negotiation of such an agreement. During 1998 the ad hoc committee did not reach any result.

Excess fissile material

The USA, the Russian Federation and the Agency continued working together on technical, legal and policy issues involved in verifying that fissile materials designated by the USA and the Russian Federation as no longer required for military purposes remain removed from nuclear weapon programmes. The Agency already applies voluntary offer safeguards to some plutonium and high enriched uranium released from the nuclear weapons programme of the USA.

The United Kingdom announced in July that substantial quantities of nuclear material previously in its military programme would become available for verification under its voluntary offer safeguards agreement.

Neptunium and americium

The Board of Governors at its November meeting discussed the proliferation potential of neptunium (Np) and americium (Am). Discussions on this subject will continue in 1999, particularly on the Secretariat's recommendation to monitor international transfers of separated Np and Am to States with a comprehensive safeguards agreement and activities related to the production of separated Np and Am in those States.

Developments inside the Agency

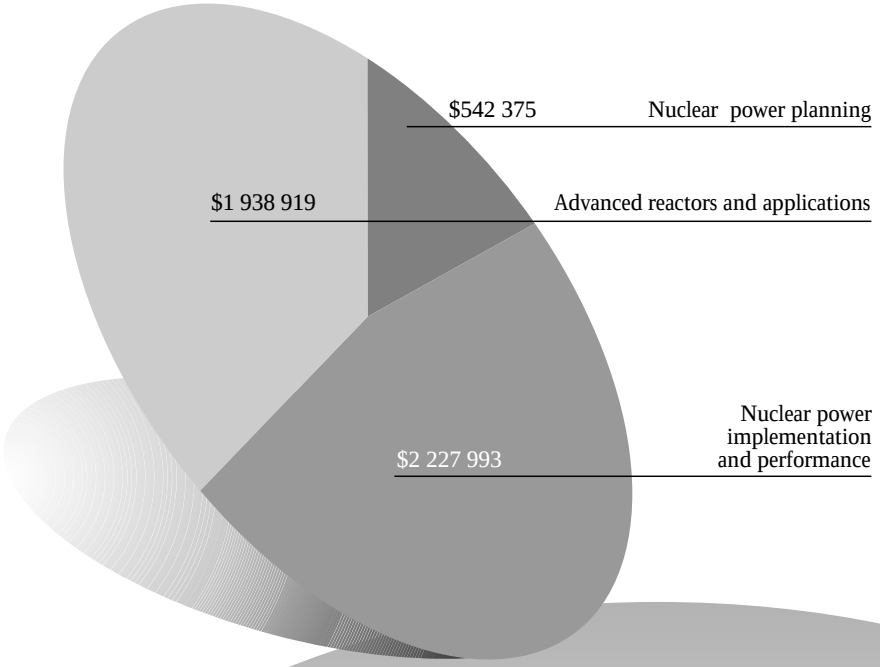
Reviews and reforms

A comprehensive three level review process covering aspects of the Agency's management and programme was set in motion in early 1998. The first level consisted of measures to improve efficiency in three areas: policy and co-ordination, programme development and evaluation, and procedures and personnel. In January, a Senior Management Conference was convened which led to an Action Plan for better management (see Box 8). Many of the initiatives had been implemented by the end of the year.

In parallel with the internal management reform, an external review by a Senior Expert Group (SEG) was initiated to conduct an in-depth review of the programme activities of the Agency in the light of new developments and challenges. In addition to reviewing four of the Agency's Major Programmes, the SEG considered and made recommendations on the Agency's objectives, inter-programme relations and synergies, and the programme management process (see Box 9).

The third part of the reform process was a review of the role and management of public information and the Agency's outreach to civil society, particularly the nuclear, arms control and development communities and the media, using the most modern and effective tools. Development of a new strategy was started.

NUCLEAR POWER



Regular budget expenditure:
$4 709 287

Extrabudgetary programme expenditure
(not included in chart):
$124 556

Programme objective

To assist Member States to pursue the nuclear power option, through the provision of advice and technology transfer in the fields of: nuclear power programme planning, feasibility studies, bid preparation and evaluation, infrastructure and personnel development; instrumentation and control, project management, operational performance, reliability improvement and life management of nuclear power plants; and the development of advanced reactor designs and non-electric applications.

The nuclear power programme assisted Member States in the planning and implementation of nuclear power projects and in the development of advanced reactor technology. Of special interest to developing Member States was the publication of a report entitled *Choosing the Nuclear Power Option: Factors to be Considered.* An international seminar was held in Mumbai, India, on the potential role and the strategies for deploying nuclear power in developing countries. The message from the seminar was that while an extensive infrastructure was needed to handle regulation, training, operations and public communication, there was considerable interest in nuclear power in developing countries as part of their future energy strategy. An international symposium was convened in Seoul on the strategic issues, technologies and economic viability of evolutionary water cooled reactors. The information from this meeting will be used to help plan future Agency activities in LWR and HWR development.

DISTRIBUTION OF AGENCY COMPUTER MODELS

	Number of releases of planning model or package				
	MAED	WASP	VALORAGUA	FINPLAN	ENPEP
Member States	66	95	43	12	54
International organizations	7	12	3	—	6
Totals	73	107	46	12	60

ENPEP: Energy and Power Evaluation Package; FINPLAN: Financial Planning; MAED: Model for Analysis of Energy Demand; VALORAGUA: 'Valor Agua' (value of water); WASP: Wien Automatic System Planning Package.

Nuclear power planning

In 1998, assistance was provided to Belarus, Bulgaria, Croatia, Lithuania, Republic of Moldova and Viet Nam to assess the role of nuclear power in the future expansion of electricity supply systems. There is also a growing interest in developing Member States in utilizing the Agency's technical assistance in planning and implementing their nuclear power programmes. Bangladesh, Egypt and Morocco received such assistance in 1998.

In the related field of the economic assessment of nuclear power plant bid evaluations, development of an improved version of the BIDEVAL software — BIDEVAL-3 — was completed. Distribution will start in early 1999, along with a companion guidebook, *Economic Evaluation of Bids for Nuclear Power Plants.*

An international seminar entitled 'Nuclear Power in Developing Countries: Its Potential Role and Strategies for its Deployment', was organized by the Agency and hosted by the Government of India in Mumbai in October. The purpose of the seminar was to explore the role of nuclear power in meeting the growing demand for electricity in the developing world while conforming to the objectives of sustainable development, and to identify and discuss suitable ways and means for the implementation of nuclear power programmes in developing countries.

Nuclear power implementation and performance

A technical report, *Choosing the Nuclear Power Option: Factors to be Considered*, was published in response to a need expressed by developing Member States. The publication provides information on the political, governmental, economic, financial, technical and safety related issues associated with planning and implementing a nuclear power programme and highlights the main areas in which policies must be developed, as well as the roles and responsibilities of the government, the plant owner and the national industry.

Thirty Member States contributed to a new publication, entitled *Country Nuclear Power Profiles*, that provides consolidated information on nuclear power infrastructure in these States related to planning, decision making and implementing nuclear power programmes. It is planned to update this document and the associated database to support the Agency's programmatic and technical co-operation activities.

The availability of competent personnel is one of the essential requirements for the safe and reliable operation and maintenance of nuclear power plants. Four technical documents were published in the area of the training and qualification of nuclear power plant personnel. These documents provide information on the experience gained in 26 Member States in the application of programmes based on the systematic approach to training (SAT).

In order to succeed in deregulated energy markets, nuclear power plants in Member States need to reach and maintain a high level of performance, safety and reliability, while at the same time being economically competitive. Some of the best performing nuclear power plants in the world have outstanding safety records, excellent capacity factors and favourable generation costs. These utilities have demonstrated that safety performance and operational excellence are closely related. Technical documents were published describing nuclear power plant organization and

staffing for improved performance and good practices with respect to the development and use of plant procedures. Another technical document, *Evaluating and Improving Nuclear Power Plant Performance*, presenting good practices and the quantitative/qualitative measures of these practices at some of the world's most productive plants, was prepared. Finally, a document on technical support for nuclear power operations was prepared to form the basis of workshops organized in different regions.

Discussions at a meeting in Vienna on the need to improve performance in a competitive environment and the major changes facing the nuclear industry and plant operators in the near future led to the start of work on an international economic performance database in co-operation with the Electric Utility Cost Group in the USA. Designed with the goal of facilitating performance optimization, this database will cover all aspects of economic performance, including activity based costing, operational and maintenance costs and performance indicators.

A technical document on the application of quality assurance/quality management within regulatory bodies was completed. The document provides information for developing systematic approaches to quality within regulatory bodies and contributes to promoting transparency in the performance of regulatory activities. Another completed technical document provides guidance on implementing effective quality assurance programmes applied to safety related software used in nuclear power installations. This document is intended for those responsible for the management and implementation of quality assurance programmes for software, and managers and assessors from suppliers, utilities, technical support organizations and regulatory bodies.

The second module of an Agency database on nuclear power plant life management was completed. Known as the 'International Database on Piping of Nuclear Power Plants', the contents include data on material properties, inspection results and case histories for piping systems in power plants. The software will be made available to all national organizations contributing to the database.

Experience at plants that have introduced upgrades of systems using digital equipment indicates that there is great variability in the costs and problems encountered in implementing, operating and maintaining the upgraded systems. Many of the problems can be traced to the specifications for the upgrades. A technical document was prepared on specifying requirements for such upgrades using digital instrumentation and control (I&C) to support safe, effective and economic modernization of I&C systems in nuclear power plants. The report presents a methodology for the determination of requirements and the development of specifications and plans needed throughout the life-cycle of digital I&C systems.

There are 43 nuclear power plants in 14 Member States that have experienced construction delays of more than five years as a result of financial, economic and public opinion issues. In response, work was undertaken to assist the managers of delayed nuclear power projects in the identification of problems, exchange experience and develop measures and guidance to maintain readiness for resuming the project implementation schedule when conditions permit. In order to optimize the use of Agency resources and enhance the impact of this guidance, these activities were implemented in conjunction with a regional technical co-operation project on delayed nuclear power plants, involving utilities within Europe. A technical document was prepared providing information and practical examples on the management actions needed to preserve and further develop the capability to restart and complete delayed projects.

Advanced reactors and applications

Small and medium sized reactors (SMRs) are of particular interest for the non-electrical applications of nuclear energy, such as the desalination of sea water and district heating. They are also a suitable option for electricity generation in countries with small electricity grid capacities or for remotely located areas. A technical document providing guidance to developing countries on the preparation of user requirement documents for SMRs and on how to include nuclear desalination requirements was drafted.

The Agency obtained educational simulators (software packages) from Canada and the USA that operate on a personal computer and simulate the responses of a number of reactor types in the SMR range under operating and accident conditions. These simulators are useful in providing insights into the operational characteristics and responses to accident conditions for

generic BWRs, PWRs and PHWRs. They are also used for the training of junior engineers and scientists. Three workshops were held using these simulators, two at the International Centre for Theoretical Physics, in Trieste, and one at the Korea Institute of Nuclear Safety. The first package to be obtained, the Advanced Reactor Simulator, has now been distributed to Member States.

A symposium on 'Evolutionary Water Cooled Reactors: Strategic Issues, Technologies, and Economic Viability' was convened in Seoul, Republic of Korea, in November–December. Organized in co-operation with the OECD Nuclear Energy Agency, the Uranium Institute, the Korean Nuclear Society and the Korea Atomic Industrial Forum, and hosted by the Korea Electric Power Corporation, the symposium reviewed the technology advancements and the readiness of evolutionary water cooled reactors to contribute to near and medium term energy needs. Topics addressed included strategic issues (the global energy outlook, the role of nuclear power in sustainable energy strategies, power generation costs, the financing of nuclear power plant projects, sociopolitical factors, nuclear safety requirements), technological advances (advances in residual heat removal, instrumentation and control, improving prevention and mitigation of severe accidents, development and testing of passive safety systems), and the keys to economic viability (standardization, improved plant management, advances in construction and project management, feedback of experience from utilities into new designs). In addition, reactor design organizations presented the key features of their designs and exhibited models of their products.

A Technical Committee meeting was held in Canada in April on fuel cycle options for LWRs and HWRs. The meeting provided a forum to identify, review and exchange information on international developments in this area. A key conclusion was that the fuel cycle should be evaluated in total, from fuel manufacture to final disposal, and that there is a potential for efficiencies and economic benefits from synergistic fuel cycles in individual countries as well as regionally and globally.

A CRP on thermohydraulic relationships for advanced water cooled reactors was completed. A technical document which presents a consistent set of relationships for critical heat flux, post dry-out heat transfer and pressure drop is being prepared. A new CRP on the establishment of a thermophysical properties database for LWRs and HWRs was initiated to foster the exchange of non-proprietary information on reactor materials properties in order to improve design and safety. Another CRP on the intercomparison of pressure tube inspection and diagnostics was started to compare techniques for the characterization of HWR pressure tubes during their service lifetimes.

A technical report, *Design Measures to Facilitate Implementation of Safeguards at Future Water Cooled Reactors*, was published to provide guidelines to designers for minimizing the impact of Agency safeguards on plant operations and ensuring efficient and effective acquisition of safeguards data, to the mutual benefit of the Member State, the plant operator and the Agency. The guidelines incorporate the Agency's experience in establishing and carrying out safeguards at operating nuclear power plants, the development of safeguards techniques and the feedback of experience from plant operators and designers.

Developments in the LMFR area included: start of construction of the small size (60 MW(th), 15 MW(e)) experimental fast power reactor in China; restart of the 250 MW(e) Phénix reactor in France; progress in R&D on the KALIMER 150 MW(e) advanced liquid metal reactor in the Republic of Korea; and the Russian Federation's decision to resume construction of the BN-800 reactor.

A collaborative project between the Agency and the European Commission on a comparison of calculation methods for severe accidents in LMFRs and evaluation of the innovative BN-800 reactor core design was completed. On the basis of analysis results, it was concluded that the proposed sodium layer above the fissile core region is quite efficient in providing an additional inherently activated safety margin for preventing fuel pin failure or local boiling in the domain of operational and severe transients in the design basis.

A CRP on the validation of thermomechanical and thermohydraulic codes and relations for LMFRs was completed and a technical document is being prepared. The document presents a consistent set of relationships for thermohydraulic modelling and thermomechanical assessments.

Two Technical Committee meetings on fast reactor technology were held, one in Obninsk, Russian Federation, in July, and the other in Vienna, in November. Several recommendations were made for reactor and core design improvements. With regard to

LMFR design approaches, the accumulated knowledge on materials, thermohydraulics and mechanical science indicates that a substantial decrease in investment costs, together with a greater assurance that safety margins are effectively maintained, can be derived from reduced emphasis on 'umbrella' transients, compensated for by an accurate analysis of actual transients and operating experience. An accurate account of experience in operating fast reactors, much of which has not been published, should be made available to the States which foresee a need to deploy the technology in the near future.

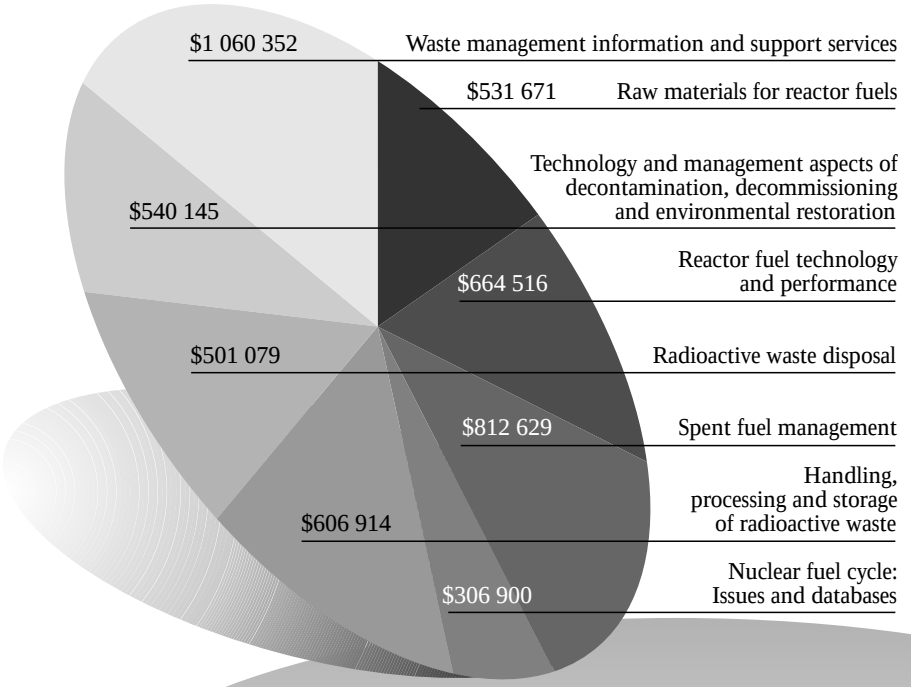
To foster the exchange of technical information and to preserve the knowledge acquired of LMFR technology, a fast reactor database (FRDB) has been developed. The FRDB contains detailed data on 35 experimental, prototype and commercial LMFRs. Each reactor plant is characterized by about 400 parameters, design data and relevant graphics materials.

A Technical Committee meeting was held to review the specific features and systems of HTGR concepts and their economics. It was concluded that co-ordination of international R&D activities, including dissemination and archiving of information and data, is of primary importance in HTGR development.

The International Nuclear Desalination Advisory Group (INDAG), at its second meeting in June, stressed the need for international co-operation in planning and implementing nuclear desalination demonstration programmes, and recommended that the Agency provide an international forum for the co-ordination and sharing of resources. Following up on this recommendation, an interregional technical co-operation project was established to provide a forum for technology suppliers and prospective end users to discuss the development of integrated nuclear desalination concepts, with the aim of demonstrating the viability of nuclear desalination. In addition, a new CRP on the optimization of the coupling of nuclear reactors and desalination systems was established. This CRP will help to improve the performance and economics of nuclear desalination plants.

Thorium fuel utilization was discussed at an Advisory Group meeting in Vienna in September. One of the conclusions was that a re-examination of this fuel cycle is necessary so that the advantages, problems and possible solutions can be realistically assessed under present conditions. It was recommended that estimates of future requirements for thorium be improved in relation to its application to fuel cycles, and for corresponding technology development in nuclear power programmes.

NUCLEAR FUEL CYCLE AND WASTE TECHNOLOGY



Regular budget expenditure: $5 024 206

Extrabudgetary programme expenditure (not included in chart): $495 245

Programme objective

To assist Member States having or planning to have nuclear fuel cycle activities or needs, either as suppliers for or as operators of power or research reactors and to assist on technology issues concerning the management of radioactive waste of all origins.

The Agency's programme on the nuclear fuel cycle covered four key areas: raw materials for reactor fuels, focusing on uranium supply and demand, and mining and milling; reactor fuel technology and performance, addressing issues on reactor materials and fuel technology; spent fuel management, dealing with spent fuel storage, treatment and transport; and nuclear fuel cycle issues and databases. A symposium on the storage of spent fuel from power reactors was held in Vienna in November. The first meeting of the newly established International Working Group on Nuclear Fuel Cycle Options was also held in Vienna, with special emphasis being given to plutonium issues. The radioactive waste technology programme covered: the handling, processing, storage and disposal of radioactive waste; decontamination and decommissioning of nuclear installations; environmental restoration; quality assurance aspects of radioactive waste management; waste management planning and infrastructure building; and technology transfer and exchange. The progress of work, including the status of national radioactive waste management programmes, was discussed at the third meeting of the Radioactive Waste Technology Advisory Committee in October.

Raw materials for reactor fuels

A Technical Committee meeting of the Joint OECD/NEA–IAEA Uranium Group was held in

Vienna in October. The primary purpose of the meeting was to prepare the 1999 'Red Book' questionnaire for submission to Member States. The schedule for preparing the 1999 Red Book was set with a target date for publication of March 2000.

A Technical Committee meeting on the impact of new environmental and safety regulations on uranium exploration, mining, milling and waste management was held in Vienna in September. The papers presented at the meeting provided examples of under- and over-regulation, with both situations being undesirable. A general recommendation was that realistic regulations must be developed that apply to a wide range of situations and which allow developing countries to benefit. It was noted that while regulations for reactors may have some application to very high grade mining operations, low grade deposits and by-product recovery operations require different regulations. There is also a need to distinguish between nuclear facilities and uranium/thorium mines, since the levels of risk and the potential for damage were very different. There was a consensus that a strong regulatory framework was important for the credibility of the industry.

A technical document providing guidance on good practices in the management of uranium mining and milling operations was published. Companion guidebooks are being prepared that address such topics as environmental impact assessment, the implementation of environmentally friendly mining and milling methods, and the treatment of effluents and in situ leaching technologies. The purpose of these guides is to promote the best operational practices in those Member States involved in the development of uranium production projects.

Reactor fuel technology and performance

Corrosion of fuel rod cladding materials and primary circuit components remains a serious concern for current water cooled power reactors, especially those being operated at high burnup and thermal rates. In response, the Agency published a technical document that reviewed waterside corrosion of zirconium alloys in nuclear power plants.

The corrosion of fuel and primary circuit components of water cooled power reactors, including in-pile, loop and autoclave tests, corrosion modelling and mechanisms, and the interrelation between water chemistry parameters and the corrosion rate, was considered at a Technical Committee meeting held in Hluboka nad Vltavou, Czech Republic. The data showed that significant improvements were achieved in the reduction of corrosion and dose rates by replacing the cladding material with one more resistant to corrosion, or by the improvement of water chemistry conditions. However, heavier fuel duties have resulted in the appearance of new corrosion related phenomena, such as sub-cooled boiling and shadow corrosion. Consequently, R&D in this area will continue.

Corrosion of zirconium alloy cladding on the fuel side is the subject of a CRP on stress corrosion cracking. This CRP has been extended for one year to repeat some tests in the experimental matrix which were unsuccessful on the first attempt as the participants were learning to cope with the difficult test procedures.

A CRP on hydrogen and hydride degradation of the zirconium alloys used for fuel cladding and pressure tube material was initiated, with the first Research Co-ordination meeting held in Vienna. The first phase of testing involves a round robin exercise in which the participants will measure delayed hydride cracking rates and hydrogen concentrations, and characterize the microstructures of standard compact tension specimens cut from a CANDU pressure tube.

The behaviour of fuel and control assemblies in current and advanced water reactor designs was considered at two Technical Committee meetings. The first meeting, in Nyköping, Sweden, focused on: fuel chemistry and fission product behaviour; swelling and pellet clad mechanical interaction; cladding failure mechanisms at high burnup; and thermal properties and fuel behaviour in off-normal conditions. A major result of this meeting was an assessment of the relative impact of burnup increase on potential clad failures. The other meeting, held in Vienna, studied control assembly materials currently used in PWRs, BWRs, WWERs and RBMKs, as well as improved replacement materials that could also be used in advanced water reactor designs. The technical discussions focused on the performance of absorber materials, cladding and guide tubes and guide cards in reactors, taking into account issues affecting and limiting the working lifetimes of control assemblies, and hence their economic viability.

The scope of the OECD/NEA–IAEA International Fuel Performance (IFPE) database was extended,

primarily by the inclusion of new data from the Russian Federation. An important application of this database was in fuel performance code improvements carried out by several Eastern European countries with WWER power plants. Specifically, qualification of a version of the TRANSURANUS code for WWER fuel was achieved using the IFPE database.

A technical assistance project in China helped in the establishment of the Centre for Quality Assurance of Nuclear Fuel by procuring a device for tube quality control, and by training staff. Also, Chinese fuel specialists were trained in the use of the IFPE and French CRACO databases.

An expert mission was undertaken to evaluate a technical assistance project in Bulgaria which will provide operators at the Kozloduy nuclear power plant with a fast and effective means to detect fuel rod failures in WWER-1000 assemblies using a visual inspection device in the spent fuel storage pool.

Spent fuel management

A symposium on the storage of spent fuel from power reactors was held in Vienna in November. The meeting provided a forum for: the exchange of information; discussions on the prospects for spent fuel storage, the worldwide situation and the major factors influencing national policies in this field, and identification of the most important directions that national efforts and international co-operation should take. There was consensus that the techniques and procedures currently in use to handle and store spent fuel are safe and meet the stringent safety requirements applicable in different countries. The main conclusion of the symposium was that the primary spent fuel management solution over the next few decades will be interim storage. Consequently, the duration of interim storage will become longer than earlier anticipated and storage facilities will have to be redesigned or adapted to accept spent fuel from advanced fuel cycle practices (i.e. high burnup and mixed oxide (MOX) spent fuel).

A Technical Committee meeting was held in Vienna in September on the technologies and safety aspects of a regional spent fuel storage facility for power and research reactor fuel. Since spent fuel storage is a well established and proven technology, the potential benefits of regional spent fuel storage in terms of the technical, economic, institutional and ethical/sociopolitical aspects were highlighted. It was emphasized that several issues still needed to be discussed further, notably the institutional and sociopolitical questions involved.

Spent fuel management for WWER/RBMK reactors was the subject of a Technical Committee meeting/workshop held at the Ignalina nuclear power plant in Lithuania. The workshop, part of the Extrabudgetary Programme on the Safety of WWER and RBMK Nuclear Power Plants, with contributions from the Government of Japan, provided an opportunity to exchange information on the drying of sound and defective fuel for dry storage and the detection technologies, classification and handling of such fuel. The major conclusions of this workshop were that fuel not foreseen for reprocessing should be put into dry storage for a long period of time, and that all defective fuel should be moved to dry storage to prevent further corrosion damage.

As a result of work in a CRP on irradiation enhanced degradation of materials in spent fuel storage facilities, a technical document reviewing the durability of spent nuclear fuels and facility components in wet storage was published. The document examines the problem of materials degradation of spent fuel in both power and research reactor wet storage facilities in an attempt to assess their durability. The objective is to assist the operators of wet storage facilities in presenting justifications to the licensing authorities to extend the lifetime of these facilities.

Nuclear fuel cycle: Issues and databases

As a result of the 1997 symposium 'Nuclear Fuel Cycle and Reactor Strategy: Adjusting to New Realities', the International Working Group on Nuclear Fuel Cycle Options (IWG-NFCO) was established to address emerging issues in the nuclear fuel cycle area, particularly the accumulation of spent fuel and separated plutonium from both civil and military uses. At the first meeting of the Group in Vienna in October, the Agency's fuel cycle programme was evaluated.

The services of consultants were used to update the status of separated civil plutonium inventories and make forecasts of future trends. It was concluded that while current inventories conformed to the Plutonium

Management Guidelines (INFCIRC/549), future trends indicated that there was a need for long term storage, and evaluation of the technical and economic impacts.

The Nuclear Fuel Cycle Information System (NFCIS) was upgraded to a modern client/server MS SQL Server database management system. This enhances data sharing and the robustness of the computer application. Methods to improve data collection, update the database and disseminate the information to Member States were identified. NFCIS data will be published in the Reference Data Series and electronically through the Internet. The Nuclear Fuel Cycle Simulation System (VISTA), a newly developed Agency model for calculating and estimating nuclear fuel cycle service requirements, continued to be developed. This system, which will be made available to Member States, will integrate existing data from other Agency databases (such as the Power Reactor Information System and the Energy and Economic Databank) and will serve as an international nuclear fuel cycle reference model. The Nuclear Fuel Cycle Profile was upgraded so as to be accessible through the NFCIS.

Handling, processing and storage of radioactive waste

Most of the world's radioactive waste is generated in a few countries operating nuclear power plants and fuel cycle facilities. While reliable and safe procedures are generally available for the management of such wastes, the management of relatively small amounts of radioactive waste generated from non-fuel-cycle applications represents a significant problem for many Agency Member States. The available infrastructure is either inadequate, or sometimes is completely missing. In view of this, almost half of the Agency's ongoing waste technology tasks are oriented to non-fuel-cycle waste. A technical document covering all aspects of waste management in the production and use of molybdenum-99 was published to assist Member States in solving the problems related to the widespread medical applications of this isotope. Two technical reports on the management of radioactive waste from various nuclear applications were also completed.

The delay in a decision on the final disposal of conditioned radioactive waste, and public opposition to the siting of disposal facilities in some countries, have resulted in great efforts being made to minimize waste and improve the quality of waste arisings packages for extended interim storage prior to disposal. To meet this challenge, two publications were prepared. One report examined waste minimization issues for the front end of the nuclear fuel cycle, while the other focused on the interim storage of radioactive waste packages.

A new CRP on the chemical durability and performance assessment of spent fuel and HLW forms under simulated repository conditions was initiated. The aim is to promote the exchange of information on research activities and to make available to developing Member States the data obtained in countries that are leaders in this field.

A technical co-operation project, originally intended to assist Armenia in the improvement of waste management techniques at the Medzamor nuclear power plant, has been extended to establish an integrated national waste technology infrastructure meeting modern safety requirements.

Radioactive waste disposal

Site selection for the disposal of radioactive waste continues to be a focus of many national programmes. In this connection, a technical report on hydrogeological investigations of geological disposal sites was completed. Since hydrogeological systems are considered in assessment scenarios to offer the most probable pathways in the event of the release of radioactivity from repositories, this report will help in understanding the role played by such investigations in the overall characterization of a site for geological disposal.

The concept of a multinational repository for radioactive waste is under discussion in the waste management community in the light of potential benefits to partner countries from the safety, technical and economic standpoints. However, such a concept involves a number of political and public acceptance issues and therefore its realization requires, as a prerequisite, a consensus among the countries and regions concerned. A report that addresses this issue and provides an assessment of the concept in terms of the factors to be taken into account in the process of consensus building was published. The assessment deals with the basic factors involved in the concept — legal aspects, safety principles, technical issues, cost and liabilities, ownership of waste materials, ethical aspects,

and public acceptance. It also covers the implication of each of these factors in terms of potential benefits and challenges, and the issues that need to be addressed in establishing a multinational repository.

A new CRP was initiated on anthropogenic analogues for use in confidence building with regard to the disposal of high level and long lived radioactive waste. Human made analogues permit comparison of the behaviour of various components of a radioactive waste repository system with the behaviour of similar systems that either occur or occurred in the earth. Migration processes related to ancient artefacts and building materials used in archaeological times, as well as transport and retardation mechanisms in underground nuclear weapon test sites, are the topics for study in this CRP.

Technology and management aspects of decontamination, decommissioning and environmental restoration

Decontamination has traditionally been addressed within the general area of decommissioning. However, advances in the technology have made it clear that the field of decontamination has now reached the stage of being a scientific and technical discipline by itself. In this regard, a CRP that focused on new methods and techniques for the optimization of decontamination for maintenance or decommissioning was completed and a technical document summarizing the results was published. Operating experience, recognition of the lessons, key results in laboratory or pilot scale research, and the validation of mathematical models were some of the achievements of this CRP.

Waste management information and support services

To supplement the *Waste Management Research Abstracts*, an Internet based 'International Research Abstracts Information System' (IRAIS) was put on-line *(http://www.iaea.org/programmes/irais)*. IRAIS provides abstract search and retrieval capabilities, as well as automated features to check and validate the abstracts and prepare a finished product for publication.

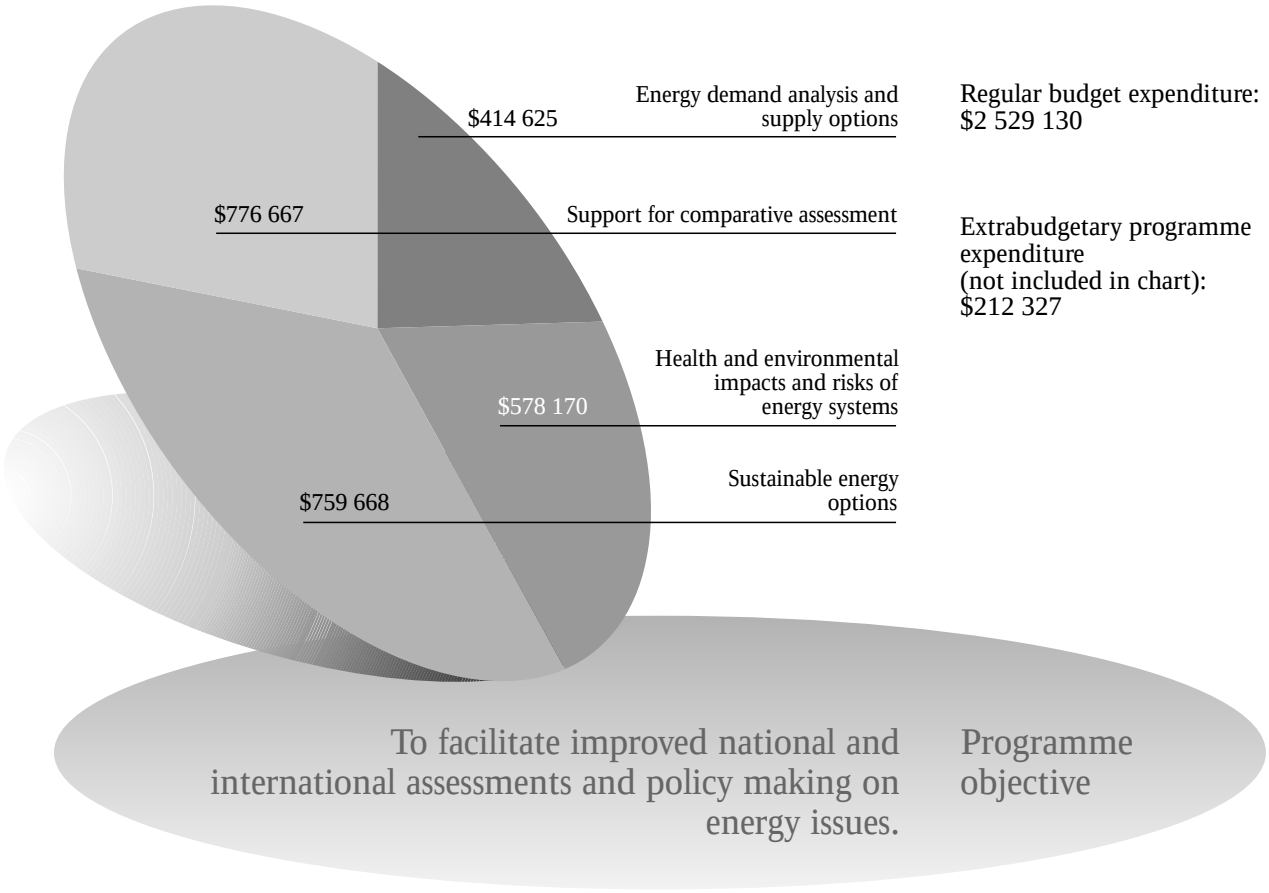
Progress was made in providing services to Member States in conditioning old radium sources for safe long term storage. The national stocks of radium in Ecuador and Paraguay were conditioned and rendered safe with the assistance of an experienced Brazilian team. This activity has been expanded by the formation of regional teams for conditioning operations in Eastern Europe, Africa and Asia. For example, a South African team carried out an operation in Ghana, while in Bosnia and Herzegovina, radium pigment paint used in a military factory was conditioned in co-operation with the Ruder Boskovič Institute of Croatia. Furthermore, teams from China, Pakistan, the Republic of Korea and Peru received training and preparation in conditioning techniques. To improve the quality of radium encapsulation, an automatic welding machine was developed in co-operation with South Africa.

The Sealed Radiation Sources (SRS) Registry, a software package designed for registering and tracking sealed sources (currently in use in over 30 Member States), was upgraded to a Windows version and made available to Member States.

A second demonstration of pre-disposal waste management methods and procedures was organized at the Lo Aguirre Nuclear Research Centre in Santiago, Chile, for participants from Ecuador, Nicaragua and Peru, while a third demonstration was held at the Çekmece Nuclear Research and Training Centre in Istanbul for trainees from Ghana, The Former Yugoslav Republic of Macedonia, Saudi Arabia and Tunisia. A similar demonstration was held for the first time in the East Asia and Pacific region at the Philippine Nuclear Research Institute, Manila, for trainees from Bangladesh, Malaysia, Myanmar and Sri Lanka. Technical and administrative preparations have been completed in Moscow to host a demonstration for the newly independent States and countries from Eastern Europe.

In its capacity as the Secretariat for the Contact Expert Group (CEG) for international co-operation with the Russian Federation in radioactive waste management, the Agency prepared a database that contains information on 175 co-operation projects. At its sixth meeting in Augusta, Georgia, USA, the CEG reached a consensus on "Initial (First Priority) Projects" for international co-operation, while at the seventh meeting in Murmansk, a list of the CEG's "Highest Priority Tasks", prepared on the basis of new material and information presented by the Russian Federation, was approved.

COMPARATIVE ASSESSMENT OF ENERGY SOURCES



Regular budget expenditure:
$2 529 130

Extrabudgetary programme expenditure
(not included in chart):
$212 327

Programme objective

To facilitate improved national and international assessments and policy making on energy issues.

The programme pursued its major objective of developing methodological tools for informed decision and policy making through comprehensive comparative assessments of all energy supply options along their respective full energy source to service chains. These comparative studies aimed at the identification of the potential role of nuclear power for achieving sustainable energy development. Member States, especially developing countries, were assisted in the formulation of national energy policies and strategies and in local analysis capacity building through the dissemination of methodology, and training through the Agency's technical co-operation programme.

Energy demand analysis and supply options

In addition to time horizons appropriate for incremental capacity expansion investment (typically 15–20 years), the Agency extended the analysis time horizon to the year 2100 for tasks related to the role of nuclear power in sustainable energy development and the mitigation of potential climate change. In co-operation with the OECD/NEA, and with national research teams from Japan, the Russian Federation and the USA, the Agency adapted long term projections of energy and electricity demand (originally developed by

IIASA and WEC) at the regional and global levels. On the basis of these regional demand projections, and using the modelling capabilities of the three participating national research teams, an overall comparative assessment of different energy supply systems was carried out and their potential in long term sustainable energy mixes under different sociopolitical conditions was analysed.

A study on fossil fuel resources for the 21st century was completed. This study not only supports the evaluation of energy resource availability and price trends within the Agency's comparative assessment activities (as well as inputs to the Energy and Economic Databank), but also forms an integral part of its contribution to the UNDP/UNDESA/WEC World Energy Assessment that will be part of the input of the United Nations to the ninth meeting of the Commission on Sustainable Development scheduled for 2001.

Health and environmental impacts and risks of energy systems

A CRP on the comparative health and environmental risks of nuclear and other energy systems was completed. The country specific case studies that were prepared will be included in an Agency database on health and environmental impacts. Procedures were also prepared for comparative assessments, including methodological approaches.

Guidance was developed for estimating and comparing accident and health risks from different electricity generation systems. On the basis of a summary of available information, it was recommended that a set of approaches be used that includes the application of cut-off values. Another report describes the methodological and data requirements of comparative assessments for decision making in different areas such as emission control or the choice of technologies.

A proposed set of reference waste disposal practices were identified as part of efforts to formulate an approach to compare the potential health and environmental effects that could result from the disposal of wastes from fuel chains for electricity generation. Transport pathways and exposure scenarios relevant for each reference practice are also being specified to work towards a standardized assessment framework.

Sustainable energy options

Within the framework of the interagency DECADES comparative assessment project, a peer review of the Reference Technology Database, which contains information on technical, economic and environmental aspects of various components of different energy chains, was initiated for nuclear power and fossil fuels. Additional data were collected on renewable energy sources (biomass, solar and wind) and on some advanced and innovative nuclear fuel cycles. In order to increase public accessibility of the database, a DECADES Web site on the Internet was developed and is now being tested.

The Joint Steering Committee of the DECADES project met in November to review achievements and to shape the programme of work for the next period. In this context, strong interest was expressed by the other international organizations participating in the project in using the DECADES tools to carry out some of their comparative assessment studies.

New capabilities added to the DECADES software included a decision aiding module. This module assists the user or decision maker in coping with information on economic and environmental impacts at three levels: the power plant; the full energy chain; and the electricity system. It also permits the analysis of trade-offs between affordability and environmental desirability.

The VALORAGUA software, which provides for a more sophisticated analysis of electricity systems that include hydro power in their generating mix, was fully integrated into DECADES. As a consequence, the structure of the Country Specific Databases was modified to accommodate data from VALORAGUA. An enhanced Control Device Sub-module, used for assessing the cost effectiveness of particulate, sulphur dioxide and nitrogen oxide abatement of fossil fuelled power generation, was also finalized. In addition, a compact disk containing the DECADES tools and the User's Manual for DECADES version 1.0 was prepared.

Attracting investment for electricity capacity in increasingly liberalized electricity and financial markets can be

quite different from the investment strategies pursued by State owned utilities under monopoly conditions. The Agency has a number of system and project planning tools that were adapted to these new trends. For example, the software for investment and financial analysis (FINPLAN) was revised with input from commercial bankers and other experts to permit assessment of energy sector investment options in competitive capital and electricity markets.

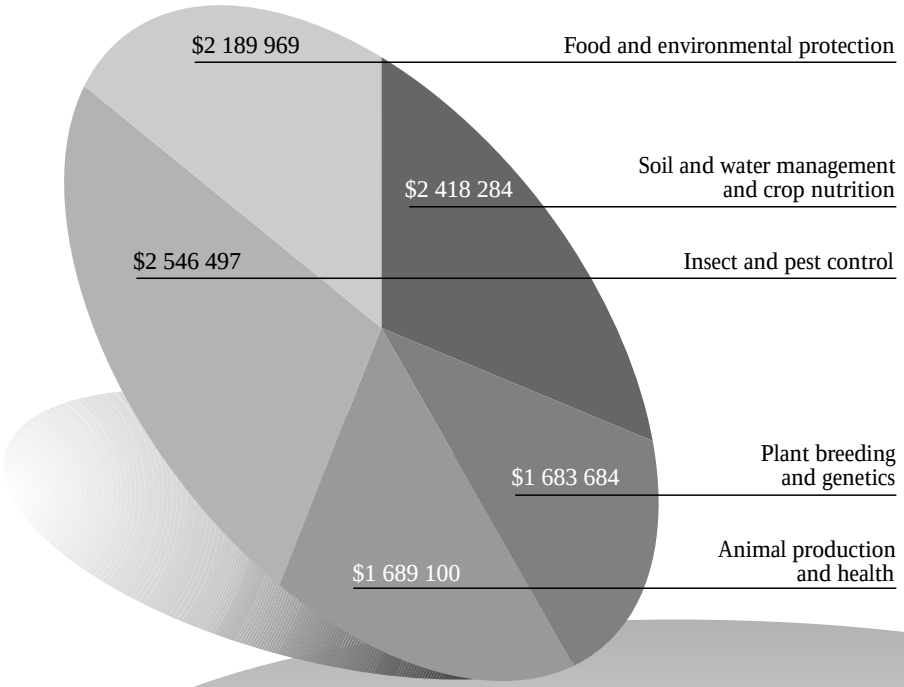
Expert group meetings were held on the calculation of greenhouse gas emissions from each of the fuel chains associated with electricity generation. These meetings resulted in several products: a set of estimates for such emissions from a given set of electricity generating options; a methodological approach for making such estimates; and a series of reports on the findings of the individual meetings. One major conclusion was that although the importance of site specific factors cannot be underestimated in greenhouse gas emission calculations, there is a strong and overriding correlation between technology efficiency gains and reductions in such emissions that holds true across the analytical spectrum.

A simplified software package for estimating and valuing the externalities (costs and benefits) associated with electricity generation is under development. This methodology can be used on personal computers with a minimum amount of data and was designed specifically for developing countries that cannot afford data intensive and costly studies. The initial part of this package (relating to the health impacts of fossil fuel based air pollution) was completed and tested at a regional workshop in Asia. This methodology will also be incorporated into the Agency's comparative assessment and energy/electricity planning tools.

Support for comparative assessment

Extending the lifetime of nuclear power plants has become an important issue for the utility industry as many plants approach the end of their licensed operating life. However, despite their age a number of plants are still in good condition and their continued safe and competitive operation is possible through modest investments in lifetime extension. In fact, for economic or sociopolitical reasons, extending plant life may often be the most viable option for the continued use of nuclear power, given the growing attention to mitigating greenhouse gas emissions. A major survey of life extension and decommissioning costs for ageing nuclear reactors in Member States was completed. The results, which were summarized in a technical document, provide a basis for further analysis of the costs of different nuclear power plant retirement options.

FOOD AND AGRICULTURE



Regular budget expenditure:
$10 527 534

Extrabudgetary programme expenditure
(not included in chart):
$3 280 512
(of which the sum of
$1 868 693 is from FAO)

Programme objective

To improve food production and quality through developing and transferring environmentally sound practices using nuclear and related biotechnology methods.

Significant progress was made in the introduction of technologies to intensify crop and livestock production, protect natural resources and improve the quality and safety of food. Examples included: the development and adoption of management practices which led to increased crop yields with less water and fertilizer; and better crop varieties and improved strategies for the identification of cost effective conversion of feeds into meat and milk by livestock. Similarly, the development and use of better methods for diagnosing important livestock diseases, coupled with the major progress achieved in extending the concept of the area wide management of insect pests through the sterile insect technique (SIT), have enhanced considerably the capacities of Member States to address important livestock and crop protection issues. The increasing acceptance of food irradiation and greater support given to the issue of food quality and safety through the newly established FAO/IAEA Training and Reference Centre at Seibersdorf, near Vienna, have contributed to enhanced trade and better food control systems.

Soil and water management and crop nutrition

A CRP on the use of nuclear techniques in the management of nitrogen fixing trees to enhance the

fertility of fragile tropical soils was completed. New information was obtained on the potential of leguminous trees to fix atmospheric nitrogen, on the ability of some species to thrive under adverse conditions and on the value of tree prunings as an organic fertilizer source. Studies conducted in Sri Lanka showed that *Gliricidia* was able to obtain more than 50% of its nitrogen requirement through biological nitrogen fixation. In Pakistan, *Acacia ampliceps* was found to thrive in hypersaline soils where other crops failed. In Chile, the biomass production of *Chamaecytisus* species was about ten times higher than the commonly grown *Acacia caven* on degraded soils under drought conditions. Results from field experiments conducted in a wide range of agro-ecological zones showed that substantial increases in crop yields can be obtained by the proper management of tree prunings. In the Democratic Republic of the Congo, the grain yield of corn increased by more than 60% owing to the application of a mixture of leaf prunings from *Albizia lebbeck* and *Acacia auriculiformis*.

A regional technical co-operation project for West Asia involving the Islamic Republic of Iran, Jordan, Lebanon, Saudi Arabia, the Syrian Arab Republic, Turkey and the United Arab Emirates on water balance and fertigation (i.e. fertilizer nitrogen applied in combination with irrigation water) for crop improvement was completed. The application of nuclear based techniques (nitrogen-15 labelled fertilizer, soil moisture neutron probe) in the field demonstrated that fertigation was a highly effective method for conserving water and increasing nitrogen fertilizer use efficiency. The yield of cottonseed in the Syrian Arab Republic was increased by more than 20% by fertigation compared with traditional fertilizer and water management practices. Moreover, water use efficiency, based on dry matter yield, increased by more than 90%, which resulted in savings of more than 30% of irrigation water.

A CRP on the use of nuclear and related techniques for evaluating the agronomic effectiveness of phosphate fertilizers, in particular phosphate rock (PR), was completed. The effectiveness of RP depends on its solubility (reactivity), which is related to the degree of carbonate substitution for phosphate in the apatite structure. Rock phosphates with low reactivity are unsuitable for direct application to annual crops. However, research carried out in Brazil, China, Cuba, Thailand and Venezuela demonstrated that effectiveness can be increased by partial acidulation or by mixing with organic materials or a water soluble phosphorus source. Effectiveness can also be enhanced through a biological approach involving inoculation with mycorrhizal fungi. The efficiency of PR also depends on crop species, being particularly powerful on crops such as canola and lupin which exude organic acids from their roots. The utilization of PR by crops is higher in soils with low pH, low available phosphorus, low exchangeable calcium, high cation exchange capacity and high organic matter content. A database is in preparation for validating a model to provide recommendations for PR application.

An indirect (nitrogen-15 dilution) technique to estimate the availability of nitrogen from a range of organic sources was developed and validated at the Agency's Laboratories at Seibersdorf. The technique involves comparison of the isotopic composition of plants grown in nitrogen-15 labelled soil with and without unlabelled residue addition. It will have wider application than the direct method (use of nitrogen-15 labelled residues) owing to the difficulty of labelling some organic materials (e.g. manures and sewage sludges).

Plant breeding and genetics

In a CRP on induced mutations for sesame improvement, the main plant characters responsible for the genetic improvement of sesame and the recommended mutagen treatments and selection criteria for major agronomic traits were determined. Mutation induction proved to be a valuable breeding technique in sesame, with several mutants with desirable characters such as indehiscence, determinate growth, increased seed yield, disease resistance and water logging resistance being obtained. It was recognized that the exchange of useful germplasm among participants in the CRP was important, and in order to facilitate future exchange a database of confirmed mutant lines was set up containing some 140 different lines with agronomically important characteristics. Some advanced mutant lines were evaluated in regional or national yield trials, and recently the mutant derived variety 'Pungsankkae' was officially released in the Republic of Korea. This was obtained by crossing a local variety with the determinate mutant 'dt-45' from Israel. It was concluded that by focusing efforts on one neglected crop such as sesame and exchanging breeding techniques and mutant germplasm, the productivity of such crops can be improved within five years.

Twenty-one new accessions were registered in the FAO/IAEA database for officially released mutant varieties. The total number has grown to 1868 mutant varieties of more than 163 species released in 59 countries.

In order to reduce the cost of tissue culture techniques for mutated generations, natural light was examined as an alternative light source for the in vitro culture of banana at the FAO/IAEA Agriculture and Biotechnology Laboratory of the Agency's Laboratories. Traditionally, in vitro plants are grown in a growth chamber under artificial light and conditions of controlled temperature and length of day. The costs of illuminating a growth chamber are around $3 per m^2 per week. Experiments showed that more in vitro shoots were produced when grown under non-controlled conditions, such as in a greenhouse or in a sunlit room with temperatures between 23° and 30°C and a photoperiod of 12–16 hours, than under artificial light in a growth chamber providing controlled conditions of light, temperature and photoperiod. The concept of using sunlight for micropropagation systems is proposed as a way of reducing tissue culture costs.

Animal production and health

Studies conducted under a CRP on the development of feed supplementation strategies for improving the productivity of dairy cattle on smallholder farms in Africa showed the value of combining field observations and measurement of progesterone by radioimmunoassay to monitor reproductive performance and in evaluating the responses of livestock to different supplementation strategies. The outcome was the development of specific feed supplements at each study location, including tree legumes, cottonseed cake, brewers' grains, urea–molasses–multinutrient blocks (UMMB) and fish silage. Using these at strategic periods, such as in the dry season or during pregnancy and lactation, resulted in significant improvements in milk production and/or reproductive performance. These concepts are now being introduced through a regional technical co-operation project for improving milk production in Africa. Similar advances have been made through technical co-operation projects in Asia and Latin America, where feed supplementation strategies developed in previous CRPs and based on UMMB are now being adopted by large numbers of dairy farmers in peri-urban and rural areas in countries such as Indonesia, Sri Lanka, Venezuela and Viet Nam.

Brucellosis is considered one of the most important diseases affecting animals and, through the consumption of milk and dairy products, is one of the most dangerous and widespread diseases affecting people. A five year study was completed in five Latin American countries on the development and validation of a diagnostic assay to separate animals vaccinated with brucellosis from those naturally infected. This represents the largest ever serological study undertaken with regard to this disease, and through the support provided by the Agency an essential tool now exists to assist Member States in the future control and eradication of brucellosis. Similar studies through this CRP concerned with foot and mouth disease, the most important livestock disease constraining trade, have resulted in the international validation of a fully standardized assay for diagnosing this disease, an essential prerequisite to its control and eradication. Over one billion dollars have been pledged to eradicate the disease from Latin America and this assay will be an essential component of this effort.

Quality assurance is central to the effective use of diagnostic assays. A comprehensive FAO/IAEA external quality assurance programme was developed involving national veterinary laboratories in over 70 Member States. Based in part on this programme, a generic veterinary laboratory accreditation scheme was developed that is being considered as the basis for a worldwide programme. The need to ensure the quality of information on livestock disease occurrence is fundamental to the international livestock trade and the work of the WTO, and the scheme developed by the Agency and FAO is considered a major step forward in this process.

Insect and pest control

An FAO/IAEA conference entitled 'Area Wide Control of Insect Pests: Integrating the Sterile Insect and Related Nuclear and other Techniques' was held in Penang, Malaysia, at the same time as the 'Fifth International Symposium on Fruit Flies of Economic Importance'. The conference was the first international event to focus on the concept of integrated pest management, addressing the economics, trade issues,

commercial perspectives and implementation of pest control programmes. It also reviewed progress in refining SIT and other developments in biotechnology, genetics and molecular biology related to insect pests.

A CRP on the development of female Mediterranean fruit fly (medfly) attractant systems for trapping and sterility assessment resulted in the development of a female attractant which allows detection of medfly females under situations of sterile male releases. The lure, which was validated in 14 countries, is now available commercially and is being used in medfly SIT programmes. Also, a filter rearing system to increase the stability of genetic sexing strains under industrial level mass rearing conditions was developed and validated for maintaining production colonies. As a result, mass rearing facilities in Argentina, Guatemala and Portugal have now demonstrated such stability during the mass production of hundreds of millions of sterile males per week for SIT programmes.

Progress in the development of tsetse mass rearing included the design and evaluation of a second prototype tsetse production unit for holding and feeding larger numbers of tsetse flies and for the more effective collection of their pupae. The system can be constructed locally and consists of a hand operated frame which holds large numbers of cages and brings them for feeding simultaneously at fixed feeding stations, and a pupal collection device which will ultimately harvest pupae to a central point. The prototype is being fine tuned and has shown promise as a system for large scale colony maintenance. New operational procedures of sex separation at emergence, previously demonstrated with *Glossina austeni*, have also been adapted to *G. pallidipes*. As a result, it is possible to automatically stock cages with the right number and sex of *G. pallidipes*, eliminating one of the most laborious steps in tsetse rearing.

Food and environmental protection

Co-operation with the International Consultative Group on Food Irradiation (ICGFI) through an RCA regional workshop led to the adoption of a harmonized regulation on food irradiation for Asia and the Pacific based on the principle of the Codex General Standard for Irradiated Foods and the relevant recommendations of the ICGFI. Governments in this region agreed to introduce new or amend existing regulations in accordance with the harmonized regulation by the year 2000. Similarly, countries in the Middle East and North Africa agreed at a regional workshop organized by the FAO Regional Office for the Near East to adopt the same harmonized regulation.

A CRP on standardized methods to verify absorbed dose in irradiated fresh and dried fruits and tree nuts was completed. This CRP demonstrated the reliability of a dose indicator label fixed to a reference position in commercial food packages to verify the minimum absorbed dose for insect control, as required by regulatory authorities. In addition, a simple, hand-held dosimeter reader capable of measuring absorbed dose from a label dose-indicator was developed. These advances strengthen inspection and control procedures for fresh and dried fruits, and tree nuts that are irradiated for insect control, as the minimum dose required by regulatory authorities does not always result in immediate mortality of the pest.

Another completed CRP on the use of irradiation as a public health intervention measure against foodborne diseases in Latin America, co-sponsored by PAHO, demonstrated that very low doses of radiation can effectively make *Vibrio* spp. bacteria in raw oysters inactive without killing the molluscs. Similar results were obtained for *Vibrio cholerae* on fresh vegetables; radiation doses required for this purpose do not damage the quality of fresh, refrigerated lettuce, cabbage or celery. The CRP also provided valuable information in confirming the radiation dose required to make *Taenia solium cysticerci* inactive in fresh pork meat.

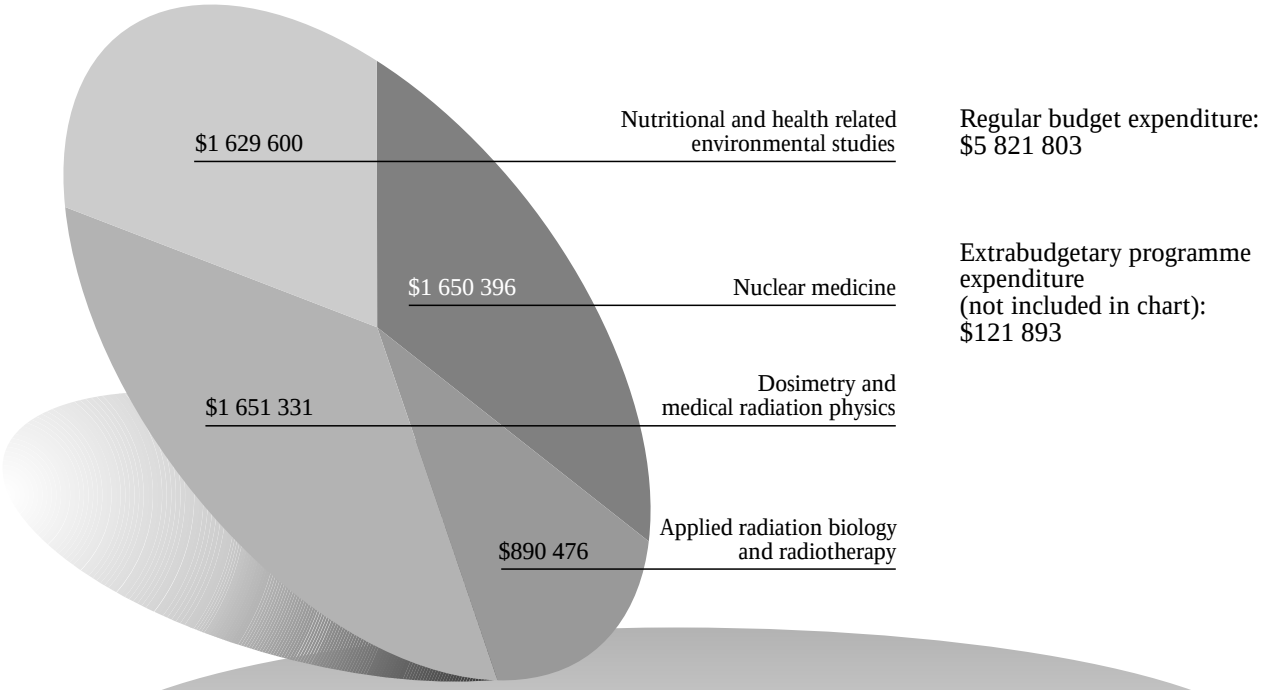
The results of a completed CRP on the use of nuclear and related techniques in studies of the agroecological effects from the use of pesticides in Central America, funded by the Swedish International Development Agency (SIDA), confirmed that agricultural activities have resulted in widespread contamination of surface and groundwater in the region. In particular, pesticides have entered food chains and potable water resources. Some water samples contained concentrations of pesticides exceeding levels that are considered toxic to some aquatic organisms. The data generated were used by government authorities to improve national water quality legislation, and by pest control experts to improve the implementation of integrated pest management programmes.

A recently completed CRP, on radionuclide transfer from air, soil and fresh water to the food chain of

humans in tropical and subtropical environments, concluded that a higher or lower uptake of radionuclides by crops is not crop specific. If an agro-ecological system shows a relatively high or low uptake for one crop, all crops will exhibit the same behaviour. It has been shown that higher or lower uptake is nuclide specific. These efforts can help countries in developing countermeasures in the event of a nuclear accident. The information on environmental parameters will help improve radiological assessment models and contribute in setting limits for authorized discharges from nuclear installations. As a result, better emergency response planning, particularly in developing countries, will lead to the replacement of generic data with those more relevant to local conditions.

Extrabudgetary funds from Austria and Sweden permitted completion of the construction and equipping of the FAO/IAEA Training and Reference Centre for Food and Pesticide Control at the Agency's Laboratories, Seibersdorf. The main objective is to strengthen the analytical capacities of Member States to fulfil the requirements for implementing international standards and agreements relevant to food quality and safety, particularly those covered by the Agreement on the Application of Sanitary and Phytosanitary (SPS) Measures being enforced by the WTO.

HUMAN HEALTH



Regular budget expenditure:
$5 821 803

Extrabudgetary programme expenditure
(not included in chart):
$121 893

Programme objective

To enhance human health through the use of nuclear techniques.

The programme on human health develops, evaluates and disseminates nuclear and related radiation technologies for application in the public health programmes of Member States. In nuclear medicine, activities dealing with infectious diseases were expanded, as were efforts to encourage the use of radioisotopes in molecular biology. New treatment methods in radiation therapy for cancer were also validated. In the field of dosimetry and medical radiation physics, a new project was implemented to disseminate traceable radiation measurement standards at the levels of dose delivered in diagnostic radiology procedures, including mammography. Quality audit postal services to Member States were extended to the verification of national standards used in radiation protection measurements. To take into account the recent development of new standards for radiation measurements, an agreement to develop a new international Code of Practice based on absorbed dose to water was reached with WHO and other international organizations. Work in nutrition and the environment focused on: applied human nutrition research and assessment of nutritional status; environmental pollution monitoring and research; and radionuclide measurements in the terrestrial environment, water and air. Nutrition intervention programmes in developing Member States were monitored by using nuclear techniques through the Agency's technical co-operation programme. Biomonitoring of the environment using nuclear analytical techniques to measure the accumulation of element in lichens and mosses was another important area of activity.

Nuclear medicine

Areas in nuclear medicine which received particular emphasis included development of diagnostic methods and the treatment of disease with open radioactive sources; optimization of the cost effectiveness of health

care; and the transfer of technology for the management of infection.

In the field of radionuclide based diagnostic techniques, a CRP on the diagnosis of genetic disorders using radionuclide based molecular methods was completed, resulting in the establishment of molecular screening techniques for the diagnosis of thalassemia, muscular dystrophy, fragile X syndrome and hereditary ataxia. In addition, prenatal diagnostic programmes were developed in the participating laboratories.

A CRP on the biological discrimination of hormone sensitive and insensitive breast cancer by radioimmunoassay was completed. The main conclusion was that radioreceptor assays for oestrogen, progesterone and epidermal growth factor receptors (a method developed by the Agency) are best carried out in specialized laboratories in developing countries. The immunoradiometric assay for the PS2 protein correlated well with oestrogen and progesterone receptors and is suitable for use in ordinary laboratories.

More than 150 existing analog gamma cameras were upgraded in Member States with the Agency's personal computer based nuclear medicine computer system.

As part of its effort to increase synergy with other international organizations, the Agency organized meetings with WHO during the Congress of the World Federation of Nuclear Medicine and Biology in Berlin in August–September. In addition to enhanceing the awareness of the public in general and the medical community in particular, an exhibition was held during the congress highlighting Agency activities in nuclear medicine. The creation of a 'Cochrane Field in Nuclear Medicine' was also announced through which the Agency, the World Federation and The Cochrane Collaboration of the United Kingdom will bring out periodic reviews of major technical advances in nuclear medicine.

Applied radiation biology and radiotherapy

In work directed at the radiobiological variation of conventional therapy, two new CRPs were initiated. The aim of one CRP is to investigate the use of regional hyperthermia, i.e. the technique of heating a tumour before or after treatment. The other CRP focuses on studying a new protocol that would increase the number of radiotherapy treatments, or 'fractions', per week. The normal protocol involves one fraction per day, or five fractions per week. The CRP will study the implications of increasing this to six fractions a week. A project on heavy particle radiotherapy was discontinued and attention focused on the clinical problem of dose reporting for hadron (proton, neutron, boron neutron capture and heavy ion) therapy (jointly with the International Commission on Radiation Units and Measurements).

A CRP on radiation responsiveness criteria for human tumours as a determinant for therapeutic modality planning was completed. An important finding was that measurement of the lack of oxygen in a tumour can predict its resistance to radiation. Cell culture techniques to measure radiation sensitivity are too difficult to justify in terms of the prediction value.

An Advisory Group meeting which included manufacturers and participants from developing countries was held to develop cost effective devices to keep patients still and comfortable during radiotherapy treatment. This resulted in a practical new design for head and neck immobilization that has been ordered by about 50 institutions in 45 developing Member States through Agency funding, representing a considerable cost saving to the Agency and to end users.

Dosimetry and medical radiation physics

A new project was implemented to disseminate traceable radiation measurement standards at the levels of dose delivered in diagnostic radiology procedures, including mammography. In addition, quality audit postal services offered to Member States have now been extended to the verification of national standards used in radiation protection measurements. For quality audits in external beam radiation therapy, efforts were made to improve the cost effectiveness of thermoluminescent dosimetry procedures and to resolve discrepancies when results from measurements in hospitals and Secondary Standard Dosimetry Laboratories (SSDLs) are outside acceptance limits.

The IAEA/WHO SSDL network presently includes 69 laboratories and 6 SSDL national organizations in 58 Member States. The network also includes 13 affiliated

members, mainly Primary Standard Dosimetry Laboratories (PSDLs), and 5 collaborating organizations. As a result of stricter demands on active participation by laboratory members, one SSDL was deleted from the network and five were listed as provisional members. Twenty-two national standards and reference ionization chambers were calibrated for Member States.

The traceability of SSDLs to the Agency is now verified regularly through quality audits using a transfer ionization chamber: 15 SSDLs participated in this programme. The performance of SSDLs is being monitored through a quality audit system based on mailed thermoluminescent dosimeters (TLDs): 88 radiation beams produced by cobalt-60 therapy units and medical accelerators supervised by SSDLs were checked through this service.

Laboratory procedures were developed for the calibration of ionization chambers at mammography dose levels. Seventeen mammography beam qualities were established for tube voltages between 23 and 40 kV, and a suitable reference ionization chamber has been chosen and is awaiting calibration at a PSDL.

The IAEA/WHO TLD postal dose quality audit service for monitoring the calibration of radiation therapy beams checked a total of 356 beams, of which 211 were cobalt-60 and 145 were high energy X ray beams from clinical accelerators. The scientific and organizational aspects of the service were improved, resulting in a substantial decrease in the total response time to participants, from six months to one to two months. Greater co-operation with WHO led to a significant increase in the return rate of the irradiated dosimeters, from 60% in the past to approximately 90% at present. Follow-up procedures for hospitals with results outside acceptable limits were also strengthened, resulting in a net increase in the percentage of resolved discrepancies.

Forty-seven cobalt-60 beams of industrial facilities and research institutes in Member States were checked through the International Dose Assurance Service (IDAS). A field study was conducted to check the usefulness and suitability of these dosimeters for electrons. The results show that these dosimeters can be used for electron beams of energy of more than 8 MeV and for restricted irradiation geometries.

Since 1959, the Agency has maintained a register of radiotherapy hospitals and clinical institutions having radionuclide and high energy teletherapy machines. This 'Directory of Radiotherapy Centres' (DIRAC) was available only in printed form and its last edition was published in 1976. An electronic version of this directory has now been developed as a database and includes information not only on teletherapy machines, but also on sources and devices used in brachytherapy, equipment for dosimetry, patient dose calculation and quality assurance, and staff strength at installations. With WHO's recent involvement, this project has now become a common undertaking to provide a single international directory of radiotherapy centres and equipment.

Nutritional and health related environmental studies

Nuclear and isotopic techniques were used to increase the sensitivity of nutrition monitoring techniques and to identify effective strategies. A draft thematic plan entitled 'Isotopic Evaluations to Add Value to Nutritional Interventions' was developed as a template for regional technical co-operation projects in Latin America and in the East Asia and Pacific region.

Reports by WHO and other international organizations indicate that chronic diseases associated with ageing are becoming a serious problem in many developing countries, especially those undergoing nutritional and demographic change. Accordingly, a CRP was initiated on the application of nuclear techniques in the prevention of degenerative diseases in ageing to study the underlying mechanisms of disease development so as to define better methods of prevention.

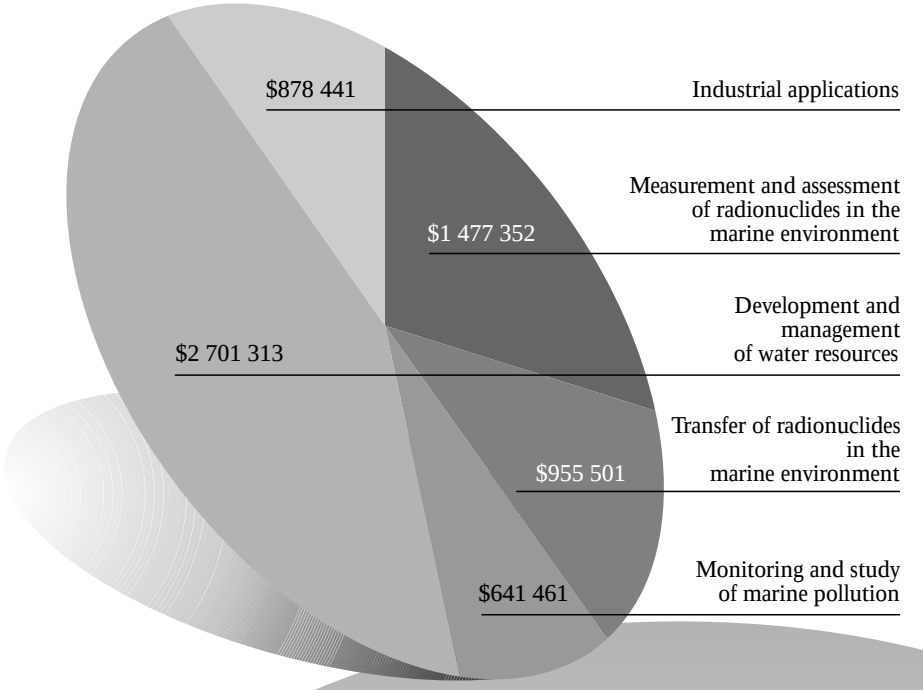
As a result of two CRPs in environmental monitoring and several technical co-operation projects, a global network of monitoring stations in more than 40 countries was established using the same sampler design providing information on element content in the (particulate matter)10 and PM2.5 fractions of airborne particulate matter. Efforts were also made to identify various plants for monitoring airborne pollution with a view to using them as biomonitors at the regional or global scale.

A radiological study on terrestrial samples collected at Mururoa and Fangataufa Atolls in the South Pacific, where French nuclear weapon testing took place, was completed and the results published. In general, the activity concentrations measured by the international team were consistent with the French data that were

available. In particular, the data for plutonium in surface soil, sand and vegetation samples were completely overlapping at all sampling locations. Differences up to a factor of 10 were observed for plutonium concentrations in coconut samples and for areas on the Colette motu, where plutonium contamination resulting from safety tests was found to be about three times higher than the French average value for this area. The ranges of caesium-137 concentrations observed by the international team overlapped with the French results, but the French data include consistently higher values, except for vegetation samples, where lower values have been reported. The international team concluded that the French data constitute a comprehensive and reliable account of the levels of artificial material in the atolls and that the very low concentration levels found in the accessible terrestrial environment were of no radiological significance.

Two proficiency test materials for measuring gamma emitting radionuclides, strontium-90 and actinides were prepared. They will be used by the Analytical Laboratories for Measuring Environmental Radioactivity (ALMERA) network.

MARINE ENVIRONMENT, WATER RESOURCES AND INDUSTRY



Regular budget expenditure:
$6 654 068

Extrabudgetary programme expenditure
(not included in chart):
$1 970 594

Programme objective

To protect the marine environment through improved capabilities to monitor and assess radioactivity and the use of nuclear and isotopic techniques to enhance understanding of the oceans and marine pollutant transfers and behaviour. To assess the need and, where appropriate, promote the development and transfer of isotope and radiation technology and applications for environmentally sustainable industrial development and the solution of practical problems in hydrology and the management of fresh-water resources.

Activities in the marine environmental field marked the United Nations International Year of the Ocean. They included an international symposium on marine pollution and the opening of the new premises of the Marine Environment Laboratory in Monaco. In addition, a major field programme in three oceans was carried out to better understand the distribution of radionuclides in the oceans of the world. Collaboration with the European Union in Mediterranean studies provided valuable new information on the processes of material transport. In the field of hydrology, a CRP on the application of isotope techniques to investigate groundwater pollution was completed. The data collected will help in the control of pollutants and mitigation of their effects. Efforts were made to integrate the Agency's work in water resources management with the work of other

United Nations agencies. For example, the Agency and WMO signed a Memorandum of Understanding to strengthen the Global Network for Isotopes in Precipitation, which will permit wider use of isotope data in hydrology and climatology. Progress was made in work related to industrial applications. In this connection, a new CRP on the radiation processing of indigenous natural polymers to convert natural products into useful materials was initiated.

Measurement and assessment of radionuclides in the marine environment

One of the major events of the United Nations International Year of the Ocean was the convening of a symposium on marine pollution in Monaco in October. The symposium was hosted by the Principality of Monaco and was co-sponsored by the IOC of UNESCO, the IMO, UNEP and the Commission Internationale pour l'Exploration Scientifique de la Mer Mediterranée (CIESM). New developments included: the identification of the sources of pollution; the behaviour and fate of contaminants in sea water, biota and sediments; the use of radioactive and non-radioactive tracers for studies of transport and circulation processes in the world's oceans and seas; studies of radioactive waste dumping sites and nuclear weapon test sites; local, regional and global computer modelling of the transport of contaminants; and high sensitivity analytical measurements of contaminants with emphasis on nuclear and isotopic methods. Information on global and regional marine pollution study programmes was presented and future trends in marine pollution studies were identified. In addition, the new premises of the Marine Environment Laboratory in Monaco, the only such laboratory in the United Nations system, were officially inaugurated during the symposium.

A ministerial meeting of Black Sea countries, organized within the framework of an Agency technical co-operation project on marine environmental assessment of this region, was also held during the symposium. Environmental ministers signed the 'Black Sea Declaration', which stresses the important role played by the Agency in upgrading the capabilities of Member States in the region to assess the marine environment. In this connection, a cruise was also organized to sample sea water, sediment and biota in the Black Sea with the participation of Member State laboratories in the region.

As part of a project on Marine Radioactivity Studies in the World Oceans (MARS), supported by the Government of Japan, three cruises took place to the Antarctic, the northeast Atlantic Ocean and the Arabian Sea in co-operation with institutes from Germany, India and Italy. The objectives were to sample sea water, biota and sediment to better understand the distribution of radionuclides in the world's oceans and the sources which have introduced anthropogenic radionuclides, such as global fallout, former nuclear weapon tests and former radioactive waste dumping sites. Samples were collected and are being analysed in several Member State laboratories. The data will be included in the Global Marine Radioactivity Database (GLOMARD).

A computer model was developed for the assessment of the radiological situation in connection with the dumping of radioactive wastes in the Far Eastern Seas. The collective effective dose equivalent of the annual intake of marine products in Japan was estimated to be only 0.8 man·Sv. About 90% of the dose derives from caesium-137, most of which is due to the consumption of fish. The total dose from radioactive wastes is about 5% of that from global fallout, which is attributed to the testing of nuclear weapons in the atmosphere. The dominant dose is from natural polonium-210 in shellfish, which contributes 99.9% of the total dose.

In the Agency's Analytical Quality Control Services (AQCS) programme, a sample of lagoon sediments from Fangataufa Atoll was prepared for a worldwide intercomparison exercise on marine radioactivity measurements. After preparation and preliminary testing, the samples were sent for radionuclide analysis to 110 laboratories in Member States. The analytical results obtained confirmed good performance for caesium-137 analysis. However, the analysis of plutonium isotopes in marine samples needs further improvement in many laboratories.

Transfer of radionuclides in the marine environment

Chemical and radiochemical analyses were completed on a wide variety of samples from the hydrothermal

vent zone off Milos Island as part of the European Union sponsored 'Aegean Sea Hydrothermal Fluxes' project. Particle dynamics studies using time series sediment traps have shown that vertical fluxes of aggregates were on average one order of magnitude higher near the vent zone than outside the vents. In periods of maximum sedimentation, the downward flux of organic material was 30–100 times higher at the vent site. Settling particles differed between sites not only in quantity but also in their composition. Higher particle fluxes and downward carbon transport near the vent fields appeared to be a consequence of enhanced biological activity, which was closely linked to the geothermal emissions. This relationship was supported by the discovery of hyperthermophilic bacteria in the sinking particles collected near the vents, as well as the relatively low carbon-13 isotopic levels in these particles, an isotopic signal which is typical of that measured in bacterial mats and surface sediments associated with hydrothermal vents.

Vent emissions are often enhanced in trace element and natural radionuclide content. Analyses were carried out to examine this aspect at sites, both inside and outside of the vent zone. For the most part, concentrations of a suite of trace metals and the natural radionuclides polonium-210 and lead-210 in sinking particles were similar at both sites. The higher downward fluxes of some metals, as well as polonium-210 and lead-210 measured at the vent site were thus attributed to the higher particle fluxes related to venting activities. Similarly, small snails found grazing on the carbon-rich bacterial mats in the vent zone did not show elevated polonium-210 or lead-210 concentrations when compared with concentrations of these radionuclides in similar organisms from outside the vent area. More specifically, their radionuclide concentrations were much lower than levels measured in vent associated worms living in the deep sea. These observations suggest that bacteria associated with the Milos mats are not an important vector for polonium-210 and lead-210 enrichment in higher feeding levels of this particular benthic food chain.

In the Mediterranean Targeted Project II (MATER), which is being carried out in collaboration with the European Union, the Agency is using radionuclides such as lead-210 and plutonium-239 and 240 to measure particle scavenging and sedimentation rates in the western Mediterranean Sea. The relationship between the inventories of these radionuclides in deep sea sediments is being used to better understand the nature of the sedimentation regimes in this relatively productive region of the Mediterranean. A sediment core from the productive Malaga upwelling area contained a much higher content of plutonium-239 and 240 relative to lead-210 than is normally observed in the basin. The enhanced plutonium deposition at this site was attributed to the nature of the sedimenting particles, which were mainly biogenic and are known to be excellent 'scavengers' of dissolved plutonium in the water column. Because of the different affinity of plutonium-239 and 240 and lead-210 for certain types of biological particles, the ratios of these radionuclides in underlying sediments may prove to be useful tools in determining the type of sedimentary regime in a given area of the Mediterranean.

Experimental nuclear application studies were focused on the use of radiotracers to assess the bioavailability, retention and transfer factors of radiologically important radionuclides and toxic heavy metals in marine molluscs which are routinely used in monitoring programmes. In one study, low energy gamma emissions of lead-210 were used to quantify the bioaccumulation of lead in mussels which are the species of choice in various 'mussel watch' type heavy metal monitoring programmes. The resultant bioaccumulation factors for whole mussels of approximately 200 were some two orders of magnitude lower than those reported for other trace metals in these bivalve molluscs, indicating that the uptake of lead by mussels in the marine environment is a very inefficient process. Both the slow uptake rate and long retention time of lead limit the ability of mussels to record short term variations of lead concentrations in surrounding waters, a fact which must be considered when defining the appropriate sampling frequency for mussels used in the biological monitoring of lead contamination.

In a separate laboratory study, a clam species typical of Arctic waters was exposed to sediments from the Kara Sea that had been labelled with a mixture of radiotracers of cobalt, zinc, silver, cadmium, caesium and americium. The transfer of the radionuclides from sediments to clams was followed for six months and it was found that direct bioaccumulation from the sedimentary phase was minor compared with the amount taken up from the interstitial water between the sediment grains. Therefore, exposure to sediments which characteristically have low radionuclide distribution coefficients (K_ds) between sediment and water, such as those from Abrosimov Bay, leads to a relatively higher bioaccumulation factor in the clams compared with those living in sediments with higher K_ds. Knowledge of site specific bioavailability variations is crucial for

adequately modelling radionuclide and heavy metal transfer in Arctic as well as other benthic ecosystems.

An assessment of the technological enhancement of radioactivity from agrochemical and non-nuclear industrial activities was carried out by examining levels of the natural radionuclide polonium-210 in specific coastal areas of China, the Syrian Arab Republic and Turkey. Along both the northern coast of China and Turkey's Black Sea coast, macroalgae, fish and shellfish were sampled near river outflows containing elevated organic phosphorus levels derived from agrochemical applications as well as in 'control' areas away from riverine inputs. High polonium-210 concentrations are known to be closely associated with many phosphorus compounds. However, for both areas there was no clear indication of elevated polonium-210 levels in biota living near rivers discharging into the sea. Hence, any perturbation of the natural radiation regime in these areas from agrochemical inputs via rivers is expected to be very small. On the other hand, in one of the main ports in the Syrian Arab Republic, where large quantities of phosphate ore have been exported for more than 20 years, polonium-210 levels in sediment and sea water were higher than those in corresponding samples collected along the coast. Such enhanced polonium levels could lead to a higher radiation dose being received by the local population consuming seafood from the port area.

Monitoring and study of marine pollution

The use of carbon isotope techniques, coupled with gas chromatographic separation, to identify the sources of organic materials present in the marine environment was further developed and its potential applications to palaeoclimatology were evaluated. A significant correlation has been found between the $\delta^{13}C$ cholesterol of suspended particulate and seawater carbon dioxide concentrations in the southern Indian Ocean.

Two new reference materials were produced, a sea plant homogenate (IAEA-140) and a marine sediment (IAEA-383), which are now available to the international scientific community. These materials are certified for pollutants such as organochlorine pesticides, petroleum hydrocarbons, PCBs, trace elements and methylmercury.

In collaboration with UNDP, assistance was provided to the Black Sea Member States to establish a regional pollution monitoring network and to obtain high quality analytical data for trace contaminants. In several laboratories instruments were installed and staff were trained for the optimum use of these instruments. A 'mussel watch' type pilot biomonitoring exercise was implemented for organic contaminants in collaboration with several national laboratories in the region. Samples were collected by the various participants and first information on the regional distribution of trace organic contaminants in mussels and sediments has been obtained.

Development and management of water resources

A CRP on the application of isotope techniques to investigate groundwater pollution was completed. Work focused on the application of isotope techniques for the assessment or mitigation of urban groundwater pollution due to domestic wastes and sewage disposal as well as landfill sites, seawater intrusion and pollution from agricultural practices. The results of this CRP, published as a technical document, have verified that the isotopes of nitrogen, boron, sulphur and oxygen in dissolved sulphate, and iodine-131 can be applied to distinguish pollutant sources and identify their transport pathways in groundwater systems. These data have practical applications in dealing with hydrological problems encountered in technical co-operation projects, such as the UNDP/RCA/IAEA project on 'Access to Clean Drinking Water'.

Another CRP was completed that focused on the use of isotopes for analyses of flow and transport dynamics in groundwater systems. Different approaches for improved quantitative evaluation of isotopes with the goal of more reliable estimates of the dynamic parameters of flow and pollutant transport in groundwater were applied to actual field cases by the participating institutes to verify the mathematical modelling procedures required for this purpose. Several computer programs for practical applications of different formulations were also developed and tested. The results of this CRP have provided a scientific basis for different conceptual model formulations and extensive data on their field applications under various hydrogeological settings.

A completed CRP studied the use of isotope techniques in water resources investigations in arid and semi-arid

regions. In addition to dealing with specific isotope methodologies in arid zone hydrology, and particularly with studies related to the evaluation of the replenishment of groundwater resources under present climatic conditions and the effects of over-exploitation, this CRP contributed to more effective utilization of isotope methods in the implementation of technical co-operation projects related to groundwater resources assessment and management in arid zones. In addition, the CRP resulted in better isotopic characterization of the present recharge to groundwater in northern Africa (Algeria), identification of non-renewable groundwater resources (palaeo-recharge) in selected African and Asian regions, and determination of the contribution of surface water and irrigation return flow to the present groundwater recharge of specific arid/semi-arid regions in Egypt and in various parts of Asia.

Through a recently completed CRP on isotope aided studies of atmospheric carbon dioxide and other greenhouse gases, the analytical precision of the participating laboratories was significantly improved to the high level necessary to determine relatively minuscule natural isotopic variations. The CRP also achieved a remarkable improvement in the comparability of analytical results by strengthening quality assurance methods and establishing measurement protocols, this being a necessary pre-requisite for merging the existing data sets from different atmospheric observation networks. Combined measurement of the stable isotope ratios of greenhouse gases and their concentrations provides the only direct method for the assessment of regional releases of these gases. The advances made in this CRP will facilitate the use of isotope techniques in the verification of the Kyoto Protocol and other international agreements on the reduction of greenhouse gases in the atmosphere.

An Advisory Group meeting was held in November in Kozhikode, India, to integrate isotope methods more effectively into water projects in the Asia and Pacific region. After reviewing the possible areas of use and the applicability of isotope techniques to the major water resources issues in the region, the meeting considered possible ways and means for their wider scale utilization. Several constraints were identified and recommendations made which will be fully taken into account in the design of future programmes. The recommmendations included: improved lines of communication between practising hydrogeologists and isotope scientists; training of hydrogeologists to facilitate the integration of isotope techniques in hydrological practices; development of a guide for the use of isotope techniques in hydrology; and assistance to universities to include a course in isotope hydrology in their curricula.

The services of consultants were used to delineate the needs, requirements and strategy to be used for more effective programming of Agency technical co-operation activities in the specific field of isotope hydrology in groundwater applications. It was emphasized that there was a need to further harmonize the Agency's technical co-operation projects with national priorities in water resources development and management in Member States. The following high priority areas were identified: groundwater recharge in arid zones; management of aquifers affected by salinity; groundwater pollution; and urban hydrology.

At the fourth co-ordination meeting for a regional Model Project on isotopes in groundwater resources development, held in June in Dakar, all four countries involved in phase I of the project (Egypt, Ethiopia, Morocco and Senegal) reported technical achievements with a direct impact on water resources management practices in their countries. In Egypt, the project results have been used to prepare a comprehensive hydrogeological map that will be used in the future for managing water resources in the area. In Senegal, the main objective of the project was to re-evaluate the potential of groundwater resources in the Cape Verde Peninsula region (i.e. Dakar and vicinity, which suffer a severe water shortage) for the supply of drinking water. The isotope studies provided critical data for the sustainable management of the most important groundwater aquifers in the vicinity of Dakar. Isotopic studies in two regions of Morocco led to a better understanding of the aquifer systems. In one of the regions (Tafilalt), the studies indicated that the Infracenomanian aquifer is not being replenished and it was therefore decided to close off five artesian wells to avoid exhaustion of the resource. In the other area (Guelmin), it was found that artificial recharge of the Seyyad aquifer by surface water (to be collected in new dams) is feasible. The potential area for this artificial recharge was also identified on the basis of the isotope study. In Ethiopia, the replenishment of water resources was assessed for the Moyale region, where three million people suffer from recurrent droughts. The results show a widespread recharge of the groundwater through rainfall. However, the rate of modern recharge was shown to be only 10% of previous estimates. The study highlighted the sustainable potential of two sedimentary and fractured rock aquifers in the region which can be used for rural water supply.

Technology transfer to Costa Rica and Venezuela from the Agency within the framework of an ARCAL XVIII programme on nuclear and related techniques in dam and reservoir leakage studies was completed in 1998. The techniques transferred have been incorporated as an additional tool in activities related to dam safety monitoring. Following the success of this project, a similar regional project has been initiated in Africa, with 22 AFRA countries requesting participation because of leakage problems in dams and reservoirs. Owing to the visible impact and simplicity of the nuclear techniques, and in view of the extensive occurrence of dam and reservoir leakage problems in Member States, the use of nuclear techniques in this field is being included as one of the subjects for the new 'thematic planning' approach in the Agency's technical co-operation programme.

Under a technical co-operation model project in Costa Rica, a chemical laboratory was set up for water and gas analysis at the Instituto Costarricense de Electridad to support monitoring which will sustain the production of steam at the Miravalles geothermal field and development of other exploration areas. In addition, the effects of injecting cooler saline wastewater produced in the power plant back to the subsurface ('reinjection') to maintain steam pressure at the production wells of the geothermal field have been monitored to avoid possible negative impacts and to protect the environment from pollution.

In support of development and technology transfer to Member States, an instructional manual entitled *Isotopic and Chemical Techniques in Geothermal Exploration, Development and Use: Sampling Methods, Data Handling and Interpretation* was prepared to guide exploration and monitoring activities that use geochemical and isotopic tools in geothermal investigations. This manual is intended for scientists working in geothermal projects, either in the exploration, exploitation or development phases for both low and high enthalpy systems, and for the investigation of freshwater resources.

The Isotope Hydrology Laboratory of the Agency's Laboratories issued five new reference materials in 1998, increasing the total number of these materials to 38. More than 800 samples of these reference materials were distributed to laboratories around the world.

In response to a 1997 General Conference resolution, a number of laboratories in developing Member States were visited and proficiency tests carried out to identify those that were able to provide analytical services to technical co-operation projects in isotope hydrology. Of the laboratories visited, six (three in Latin America, two in Africa and one in the Asia and Pacific region) were selected for further consideration as regional resource centres to provide analytical support in the region.

In September, an Internet Web site *(http://www.iaea.org/programmes/ripc/ih/index.html)* dealing with the development and management of water resources was inaugurated. The site includes the *Water and Environment News* newsletter and links to other relevant activities such as the Global Network for Isotopes in Precipitation (GNIP) database and the Isotope Hydrology Information System (ISOHIS).

A preparatory meeting for the establishment of a joint IAEA–WMO GNIP Scientific Steering Committee was held in Vienna. At this meeting a Memorandum of Understanding (MoU) was finalized. The MoU was signed by the Director General and the Secretary General of WMO in December. It paves the way for greater collaboration between the Agency and WMO and permits wider use of isotope data by the hydrology and climatology communities represented by the International Association for Hydrological Sciences, World Climate Research Programme, and the International Geosphere–Biosphere Programme.

Efforts to seek synergies with other United Nations system organizations resulted in discussions at the Subcommittee on Water Resources of the United Nations Administrative Committee on Co-ordination that identified projects where immediate collaboration is possible. The Agency was invited to participate in a new system-wide initiative to develop mitigation strategies for polluted drinking water. The initial focus of this work is on arsenic contamination in drinking water in Bangladesh. This initiative is being co-ordinated by UNICEF, with the Agency and UNESCO responsible for hydrogeology activities.

An ad hoc meeting, organized by the Agency jointly with the WMO–World Climate Research Programme (WCRP) and hosted by UNESCO, was held in Paris in December to discuss the scope and objectives of a new initiative entitled the 'International Programme for Isotopes in the Hydrological Cycle'. Conceived as an interagency co-operative programme, the main goal of this initiative is to integrate isotope hydrology in water sciences as a teaching discipline at universities around the world and establish (through the UNESCO

International Hydrological Programme) national committees to conduct activities related to the further development of isotope hydrology and its application in the water and climate sector of countries. It was recommended that the Agency, in co-operation with UNESCO and WMO–WCRP, take the lead in preparations for the launch of this programme. To this end, a task force was established to co-ordinate further activities.

Industrial applications

Sterilization of single use medical products continues to be the major industrial application of radiation technology around the world. New applications based on the radiobiological effects of ionizing radiation are emerging, such as blood irradiation and tissue sterilization. A new CRP was initiated to facilitate the introduction of radiation sterilization into the pharmaceutical industry to sterilize or decontaminate pharmaceuticals and pharmaceutical raw materials. The objectives include: identification and quantification of radiolytic products; establishment of maximum tolerated dose for the radiation response pattern in a particular product; and testing of safety and screening for toxicity and mutagenicity.

Two Advisory Group meetings, in Budapest in March and in Vienna in October, held to identify emerging new applications in the radiation processing of materials, particularly polymers, demonstrated the increasing attention being devoted to this subject by industry. The new radiation application programmes studied in these meetings included: electron beam curing of advanced composites used in the aircraft industry; new fibre materials for applications under extreme conditions; stimuli-responsive materials obtained through the radiation grafting of track membranes; pre-crosslinking of thermoplastics; radiation vulcanization of natural rubber latex; cross-linking of thicker and bulky polymeric products; and cross-linking of Teflon at high temperature. In addition to reviewing the current and emerging applications for electron beam processing, the meeting assessed the use of ion beams for processing materials, in particular polymers. The dramatic changes brought about in the surface properties of polymers irradiated with ion beams include: greatly enhanced resistance to chemical attack; induced electrical conductivity; significantly lowered permeability to gaseous molecules; and dramatically increased hardness and abrasion resistance.

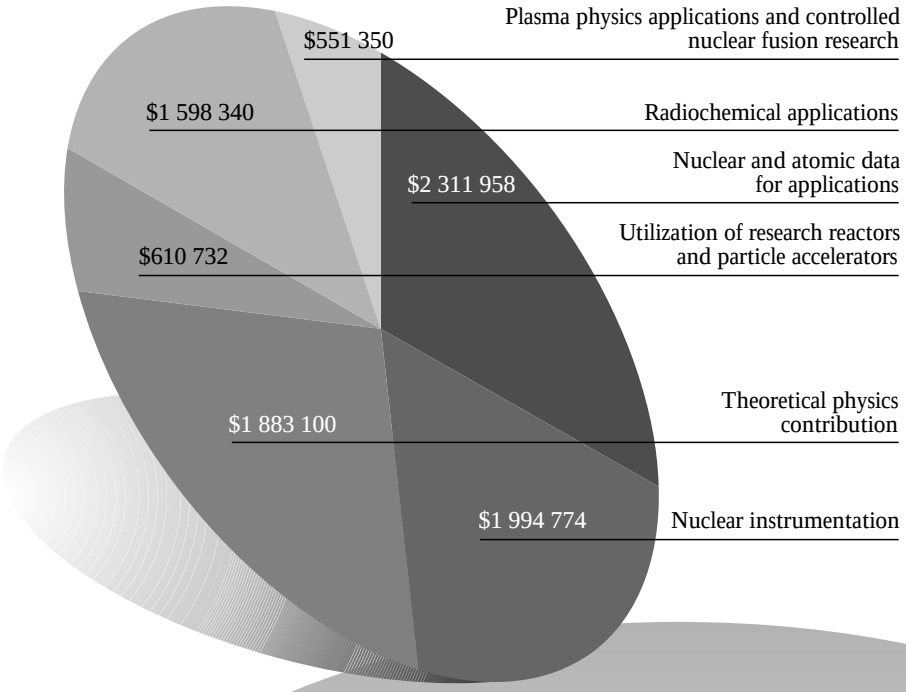
In a CRP on the validation of protocols for the evaluation of corrosion and deposits in pipes by radiography, including the quality assurance aspects of non-destructive testing (NDT) measurements, metallic pieces with known and simulated corrosion defects were prepared and experimental results achieved in many of the participating laboratories. These specimens were then exchanged within the network for inter-laboratory quality control testing.

The services of consultants were used to study the area of digital radioscopy in industrial applications. It was recommended that research on the following NDT methods be supported in view of their cost advantages and greater industrial safety: radioscopy with digital image processing; film digitization with archiving and digital image processing; and imaging plate radiography. In related work, a report entitled *Non-destructive Testing: A Guidebook for Industrial Management and Quality Control Personnel* was completed for publication.

A CRP on radiotracer technology for unit operation studies and unit process optimization was initiated. Its main purpose is to upgrade the capability of radiotracer groups in developing countries, refine, consolidate and systematize existing know-how, and promote new applications. The main areas of research will be: expert systems for experiment design; customization of mathematical software; signal decomposition for better flow visualization; residence time distribution coupling with computer fluid dynamics modelling; optimization of multidetection units; automatic fast and safe tracer injectors; and quality control of data and accreditation to ISO standards. Case studies from catalytic cracking units in the petroleum industry, grinding and flotation in mineral ore processing, model identification and kinetic determination of the crystallization process, and testing the efficiency of sedimentation and aeration tanks of waste water treatment plants are the major targets of the CRP.

An Advisory Group meeting was convened in Vienna in May to study emerging applications of nucleonic control systems in industry. At the meeting the current status of the technology was evaluated and recommendations were made on the best ways to further develop the new applications and transfer them to developing countries. It was recommended that prototypes of portable low cost and low activity double beam gauges be designed and manufactured for niche applications in the natural resource mining and processing industries.

PHYSICAL AND CHEMICAL SCIENCES



Regular budget expenditure:
$8 950 254

Extrabudgetary programme expenditure
(not included in chart):
$82 841

Programme objective

To promote application oriented research, development and implementation of techniques and technologies based on nuclear physical and chemical sciences for solving practical problems in the fields of medicine, environment, energy and mineral resources prospecting; to assist in the better utilization of research reactors and accelerators and provide technical help to national analytical laboratories to improve the quality of their analytical measurements.

The activities of the physical and chemical sciences programme focused on advanced areas of nuclear science and on the use of nuclear technology for the benefit of Member States. Version 2 of the Fusion Evaluated Nuclear Data Library (FENDL-2) was completed and made available to users in Member States on the Internet and on CD-ROM. The incorporation of a World Wide Web graphic interface led to the Agency's nuclear database being more user-friendly and resulted in a large increase in the number of nuclear data retrievals and the volume of data retrieved. The Agency's Laboratories at Seibersdorf conducted a worldwide survey of X ray fluorescence (XRF) laboratories and developed a new 'fluorescence/Compton ratio' method and software for XRF applications and analysis. These advances will help Member States conduct rapid, accurate analyses of environmental, industrial and medical samples. One of the results of a

CRP concluded in 1998 was standardization of the production methods of therapeutic radiopharmaceuticals for metastatic bone pain and arthritis. Work also began on the development of such agents for other therapeutic applications. The Agency's 17th Fusion Energy Conference was held in October in Yokohama. And the design of the International Thermonuclear Experimental Reactor was finalized by the collaborating parties and the Final Design Report published.

Nuclear and atomic data for applications

The development of a full World Wide Web user interface to the Agency's comprehensive nuclear and atomic databases was completed. This method of access is now offered in addition to the existing Telnet based on-line nuclear and atomic data retrieval system. Owing to its convenient graphic user interface, more and more users prefer to use the Web environment to retrieve their data. As a result, the number of user retrievals through Telnet decreased in 1998, while the number of Web based data retrievals increased sharply, with users located in 90 Member States.

Since some data users have limited access to the Internet, CD-ROM versions of the main nuclear databases — Computer Index of Neutron Data (CINDA), Compiled Experimental Nuclear Data (EXFOR) and Evaluated Nuclear Reaction Data Files (ENDF) — were prepared in co-operation with other data centres. Since they are completely analogous to the databases accessible on-line, they provide effective, updated off-line retrieval of the specific data needed by a local user. In addition, new releases of the ENDF/B-VI data library and the evaluated photon data library EPDL97 were made available to users as a result of the continuing worldwide co-operation between nuclear reaction data centres.

In order to reduce printing costs, the practice of porting certain data relevant publications to the Web was started. Electronic versions of 6 nuclear data newsletters and 11 data reports have been placed on the Web in HTML or PDF formats. Electronic versions are more convenient for many users and also facilitate the updating of frequently revised information.

Development of the Reference Input Parameter Library (RIPL Starter File) was completed with the aim of producing a tool for the effective evaluation of nuclear data for emerging nuclear applications. The library organizes and preserves the immense knowledge accumulated over the years by the worldwide nuclear physics community in calculations of low energy nuclear reactions. A technical document describing the library was published and the library was made available on the Web and on CD-ROM.

A major international library of nuclear data for fusion applications (FENDL-2), developed under Agency auspices, underwent successful quality assurance tests. In addition, documentation for users was prepared and, as with other databases, the library was made available on the Web and issued on CD-ROM.

A workshop on nuclear reaction data and nuclear reactors was conducted at the International Centre for Theoretical Physics in Trieste. Its primary goal was to facilitate the transfer of know-how on the use of nuclear data in nuclear reactor calculations to scientists and engineers from developing countries. The workshop resulted in more than 300 requests for computer codes being submitted to the Computer Program Services jointly operated by the Agency and the OECD/NEA.

Two new CRPs were initiated. The first addresses X and gamma ray emission data for detector calibration in

NUCLEAR DATA RETRIEVALS

	1994	1995	1996	1997	1998
Volume of data retrieved from the Web (megabytes)	—	—	100	2600	8600
Telnet nuclear data on-line retrievals	3200	4400	5700	7350	2700
CD-ROMs with databases, libraries and files distributed on request	—	—	—	—	205
Off-line retrievals	1950	1550	800	1900	1995

response to needs for improved quality of data in spectroscopy measurements in safeguards, dosimetry and industry. The second one deals with nuclear model parameter testing for nuclear data evaluation in order to provide quality assurance of these evaluation tools for emerging nuclear applications.

Two major numerical databases dealing with atomic and molecular data were completed: one on the chemical erosion of fusion reactor plasma facing materials induced by plasma particle impact; and the other on the total and differential cross-sections for elastic scattering and momentum transfer processes in collisions involving hydrogenic ions, atoms and molecules, and their isotopic variants. These databases can be used by fusion plasma modellers and fusion reactor engineers in predicting the behaviour of large plasma devices.

In response to the needs of several fusion research laboratories, and in collaboration with the Institute for Plasma Physics in Garching, Germany, and the Technical University of Vienna, an atomic database for lithium beam penetration in fusion edge plasmas was completed. This database is already being used in the lithium beam diagnostics of ASDEX, TEXTOR and other tokamak plasmas.

Work on an international database on the thermomechanical properties of irradiated nuclear graphites was initiated using extrabudgetary funds. This database will permanently archive the properties of nuclear graphites in graphite moderated power reactors in order to preserve the information gathered over many years by the nuclear power industry.

Nuclear instrumentation

The Agency provided technical support to Member States to enhance their capacity for the repair and maintenance of nuclear instruments. An evaluation carried out on repair trends found that during the years 1995–1997, Latin American countries repaired 240 items of equipment, with a total value of $1.35 million, using spare parts provided by the Agency at a total cost of only $52 000.

Seven modular nuclear instruments (quad timing single channel analyser, crate controller, multi-purpose pulse generator, simulated pulse generator, spectroscopy amplifier, single channel analyser, and counter/timer) developed at the Agency's Laboratories at Seibersdorf or under individual Research Contracts/Agreements were evaluated by external experts. The evaluation indicated that these low cost instruments were ideal for education and for application in such fields as nuclear medicine and environmental monitoring.

The Agency's Laboratories at Seibersdorf developed and tested the following:

- Educational kits (including manuals) for training in nuclear electronics, such as the EURO CAN bus controller for real-time applications and a microcontroller training kit;
- A temperature control unit for use in dosimetry;
- A medfly pupae sorter for use in entomology;
- A portable X ray fluorescence (XRF) spectrometer based on a thermoelectrically cooled cadmium telluride (CdZnTe) detector and a portable multichannel analyser.

A new quantitative method based on the 'fluorescence/Compton ratio' concept was developed for laboratory and in-field XRF applications. A dedicated software program was implemented in the laboratory X ray microfluorescence system. In order to improve interpretation of the analytical results, cluster analysis was adopted for classification of the individual particles analysed by an electron microprobe. A worldwide intercomparison survey of XRF laboratories was concluded. The results were evaluated according to the recognized international protocol, which ensured both comparability and proper classification of the participating laboratories.

A Research Co-ordination meeting on the development of computer based troubleshooting tools and instruments was held in Vienna in November. In addition to summarizing recent developments, recommendations were made to develop: a troubleshooting database, including checklists; an in-circuit emulator and analog signal generator; a computer based maintenance and quality control programme; and an expert system for nuclear instrument troubleshooting.

In addition to existing nuclear spectrometry software, gamma ray and alpha particle test spectra were distributed to Member States on diskettes and through the Internet. Several programmes for spectroscopy applications were developed or upgraded. And more than 100 copies of the Agency's nuclear spectrometry software were distributed to Member States.

With the advent of modern notebook computers, the capabilities of portable spectrometry systems have become more powerful and convenient. A workshop was held at the Agency's Laboratories at Seibersdorf to compare the performance of several portable XRF and gamma ray spectrometry systems. The systems under test were classified as portable, hand-held and miniaturized, though it was concluded that they did not contain all of the necessary attributes that would qualify them for use in the field. The report of this workshop will assist Member States in selecting suitable instruments for their specific applications.

Utilization of research reactors and particle accelerators

The WIMS-D thermal reactor physics code is widely used, especially by scientists in developing countries, for research reactors, but the available nuclear data library is based on old information. In order to solve this problem, a new CRP was initiated on updating the WIMS-D Library.

An Advisory Group meeting on the enhancement of research reactor utilization for neutron activation analysis, held in Vienna in June, concluded that neutron activation analysis in its various forms is still a viable and useful technique. There are good prospects in developing countries for long term growth, which can be achieved by the more effective use of existing facilities and with a better end user orientation. It was agreed that neutron activation analysis, which can be carried out with low power research reactors, can contribute to the development of the economy and nuclear infrastructure in many developing countries. For example, it provides a quick method of screening geological samples for minerals which may be commercially useful. Since it also involves a nuclear technique, it stimulates the development of appropriate regulations and procedures for handling radioactive material. Finally, the use of neutron activation analysis requires the training of personnel in sophisticated nuclear techniques, thereby contributing to the technical and scientific 'knowledge base' of the country.

Another Advisory Group meeting in Vienna in July reviewed the technological requirements for proton therapy facilities. At present, most proton therapy centres are not located in hospitals, but in nuclear institutes that are used only partly for therapy. Following the dedication of the world's first hospital based proton therapy centre in 1990, several similar centres are currently under construction and many more are being planned. The typical structure of a hospital based facility was discussed. Many different types of accelerator can be used, with the accelerator system accounting for only about 20% of the cost of all the technical components. The factors influencing the cost of proton therapy centres were also discussed.

Radiochemical applications

After a gap of nearly 12 years, the Agency organized an international symposium on radiopharmaceuticals, in Lisbon in March–April. The papers presented at the meeting reflected the current developments and future trends in the use of diagnostic and therapeutic agents. The continuing importance of technetium-99m in nuclear medicine and the role of imaging as an important tool in its use were highlighted. Emerging interest in therapeutic radiopharmaceuticals based on beta emitting short lived isotopes such as rhenium-186 and samarium-153 was also recognized. This trend, next in importance only to the use of technetium-99m, seems to be the direction of future developments in radiopharmaceuticals. There was also interest in the development of agents labelled with other established isotopes, especially radioiodine and also indium-111 and gallium-67. The importance of a proper regulatory structure, training and good manufacturing practices for ensuring safety in the regular use of radiopharmaceuticals was also underlined.

A CRP on the optimization of the production and quality control of therapeutic radionuclides and radiopharmaceuticals was concluded. During the course of this CRP, simplified and optimized procedures were developed for the production of the short lived beta emitting isotopes samarium-153, holmium-166 and rhenium-186, including preparation of phosphonate based radiopharmaceuticals for the palliative therapy of metastatic bone pain, and labelled particles for treating certain types of arthritis. These products have been put to regular patient use. The results of the CRP have been published as a technical document.

A new CRP on labelled biomolecules for targeted radiotherapy was initiated. The work will focus on labelling a few selected peptides with rhenium-188, yttrium-90 and samarium-153. Targeted radiotherapy

has several advantages over external beam therapy, including the possibility of selectively delivering higher doses to the tumour and treating multiple metastases. The aim of the CRP is to develop procedures for the preparation of radiolabelled biomolecules such as monoclonal antibodies and peptides.

In a CRP on the development of kits for radioimmunometric assays for tumour markers, progress was made in the local production of the basic reagents needed for total prostate specific antigen (PSA) assay, useful in the early diagnosis of prostate cancer. Purification of the PSA from seminal fluid, preparation of polyclonal and monoclonal anti-PSA antibodies, studies on optimizing antibody coating to solid phase, and standardization of the methodology for enzyme linked immunosorbent assay (ELISA), radioimmunoassay (RIA) and immunoradiometric assay (IRMA) for PSA using external reagents were some of the main achievements.

Implementation of good manufacturing practices and practical regulatory practices for radiopharmaceuticals in many developing Member States is an area that requires support and guidance from the Agency. A draft guidelines document for good radiopharmacy practices in developing countries was prepared and circulated to experts in the field for comments.

An Advisory Group meeting was held in Vienna on the introduction and implementation of quality assurance principles in laboratories using nuclear and nuclear related analytical techniques. A report prepared at the meeting outlined the potential actions that could be taken to implement quality assurance concepts in Agency technical co-operation projects. The report also contains recommendations on the nuclear analytical techniques that can be targeted in a Model Project. The services of consultants were used to prepare training material for another workshop on this subject, and to prepare questionnaires for the selection of the laboratories to participate in the Model Project. These questionnaires were sent out in November.

The Agency's Laboratories at Seibersdorf supported CRPs by: providing supplemental characterization of materials supplied by the US National Institute of Standards and Technology, and characterization of three new air filter samples loaded with Vienna and Prague dust; the preparation, distribution, characterization and certification of reference materials IAEA-391/392/393; the organization and evaluation of intercomparison exercises for reference materials IAEA-085/086 and IAEA-336; the organization of proficiency tests for radionuclide analysis in Member State laboratories; and the co-ordination of the activities of the Analytical Laboratories for Measuring Environmental Radioactivity (ALMERA) network.

Plasma physics applications and controlled fusion research

At the 17th Fusion Energy Conference, held in Yokohama in October, papers were presented on: magnetic confinement experiments; plasma heating and current drive; International Thermonuclear Exterimental Reactor (ITER) engineering design activities; magnetic confinement theory; inertial fusion energy; innovative concepts; and fusion technology. One of the significant results achieved since the last conference was the realization of significant levels of fusion power — 10.7 MW for 0.4 seconds in the Tokamak Fusion Test Reactor at the Princeton Plasma Physics Laboratory, followed by 16.1 MW for 0.85 seconds in the Joint European Torus in Culham, United Kingdom. These achievements have allowed the experimental observation of significant alpha particle heating. Another key result was obtained in a first experiment with the newly commissioned superconducting Large Helical Device at the Japan Atomic Energy Research Institute, where the predicted theoretical confinement time was reached by the experiment. ITER papers presented: the successful development of large superconducting magnets; high power gyrotrons; the construction of a vacuum vessel sector and divertor; and remote handling equipment.

The sixth Technical Committee meeting on fusion power plant design was held in Culham, the United Kingdom, in March. The meeting reviewed the status of commercial fusion power plant concepts, including technology, material development, economics, environmental aspects, and the safety and socioeconomic aspects of fusion energy. Results were presented on the European Long-Term Fusion Technology Programme, concentrating on four major lines: the European Blanket Project with the main emphasis on water cooled lithium tiles inside stainless steel cases; the helium cooled pebble breeder blanket concept; advanced material studies, including results of the International Fusion Irradiation Facility; and the Safety and Environmental Assessment of Fusion Power within the European Union Framework Programme 5.

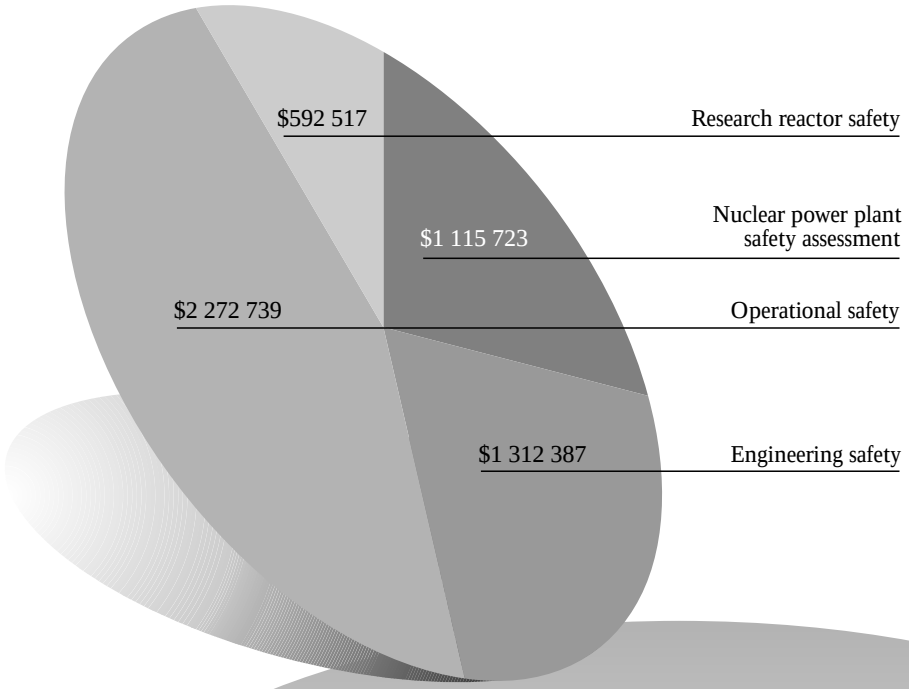
Detailed comparisons were presented from Japan on four tokamak reactor studies, one helical reactor study and one laser fusion reactor study. The Engineering Design Options from the US Fusion Reactor Program's studies on the development of spherical tokamaks were assessed on the basis of high performance structural materials such as ferritic steels, vanadium alloys and SiC composites. Optimization criteria for an alternative path to a fusion power plant — the heliac reactor in Germany — were also presented.

A Technical Committee meeting on the steady state operation of tokamaks was held in Hefei, China, in October. Among the topics discussed were: the operation of present long pulse tokamaks, the plans for future steady state tokamaks, advanced magnetic confinement configurations, and hybrid fusion–fission systems. Highlights included the presentation of long pulse experiments in France, Japan and the Russian Federation. Steady state devices are being planned or constructed in China, France, India, Japan and the Republic of Korea. The two hour experiment TRIAM-1M demonstrated good control of plasma position, particle flow and heat control at low plasma density. China will study hybrid fusion–fission systems that use fusion reactor generated neutrons to breed plutonium-239 fuel and to transmute high level wastes from fission reactors.

At a Technical Committee meeting held in Tokyo in October, there was a comprehensive review of present spherical torus experiments, related plasma physics theory, modelling, and future experimental devices. Papers were presented from the spherical tokamak experiments in Japan, the United Kingdom and the USA. The results attained by the START experiment at Culham Laboratory, in the United Kingdom, include good stability, high beta operation and the absence of disruptions. This success has inspired other experiments which are being planned in Brazil (ETE), the Russian Federation (GLOBUS-M), the United Kingdom (Meg Ampere Spherical Tokamak) and the USA (National Spherical Torus Experiment).

At the 13th Technical Committee meeting on research using small fusion devices, held in Shonan Village, Japan, in October, tokamak experiments, compact tori, helical devices, dense plasmas, inertial fusion and theory were discussed. The WT-3 experiment in Japan reported new results on the control of pressure driven $m = 1$ instabilities in a tokamak with significant lower hybrid current drive. The HT-2 experiment (Japan) reported novel results on ohmic breakdown in low resistance vacuum vessels and on vertical displacement event disruptive instabilities in elongated plasmas. The SINP tokamak in India has shown significant improvement in confinement characteristics and the length of time for which plasma current could be sustained. The Large Helical Device experiment provided very impressive results on first plasmas. The magnetic configuration has been measured, compares favourably with the numerical codes and has shown plasma confinement which is much better than expected on the basis of stellarator scaling laws. The performance of reversed field pinches was improved considerably by applying external resonant helical fields. The ADITYA tokamak in India has been modified to enable it to approach the full design parameters and to improve its diagnostic capabilities. First estimations on magnetized targets induced by circular polarized laser light have shown that high energy gain could be reached in powerful Z-pinches combined with sub-nanosecond lasers.

NUCLEAR SAFETY



Regular budget expenditure: $5 293 366

Extrabudgetary programme expenditure (not included in chart): $1 981 447

Programme objective

To promote the achievement and maintenance of required levels of safety performance in nuclear power plants, research reactors and other nuclear installations through: the development of safety documents; assistance in performing safety assessments; the collection and dissemination of information on safe operational practices; and the provision of peer review safety services.

Activities concentrated on supporting intergovernmental efforts to strengthen nuclear safety around the world. The focus was on developing common safety standards, providing a variety of expert services, fostering the exchange of information on safety issues and supporting co-ordinated research in Member States. The development of the Nuclear Safety Standards (NUSS) focused on their review, revision and elaboration in the areas of siting, design and operation of nuclear power plants, and research reactors. Additionally, the standards on governmental organization were revised to make them suitable for the general safety area.

Nuclear power plant safety assessment

Reports were published discussing safety issues for advanced nuclear power plant protection, control and

human–machine interface systems, and proposing a common basis for judgements on the safety of nuclear power plants built to earlier standards. Draft safety performance indicators were developed and are being tested in pilot applications at several nuclear power plants.

A CRP on the collection and classification of human reliability data for use in probabilistic safety assessments (PSAs) was completed. The major results, published as a technical document, included the development and application of methods for data analysis to support the modelling of errors in decision making where so called 'cognitive' errors have been identified as major elements in severe accidents.

With the finalization of the identification and ranking of safety issues for WWER-1000 and early RBMK plants, the Extrabudgetary Programme on the Safety of WWER and RBMK nuclear power plants, launched in 1990, was completed. The Agency database on the findings and recommendations for the various types of reactors (RBMK, WWER-1000, WWER 440/V-213 and WWER 440/V-230) is available on CD-ROM.

A database of generic safety issues for nuclear power plants with LWRs, and the measures taken to resolve them, was created, and also issued as a technical document. This database will enable Member States to learn from the safety decisions made by other countries.

Engineering safety

Expert missions were conducted to advise on protection measures against seismic and other external events at nuclear power plants, other reactors and proposed reactor sites. This included a seismic review of the Mochovce nuclear power plant in Slovakia.

In a General Conference resolution (GC(42)/RES/11), the Agency was requested to act as a clearinghouse and central point of contact for Member States to exchange information on diagnostic and remedial actions being taken at nuclear power plants, fuel cycle and/or medical facilities which use radioactive materials, the aim being to make these facilities Year 2000 compliant. A special project was initiated, and pages were set up on the Agency's Web site *(http://www.iaea.org/ns/nusafe/y2000/y2k.htm)* to collect data from Member States (through an electronic questionnaire) and as a medium for disseminating information.

The draft of a technical document entitled *Achieving Year 2000 Readiness: Basic Processes* was made available on the Internet. This document provides guidance on Y2K programme management, initial assessment (classification and inventory), detailed assessment and contingency planning.

Operational safety

Efforts were made to improve the integration and co-ordination of the various safety services offered by the Agency as a means of enhancing their quality. This was accomplished, in part, by combining services during a mission and further optimizing the selection of staff for assignments which involved Operational Safety Review Team (OSART), Assessment of Safety Significant Events Team (ASSET) and International Regulatory Review Team (IRRT) missions. While many of the missions were supported by resources from the Technical Co-operation Fund, priority was also given to improving co-ordination and communication with international organizations that provide operational safety services. Additionally, activities were supported that recognize the importance of communicating with the public on matters relating to the operational safety of nuclear power plants. An example was the participation of the Agency in a national seminar on public information on the peaceful uses of nuclear energy, which was held in Romania.

Initiatives were taken to evaluate utility peer review processes and other self-assessment activities to gauge their effectiveness in improving operational safety performance, and on how these activities should be incorporated into operational safety services. In this connection, a Technical Committee meeting was held in Vienna in December on national practices for nuclear power plant self-assessment and their effectiveness in enhancing safety performance.

Four OSART missions were carried out, along with three preparatory visits for 1999 missions and five follow-up visits. In order to provide greater assistance to those Member States receiving OSART visits, seminars and technical assistance missions were conducted before and after each visit. For example, seminars on the OSART methodology to support nuclear power

plants in the self-assessment of operational safety performance were carried out in Bulgaria, China, Kazakhstan, Lithuania and Pakistan. Technical assistance missions, both before and after OSART visits, were organized at the request of authorities in Argentina, China and Mexico. The ASSET service included four missions for the review of plant self-assessments of operational events and six seminars covering the evaluation of the consequences and analysis of the causes of operational events.

An ASSET peer review at the Aktau nuclear power plant in Kazakhstan was notable because it immediately preceded an OSART mission to the plant. The conclusions of the plant self-assessment, together with the comments and recommendations of the ASSET peer review, were utilized by the OSART team to study safety performance issues identified earlier at the plant. This was the first time the two services have been co-ordinated in such a way and the results of the combined mission will be studied to determine the future benefits of this approach. The plant self-assessments and ASSET peer review identified the need for lower internal reporting thresholds and broader reporting criteria; the requirement to continue to develop internal operational experience feedback programmes; and the need to enhance organizational safety culture, especially in the commitment to correcting known safety problems. Equipment reliability, procedure adequacy and personnel proficiency were areas of concern highlighted by the self-assessments.

The Joint IAEA–OECD/NEA Incident Reporting System (IRS) Guidelines were issued in May, establishing a unified method of reporting incidents. In 1998, the IRS system received 127 reports from participating countries. Ten of these reports were classified as being of high safety importance, with important lessons to be learned. One group of events, caused by equipment failures, includes problems of erosion–corrosion, stress corrosion cracking, fuel and control rod problems, water hammer phenomenon, faults in electrical systems, design deficiencies and ageing. A large proportion of the events was connected with the management of safety, including human error during operation, problems of compliance with procedures, and control of maintenance work and modifications.

During 1998 the Assessment of Safety Culture in Organizations Team (ASCOT) services were changed to 'Safety Culture Seminars' with a focus on how to: develop and improve safety management and safety culture; assess the developmental stages of an organization; and increase awareness of the importance of learning processes and a learning culture to support these developments. These services were provided for a utility in Lithuania and for the regulator, utilities and support organizations in China. A preparatory meeting was held for utility personnel in Brazil in order to set up a programme for Agency assistance in performing a self-assessment of the utility organization's safety culture, as well as a peer review of the assessment.

A Technical Committee meeting was held on safety culture self-assessment highlights and good practices. In addition to highlighting the fact that self-assessments of safety culture have now been performed in several countries, the meeting also identified early warning signs of a weakening safety culture. In addition, an evaluation was made of the relative merits of different methods of extracting important safety culture attributes. At the request of the Canadian Government, a working group was convened in Vienna in June to review Ontario Hydro's recent performance degradation in comparison with similar situations elsewhere. The experience and the lessons learned regarding the symptoms, causes and correction of the degradation in safety culture and safety management were presented at the international conference on 'Topical Issues in Nuclear, Radiation and Radioactive Waste Safety', held in Vienna in August.

Research reactor safety

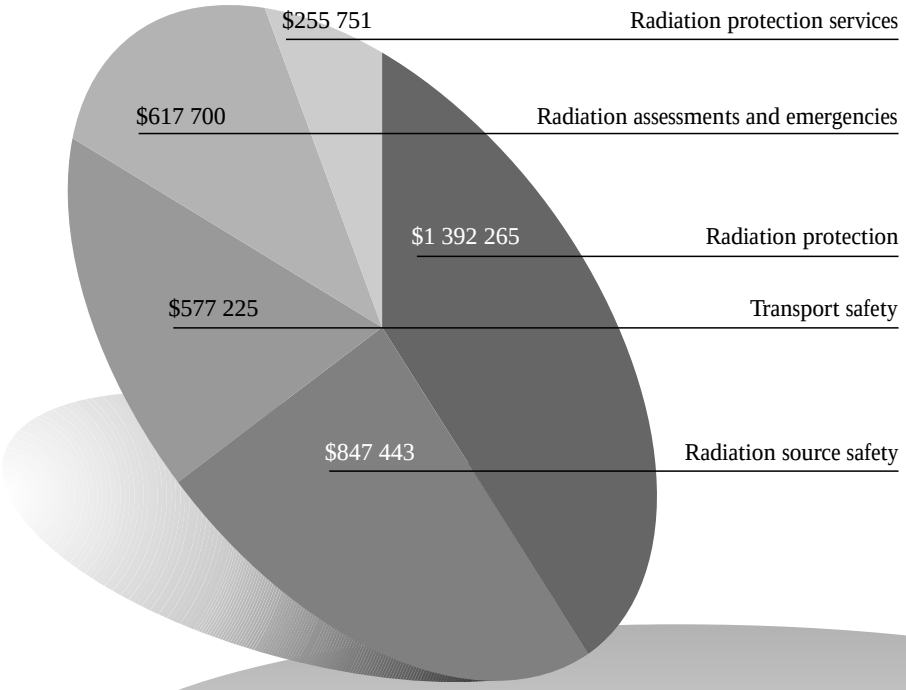
Five more States joined the Incident Reporting System for Research Reactors (IRSRR), raising the total number of participating Member States to 20.

An Integrated Safety Assessment of Research Reactors (INSARR) mission, funded by the Extrabudgetary Project for East Asia and the Pacific, visited the 30 MW research reactor in Serpong, Indonesia, to review operational safety issues. Another mission reviewed the Preliminary Safety Analysis Report for the research reactor to be constructed in Ongkaharak District, Thailand. There were technical co-operation missions to a research reactor in Tajura, Libyan Arab Jamahiriya, to advise on reactor modification issues, and a mission, partially funded by Italy, to the Vinča research reactor in Yugoslavia to advise on the management of the spent fuel storage pool, for which a remedial action plan has been initiated.

The final Research Co-ordination meeting for a CRP on the applications of non-destructive testing and in-service inspection to research reactors was held in Prague. The major outcome was the development of special techniques to examine and monitor the condition of reactor structures, systems and components for their assessment in relation to the safe operation and management of the reactor.

Four Safety Guides on operational limits and conditions, commissioning, maintenance and periodic testing, and design, assessment and operation of spent fuel storage pools were completed. These publications provide guidance on the implementation of requirements for the design and operation, including utilization and modifications, of research reactors.

RADIATION SAFETY



Regular budget expenditure:
$3 690 384

Extrabudgetary programme expenditure
(not included in chart):
$746 426

Programme objective

To promote adequate levels of protection against ionizing radiation and for the safety of radiation sources.

The radiation safety programme has two complementary objectives: development of a unified set of safety standards based on consensus; and provision for the application of these standards in Member States and through other international organizations. In order to achieve these objectives, the programme emphasized a number of areas of work covering the relevant research, the development of requirements level consensus documents and supporting guides, and the preparation of practical manuals and other documents to assist in standards implementation by regulatory authorities. Many of these documents provide the technical underpinning for technical co-operation projects, including the Model Project on strengthening radiation and waste safety infrastructures in over 50 Member States. In addition, considerable effort was devoted to emergency response activities, including servicing the Conventions of Early Notification of a Nuclear Accident and Assistance in the Case of a Nuclear Accident or Radiological Emergency. To support these activities a considerable number of research programmes, training courses, conferences and other information exchange meetings were organized under the technical co-operation programme.

Radiation protection

Three Safety Guides on occupational radiation protection, co-sponsored with ILO, were completed. One provides general guidance on the application of the requirements of the International Basic Safety

Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (BSS), while the other two provide detailed guidance on assessing occupational exposure due to external and internal sources.

The Agency became a joint member of the Secretariat, together with the OECD/NEA, for the Information System on Occupational Exposure (ISOE). This will strengthen its influence and responsibility in the ISOE. The Agency also acts as the technical centre which co-ordinates data gathering for utilities and regulatory authorities in non-OECD/NEA Member States with nuclear power plants.

Within the framework of the technical co-operation Model Project on upgrading radiation protection infrastructures, a regional seminar on approaches and practices in strengthening radiation protection and waste management infrastructures in countries of Eastern Europe and the former Soviet Union was held in Bratislava, Slovakia. The seminar confirmed that the Agency's Model Project has played an important role in establishing and strengthening national infrastructures for radiation and waste safety. The setting up of peer reviews was recommended to assess the effectiveness of infrastructures in the participating countries.

The Regulatory Authority Information System (RAIS), a personal computer based application for the management of the data needed by a regulatory authority, such as record systems for radiation sources and doses, was completed and made available to Member States involved in the Model Project.

In a European regional technical co-operation project on improving occupational radiation protection at nuclear power plants, three meetings for health physicists were held at which data and experiences were exchanged. Decreases in collective dose at nuclear power plants were reported, and improvements were noted in the implementation of the principle of optimization of protection.

Radiation source safety

An international conference entitled 'The Safety of Radiation Sources and Security of Radioactive Materials' was held in Dijon, France. An important recommendation from the meeting was that radiation sources should not be allowed to drop out of the regulatory control system. This means that the regulatory authority must keep up-to-date records of those responsible for each source, monitor transfers of the sources and track their fate at the end of their useful life. Efforts should also be made to find radiation sources that are not in the regulatory authority's inventory ('orphan sources') because they were in the country before the inventory was established, were never specifically licensed, or were lost, abandoned or stolen. Another conclusion was that because there are many orphan sources throughout the world, efforts to improve the detection of radioactive materials crossing national borders and moving within countries should be intensified by carrying out radiation measurements and through intelligence gathering. Optimum detection techniques need to be developed, and confusion could be avoided if an international agreement was achieved on quantitative levels that would trigger investigations, for example, at border crossings. The conclusions of the conference led to Resolution GC(42)/RES/12 of the Agency's General Conference that encouraged all governments "to take steps to ensure the existence within their territories of effective national systems of control for ensuring the safety of radiation sources and the security of radioactive materials."

Work continued on the elaboration of guidance relating to the safety of radiation sources and sources of potential exposure, and the prevention, detection and response to illicit trafficking in radioactive materials. In addition, several reports were published on accidents in: San José, Costa Rica; Tammiku, Estonia; and Tomsk, the Russian Federation. These reports identify a number of lessons that may help Member States in preventing similar events. For example, in the report of the accidental overexposure of radiotherapy patients in San José, the main causes were insufficent education and training and lack of a quality assurance programme. According to the report on the radiological accident in Tammiku, the existence of orphan sources, together with insufficient security of a waste repository, were the most important factors contributing to the accident.

Transport safety

Progress was made in assisting international organizations in their adoption of transportation safety requirements for radioactive material as set forth by the

Agency. The transportation safety regulations of the International Civil Aviation Organization, International Maritime Organization and the United Nations Economic and Social Council Committee of Experts on the Transport of Dangerous Goods are being revised to implement requirements for radioactive material based on the 1996 edition of the *Regulations for the Safe Transport of Radioactive Material* (the Transport Regulations), with a planned uniform date for entry into force of 1 January 2001.

On the basis of recommendations from the Transport Safety Standards Advisory Committee (TRANSSAC), a modified process for revising the Transport Regulations was instituted. This process will support a more frequent publication cycle designed to ease adoption by international organizations and Member States.

As requested by the General Conference, a report was prepared on legally binding and non-binding instruments and regulations for radioactive material transport safety and the interactions between them. It was submitted to the Board of Governors in June and made available to the General Conference in September.

As part of an interregional technical co-operation project, a simplified version of the Agency's Transport Regulations was prepared to facilitate implementation in Member States and for use in training activities. At a course on transport safety, organized for competent authorities in Eastern Europe in Braunschweig, Germany, the syllabus, modules and training manual for transport safety training courses to support Member States with and without nuclear power programmes were developed.

Radiation assessments and emergencies

The development of one consolidated document of general safety requirements on emergency preparedness and response, and transport was initiated and is being co-sponsored by the Agency, FAO, OECD/NEA and WHO. A safety report on planning the medical response to radiological accidents, co-sponsored by the Agency and WHO, was published. A document on response procedures for radiological emergencies and another on monitoring procedures for nuclear and radiological emergencies were prepared. These reports feature step-by-step procedures which can be used immediately and can also be easily adapted to suit the needs of a specific country.

The Agency began an audit of its own emergency response system for fulfilling its obligations under the Convention on Early Notification of a Nuclear Accident and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency. The Agency participated in the OECD/NEA INEX-2 international emergency exercise, which was held in Paks, Hungary. European Commission forms for notification of an accident have been harmonized with the Agency's forms.

A key outcome of a European regional technical co-operation project on harmonization of emergency preparedness was the signing of a Memorandum of Understanding between 22 States and 7 observer States to co-ordinate their emergency response procedures. In particular, the project addresses the classification of emergencies, integrated planning concepts, notification procedures, protective action recommendations and monitoring and public information procedures. In addition, a Russian language version of *InterRAS* (a computer code for assessing the implications of nuclear accidents) was developed, audits of emergency preparedness in the project countries were completed, and an accident classification scheme for RBMK reactors was developed. The preliminary results of the audit show a wide range of capabilities and preparedness.

Major training exercises were carried out in Europe on medical preparedness, in East Asia on radiological emergency response teams and in Africa on emergency preparedness and response. For example, a technical co-operation workshop was held in China to exercise the capabilities of six emergency response teams from the East Asia region to respond to a range of radiological accidents.

Radiation protection services

Radiation safety services were provided to the staff of the Agency's Laboratories at Seibersdorf, near Vienna, and at IAEA–MEL. Up to 400 Agency staff and 200 field experts were monitored for radiation exposure.

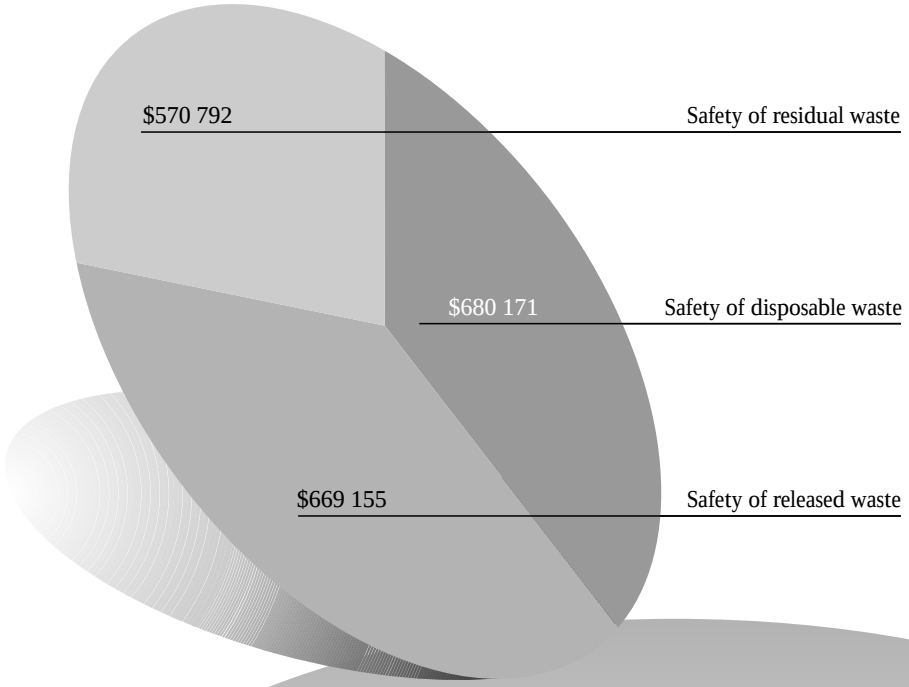
In order to promote the proper use of operational quantities, the Agency organized three dosimetry intercomparison exercises: a regional intercomparison of

personal dosimetry and two intercalibration exercises for the individual monitoring of external and internal exposure. The results of the exercises were incorporated into two documents completed at the end of the year, one on intercomparisons for the individual monitoring of external exposure from photon radiation and the other on intercomparison of biokinetic model validation of radionuclide intake assessment.

Technical support using resources from the Technical Co-operation Fund was provided to safety missions in response to requests for emergency assistance in Georgia, where radioactive sources were discovered at a training centre. The assistance given to the Government of Georgia took the form of expertise and equipment for the radiological investigation of the territory.

Arrangements are now in place with specialized laboratories in Cuba, France and the United Kingdom for the medical treatment of overexposed persons. These arrangements are required because of the difficulties encountered in finding an appropriate laboratory capable of carrying out chromosomal aberration counting at short notice.

RADIOACTIVE WASTE SAFETY



Regular budget expenditure:
$1 920 118

Extrabudgetary programme expenditure
(not included in chart):
$134 814

Programme objective

To promote the safe management of the non-usable radioactive remains from nuclear energy and other practices making use of radioactive materials, including: the safe management of radioactive waste; the control of environmental releases of radioactive materials into the environment; and the safe restoration of environments having radioactive residues from past events and activities.

The programme on waste safety is focused on the establishment of a comprehensive set of internationally agreed safety standards with the active involvement of Member States and under the supervision of an international advisory committee. A Safety Requirements document on the near surface disposal of radioactive waste was recommended for approval by the Agency's Board of Governors. An international conference on topical issues in nuclear, radiation and radioactive waste safety, held in Vienna, provided guidance for the future direction of work on radioactive waste disposal safety and residual waste safety.

Safety of disposable waste

Following the recommendations of a 1997 specialists meeting on the application of the concepts of exclusion, exemption and clearance, work focused on establishing agreed terminology and a common understanding of the terms and of their application in delineating the scope of regulations concerned with protection from ionizing radiation. A draft Safety Guide on this subject was developed and reviewed at a Technical Committee meeting in Vienna.

Progress was made on several documents in the Radioactive Waste Safety Standards (RADWASS) programme. Of particular note was the endorsement by the Advisory Commission for Safety Standards (ACSS) of a Safety Requirements document on the near surface disposal of radioactive wastes. A supporting Safety Guide on the assessment of near surface disposal facilities, and two other Safety Guides on the decommissioning of different types of facilities, were also approved for publication.

The Agency is encouraging research through a CRP on methods for assessing the safety of near surface disposal facilities. A general methodology for assessment is being developed which will be applied in the evaluation of test cases concerned with trench and vault disposal facilities typical of those used in the Russian Federation, Eastern Europe, Western Europe and North America, and to the 'borehole' types of repository operated and planned in various countries. In this connection, expert reviews of the safety of near surface repositories in South Africa and the Republic of Moldova were conducted. For the trench and vault disposal facilities, the review confirmed that an incident involving leaking waste containers at the disposal site was not of radiological significance. For the borehole types of repository, the experts gave advice to help ensure the safety of a histone repository which does not comply fully with current design standards.

Safety of released waste

Increasing attention is being given to the environment and to its well-being in international and regional agreements and conventions. The Agency is striving to harmonize the approach taken for protecting the environment against the effects of ionizing radiation with that commonly adopted for protection against other pollutants. A paper which addresses the principles and the technical issues involved was finalized at a Technical Committee meeting before being circulated to Member States. Its purpose is to stimulate discussion so that steps can be taken towards developing an international standard in this area.

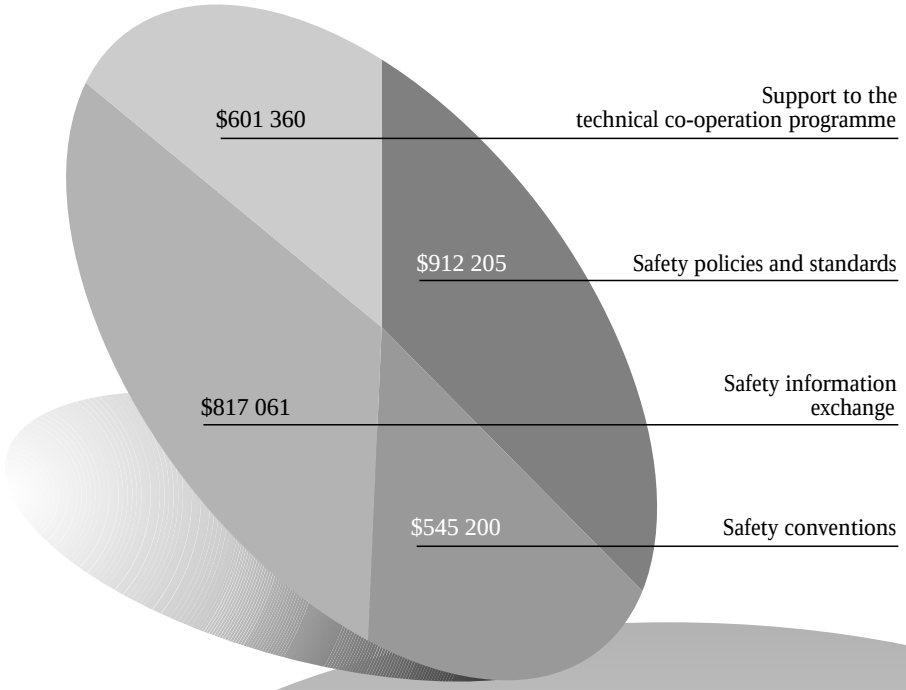
In order to establish databases recording all types of controlled radioactive releases and disposals into the atmosphere and the oceans, an Agency technical document (IAEA-TECDOC-588) on solid radioactive disposals to the marine environment was updated, and a prototype database of discharges of gaseous and liquid materials into the environment was developed. At the request of the Convention on the Prevention of Marine Pollution by Dumping of Waste and Other Matter (London Convention, 1972), the Agency provided advice on the types of materials containing radionuclides which can be exempted from the requirements of the convention. The report containing the advice was presented at the 20th meeting of Contracting Parties to the Convention.

Safety of residual waste

The current programme of assessments of the radiological conditions at sites where there are residues from previous nuclear activities, such as nuclear weapons testing and waste dumping, was completed with the publication of four documents in the Radiological Assessment Reports Series. These cover the radiological situations at: Bikini Atoll, Marshall Islands; Mururoa and Fangataufa Atolls in French Polynesia; Semipalatinsk, Kazahkstan; and in the Kara Sea following high level waste dumping. In the case of Bikini Atoll and Semipalatinsk, consideration had to be given to the prospects for resettlement by populations in the affected areas. For this purpose, guidance on radiological principles and criteria for guiding decisions on the cleanup and reoccupation of contaminated areas was developed and published as IAEA-TECDOC-987. In addition, a special international conference was held to disseminate the results of the study of the radiological situation at the Mururoa and Fangataufa Atolls, and participants in the study visited the South Pacific to present the results to the people of that region.

Safety Guides on the decommissioning of nuclear power plants and of medical, industrial and research facilities where radioactive materials are being used were approved for publication as part of the RADWASS programme. These documents provide Member States with comprehensive guidance on the steps and considerations necessary to ensure safety in the various stages of decommissioning, leading to final release of the facility and the site from regulatory control.

CO-ORDINATION OF SAFETY ACTIVITIES



Regular budget expenditure: $2 875 826

Extrabudgetary programme expenditure (not included in chart): $309 721

Programme objective

To ensure technical consistency and co-ordination of the activities carried out by the Agency in performing the safety related functions, either laid down in its Statue or entrusted by the parties of international conventions, as well as coherence with the corresponding safety activities carried out by Member States and other international organizations, through interaction with the topical programmes of nuclear safety, radiation safety and radioactive waste safety.

The safety activities co-ordination programme aims to ensure that there is technical consistency between the Agency's nuclear, radiation and radioactive waste safety activities. This involves work in four main areas: co-ordinating the development and review process for the Agency's safety standards; administering and, where appropriate, implementing the safety related conventions; supporting research and development; promoting safety related information exchange; and co-ordinating the technical input to safety related projects in the Agency's technical co-operation programme.

Safety policies and standards

The focus of work was on the development of guidance on legal and governmental infrastructures for the safety of nuclear facilities. Drafts of four Safety Guides on staffing and organization, review and assessment, inspection and enforcement, and the required documentation for the authorization process of nuclear facilities were prepared for review by the standing advisory committees on safety standards. A glossary covering terms from nuclear, radiation, radioactive waste and transport safety was compiled to harmonize

the terminology used in all Agency publications dealing with these areas. Under the Peer Discussions on Regulatory Practices (PDRP) scheme, three meetings were held on the regulation of the life-cycle management of nuclear installations. The purpose was to assist Member States in the formulation and enhancement of policies, principles, requirements and regulatory control over plant life-cycle management by identifying commonly accepted good practices. A report summarizing the discussions is being prepared.

Demand for the International Regulatory Review Teams (IRRT) service continued to increase. Missions to Romania, Slovakia, Switzerland and Ukraine were carried out, with the waiting list now covering more than two years. A significant development was that whereas previous IRRT missions had been mainly to the States of Central and Eastern Europe and the former Soviet Union, requests were received for the first time from States outside of these areas (e.g. Switzerland). Another development was the expansion of the scope of the missions to include regulations for radiation and waste safety.

A European regional technical co-operation project on nuclear safety regulatory infrastructures focused on: RBMK pipework cracking; IRRT, International Peer Review Service (IPERS) and seismic safety missions; and Year 2000 computer system problems. The project made a significant contribution to the ability of the participating nuclear regulatory bodies in the region to carry out their assigned regulatory functions in accordance with Agency standards and internationally recognized good practices.

Safety conventions

Two informal meetings of signatories and other interested States were held in preparation for the first review meeting of the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management. Draft guidelines for the review process, for the preparation of national reports, and the drafting of financial and procedural rules have been developed as a result of these meetings. By the end of 1998, 49 States had ratified the Convention.

Following the Preparatory Meeting of Contracting Parties to the Convention on Nuclear Safety in 1997, an organizational meeting and several briefing meetings were held to prepare for the first Review Meeting of Contracting Parties in 1999. For the first time, national reports provided by the Contracting Parties for the Review Meeting were collected and distributed. By the end of 1998, 49 States had become Contracting Parties to the Convention on Nuclear Safety.

Four States became Contracting Parties to the Convention on Early Notification of a Nuclear Accident, bringing the total to 82 (79 States and 3 international organizations) at the end of 1998. Although the Convention was not invoked during 1998, the infrastructure designed for notification of nuclear accidents was used to disseminate information to Member States on less significant events, notably the release of caesium-137 from a steel mill in Algeciras, Spain, in May.

Three States became Contracting Parties to the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, bringing the total to 77 (74 States and 3 international organizations) at the end of 1998. In this connection, assistance was provided in response to radiological emergency situations in Bangladesh, Georgia and the Russian Federation.

Safety information exchange

A conference was held in Vienna on topical issues in nuclear, radiation and radioactive waste safety, with the objective of consolidating an international consensus on the present status of the issues, the priorities for future work and the need for strengthening international co-operation. Though many technical aspects were discussed and various recommendations made, attention was also paid to the 'softer' aspects of safety. For example, there was great interest in the effectiveness of safety management and the role of safety culture, transparency in decision making and the criteria used, and the effectiveness of the regulator.

A handbook on communication in the areas of nuclear, radiation, transport and waste safety, designed for regulatory authorities, was prepared to promote a consistent approach in communications with the public, media and decision makers. The handbook explains the role of regulators in nuclear safety communication, the major public concerns in each area of activity based on frequently raised issues and the key messages to be communicated. It also provides

guidance on how to develop and implement a programme on communication.

The nuclear safety information centre provides information on nuclear, radiation and radioactive waste safety. To date the centre has over 6000 acquisitions in the form of publications, journals and books. The centre was re-organized and the database for registering documents was upgraded in 1998. In addition, a Web site for the Advanced Nuclear Safety Information Registry (ANSIR) *(http://www.161.5.37.17/ansir)* was established offering desktop computer access to the database and other information products. Stored internal and external full text documents are searchable by electronic means.

The International Nuclear Event Scale (INES) service disseminated information on 19 events. In addition to the reporting activities of the information programme, INES official documents (i.e. the information leaflet and user's manual) were refined. Training in the use of the rating procedures was also conducted at the request of Hungary and Egypt.

Support to the technical co-operation programme

Two components of the integrated stategy for assisting Member States in establishing and strengthening their nuclear safety infrastructures were implemented. First, questionnaires were sent on nuclear safety infrastructure, derived from the Agency's safety requirements on legal and governmental frameworks, siting, design, operation and quality assurance. Second, nuclear safety profiles covering legislative, regulatory and operational nuclear safety activities were prepared for 23 Member States either receiving Agency assistance and having nuclear power plants in operation or embarking on nuclear power programmes.

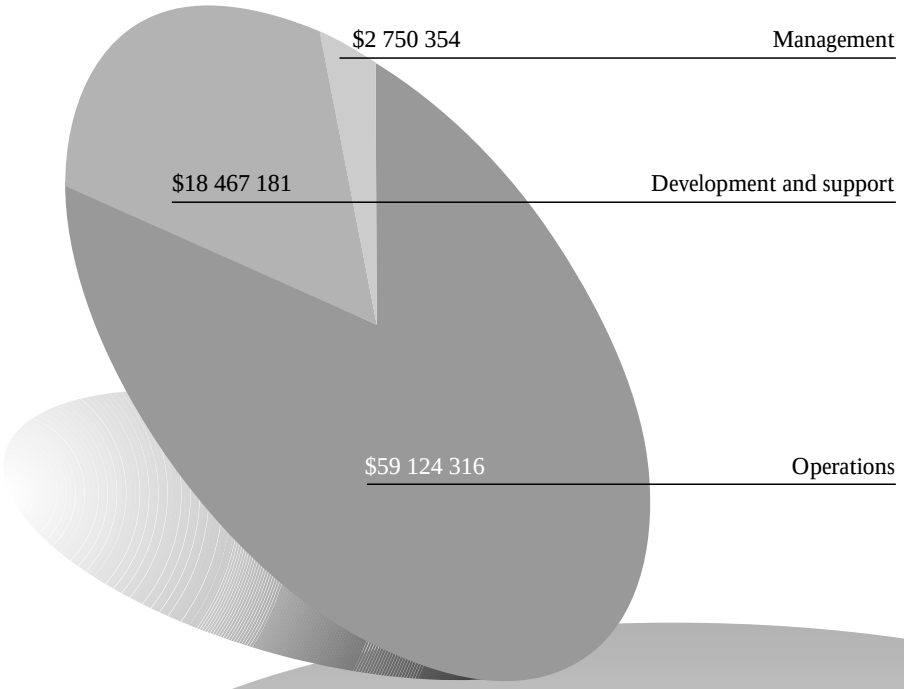
Similar work was initiated on safety profiles for radiation and waste safety. Questionnaires on infrastructure for radiation protection, safety of sources, waste safety and transport safety were updated in accordance with the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (BSS).

Extensive technical support was devoted to the Model Project on upgrading radiation protection infrastructures to prepare and fine tune the technical documents and tools required for the prompt and harmonized implementation of the project. Major activities included the preparation of a document, *Organization and Implementation of a National Infrastructure Governing Protection against Ionizing Radiation and the Safety of Radiation Sources.* Distributed and in use in the more than 50 Member States receiving assistance under the Model Project, this document, in addition to offering guidance on how to establish, optimize and sustain a regulatory framework, included model legislation and regulations based upon the BSS as well as other model regulations covering radioactive waste management and radioactive transport safety. In order to reach the widest possible audience, these regulatory models were also translated into Arabic, French, Russian and Spanish.

Another activity connected with the Model Project was the preparation of a technical document describing the methods and review plans to facilitate the authorization and inspection of radiation sources, including information on how to prepare and conduct an inspection and follow-up actions. The document includes specific checklists for the principal common practices involving the use of radiation sources to assist regulatory authorities in reviewing safety in the process of authorization and inspection.

A software inventory, monitoring and control tool, the Regulatory Authority Information System (RAIS), was developed and is being used by more than 35 Member States. The system is composed of five modules covering: inventory of radiation sources and installations; the authorization process; inspection and enforcement; dosimetry of occupationally exposed personnel; and performance indicators for individual installations as well as for the overall regulatory programme. The system will also be available in Arabic, French, Russian and Spanish.

SAFEGUARDS



Regular budget expenditure:
$80 341 851

Extrabudgetary programme expenditure
(not included in chart):
$18 214 813

Note:
An amount of $2 658 801 for implementation of UN Security Council Resolution 687 on Iraq is included in the extrabudgetary figure.

Programme objective

To verify whether States are complying with their safeguards agreements with the Agency and thereby to deter the diversion of nuclear material or the misuse of facilities, equipment or non-nuclear material subject to Agency safeguards.

During 1998, the main emphasis of the programme was on the implementation of safeguards agreements and on the continued development and implementation of measures to strengthen safeguards.

Protocols Additional to Safeguards Agreements had at the end of the year been approved by the Board of Governors for 38 States and, when implemented, will enable the Agency to provide increased assurance about the absence of undeclared nuclear material and activities. Five Protocols had entered into force with Australia, the Holy See, Jordan, New Zealand and Uzbekistan by the end of 1998. Implementation of the first Additional Protocol to enter into force, with Australia, began in 1998. In addition, preparations for the entry into force of the Additional Protocols were undertaken with a number of States: an implementation trial, including preparation, submission and evaluation of a declaration and complementary access, was conducted at a large R&D site in Japan; work started on assembling and computerizing all available information on nuclear activities in States; and discussions on possible implementation trials in the non-nuclear-weapon States of the European Union were initiated with EURATOM.

Note: The *Safeguards Statement for 1998* will be included in the final version of this document.

Model Subsidiary Arrangements and statements in connection with the implementation of the Additional Protocols were developed. The current model statements were modified to provide States with information about environmental sampling activities undertaken by the Agency.

The Remote Monitoring Project concluded its work, and steps have been taken to begin implementation of remote monitoring techniques in 1999. In addition, the Agency selected the new generation of digital surveillance systems. An implementation plan was developed and a target was set for the installation of 80 systems per year.

The transuranic elements, in particular neptunium and americium, if available in sufficient quantities in separated form, could be used for nuclear explosive devices. Recognizing this, the Secretariat prepared a report for consideration by the Board of Governors in November regarding the proliferation potential of these elements and outlining options for addressing this issue. The Board requested the Secretariat to provide further information on the legal, technical and financial implications of its recommendations and on possible additional options which might be considered.

As of 31 December 1998, 222 safeguards agreements were in force with 138 States (and with Taiwan, China). At the end of 1998, safeguards agreements which satisfy the requirements of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) were in force with 126 States. NPT safeguards agreements entered into force with Ukraine in January, Namibia in April and San Marino in September. The Board of Governors approved draft NPT safeguards agreements with Azerbaijan, Kyrgyzstan (both of which have been signed) and Slovakia. These agreements had not entered into force at the end of the year.

NPT safeguards agreements are in force with seven of the nine States party to the Treaty in the South East Asia Nuclear Weapon Free Zone (Treaty of Bangkok) and with all 11 signatories of the South Pacific Nuclear Free Zone Treaty (Rarotonga Treaty). Thirty-one of the 32 States Contracting Parties to the Treaty for the Prohibition of Nuclear Weapons in Latin America and the Caribbean (Treaty of Tlatelolco) have safeguards agreements in force which satisfy the requirements of this Treaty. Safeguards agreements pursuant to Additional Protocol I of the Treaty of Tlatelolco are in force with the Netherlands and the USA, two of the four States outside Latin America which have jurisdiction over territories in the zone of application of the Treaty. The Board of Governors approved a safeguards agreement with France pursuant to Additional Protocol I of the Treaty. The Treaty of Pelindaba, which has not yet entered into force, also foresees the application of Agency safeguards in the States party to the Treaty.

Operations

Work continued on implementing strengthened safeguards. Of particular note were the following:

- The implementation of the Additional Protocol with Australia, which began during 1998, included a review of the expanded declaration and complementary access visits.
- A new information system was introduced to process declarations under the Additional Protocol. The first declaration, from Australia, was successfully processed.
- Environmental swipe samples from collections at 6 enrichment plants and 27 facilities with hot cells were sent to the Agency's Network of Analytical Laboratories (NWAL) for analysis.
- Evaluations of information related to nuclear programmes of States were completed and reviewed for several countries. Further evaluations are under way.

Following discussion with States, new safeguards equipment and techniques were introduced in a number of facilities. For example:

- Short notice random inspections (SNRIs) were implemented at a low enriched uranium (LEU) fabrication facility in Japan. This was the first such routine implementation by the Agency, permitting full verification of the flow of nuclear material without additional interim inspections. Preparations for field testing of a similar safeguards approach based on SNRIs were initiated for another low enriched fuel fabrication plant in Spain. This regime is also part of the new approach being developed to confirm the absence of unrecorded plutonium production at large research reactors.
- Two unattended waste measurement systems, a vitrified waste canister counter and a hull measurement and monitoring system, were installed at a reprocessing plant in Japan; the acceptance test of the vitrified waste canister counter was completed.

VERIFICATION ACTIVITIES

	1996	1997	1998
Inspections performed	2 476	2 499	2 507
Person-days of inspection	10 831	10 240	10 060
Seals applied to nuclear material or safeguards equipment, detached and subsequently verified (including seals applied jointly with EURATOM)	27 029	24 943	26 824
Optical surveillance films reviewed	2 173	1 500	932
Video tapes reviewed	4 045	4 010	4 884
Nuclear material samples analysed	937	888	645
Nuclear material analytical results reported	2 299	2 150	1 610
Environmental samples analysed	278	585	497
Environmental sample results reported	4 200	7400	4 000
Nuclear material under safeguards (in tonnes)			
Separated plutonium outside reactor core	53.6	57.6	62.5
Plutonium contained in irradiated fuel	533	571	600
High enriched uranium	20.7	20.5	21.4
Low enriched uranium	48 620	49 282	49 483
Source material	105 395	108 648	90 622

- For enrichment plants in Japan, significant progress was made to resolve the longstanding issues of sample taking for destructive analysis and the provision of operator data necessary for the intermittent assessment of the material balance. An inspection regime for confirming that nuclear material has not been borrowed was agreed upon.
- Agreement was reached with the operator of a Japanese mixed oxide (MOX) fuel fabrication facility and the State's system of accounting and control (SSAC) on a five year programme aimed at reducing the inventory of heterogeneous scrap material. The material will be gradually homogenized to allow enhanced verification, including destructive analysis.
- Unattended safeguards equipment was installed in hot cells in the Republic of Korea in order to monitor experimental powder and pellet characterization studies which are to be carried out under a joint project between Canada, the Republic of Korea, the USA and the Agency on the direct use of irradiated plutonium in CANDU reactors.
- A six month field trial of the continuous enrichment monitor was completed at an enrichment plant in the Netherlands. The equipment performed reliably throughout the trial, the system produced no false alarms and the results confirmed that no production of high enriched uranium (HEU) had occurred during the period. The system was demonstrated to be a viable means of confirming the absence of HEU production.
- In co-operation with EURATOM, an inspection regime based on the use of unattended, non-destructive analysis equipment in conjunction with multiple surveillance systems and the use of dual containment/surveillance (C/S) measures was introduced at a MOX fuel fabrication plant in Belgium. This regime makes full use of the 'New Partnership Approach' arrangements already in place. The new approach is expected to result in a significant reduction in the presence of Agency inspectors at the facility without reducing the effectiveness of verification activities.
- Unattended verification of inter-bay spent fuel transfers in a CANDU multi-unit plant in Canada was introduced. The use of this system resulted in saving a considerable amount of inspection effort.
- Procedures were tested at enrichment plants in Brazil for unannounced inspections to be carried out by ABACC or Agency inspectors.
- Procedures for the joint use of instruments were agreed between ABACC and the Agency. Such procedures were also proposed to the Republic of Korea and, if implemented, are expected to further strengthen the SSAC and the efficiency of safeguards.

Major efforts were made in the newly independent States of the former Soviet Union:

- After the entry into force of the NPT safeguards agreement between the Agency and Ukraine in January, initial inventory verifications were carried out at all facilities in Ukraine, account being taken of the results obtained under the earlier comprehensive safeguards agreement. An extensive repackaging campaign at a facility for HEU and LEU materials ended in July, at the same time as the verification campaign. This marked the conclusion of a two year effort by the Agency, donor States and the Ukraine to characterize, package and store the materials in such a way that they could be suitably verified. The initial inventory verification was completed in September, and the verification results are being analysed.
- Following the decision of Kazakhstan to start the conditioning of fuel from the BN-350 fast breeder reactor for verification purposes, three meetings were held between Kazakhstan, the USA and the Agency to resolve technical issues and to discuss arrangements for the measurement and fuel canning campaign. The Agency introduced an advanced non-destructive technique, developed jointly with the USA, for underwater spent fuel measurements.

Activities carried out in nuclear weapon States included the following:

- Inspections at an enrichment plant in China commenced in early 1998. Work on the development of the safeguards approach continued and progress towards its completion is expected in 1999.
- Following the decision by the USA in 1993 to submit to Agency safeguards nuclear material removed from nuclear weapon programmes, the Agency continued inspections of HEU and plutonium.
- Safeguards verification activities in the USA in connection with the down-blending of a quantity of HEU, which the USA stated it acquired from Kazakhstan, were completed at one facility. The evaluation report was completed in early 1998 and transmitted to the State authorities.
- The Agency undertook a verification experiment at an enrichment plant in the USA in relation to the down-blending of a quantity of HEU with a view to developing a suitable verification approach for such down-blending activities. The experiment was completed in October. The Agency observed the down-blending of the HEU to LEU; the feasibility of a new verification concept was demonstrated and innovative verification techniques were tested.

Further progress was made in the negotiation of Subsidiary Arrangements: two new General Parts of Subsidiary Arrangements, as well as 28 new or revised Facility Attachments, entered into force.

An international seminar on safeguards information reporting and processing was held at the end of the year. Discussions focused on: new developments in nuclear material accounting, including the Year 2000 problem; reporting under the Additional Protocol; and the illicit trafficking database programme. The Agency also informed Member States of the new reporting options offered with respect to the accounting correction principle and the electronic transmission of data, and presented the tools it is planning to use and make available to Member States for reporting under the Additional Protocols.

Progress in information retrieval and analysis included the development of a complete set of 'topic trees' for all steps of the fuel cycle. Topic trees are advanced search tools which embed expert knowledge, permitting the efficient retrieval of documents. In addition, 'Pathfinder', a software tool offering sophisticated functions to support information analysis, was deployed; it is available to users in support of State evaluations.

In the area of equipment management, field tests of a new CANDU bundle counter were completed and authorized for inspection use. Thirteen of these systems were either installed in new applications or replaced old systems. Related core discharge and yes/no monitor systems are undergoing field tests in Canada and the Republic of Korea.

Following the development and evaluation of a number of multichannel analysers early in 1998, two were selected for the replacement of ageing portable multichannel analyser (PMCA) systems. About 40 of these systems were acquired in 1998, and the withdrawal from service of the existing PMCAs began.

The Safeguards Analytical Laboratory (SAL) and NWAL analysed 645 samples of nuclear materials and heavy water, leading to the reporting of 1586 results for the verification of operators' material accountancy. Thirty-five nuclear material samples were taken and analysed for confirming other safeguards relevant

information. SAL received and screened over 400 environmental samples. Procedures were set up to examine particles from hot cell swipes by electron microscopy.

SAL continued to support the Agency's Action Team on Iraq by producing 400 sampling kits for inspections and environmental baseline sampling. SAL and NWAL analysed 207 samples taken in Iraq by the Action Team pursuant to United Nations Security Council Resolution 687.

The development and implementation of a safeguards approach for the Rokkasho fuel reprocessing plant in Japan continued. Instrumentation was installed in the spent fuel receipt and storage area. Commissioning will be completed upon receipt of spent fuel at the facility.

The Agency is still unable to verify the correctness and completeness of the initial declaration of the Democratic People's Republic of Korea (DPRK) concerning its nuclear material subject to safeguards under its NPT safeguards agreement with the Agency, and accordingly cannot conclude that there has been no diversion of nuclear material. The DPRK remains in non-compliance with its safeguards agreement.

The Agency maintained a continuous presence of inspectors in the Nyongbyon area throughout 1998. It has done so on the basis of a decision of the Board of Governors, following a request of the United Nations Security Council for the purpose of monitoring the freeze on the DPRK's graphite moderated reactors and related facilities.

Three rounds of technical discussions took place between a technical team from the Agency and the DPRK without progress on any of the key issues outstanding regarding the DPRK's compliance with its safeguards agreement. These include the preservation of information which must remain available to enable the Agency to verify, in the future, the correctness and completeness of the DPRK's initial declaration.

Development and support

The Remote Monitoring Project, established in 1996 to prepare safeguards policy, approaches and procedures, specify equipment, conduct field tests and develop an implementation scheme for remote monitoring, completed its work in December. The results included the following:

- The safeguards approach for LWRs where remote monitoring will be used was finalized in November. The approaches for other individual facility types, such as CANDU reactors and storage facilities containing unirradiated direct use material, are under way.
- Remote monitoring equipment was selected, installed and tested in a number of facilities.
- Argentina, Canada, Finland, Germany, Japan, the Republic of Korea, South Africa, Sweden, Switzerland and the USA participated in feasibility studies and field trials which were carried out to test the implementation of remote monitoring via satellite and terrestrial communication links.
- The equipment for the initial phase of routine implementation of remote monitoring was specified and procurement initiated for gradual introduction starting in 1999.

Field testing of a new generation of digital surveillance systems was completed in June. On the basis of the test results, technical characteristics, cost and supplier evaluation, the VDIS system with its three different configurations was selected as the digital surveillance system to be implemented. In addition, EMOSS, in its new configuration, was selected as the alternative system to avoid reliance on a single system and supplier.

New cadmium telluride detectors with improved resolution, combined with new evaluation software, were developed to permit simplified verification measurements of spent fuel. Development work continues to increase the volume of cadmium telluride detectors, making them as sensitive as sodium iodide detectors.

Work continued on ensuring that the computer systems for Agency safeguards are Year 2000 compliant. This has involved major changes to the mainframe information systems. The schedule for completion is March 1999, leaving sufficient time for thorough testing of the systems.

The security of the safeguards network and communications infrastructure was reviewed. As a result, stricter local area network access control from user workstations was implemented and a security incidents response procedure defined.

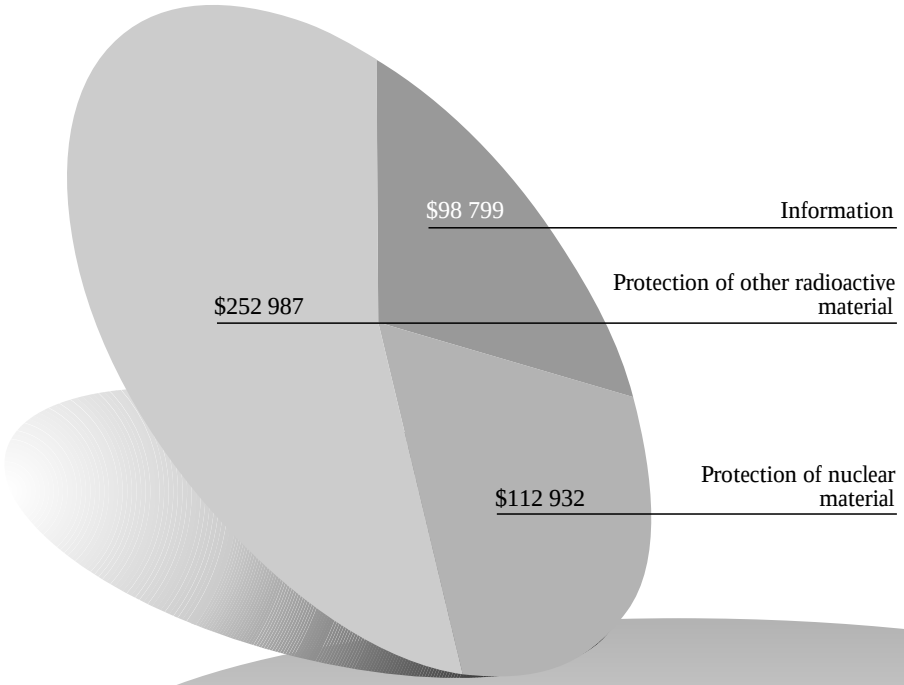
The Safeguards Research and Development and Implementation Support Programme for 1999–2000

was completed and submitted to Member States with safeguards support programmes. The programme provides a framework for safeguards R&D activities conducted both by the Agency and in Member States on the development and application of the elements of a strengthened safeguards system and the gradual transition to an integrated safeguards system.

Environmental sample collection continued, new sampling tools were tested and implemented, and the development of a central database was largely completed. The services of consultants from NWAL were used to prepare a series of recommendations related to techniques for the screening and analysis of swipe samples, to the quality control programme and to the overall operation of the network services concerning procedures and arrangements for environmental sampling and analysis.

The safeguards training curriculum was improved. In addition to regular training courses for inspectors, staff training focused on the implementation of the strengthened safeguards system and, in particular, on the taking of environmental samples, the nuclear fuel cycle and proliferation indicators, enhanced observational skills, design information review at research reactors and evaluation of the nuclear activities of States.

SECURITY OF MATERIAL



Regular budget expenditure:
$464 718

Extrabudgetary programme expenditure
(not included in chart):
$1 025 160

Programme objective

To help ensure the exclusively peaceful and safe use of radioactive material and prevent illicit trafficking in nuclear material and other radioactive sources.

During 1998, the programme on the security of material continued to focus on activities aimed at assisting Member States to establish the systems necessary to prevent nuclear material and other radioactive sources from being used for unauthorized purposes, and to detect and respond to trafficking cases, should they occur. A programme of assistance was established to facilitate the exchange of information and continue the training of staff in State regulatory authorities, facilities and customs services. Joint training efforts with WCO took place. International standards for the physical protection of nuclear material were strengthened. In regular meetings with State representatives and international organizations, joint activities were established for further co-operation. Selected equipment was tested within a project with the Austrian and Hungarian authorities to evaluate equipment for border controls.

Information

Currently, 60 States participate in the Agency's Illicit Trafficking Database Programme. Out of 33 trafficking incidents which were added to the database as having occurred during the year, 9 involved nuclear material. As of 31 December 1998, the database contained information on 304 incidents, 237 of which have been confirmed by States. In April, the Agency convened a meeting of experts to review the database programme. The review resulted in an improved reporting document, revised terms of reference and agreed rules for maintaining the confidentiality of the information reported. Recommendations were also made for additional information to be included in the database. In addition, the experts suggested the development of a simple scale to convey the significance of incidents to the public. The Agency initiated an upgrade of the database software.

Protection of nuclear material

A review of INFCIRC/225/Rev.3, 'The Physical Protection of Nuclear Material', was carried out. The document was revised to incorporate strengthened requirements for physical protection during transport and to protect against sabotage at nuclear facilities.

The sixth International Physical Protection Advisory Service (IPPAS) mission was conducted. Arrangements were made through the Agency's technical co-operation programme to provide limited physical protection equipment to urgently upgrade the security at a research reactor. Earlier IPPAS missions had, in some cases, resulted in recommendations for modifications of physical protection systems. Such modifications were made through bilateral support.

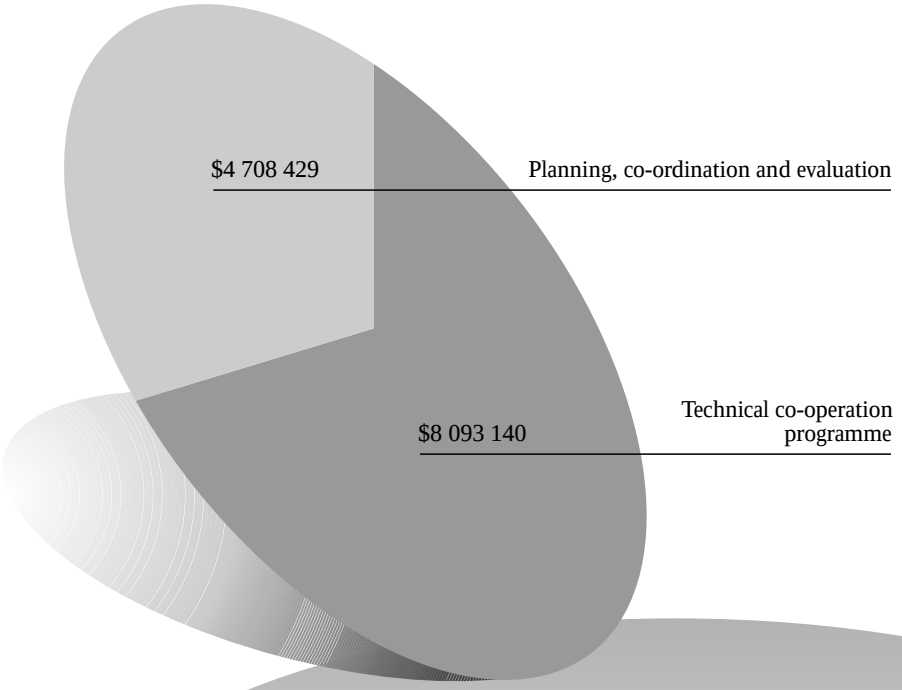
The third annual review meeting of the Co-ordinated Technical Support Programme to the newly independent States of the former Soviet Union was held in Vienna in February. Through this programme, bilateral support to these States is co-ordinated and duplication of efforts avoided. The States requested assistance in establishing a methodology for performing self-assessments of their SSAC, and more focused training and evaluation of their State control systems. As a follow-up, two workshops were arranged. One, held in Vienna on nuclear export/import controls targeting the southern tier newly independent States, helped participants assess the strength of their current systems and prioritize specific needs for assistance in nuclear legislation, licensing, and customs and border controls related to nuclear material. The second workshop, held in Belarus on familiarization with Agency safeguards activities and non-destructive analysis measurement techniques, was a first attempt at using a local nuclear facility and equipment provided by a donor State in implementing the 'train the trainer' concept.

Protection of other radioactive material

A draft Safety Guide on preventing, detecting and responding to illicit trafficking in radioactive materials was completed and submitted to the Advisory Commission on Safety Standards for approval. This Guide will be supported by five technical manuals containing detailed information on the radioactive materials likely to be seized, prevention by enhancing national legal infrastructures, detection at borders, response measures and training programmes. In order to derive practical performance requirements for border monitoring instrumentation, a pilot study was initiated involving equipment from 21 manufacturers from 15 countries. The study includes laboratory testing at the Austrian Research Centre at Seibersdorf and field testing at the Austrian/Hungarian border and Vienna airport for one year. The study is financed by the Austrian Government and is being carried out in co-operation with the Austrian Research Centre Seibersdorf, the US Customs Service and Los Alamos National Laboratory. Similarly, a peer review mission in Malta was conducted to assist in the implementation of a national programme for border monitoring.

An international conference on the safety of radiation sources and the security of radioactive materials, co-sponsored by the European Commission, INTERPOL and WCO, was held in Dijon. Hosted by the French Government and the French Atomic Energy Commission, it was the first conference devoted to this subject. The conference results highlighted the need for effective national systems of control for ensuring the safety of radiation sources and the security of radioactive materials, and provided the basis for a resolution of the General Conference (GC(42)/RES/12) on these issues that was adopted in September.

MANAGEMENT OF TECHNICAL CO-OPERATION FOR DEVELOPMENT



Regular budget expenditure:
$12 801 569

Extrabudgetary programme expenditure
(not included in chart):
$328 270

Programme objective

To accelerate and enlarge the contribution of atomic energy to peace, health and prosperity in Member States by facilitating their access to the peaceful uses of nuclear energy, the transfer of nuclear technology, the application and utilization of nuclear energy for peaceful purposes in Member States and the promotion of co-operation between them for that purpose.

This was the first year that the Agency planned and delivered its technical co-operation programme in the light of a newly approved 'Strategy for Technical Co-operation', with the focus on strengthening synergy on a variety of different levels. A major change was a reduction in the number of subprogrammes from three to two, i.e. 'Technical Co-operation Programme' and 'Planning, Co-ordination and Evaluation', and redeployment of staff into a structure that reflects the key principles of the strategy. Key outcomes in the management of technical co-operation included the following:

- Finalization and approval of a new style programme for the 1999–2000 biennium. More than $133 million of core programming plus $51 million of 'footnote a/' projects were designed, discussed with the counterparts and later approved, including 59 new Model Projects.

- Increased synergy with international development organizations through Thematic Planning. A total of five Thematic Plans were completed during the year.
- Increased co-operation with counterpart organizations and other national institutions through regionally based meetings to discuss priority setting and design of Country Programme Frameworks (CPFs).
- Increased synergy between Member States through greater use of existing national technical and scientific capacity and a more substantive role for more advanced national institutions.
- Improved programme design and accountability through joint evaluations and reviews undertaken with the technical Departments.
- A healthy financial situation at year end despite a severe financial shortfall for the technical co-operation programme at the start of the year and uncertainty in pledges during the year.
- A more streamlined management structure without any loss of performance through better integration of programming and implementation within the two operational Divisions.

Technical co-operation programme

The CPF process seeks to focus national programmes on a few well defined areas with the potential for significant impact. The process has strengthened institutional arrangements and fostered greater collaboration between national counterpart organizations and other national authorities. The process of integrating CPFs with Thematic Plans began during the year in the areas of groundwater management using isotope techniques and tissue banking using radiation sterilization. These planning processes are contributing to a more demand-led rather than supply-driven programme of technical co-operation.

To complement the CPF process, efforts were also made to improve the design of projects. Training courses and workshops for national liaison officers, national counterparts, project managers and technical staff helped strengthen their programme management capabilities by reinforcing their understanding of new project design standards and allowing them to gain practical experience in programme planning and partnership development.

The Agency expanded its programme in water resources management in Africa to include groundwater assessments in eastern and southern Africa in view of the acute water shortages afflicting several Member States, and the success and experience gained in North Africa under a Model Project. Consultations with Member States, the private sector, donors, United Nations sister organizations, and national water authorities led to the establishment of regional partnerships for two activities. The first focuses on the development and management of groundwater resources in fractured hard rock aquifers. The second investigates alluvial aquifer systems, where the issues of salinization, surface and groundwater interactions and resource management are of great importance. Discussions in December with the World Bank/UNDP/UNEP Global Environmental Facility (GEF) identified complementary activities, with a new GEF project to develop a sustainable development plan for the Okavango River Basin in southern Africa.

In the East Asia and Pacific region, the UNDP/RCA/IAEA project deals with five subprojects: access to clean drinking water; management of the marine coastal environment and pollution; air pollution and trends; electronic networking and outreach; and clean and energy efficient production processes. In electronic networking and outreach, agreements were reached on information management between programme partners and another UNDP funded project, the Asia Pacific Development Information Programme (APDIP), which is concerned with establishing an information technology capability in certain countries of the region. APDIP agreed to provide server capabilities for an RCA home page linked to national home pages, on-line technical catalogues, radiation protection distance learning courses and emergency preparedness. In addition, APDIP will conduct training courses for RCA members on information technology using their facilities and course materials. As a result, the Agency will only have to cover the costs of stipends and travel for participants.

Formulation of the Regional Programme in Europe followed a process of joint prioritization with recipient institutions, donors and outside organizations. One step in the process was the development of an 'Integrated Strategy for Assisting Member States in Establishing and Strengthening their Nuclear Safety Infrastructure'. This led to a high level of confidence from the donor community, which provided extrabudgetary support of $2.8 million. Model legislation was also developed to provide a legal framework for

Member States seeking to meet the International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources (BSS). In this regard, the Agency is currently assisting 14 Member States in Europe with legal and regulatory questions with the aid of this legal reference and check-lists.

The Agency's partnership with counterpart organizations in Latin America was strengthened with the convening of a Working Group on Technical Co-operation, National Strategy and the Country Programme Framework, in Buenos Aires, Argentina. National strategies, private sector and commercial interests, planning mechanisms, implementation modalities and institutional arrangements were examined. The importance of the CPF process at the preparatory stage of programme development was recognized, but it was also acknowledged that in some countries priority areas for technical co-operation are already sufficiently evident or well established and that a detailed CPF process may not be required. Among the important recommendations of the Working Group was a call for greater coherence and synergy among national, regional and regional agreement (ARCAL) projects. The Group drafted criteria to help guide countries in deciding the most appropriate modality to meet their requirements.

Member States in Latin America and the Caribbean were assisted in elevating the ARCAL programme from an agreement between institutions to the level of a Government Agreement. The necessary consultations and related documents were completed by August and approved during the meeting of the Board of Governors in September. So far, 12 Member States from the region have signed the Agreement.

In West Asia the regional programme was formulated to include the more direct involvement of Member States and relevant regional organizations. Efforts were made to improve management of sterile insect technique (SIT) related projects for the control/eradication of the Mediterranean fruit fly (medfly) in a subregion consisting of territories in Israel, Jordan and the Palestinian Authority. The Agency held a meeting in Vienna in October at which the possibility of carrying out the projects in a co-ordinated manner, for increasing the efficiency of programme delivery and promoting co-operation between the counterparts was discussed. These deliberations led to a joint communiqué expressing the common intent of all three parties to co-operate in the control of the medfly within the scope of Agency projects.

Planning, co-ordination and evaluation

Thematic Planning has the goal of improving synergy between the Agency and outside organizations, and between Member State institutions. Five Thematic Plans were completed, covering: neonatal screening for childhood diseases; child nutrition investigations; tissue banking; groundwater management; and screwworm eradication.

The Agency used the project selection criteria that resulted from the Thematic Plans as a basis for its evaluation of project proposals for the 1999–2000 project cycle. They also led to the redesign of two CRPs, one on isotope aided studies of nutritional factors associated with chronic and degenerative diseases during ageing and the other on the development and validation of isotopic and complementary tools for the nutritional assessment of household food security in developing country populations.

The Thematic Plan for SIT eradication of the New and Old World Screwworm resulted in the identification of new research priorities and partnership roles. These include: strain development, genetic sexing and molecular biology in co-ordination with the United States Department of Agriculture and the Commonwealth Scientific and Industrial Research Organization in Australia.

A serious shortfall in expected resources for the Technical Co-operation Fund led to an unexpected overprogramming level of almost 25% at the start of the 1998 approved programme. While this exceeded the limit on overprogramming established by the Board, it was agreed to allow the overprogramming rate to "float" for the first half of 1998 in order to permit the Secretariat to reassess the programme, employ strict financial controls and appeal to Member States for support. In response to appeals, several Member States pledged new funds and many increased payments to cover arrears for assessed programme costs, although not all promises of funding were converted into actual pledges by the end of 1998. As a result, the programme ended the year with modest overprogramming of less than 7%.

One management priority realized during the year was improving information exchange and the work planning environment. The intranet application designated TC-PRIDE (Project Information Dissemination Environment) became operational. Designed to

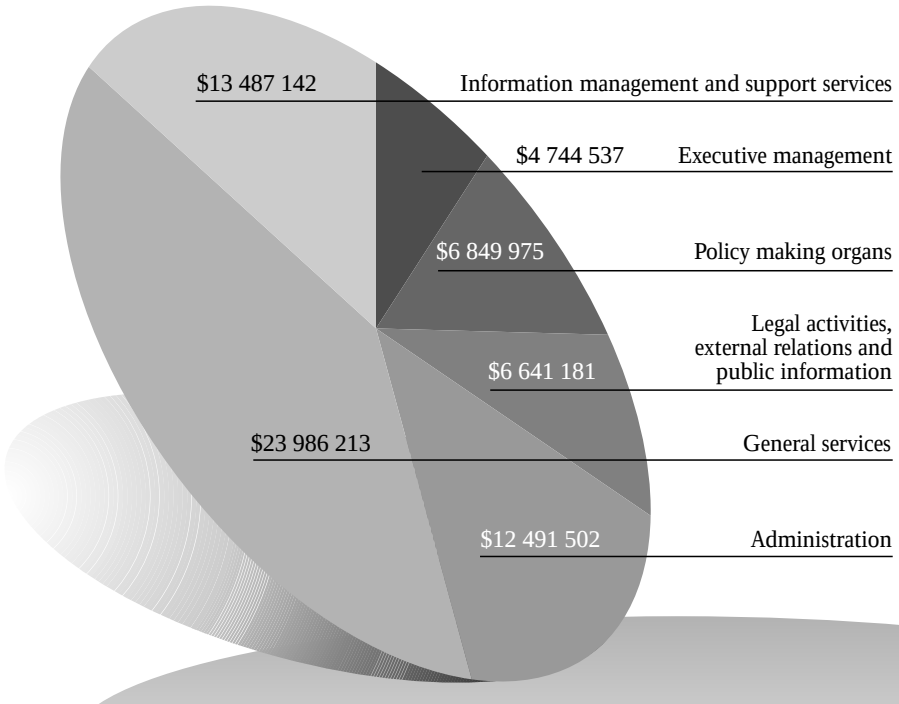
improve information exchange and work planning, TC-PRIDE provides comprehensive data on all current technical co-operation projects, including those just approved in the 1999–2000 programme. It is interactive with all of the major databases used in the Agency's technical co-operation programme and therefore requires no special updates of its own. One source of these data is the new contact information system, which provides an authority file for all personnel and institutes, along with the corresponding addresses. This system facilitates the fostering of contacts and information exchange with all institutes and personnel dealing with projects. It has proven particularly valuable for interregional and regional projects which often involve a large number of national contact points.

Efforts to standardize the procurement of project equipment items resulted in standing offers with global suppliers covering 54 items. A comparison of the standing prices against the average prices prevailing prior to the introduction of standing offers indicates a total saving of $1 million, up from $600 000 in savings achieved in 1997. Additional economies of 36 to 84% were realized in administrative time and effort for typical procurement actions. While savings for these selected items may not increase indefinitely, the results achieved from the exercise demonstrate the value of standardized procurement, which will be extended to other procurement items.

Efforts to ensure quality management of procurement activities included a survey of major suppliers to the Agency's technical co-operation programme of computer equipment, nuclear instrumentation, radiation therapy and analytical and laboratory equipment in order to prepare for possible Year 2000 (Y2K) problems.

In order to manage procurement more efficiently and improve the Agency's database of service providers, a registration form was sent to 77 institutions/companies around the world. The information was used to expand the scope and process of comparative assessment for procurement.

POLICY MAKING, CO-ORDINATION AND SUPPORT



Regular budget expenditure: $68 200 550

Extrabudgetary programme expenditure (not included in chart): $1 896 932

Programme objective

To provide policy guidance and legal advice, co-ordination and administrative support.

Legal activities

Actions to expand and refine the processes of legislative assistance in support of Member States seeking to establish a comprehensive, harmonized and up-to-date system of nuclear legislation were continued. The basis for institutionalizing this assistance was established, including measures designed to enhance the co-ordination of all Agency programmes that have nuclear legislative or regulatory related components.

Three main types of activities for the provision of legislative assistance by the Agency have been developed:

- Design and provision of training in nuclear law, through seminars and workshops and individual training of persons from Member States involved in drafting nuclear legislation;
- Advice on specific nuclear national legislation;
- Development of reference material for the assessment of national nuclear regulatory regimes and for the drafting of nuclear legislation.

Advice on specific national legislation was provided to Belarus, Croatia, Lithuania, The Former Yugoslav Republic of Macedonia, and Ukraine, and preparations were made for legislative assistance to be given to countries of the East Asia and Pacific region.

Public information

A brochure outlining the conclusions of the report by the International Advisory Committee on the radiological situation at the atolls of Mururoa and Fangataufa was issued, as was another marking the opening of the

new premises for the Marine Environment Laboratory in Monaco. The quarterly publication *Meetings on Atomic Energy* was adapted to enable more efficient hard copy distribution and electronic on-line access. Video production for television outlets included features on biofertilizer use in Zimbabwe and the safe transport of radioactive material.

National or regional public information seminars were held in Bolivia, Costa Rica, Romania, Slovakia, Thailand and Tunisia. Additionally, a pilot workshop was held in Vienna for professional communicators from nuclear power plants and regulatory bodies in Eastern and Central Europe.

Financial management

For 1998, the General Conference appropriated an amount of $221.4 million for the Agency's Regular Budget on the basis of an exchange rate of 12.70 Austrian Schillings to one United States dollar, of which $216.5 million was related to Agency programmes. The latter amount was adjusted to $221 million to account for the average United Nations exchange rate (12.40 Austrian Schillings to one US dollar) actually experienced during the year.

The Regular Budget for 1998, at an exchange rate of 12.40 Austrian Schillings to one US dollar, amounted to $226 million, of which $216 million was to be financed from contributions by Member States on the basis of the 1998 scale of assessment, $5 million from income from reimbursable work for others and $4.7 million from other miscellaneous income.

The actual expenditures for the Agency's Regular Budget in 1998 amounted to $225.4 million, of which $219.8 million was related to the Agency's programmes. The unused budget from the Agency's programmes amounted to $1.2 million, while the total unused budget was $0.6 million when account was taken of reimbursable work for others.

The target for voluntary contributions to the Technical Co-operation Fund for 1998 was established at $71.5 million, of which $53.4 million was pledged by Member States.

A total of $28.2 million in extrabudgetary funds was provided by Member States, the United Nations, other international organizations and other sources during 1998. Of this amount, $14.6 million was in support of safeguards, $2.8 million for food and agriculture, $2.2 million for nuclear safety and $2.6 million for implementation of United Nations Security Council Resolution 687 on Iraq. An amount of $1.9 million (supplemented by the Agency's contribution of $3.1 million) was in support of IAEA-MEL. The remaining $4.1 million was in support of various other projects implemented by the Agency.

A total of $2.4 million was administered on behalf of research institutions and $2.3 million for the International Thermonuclear Experimental Reactor.

Personnel management

At a 'Senior Management Conference', held in January, the Director General, the heads of Departments and Division Directors reviewed the internal management process and identified a number of issues that needed to be addressed, including personnel policies and practices. In line with the recommendations made, a comprehensive policy and framework for staff training was adopted with the objective of enhancing managerial effectiveness and improving individual performance. Development commenced of a management training curriculum aimed at fostering good management practices within a common framework of policies, procedures and terminology throughout the Agency.

Personnel policies were promulgated on a number of subjects, including the use of cost-free experts and consultants, retirement age, re-employment of retirees, delegations of authority and performance management. Internal disciplinary procedures were revised following an earlier judgement by the ILO Administrative Tribunal, which had identified flaws in the existing procedures.

In the light of a judgement rendered by the ILO Administrative Tribunal, the practice of requiring government sponsorship for the appointment of Professional staff in posts subject to geographical distribution was discontinued.

Computer services

An Office of Information Management was established. The objective of this office is to streamline the planning,

creation, processing, flow and dissemination of information in order to harmonize activities and ensure consistent and efficient presentation to information users within and outside the Agency. In this connection, a pilot project was initiated to add a multilingual, full text search facility to documents of the Board of Governors on *GovAtom*, the restricted Web site of the Board. Standard document designs were also improved, and an information management course was held as part of the Agency's management training activities.

In addition to software development support for specific Agency programmes, the first phase in the establishment of a Contacts Information System was completed with the implementation of the part dealing with institutions and personnel involved in technical co-operation projects. The second phase — migration and modernization of the Agency's Mailing List System — is under way.

Installation of Microsoft Office 95 as the standard software throughout the Agency was completed. A training course accompanied this product roll-out, with approximately 800 staff being trained in the use of Microsoft Word. A security audit was completed, with approximately half of the identified vulnerabilities being resolved. Technical enhancements in the security area included: the installation of virus protection software on user workstations and the mail servers; Windows NT password reform; introduction of e-mail and document encryption (used almost exclusively in the Department of Safeguards); and implementation of Virtual Private Networking (VPN) standards. Procedures for performing risk assessments of individual in-house desktop personal computers were established. The Agency's Liaison Office in New York will be the first to use VPN technology to obtain secure remote access to the Agency local area network in Vienna.

Library services

A Joint Management Consultative Committee on the VIC Library Services was established by the Agency in co-operation with UNIDO, the United Nations Office at Vienna/Office for Drug Control and Crime Prevention and the CTBTO to ensure co-ordination at the senior management level of the provision of library services and to provide advice and recommendations to help ensure that the services are in harmony with the strategies and objectives of the organizations in the Vienna International Centre.

The VIC Library's home page — VICLNET — provided 17 subscribed electronic journals, 128 free Internet journals and 3 general electronic information services to the staff.

A journal subscription review was undertaken to analyse journal needs against programme requirements. The content and value of journals were assessed, resulting in savings that could be used for funding the acquisition of new information materials and services required to support the changing needs of programmes.

After a two year study investigating options for a new generation of integrated library systems, a new software system was licensed for the Library. This system makes possible further integration of Internet information resources with the Library's collections. It will also help to improve the efficiency and effectiveness of all library operations. A project to migrate to the new system was initiated.

Publishing services

The journal *Nuclear Fusion* was made available in both printed and Internet versions *(http://epub.iaea.org/fusion)*. For the electronic version the original text is coded using the LaTeX mark-up language. The desired final products are then generated from this text, that is versions for printing and for the Internet.

A study on electronic publishing throughout the Agency was initiated to review this area of rapidly expanding importance.

In 1998, 155 books, reports, journal issues and booklets were published in English. In addition, there were 2 publications in Arabic, 3 in French, 4 in Spanish and 13 in Russian. Of particular note were:

- *Accidental Overexposure of Radiotheraphy Patients in San José, Costa Rica;*
- *Choosing the Nuclear Power Option: Factors to be Considered;*
- *Goiânia: Ten Years Later;*
- *Low Doses of Ionizing Radiation: Biological Effects and Regulatory Control;*
- *Nuclear Fuel Cycle and Reactor Strategies: Adjusting to New Realities;*
- *Physical Protection of Nuclear Materials: Experience in Regulation, Implementation and Operations;*

- *Radiological Conditions at Bikini Atoll: Prospects for Resettlement;*
- *Radiological Conditions at the Semipalatinsk Test Site, Kazakhstan: Preliminary Assessment and Recommendations for Further Study;*
- *Radiological Conditions of the Western Kara Sea: Assessment of the Radiological Impact of the Dumping of Radioactive Waste in the Arctic Seas;*
- *Safe Handling and Storage of Plutonium;*
- *The Radiological Accident at Tammiku;*
- *The Radiological Accident in the Reprocessing Plant at Tomsk;*
- *The Radiological Situation at the Atolls of Mururoa and Fangataufa* (nine volumes).

International Nuclear Information System

Senegal, the United Arab Emirates, the CTBTO and the World Council of Nuclear Workers were among the Member States and organizations that joined INIS in 1998. The current number of participating members is 103 countries and 19 international organizations.

The INIS Database contained 2 083 952 records of conventional and non-conventional literature (NCL) at the end of 1998 (67 857 records were added during the year). Beginning in October, the database was made accessible for the first time from a new Internet based on-line retrieval system. At the end of 1998, there were 157 free registered users and 426 users with paid subscriptions to the service, for a total of nearly 600 users.

The INIS Clearinghouse imaging process reached the one million page milestone (over 15 000 documents) in December. During the year, 6673 NCL documents were imaged for a total of 448 170 pages scanned. Scans from a further 3130 documents were also sent by Member States for an overall total of 9803 documents in 1998. In addition, 36 CD-ROMs were produced during the year, bringing the total to 81 since imaging began. The production of NCL continues on microfiche for archival purposes.

The 26th Annual Consultative meeting of INIS Liaison Officers was held in June. Recommendations were made on: pricing and access policy for the INIS Database on the Internet; document delivery mechanisms for NCL; a distance education strategy; and the development of a new INIS record format. The fourth Joint INIS/ETDE Technical Committee meeting was held in October. A significant outcome of this meeting was the redesign of the INIS/ETDE record format to simplify and reduce the cost of input preparation.

THE BOARD OF GOVERNORS AND THE GENERAL CONFERENCE

The application of Benin for membership of the Agency was approved by the General Conference on the recommendation of the Board of Governors.

The Informal Working Group on the Restoration of Voting Rights, established by the Board in 1997, completed its task. Consequently, the General Conference adopted criteria and guidelines for the consideration of future requests for the restoration of voting rights, as well as procedural rules and practices related to early notification to Member States in arrears. At the request of the General Conference, the Board subsequently agreed on further measures to facilitate the payment of contributions by Member States in arrears.

The Informal Working Group on the Financing of Technical Assistance, established by the Board in 1997, completed its work and its recommendations were approved by the Board.

The Chairperson of the Joint Consultative Group on IAEA/CTBTO Co-operation submitted her report. The Board encouraged the Secretariat and the Provisional Technical Secretariat of the CTBTO to continue their co-operation according to their respective mandates.

The General Conference referred all issues relating to Article VI back to the Board for further consideration and urged the Board to redouble its efforts to achieve a solution to this long standing issue and to report to the Conference, at its 43rd regular session, on a finalized formula, taking into account the progress achieved so far.

The General Conference decided to confer upon Palestine, in its capacity as observer, additional rights and privileges of participation in the work of the Agency, as set out in the Annex to the Resolution adopted by the Conference.

Following the endorsement of the Board, the General Conference approved the recommendations made by the Secretariat on streamlining the working practices of the General Conference.

ANNEX

SUMMARY OF ALLOCATION AND UTILIZATION OF REGULAR BUDGET RESOURCES IN 1998

Major Programme/Programme	1998 budget GC(41)/10 (at AS 12.70)	1998 adjusted budget (at AS 12.40)	1998 total expenditure		Unused (over-expended) budget
			Amount	% of adjusted budget (3)/(2)	(2)–(3)
	(1)	(2)	(3)	(4)	(5)
NUCLEAR POWER AND FUEL CYCLE					
Nuclear power	4 613 000	4 699 000	4 709 287	100.22%	(10 287)
Nuclear fuel cycle and waste technology	5 100 000	5 190 000	5 024 206	96.81%	165 794
Comparative assessment of energy sources	2 526 000	2 571 000	2 529 130	98.37%	41 870
Subtotal	12 239 000	12 460 000	12 262 623	98.42%	197 377
NUCLEAR APPLICATIONS					
Food and agriculture	10 495 000	10 677 000	10 527 534	98.60%	149 466
Human health	5 805 000	5 899 000	5 821 803	98.69%	77 197
Marine environment, water resources and industry	6 507 000	6 626 000	6 654 068	100.42%	(28 068)
Physical and chemical sciences	8 740 000	8 866 000	8 950 254	100.95%	(84 254)
Subtotal	31 547 000	32 068 000	31 953 659	99.64%	114 341
NUCLEAR, RADIATION AND WASTE SAFETY					
Nuclear safety	5 506 000	5 617 000	5 293 366	94.24%	323 634
Radiation safety	3 464 000	3 534 000	3 690 384	104.43%	(156 384)
Radioactive waste safety	1 870 000	1 908 000	1 920 118	100.64%	(12 118)
Co-ordination of safety activities	2 902 000	2 963 000	2 875 826	97.06%	87 174
Subtotal	13 742 000	14 022 000	13 779 694	98.27%	242 306
NUCLEAR VERIFICATION AND SECURITY OF MATERIAL					
Safeguards	78 585 000	80 254 000	80 341 851	100.11%	(87 851)
Security of material	542 000	553 000	464 718	84.04%	88 282
Subtotal	79 127 000	80 807 000	80 806 569	100.00%	431
MANAGEMENT OF TECHNICAL CO-OPERATION FOR DEVELOPMENT					
Management of technical co-operation for development	12 526 000	12 806 000	12 801 569	99.97%	4 431
Subtotal	12 526 000	12 806 000	12 801 569	99.97%	4 431
POLICY MAKING, CO-ORDINATION AND SUPPORT					
Executive management	4 886 000	4 992 000	4 744 537	95.04%	247 463
Policy making organs	6 926 000	7 078 000	6 849 975	96.78%	228 025
Legal activities, external relations and public information	7 153 000	7 301 000	6 641 181	90.96%	659 819
Administration	12 364 000	12 643 000	12 491 502	98.80%	151 498
General services	22 340 000	22 865 000	23 986 213	104.90%	(1 121 213)
Information management and support services	13 624 000	13 921 000	13 487 142	96.88%	433 858
Subtotal	67 293 000	68 800 000	68 200 550	99.13%	599 450
Agency's Programmes	216 474 000	220 963 000	219 804 664	99.48%	1 158 336
Plus: reimbursable work for others	4 896 000	5 004 000	5 546 725	110.85%	(542 725)
TOTAL regular budget	221 370 000	225 967 000	225 351 389	99.73%	615 611

EXTRABUDGETARY PROGRAMME FUND 1998 (RESOURCES AND EXPENDITURES)

Programme	Resources			Total Expenditure	Unused balance as at 31 December 1998
	Unused balance as at 1 January 1998	Receipts	Adjusted Budget		
	(1)	(2)	(1)+(2) (3)	(4)	(3)–(4) (5)
Projects funded by individual Member States					
Nuclear power	288 036	66 467	354 503	120 956	233 547
Nuclear fuel cycle and waste technology	220 134	494 901	715 035	425 188	289 847
Comparative assessment of energy sources	138 430	210 000	348 430	212 327	136 103
Food and agriculture	1 239 346	832 452	2 071 798	1 342 376	729 422
Human health	308 893	120 213	429 106	121 893	307 213
Marine environment, water resources and industry	1 501 520	1 177 234	2 678 754	1 526 931	1 151 823
Physical and chemical sciences	100 490	9 349	109 839	82 841	26 998
Nuclear safety	1 057 463	2 019 172	3 076 635	1 467 037	1 609 598
Radiation safety	614 611	217 216	831 827	746 426	85 401
Radioactive waste safety	188 024	0	188 024	134 814	53 210
Co-ordination of safety activities	292 413	198 459	490 872	309 721	181 151
Safeguards	10 881 620	14 619 779	25 501 399	15 556 012	9 945 387
Security of material	1 078 863	371 079	1 449 942	1 025 160	424 782
Management of technical co-operation for development	285 735	204 670	490 405	328 270	162 135
Executive management	492 198	726 900	1 219 098	661 862	557 236
Legal activities, external relations and public information	628 382	957 504	1 585 886	962 293	623 593
Administration	111 371	48 000	159 371	121 151	38 220
Subtotal	19 427 529	22 273 395	41 700 924	25 145 258	16 555 666
Multi-funded projects					
Nuclear power	80 407	29 121	109 528	3 600	105 928
Nuclear fuel cycle and waste technology	10 075	85 697	95 772	70 057	25 715
Food and agriculture	127 907	160 252	288 159	120 283	167 876
Nuclear safety	412 227	203 441	615 668	514 410	101 258
Co-ordination of safety activities	0	54 299	54 299	0	54 299
Subtotal	630 616	532 810	1 163 426	708 350	455 076
International organizations					
Food and agriculture	190 839	1 850 114	2 040 953	1 817 853	223 100
Marine environment, water resources and industry	79 218	766 968	846 186	443 663	402 523
Executive management	138 322	1 885 000	2 023 322	1 996 939	26 383
Subtotal	408 379	4 502 082	4 910 461	4 258 455	652 006
Agency's programmes	20 466 524	27 308 287	47 774 811	30 112 063	17 662 748
FAO: AGRIS	0	867 656	867 656	813 488	54 168
Total Extrabudgetary Programme Fund	20 466 524	28 175 943	48 642 467	30 925 551	17 716 916

TECHNICAL CO-OPERATION DISBURSEMENTS BY AGENCY PROGRAMME/MAJOR PROGRAMME AND REGION IN 1998 *(in thousands of dollars)*

	Africa	Latin America	East Asia and Pacific	West Asia	Europe	Inter-regional	Total
Nuclear power	123.20	430.00	700.10	288.80	1 883.30	329.80	3 755.20
Nuclear fuel cycle and waste technology	379.20	228.50	457.00	2 162.20	1 069.60	391.70	4 688.20
Comparative assessment of energy sources	13.40	26.60	212.30	4.80	150.70	—	407.80
Food and agriculture	4 692.70	2 292.30	1 556.40	1 032.40	446.60	410.40	10 430.80
Human health	3 204.20	4 613.00	1 862.70	1 367.50	2 258.20	225.20	13 530.80
Marine environment, water resources and industry	1 559.30	1 075.30	1 026.90	454.50	2 822.90	60.90	6 999.80
Physical and chemical sciences	2 673.40	1 109.00	656.70	1 308.70	1 369.60	208.60	7 326.00
Nuclear safety	215.50	204.60	885.30	122.40	1 527.40	331.00	3 286.20
Radiation safety	1 423.20	1 397.90	972.30	891.10	2 474.00	1 101.30	8 259.80
Radioactive waste safety	132.30	162.10	21.50	34.00	580.40	81.60	1 011.90
Co-ordination of safety activities	405.40	14.50	95.50	73.70	589.80	54.80	1 233.70
Safeguards	—	18.60	—	—	—	—	18.60
Security of material	7.60	—	—	—	—	—	7.60
Management of technical co-operation for development	371.80	674.60	656.90	169.30	273.70	1 115.00	3 261.30
Policy making, co-ordination and support	9.00	3.80	2.60	19.50	216.10	52.00	303.00
	15 210.20	12 250.80	9 106.20	7 928.90	15 662.30	4 362.30	64 520.70

ASSESSMENT OF SAFETY SIGNIFICANT EVENTS TEAM (ASSET) SERVICES, 1998

Type	Country	Location/ nuclear power plant
S_A	Hungary	Paks
S	Ukraine	Chernobyl
S_A	Egypt	Cairo
S	Lithuania	Ignalina
S	United Kingdom	Hartlepool
S	Ukraine	South Ukraine
Z	Ukraine	Chernobyl
Z	Finland	Olkiluoto
Z	Romania	Cernavoda
Z	Kazakhstan	Aktau

S: ASSET seminar to present guidance for plant self-assessment.
S_A: ASSET seminar on analysis of the root causes of events.
Z: Peer review of self-assessment of plant operational events.

ENGINEERING SAFETY REVIEW SERVICES (ESRS) RELATED TO SITE AND EXTERNAL HAZARDS, 1998

Country	Site/plant	Service
Pakistan	Kanupp	SI
China	Lianyungang	SI
Russian Federation		EEPSA
Slovenia	Krško	EEPSA
Australia	Lucas Heights	S
Islamic Republic of Iran	Bushehr	SI–W
Indonesia	Muria	S
Armenia	Medzamor	SC–F
Romania	Cernavoda	S

EEPSA: External Events PSA Review/workshop.
S: Review of site investigations for all disciplines involved.
SC–F: Follow-up mission of previous reviews of seismic capacity and upgrades of systems, structures and components.
SI: Review of investigations for determining the seismic input parameters specific to the site.
SI–W: Review of investigations for determining the seismic input parameters specific to the site/workshop.

INTERNATIONAL NUCLEAR EVENT SCALE (INES) RATINGS REPORTED, 1998

Level	Description	Number reported
Below scale	Deviation	5
1	Anomaly	1
2	Incident	13
3	Serious incident	0
4–7	Accidents	0

INTERNATIONAL PEER REVIEW SERVICE (IPERS) ON PROBABILISTIC SAFETY ANALYSIS REVIEWS, 1998

Review type	Country	Location/ nuclear power plant
Fire PSA	Slovenia	Krško
Review PSAPRO software	Austria	
Internal event+fire+ flood PSA	Czech Republic	Dukovany
Internal events PSA	Russian Federation	Novovoronezh 5
Internal events PSA	China	Daya Bay

INTERNATIONAL REGULATORY REVIEW TEAM (IRRT) MISSIONS, 1998

Type of mission	Country
Reduced scope	Romania
Reduced scope	Slovakia
Full scope	Ukraine
Full scope	Switzerland

INTEGRATED SAFETY ASSESSMENT OF RESEARCH REACTORS (INSARR) MISSIONS, 1998

Country	Type	Location/ nuclear power plant
Thailand	Review of PSAR for a new reactor	Bangkok
Indonesia	Review of operational safety issues	Serpong, near Jakarta

OPERATIONAL SAFETY REVIEW TEAM (OSART) MISSIONS, 1998

Type	Location/nuclear power plant	Plant type	Country
OSART	Paluel	PWR	France
Follow-up OSART	Beznau	PWR	Switzerland
Follow-up OSART	Bohunice	WWER	Slovakia
Follow-up OSART	Guangdong	PWR	China
OSART	Asco	PWR	Spain
Follow-up OSART	Dampierre	PWR	France
Follow-up OSART	Laguna Verde	BWR	Mexico
Preparatory visit	Chasnupp	PWR	Pakistan
Preparatory visit	Bugey	PWR	France
OSART	Golfech	PWR	France
Preparatory visit	Gösgen	PWR	Switzerland
OSART	BN-350, Aktau	FBR	Kazakhstan

RADIOACTIVE WASTE SAFETY ASSESSMENT SERVICES, 1998

Location	Type
Vaalputs, South Africa	Low level waste repository
Republic of Moldova	Low level waste repository

SAFETY CULTURE SEMINARS, 1998

Location	Country
Point Lepereau Nuclear Generating Station	Canada
Ignalina	Lithuania
National Nuclear Safety Administration, Beijing	China
KEPCO Nuclear Training Centre, Kori	Republic of Korea
Karachi Nuclear Power Plant	Pakistan
Eletronuclear, Rio de Janeiro, Angra	Brazil
Rovno Nuclear Power Plant	Ukraine

NUMBER OF STATES HAVING SIGNIFICANT NUCLEAR ACTIVITIES AT THE END OF 1996, 1997 AND 1998

	Number of States		
	1996	1997	1998
States with safeguards applied under NPT or NPT/Tlatelolco agreements	54[a]	56[a]	57[a]
States with safeguards applied under Tlatelolco agreements	1	2	2
States with safeguards applied pursuant to other comprehensive safeguards agreements	3	1	0
States with safeguards applied under INFCIRC/66/Rev.2-type agreements[b]	5	4	4
Nuclear weapon States with safeguards applied under voluntary offer agreements	5	5	5
States without any safeguards agreement in force	1	1	1
Total number of States with significant nuclear activities[c]	69	69	69

[a] This excludes Iraq, where safeguards activities in 1998 continued to be subsumed under activities carried out pursuant to United Nations Security Council Resolution 687.

[b] Some States with INFCIRC/66/Rev.2-type agreements under which the application of safeguards has not yet been suspended, although NPT or other comprehensive safeguards agreements have entered into force, are listed under NPT agreements only. Nuclear weapon States with INFCIRC/66/Rev.2-type agreements in force are not included. Safeguards are also applied to nuclear installations in Taiwan, China.

[c] According to information available to the Agency for the year in question.

SITUATION ON 31 DECEMBER 1998 WITH RESPECT TO THE CONCLUSION OF SAFEGUARDS AGREEMENTS BETWEEN THE AGENCY AND NON-NUCLEAR-WEAPON STATES IN CONNECTION WITH NPT

Non-nuclear-weapon States which have signed, ratified, acceded to or succeeded to NPT[a] (1)	Date of ratification, accession or succession[a] (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Afghanistan	4 February 1970	In force: 20 February 1978	257
Albania[b]	12 September 1990		
Algeria	12 January 1995	In force: 7 January 1997	531
Andorra	25 June 1996		
Angola	14 October 1996		
Antigua and Barbuda[c]	1 November 1981	In force: 9 September 1996	528
Argentina[d]	10 February 1995	In force: 18 March 1997	435/Mod.1
Armenia	15 July 1993	In force: 5 May 1994	455
Australia	23 January 1973	In force: 10 July 1974	217
Austria[e]	27 June 1969	Accession: 31 July 1996	193
Azerbaijan	22 September 1992	Signed: 6 November 1998	
Bahamas[c]	10 July 1973	In force: 12 September 1997	544
Bahrain	3 November 1988		
Bangladesh	27 September 1979	In force: 11 June 1982	301
Barbados[c]	21 February 1980	In force: 14 August 1996	527
Belarus	22 July 1993	In force: 2 August 1995	495
Belgium	2 May 1975	In force: 21 February 1977	193
Belize[f]	9 August 1985	In force: 21 January 1997	532
Benin	31 October 1972		
Bhutan	23 May 1985	In force: 24 October 1989	371
Bolivia[c]	26 May 1970	In force: 6 February 1995	465
Bosnia and Herzegovina[g]	15 August 1994	In force: 28 December 1973	204
Botswana	28 April 1969		
Brazil[h]	18 September 1998		
Brunei Darussalam	25 March 1985	In force: 4 November 1987	365
Bulgaria	5 September 1969	In force: 29 February 1972	178
Burkina Faso	3 March 1970		
Burundi	19 March 1971		
Cambodia	2 June 1972		
Cameroon	8 January 1969	Signed: 21 May 1992	
Canada	8 January 1969	In force: 21 February 1972	164
Cape Verde	24 October 1979		
Central African Republic	25 October 1970		
Chad	10 March 1971		
Chile[i]	25 May 1995	In force: 9 September 1996	476/Mod.1
Colombia[j]	8 April 1986		
Comoros	4 October 1995		
Congo	23 October 1978		
Costa Rica[c]	3 March 1970	In force: 22 November 1979	278
Côte d'Ivoire	6 March 1973	In force: 8 September 1983	309
Croatia	29 June 1992	In force: 19 January 1995	463
Cyprus	10 February 1970	In force: 26 January 1973	189
Czech Republic[k]	1 January 1993	In force: 11 September 1997	541
Democratic People's Republic of Korea	12 December 1985	In force: 10 April 1992	403
Democratic Republic of the Congo	4 August 1970	In force: 9 November 1972	183
Denmark[l]	3 January 1969	In force: 21 February 1977	193

Non-nuclear-weapon States which have signed, ratified, acceded to or succeeded to NPT[a] (1)	Date of ratification, accession or succession[a] (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Djibouti	16 October 1996		
Dominica[f]	10 August 1984	In force: 3 May 1996	513
Dominican Republic[c]	24 July 1971	In force: 11 October 1973	201
Ecuador[c]	7 March 1969	In force: 10 March 1975	231
Egypt	26 February 1981	In force: 30 June 1982	302
El Salvador[c]	11 July 1972	In force: 22 April 1975	232
Equatorial Guinea	1 November 1984	Approved by the Board, June 1986	
Eritrea	16 March 1995		
Estonia	31 January 1992	In force: 24 November 1997	547
Ethiopia	5 February 1970	In force: 2 December 1977	261
Fiji	14 July 1972	In force: 22 March 1973	192
Finland[m]	5 February 1969	Accession: 1 October 1995	193
Gabon	19 February 1974	Signed: 3 December 1979	
Gambia	12 May 1975	In force: 8 August 1978	277
Georgia	7 March 1994	Signed: 29 September 1997	
Germany[n]	2 May 1975	In force: 21 February 1977	193
Ghana	5 May 1970	In force: 17 February 1975	226
Greece[o]	11 March 1970	Accession: 17 December 1981	193
Grenada[c]	19 August 1974	In force: 23 July 1996	525
Guatemala[c]	22 September 1970	In force: 1 February 1982	299
Guinea	29 April 1985		
Guinea-Bissau	20 August 1976		
Guyana[c]	19 October 1993	In force: 23 May 1997	543
Haiti[c]	2 June 1970	Signed: 6 January 1975	
Holy See	25 February 1971	In force: 1 August 1972	187
Honduras[c]	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	12 July 1979	In force: 14 July 1980	283
Iran, Islamic Republic of	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
Jamaica[c]	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
Kazakhstan	14 February 1994	In force: 11 August 1995	504
Kenya	11 June 1970		
Kiribati	18 April 1985	In force: 19 December 1990	390
Korea, Republic of	23 April 1975	In force: 14 November 1975	236
Kuwait	17 November 1989	Signed: 18 March 1998	
Kyrgyzstan	5 July 1994	Signed: 18 March 1998	
Lao People's Democratic Republic	20 February 1970	Signed: 22 November 1991	
Latvia	31 January 1992	In force: 21 December 1993	434
Lebanon	15 July 1970	In force: 5 March 1973	191
Lesotho	20 May 1970	In force: 12 June 1973	199

Non-nuclear-weapon States which have signed, ratified, acceded to or succeeded to NPT[a] (1)	Date of ratification, accession or succession[a] (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Liberia	5 March 1970		
Libyan Arab Jamahiriya	26 May 1975	In force: 8 July 1980	282
Liechtenstein	20 April 1978	In force: 4 October 1979	275
Lithuania	23 September 1991	In force: 15 October 1992	413
Luxembourg	2 May 1975	In force: 21 February 1977	193
Madagascar	8 October 1970	In force: 14 June 1973	200
Malawi	18 February 1986	In force: 3 August 1992	409
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	In force: 13 November 1990	387
Marshall Islands	30 January 1995		
Mauritania	26 October 1993		
Mauritius	25 April 1969	In force: 31 January 1973	190
Mexico[c]	21 January 1969	In force: 14 September 1973	197
Micronesia, Federated States of	14 April 1995		
Moldova, Republic of	11 October 1994	Signed: 14 June 1996	
Monaco	13 March 1995	In force: 13 June 1996	524
Mongolia	14 May 1969	In force: 5 September 1972	188
Morocco	27 November 1970	In force: 18 February 1975	228
Mozambique	4 September 1990		
Myanmar	2 December 1992	In force: 20 April 1995	477
Namibia	2 October 1992	In force: 15 April 1998	551
Nauru	7 June 1982	In force: 13 April 1984	317
Nepal	5 January 1970	In force: 22 June 1972	186
Netherlands[p]	2 May 1975	In force: 21 February 1977	193
New Zealand[q]	10 September 1969	In force: 29 February 1972	185
Nicaragua[c]	6 March 1973	In force: 29 December 1976	246
Niger	9 October 1992		
Nigeria	27 September 1968	In force: 29 February 1988	358
Norway	5 February 1969	In force: 1 March 1972	177
Oman	23 January 1997		
Palau, Republic of	14 April 1995		
Panama[c,r]	13 January 1977	Signed : 22 December 1988	
Papua New Guinea	25 January 1982	In force: 13 October 1983	312
Paraguay[c]	4 February 1970	In force: 20 March 1979	279
Peru[c]	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[s]	15 December 1977	Accession: 1 July 1986	193
Qatar	3 April 1989		
Romania	4 February 1970	In force: 27 October 1972	180
Rwanda	20 May 1975		
St. Kitts and Nevis[f]	22 March 1993	In force: 7 May 1996	514
St. Lucia[f]	28 December 1979	In force: 2 February 1990	379
St. Vincent and the Grenadines[f]	6 November 1984	In force: 8 January 1992	400

Non-nuclear-weapon States which have signed, ratified, acceded to or succeeded to NPT[a] (1)	Date of ratification, accession or succession[a] (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Samoa	17 March 1975	In force: 22 January 1979	268
San Marino	10 August 1970	In force: 21 September 1998	575
São Tome and Principe	20 July 1983		
Saudi Arabia	3 October 1988		
Senegal	17 December 1970	In force: 14 January 1980	276
Seychelles	12 March 1985		
Sierra Leone	26 February 1975	Signed: 10 November 1977	
Singapore	10 March 1976	In force: 18 October 1977	259
Slovakia[t]	1 January 1993	In force: 3 March 1972	173
Slovenia	7 April 1992	In force: 1 August 1997	538
Solomon Islands	17 June 1981	In force: 17 June 1993	420
Somalia	5 March 1970		
South Africa	10 July 1991	In force: 16 September 1991	394
Spain	5 November 1987	Accession: 5 April 1989	193
Sri Lanka	5 March 1979	In force: 6 August 1984	320
Sudan	31 October 1973	In force: 7 January 1977	245
Suriname[c]	30 June 1976	In force: 2 February 1979	269
Swaziland	11 December 1969	In force: 28 July 1975	227
Sweden[u]	9 January 1970	Accession: 1 June 1995	193
Switzerland	9 March 1977	In force: 6 September 1978	264
Syrian Arab Republic	24 September 1969	In force: 18 May 1992	407
Tajikistan	17 January 1997		
Thailand	7 December 1972	In force: 16 May 1974	241
The Former Yugoslav Republic of Macedonia	12 April 1995		
Togo	26 February 1970	Signed: 29 November 1990	
Tonga	7 July 1971	In force: 18 November 1993	426
Trinidad and Tobago[c]	30 October 1986	In force: 4 November 1992	414
Tunisia	26 February 1970	In force: 13 March 1990	381
Turkey	17 April 1980	In force: 1 September 1981	295
Turkmenistan	29 September 1994		
Tuvalu	19 January 1979	In force: 15 March 1991	391
Uganda	20 October 1982		
Ukraine	5 December 1994	In force: 22 January 1998	550
United Arab Emirates	26 September 1995		
United Republic of Tanzania	7 June 1991	Signed: 26 August 1992	
Uruguay[c]	31 August 1970	In force: 17 September 1976	157
Uzbekistan	7 May 1992	In force: 8 October 1994	508
Vanuatu	24 August 1995		
Venezuela[c]	26 September 1975	In force: 11 March 1982	300
Viet Nam	14 June 1982	In force: 23 February 1990	376
Yemen, Republic of	1 June 1979		
Yugoslavia[v], Federal Republic of	3 March 1970	In force: 28 December 1973	204
Zambia	15 May 1991	In force: 22 September 1994	456
Zimbabwe	26 September 1991	In force: 26 June 1995	483

[a] The information in columns (1) and (2) was provided to the Agency by 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. The table does not contain information relating to the participation of Taiwan, China, in NPT.

[b] A sui generis comprehensive safeguards agreement with Albania entered into force on 25 March 1988 (INFCIRC/359).

[c] The relevant safeguards agreement refers to both NPT and the Treaty of Tlatelolco.

[d] An exchange of letters has taken place between Argentina and the Agency confirming that the safeguards agreement condluded between Argentina, Brazil, ABACC and the Agency for the application of safeguards which entered into force on 4 March 1994 (INFCIRC/435) satisfies the requirements of Argentina under Article III of the NPT to conclude a safeguards agreement with the Agency. The exchange of letters entered into force on the date of approval by the Board of Governors.

[e] The application of safeguards in Austria under the NPT safeguards agreement INFCIRC/156, in force since 23 July 1972, was suspended on 31 July 1996, on which date the agreement of 5 April 1973 (INFCIRC/193) between the non-nuclear-weapon States of EURATOM, EURATOM and the Agency, to which Austria had acceded, entered into force for Austria.

[f] An exchange of letters has taken place between this State and the Agency confirming that the NPT safeguards agreement concluded with the State satisfies the obligations of the State under Article 13 of the Treaty of Tlatelolco to conclude a safeguards agreement with the Agency.

[g] The NPT safeguards agreement concluded with the Socialist Federal Republic of Yugoslavia (INFCIRC/204), which entered into force on 28 December 1973, continues to be applied in Bosnia and Herzegovina to the extent relevant to the territory of Bosnia and Herzegovina.

[h] The Board of Governors has concluded that the agreement between Argentina, Brazil, the ABACC and the Agency for the application of safeguards which entered into force on 4 March 1994 (INFCIRC/435) is compatible with the Treaty of Tlatelolco and the NPT.

[i] An exchange of letters has taken place between this State and the Agency confirming that the safeguards agreement concluded with the State pursuant to the Treaty of Tlatelolco satisfies the requirements of the obligations of the State under Article III of the NPT to conclude a safeguards agreement with the Agency. The exchange of letters entered into force on the date of approval by the Board of Governors.

[j] A comprehensive safeguards agreement with Colombia concluded pursuant to the Treaty of Tlatelolco entered into force on 22 December 1982 (INFCIRC/306).

[k] The NPT safeguards agreement concluded with the Czechoslovak Socialist Republic (INFCIRC/173), which entered into force on 3 March 1972, continued to be applied in the Czech Republic to the extent relevant to the territory of the Czech Republic until 11 September 1997, on which date the NPT safeguards agreement concluded with the Czech Republic entered into force.

[l] 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 non-nuclear-weapon States of EURATOM, EURATOM and the Agency (INFCIRC/193) but still applies to the Faroe Islands. Upon Greenland's secession from EURATOM as of 31 January 1985, the Agreement between the Agency and Denmark (INFCIRC/176) re-entered into force as to Greenland.

[m] The application of safeguards in Finland under the NPT safeguards agreement INFCIRC/155, in force since 9 February 1972, was suspended on 1 October 1995, on which date the agreement of 5 April 1973 (INFCIRC/193) between the non-nuclear-weapon States of EURATOM, EURATOM and the Agency, to which Finland had acceded, entered into force for Finland.

[n] The NPT safeguards agreement of 7 March 1972 concluded with the German Democratic Republic (INFCIRC/181) is no longer in force with effect from 3 October 1990, on which date the German Democratic Republic acceded to the Federal Republic of Germany.

[o] The application of safeguards in Greece under the NPT safeguards agreement INFCIRC/166, provisionally in force since 1 March 1972, was suspended on 17 December 1981, on which date Greece acceded to the agreement of 5 April 1973 (INFCIRC/193) between the non-nuclear-weapon States of EURATOM, EURATOM and the Agency.

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

[q] The NPT safeguards agreement with New Zealand (INFCIRC/185) also applies to Cook Islands, Niue and Tokelau.

[r] A comprehensive safeguards agreement with Panama concluded pursuant to the Treaty of Tlatelolco entered into force on 23 March 1984 (INFCIRC/316).

[s] The application of safeguards in Portugal under the NPT safeguards agreement INFCIRC/272, in force since 14 June 1979, was suspended on 1 July 1986, on which date Portugal acceded to the agreement of 5 April 1973 (INFCIRC/193) between the non-nuclear-weapon States of EURATOM, EURATOM and the Agency.

[t] The NPT safeguards agreement concluded with the Czechoslovak Socialist Republic (INFCIRC/173), which entered into force on 3 March 1972, continues to be applied in Slovakia to the extent relevant to the territory of Slovakia. A new NPT safeguards agreement concluded with Slovakia was approved by the Board of Governors on 14 September 1998.

[u] The application of safeguards in Sweden under the NPT safeguards agreement INFCIRC/234, in force since 14 April 1975, was suspended on 1 June 1995, on which date the agreement of 5 April 1973 (INFCIRC/193) between the non-nuclear-weapon States of EURATOM, EURATOM and the Agency, to which Sweden had acceded, entered into force for Sweden.

[v] The NPT safeguards agreement concluded with the Socialist Federal Republic of Yugoslavia (INFCIRC/204), which entered into force on 28 December 1973, continues to be applied in the Federal Republic of Yugoslavia to the extent relevant to the territory of the Federal Republic of Yugoslavia.

SITUATION ON 31 DECEMBER 1998 WITH RESPECT TO THE CONCLUSION OF SAFEGUARDS AGREEMENTS BETWEEN THE AGENCY AND STATES PARTY TO THE TREATY OF TLATELOLCO[a]

States party to the Treaty of Tlatelolco (1)	Date of becoming a party to the Treaty of Tlatelolco (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Antigua and Barbuda[b]	11 October 1983	In force: 9 September 1996	528
Argentina[c]	18 January 1994	In force: 18 March 1997	435/Mod.1
Bahamas[b]	26 April 1977	In force: 12 September 1997	544
Barbados[b]	25 April 1969	In force: 14 August 1996	527
Belize[d]	4 November 1994	In force: 18 March 1997	532/Mod.1
Bolivia[b]	18 February 1969	In force: 6 February 1995	465
Brazil[c]	30 May 1994	In force: 10 June 1997	435/Mod.2
Chile	18 January 1994	In force: 5 April 1995	476
Colombia	6 September 1972	In force: 22 December 1982	306
Costa Rica[b]	25 August 1969	In force: 22 November 1979	278
Dominica[d]	25 August 1993	In force: 10 June 1997	513/Mod.1
Dominican Republic[b]	14 June 1968	In force: 11 October 1973	201
Ecuador[b]	11 February 1969	In force: 10 March 1975	231
El Salvador[b]	22 April 1968	In force: 22 April 1975	232
Grenada[b]	20 June 1975	In force: 23 July 1996	525
Guatemala[b]	6 February 1970	In force: 1 February 1982	299
Guyana[b]	6 May 1996	In force: 23 May 1997	543
Haiti[b]	23 May 1969	Signed: 6 January 1975	
Honduras[b]	23 September 1968	In force: 18 April 1975	235
Jamaica[b]	26 June 1969	In force: 6 November 1978	265
Mexico[b,e]	20 September 1967	In force: 14 September 1973	197
Nicaragua[b]	24 October 1968	In force: 29 December 1976	246
Panama[f]	11 June 1971	In force: 23 March 1984	316
Paraguay[b]	19 March 1969	In force: 20 March 1979	279
Peru[b]	4 March 1969	In force: 1 August 1979	273
St. Kitts and Nevis[d]	14 February 1997	In force: 18 March 1997	514/Mod.1
St. Lucia[d]	2 June 1995	In force: 12 June 1996	379/Mod.1
St. Vincent and the Grenadines[d]	11 May 1992	In force: 18 March 1997	400/Mod.1
Suriname[b]	10 June 1977	In force: 2 February 1979	269
Trinidad and Tobago[b]	27 June 1975	In force: 4 November 1992	414
Uruguay[b]	20 August 1968	In force: 17 September 1976	157
Venezuela[b]	23 March 1970	In force: 11 March 1982	300
In addition, there are the following safeguards agreements with States party to Additional Protocol I to the Treaty[g]:			
	France	Approved by the Board, March 1998	
	Netherlands[b]	In force: 5 June 1975	229
	United Kingdom	Approved by the Board, Sep.1992	
	United States of America	In force: 6 April 1989	366

[a] The information in columns (1) and (2) was provided by Mexico as depositary of the Treaty of Tlatelolco. In addition to the States listed in column (1), Cuba signed the Treaty on 25 March 1995.

[b] The relevant safeguards agreement refers to both the Treaty of Tlatelolco and the NPT.

[c] An exchange of letters has taken place between this State and the Agency confirming that the safeguards agreement concluded between Argentina, Brazil, ABACC and the Agency for the application of safeguards which entered into force on 4 March 1994 (INFCIRC/435) satisfies the requirements of this State under Article 13 of the Treaty of Tlatelolco to conclude a safeguards agreement with the Agency. The exchange of letters entered into force on the date of approval by the Board of Governors.

[d] An exchange of letters has taken place between this State and the Agency confirming that the NPT safeguards agreement concluded with the State satisfies the obligations of the State under Article 13 of the Treaty of Tlatelolco to conclude a safeguards agreement with the Agency. The exchange of letters entered into force on the date of approval by the Board of Governors.

[e] The application of safeguards under an agreement with Mexico in connection with the Treaty of Tlatelolco which entered into force on 6 September 1968 (INFCIRC/118) was suspended after the conclusion of an agreement with Mexico in connection with both the Treaty of Tlatelolco and NPT (INFCIRC/197).

[f] A safeguards agreement pursuant to both the Treaty of Tlatelolco and NPT has been concluded with Panama; the agreement has not yet entered into force.

[g] Additional Protocol I refers to States outside Latin America and the Caribbean which have de jure or de facto jurisdiction over territories which lie within the limits of the geographical zone established in the Treaty.

AGREEMENTS PROVIDING FOR SAFEGUARDS, OTHER THAN THOSE IN CONNECTION WITH NPT OR THE TREATY OF TLATELOLCO, APPROVED BY THE BOARD OF GOVERNORS AS OF 31 DECEMBER 1998[a]

Party(ies)[b]	Subject	Entry into force	INFCIRC
(While the Agency is a party to each of the following agreements, only the State(s) party to them is (are) listed.)			
(i) Project agreements			
Argentina[c]	Siemens SUR-100	13 March 1970	143
	RAEP reactor	2 December 1964	62
Chile[d]	Herald reactor	19 December 1969	137
Colombia[d]	Fuel for research reactor	17 June 1994	460
Democratic Republic of the Congo[e]	TRICO reactor	27 June 1962	37
	Fuel for research reactor	20 September 1990	389
Finland[e]	FIR-1 reactor	30 December 1960	24
	FINN subcritical assembly	30 July 1963	53
Ghana[e]	Research reactor and fuel therefor	14 October 1994	468
Greece[e]	GRR-1 reactor	1 March 1972	163
Indonesia[e]	Additional core-load for TRIGA reactor	19 December 1969	136
	Supply of enriched uranium	15 January 1993	453
	Supply of enriched uranium	15 January 1993	454
Iran, Islamic Republic of[e]	UTRR reactor	10 May 1967	97
Jamaica[e]	Fuel for research reactor	25 January 1984	315
Japan[e]	JRR-3	24 March 1959	3
Malaysia[e]	TRIGA-II reactor	22 September 1980	287
Mexico[e]	TRIGA-III reactor	18 December 1963	52
	Siemens SUR-100	21 December 1971	162
	Laguna Verde Nuclear Power Plant	12 February 1974	203
Morocco[e]	Fuel for research reactor	2 December 1983	313
Nigeria[e]	Research reactor and fuel therefor	29 August 1996	526
Pakistan	PRR reactor	5 March 1962	34
	Booster rods for KANUPP	17 June 1968	116
Peru[e]	Research reactor and fuel therefor	9 May 1978	266
Philippines[e]	PRR-1 reactor	28 September 1966	88
Romania[e]	TRIGA reactor	30 March 1973	206
	Experimental fuel elements	1 July 1983	307
Slovenia[e]	TRIGA-II reactor	4 October 1961	32
	Krško Nuclear Power Plant	14 June 1974	213
Spain[e]	Coral-I reactor	23 June 1967	99
Syrian Arab Republic[e]	Miniature neutron source reactor and enriched uranium	18 May 1992	408
Thailand[e]	Fuel for research reactor	30 September 1986	342
Turkey[e]	Subcritical assembly	17 May 1974	212
Uruguay[e]	URR reactor	24 September 1965	67
Venezuela[e]	RV-1 reactor	7 November 1975	238
Viet Nam[e]	Fuel for research reactor	1 July 1983	308

Party(ies)[b]	Subject	Entry into force	INFCIRC
(ii) Unilateral submissions			
Algeria	Nur research reactor[h]	9 April 1990	361
	Es Salam research reactor[h]	2 June 1992	401
Argentina	Atucha Power Reactor Facility [f]	3 October 1972	168
	Nuclear material [f]	23 October 1973	202
	Embalse Power Reactor Facility [f]	6 December 1974	224
	Equipment and nuclear material [f]	22 July 1977	250
	Nuclear material, material, equipment and facilities [f]	22 July 1977	251
	Atucha II Nuclear Power Plant [f]	15 July 1981	294
	Heavy water plant [f]	14 October 1981	296
	Heavy water [f]	14 October 1981	297
	Nuclear material [f]	8 July 1982	303
Chile	Nuclear material[g]	31 December 1974	256
	Nuclear material[g]	22 September 1982	304
	Nuclear material[g]	18 September 1987	350
Cuba	Nuclear power plant and nuclear material	5 May 1980	281
	Zero power nuclear reactor and fuel therefor	7 October 1983	311
Democratic People's Republic of Korea	Research reactor and nuclear material therefor[h]	20 July 1977	252
India	Nuclear material, material and facilities	17 November 1977	260
	Nuclear power station	27 September 1988	360
	Nuclear material	11 October 1989	374
	All nuclear material subject to safeguards under INFCIRC/154	1 March 1994	433*
Pakistan	Nuclear material	2 March 1977	248
	Miniature neutron source reactor	10 September 1991	393
	Nuclear power reactor	24 February 1993	418
Spain	Nuclear material[h]	18 June 1975	221
	Vandellos Nuclear Power Plant[h]	11 May 1981	292
	Specified nuclear facilities[h]	11 May 1981	291**
United Kingdom	Nuclear material	14 December 1972	175
Viet Nam	Research reactor and fuel therefor[h]	12 June 1981	293

* Amended in 1994 to cover nuclear material supplied for use in the Tarapur Atomic Power Station (TAPS) which material is required by the supplier to be subject to safeguards. The amendment entered into force on 12 September 1994 (INFCIRC/433/Mod.1).

** Amended in 1985 to cover specified nuclear facilities. The amendment entered into force on 8 November 1985 (INFCIRC/291/Mod.1/Corr.1).

Party(ies)[b]	Subject	Entry into force	INFCIRC
(iii) Agreements concluded with nuclear weapon States on the basis of voluntary offers			
China	Nuclear material in facilities selected from list of facilities provided by China	18 September 1989	369
France	Nuclear material in facilities submitted to safeguards	12 September 1981	290
Russian Federation	Nuclear material in facilities selected from list of facilities provided by the Russian Federation	10 June 1985	327
United Kingdom	Nuclear material in facilities designated by the Agency	14 August 1978	263
United States of America	Nuclear material in facilities designated by the Agency	9 December 1980	288
(iv) Other comprehensive safeguards agreements			
Albania	All nuclear material and facilities	25 March 1988	359
Argentina/Brazil	All nuclear material in all nuclear activities	4 March 1994	435
(v) Other safeguards agreements			
Argentina[f]/United States of America[i]		25 July 1969	130
Austria[h]/United States of America		24 January 1970	152
Brazil/Germany[h]		26 February 1976	237
Brazil[f]/United States of America[i]		31 October 1968	110
Colombia/United States of America		9 December 1970	144
India/Canada[h]		30 September 1971	211
Iran, Islamic Republic of [h]/United States of America		20 August 1969	127
Israel/United States of America		4 April 1975	249
Japan[h]/Canada[h]		20 June 1966	85
Japan[h]/France		22 September 1972	171
Korea, Republic of/United States of America		5 January 1968	111
Korea, Republic of [h]/France		22 September 1975	233
Pakistan/Canada		17 October 1969	135
Pakistan/France		18 March 1976	239
Philippines[h]/United States of America		19 July 1968	120
Portugal[h]/United States of America[i]		19 July 1969	131
South Africa/United States of America		26 July 1967	98
South Africa/France		5 January 1977	244
Spain/Germany[h]		29 September 1982	305
Spain[h]/United States of America[i]		9 December 1966	92
Spain/Canada[h]		10 February 1977	247
Sweden[h]/United States of America		1 March 1972	165
Switzerland[h]/United States of America[i]		28 February 1972	161
Turkey[h]/United States of America[i]		5 June 1969	123
Venezuela[h]/United States of America[i]		27 March 1968	122

(vi) The Agency also applies safeguards under two agreements (INFCIRC/133 and INFCIRC/158) to the nuclear facilities in Taiwan, China. Pursuant to the decision adopted by the Board of Governors on 9 December 1971 that the Government of the People's Republic of China is the only government which has the right to represent China in the Agency, the relations between the Agency and the authorities in Taiwan, China, are non-governmental. The agreements are implemented by the Agency on that basis.

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[a] Safeguards agreements pursuant to the South Pacific Nuclear Weapon Free Zone Treaty (Rarotonga Treaty) are not separately listed with this compilation since the Treaty requires that safeguards by the Agency will be applied pursuant to safeguards agreements equivalent in scope and effect to an agreement required in connection with the NPT on the basis of the material reproduced in INFCIRC/153 (Corrected). As of 31 December 1997, all 11 States Party to the Treaty (Australia, Cook Islands, Fiji, Kiribati, Nauru, New Zealand, Niue, Papua New Guinea, Solomon Islands, Tuvalu and Samoa) were covered by safeguards agreements concluded pursuant to NPT.

[b] An entry in this column does not imply the expression of any opinion whatsoever on the part of the Agency concerning the legal status of any country or territory or of its authorities or concerning the delimitation of its frontiers.

[c] Agency safeguards required by this project agreement are implemented pursuant to the comprehensive safeguards agreement concluded between Argentina, Brazil, the ABACC and the Agency (INFCIRC/435).

[d] Agency safeguards required by this project agreement are implemented pursuant to a safeguards agreement in connection with the Treaty of Tlatelolco covering the State indicated.

[e] Agency safeguards required by this (these) project agreement(s) are implemented pursuant to an agreement in connection with NPT covering the State indicated.

[f] Application of Agency safeguards under this agreement has been suspended in the State indicated. Safeguards are applied pursuant to the comprehensive safeguards agreement concluded between Argentina, Brazil, the ABACC and the Agency (INFCIRC/435).

[g] Application of Agency safeguards under this agreement has been suspended in the State indicated as the State has concluded an agreement in connection with the Treaty of Tlatelolco.

[h] Application of Agency safeguards under this agreement has been suspended in the State indicated as the State has concluded an agreement in connection with NPT.

[i] Application of Agency safeguards under this agreement has been suspended in the USA in order to comply with a provision of INFCIRC/228.

APPROXIMATE QUANTITIES OF MATERIAL SUBJECT TO AGENCY SAFEGUARDS AT THE END OF 1998

Type of material	Quantity of material (t)			
	Comprehensive safeguards agreements[a]	INFCIRC/66[b]	Nuclear weapon States	Quantity in SQs
Nuclear material				
Plutonium[c] contained in irradiated fuel	464.9	25.1	102.9	74 111
Separated plutonium outside reactor cores	12.7	0.1	49.7	7 797
Recycled plutonium in fuel elements in reactor cores	6.8	0.4	0	905
HEU (equal to or greater than 20% ^{235}U)	11.3	0.1	10.0	604
LEU (less than 20% ^{235}U)	39 981	2 597	6 905	13 682
Source material[d] (natural or depleted uranium and thorium)	77 089	1 505	12 028	6 758
Non-nuclear material[e]				
Heavy water	0	528	0	26
Total significant quantities				103 883

[a] Covering safeguards agreements pursuant to NPT and/or Treaty of Tlatelolco and other comprehensive safeguards agreements.
[b] Excluding installations in nuclear weapon States; including installations in Taiwan, China.
[c] The quantity includes an estimated 87 t (10 852 SQ) of plutonium in irradiated fuel, which is not yet reported to the Agency under the reporting procedures agreed to (the non-reported plutonium is contained in irradiated fuel assemblies to which item accountancy and C/S measures are applied).
[d] This table does not include material within the terms of subparagraphs 34(a) and (b) of INFCIRC/153 (Corrected).
[e] Non-nuclear material subject to Agency safeguards under INFCIRC/66/Rev.2-type agreements.

NUMBER OF FACILITIES UNDER SAFEGUARDS OR CONTAINING SAFEGUARDED MATERIAL ON 31 DECEMBER 1998

Facility type	Number of facilities (number of installations)			
	Comprehensive safeguards agreements[a]	INFCIRC/66[b]	Nuclear weapon States	Total
Power reactors	184 (221)	11 (14)	1 (1)	196 (236)
Research reactors and critical assemblies	148 (160)	8 (8)	1 (1)	157 (169)
Conversion plants	12 (12)	1 (1)	0 (0)	13 (13)
Fuel fabrication plants	40 (42)	4 (4)	0 (0)	44 (46)
Reprocessing plants	5 (5)	1 (1)	0 (0)	6 (6)
Enrichment plants	11 (11)	0 (0)	3 (3)	14 (14)
Separate storage facilities	58 (59)	3 (3)	8 (8)	69 (70)
Other facilities	74 (80)	1 (1)	1 (1)	82 (82)
Subtotals	532 (590)	29 (32)	14 (14)	575 (636)
Other locations	318 (417)	3 (31)	0 (0)	321 (448)
Non-nuclear installations	0 (0)	1 (1)	0 (0)	1 (1)
Totals	850 (1007)	33 (64)	14 (14)	897 (1085)

[a] Covering safeguards agreements pursuant to NPT and/or Treaty of Tlatelolco and other comprehensive safeguards agreements; excludes locations in Iraq.
[b] Excluding installations in nuclear weapon States; including installations in Taiwan, China.

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Power reactors				
Argentina	Atucha NPP	1	Lima	—
	Embalse NPP	1	Embalse	—
Armenia	Armenia NPP	2	Medzamor	—
Belgium	BR3-Mol	1	Mol	x
	DOEL-1	2	Doel	x
	DOEL-3	1	Doel	x
	DOEL-4	1	Doel	x
	Tihange-1	1	Tihange	x
	Tihange-2	1	Tihange	x
	Tihange-3	1	Tihange	x
Brazil	Admiral Alvaro Alberto	1	Angra dos Reis	x
Bulgaria	Kozloduy-I	2	Kozloduy	x
	Kozloduy-II	2	Kozloduy	x
	Kozloduy-III	2	Kozloduy	x
Canada	Bruce A	4	Tiverton	x
	Bruce B	4	Tiverton	x
	Darlington N.G.S.	4	Bowmanville	x
	Gentilly-2	1	Gentilly	x
	Pickering G.S.	8	Pickering	x
	Point Lepreau G.S.	1	Point Lepreau	x
China	QSNPP	1	Hai Yan	x
Cuba	Juragua	2	Juragua	x
Czech Republic	EDU-1	2	Dukovany	x
	EDU-2	2	Dukovany	x
	Temelin	2	Temelin	—
Democratic People's Republic of Korea	Nyongbyon-1	1	Nyongbyon	—
Finland	Loviisa	2	Loviisa	—
	OL 1	1	Olkiluoto	—
	OL 2	1	Olkiluoto	—
Germany	AVR	1	Jülich	—
	KWG Grohnde	1	Grohnde	x
	GKN-2	1	Neckarwestheim	x
	RWE Biblis-A	1	Biblis	x
	RWE Biblis-B	1	Biblis	x
	KBR Brokdorf	1	Brokdorf	x
	KKB Brunsbüttel	1	Brunsbüttel	x
	KKE Emsland	1	Lingen	x
	KKG Grafenrheinfeld	1	Grafenrheinfeld	x
	KKI Isar-Ohu	1	Ohu bei Landshut	x
	KKI Isar-2	1	Essenbach	x
	KKK Krümmel	1	Geesthacht	x
	RWE Mühlheim-Kärlich	1	Mühlheim-Kärlich	x

SAFEGUARDED FACILITIES (cont.)

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Germany (cont.)	GKN Neckarwestheim	1	Neckarwestheim	x
	KWO Obrigheim	1	Obrigheim	x
	KKP Philippsburg-1	1	Philippsburg	x
	KKP Philippsburg-2	1	Philippsburg	x
	KRB II Gundremmingen B	1	Gundremmingen	x
	KRB II Gundremmingen C	1	Gundremmingen	x
	KKS Stade	1	Stade	x
	KKU Unterweser	1	Unterweser	x
	KWW Würgassen	1	Würgassen	x
	HKG-THTR 300	1	Hamm	—
	KKW Greifswald 1	2	Lubmin	—
	KKW Greifswald 2	2	Lubmin	—
	KKW Greifswald 3	1	Lubmin	—
	KKW Rheinsberg	1	Rheinsberg	x
Hungary	PAKS-I	2	Paks	x
	PAKS-II	2	Paks	x
India	RAPS	2	Rajasthan	x
	TAPS	2	Tarapur	x
Italy	ENEL-Latina	1	Borgo-Sabatino	x
	ENEL-Caorso	1	Caorso	x
	ENEL-Trino	1	Trino-Vercellese	x
Japan	Fugen	1	Tsuruga-shi, Fukui-ken	x
	Fukushima Dai-Ichi-1	1	Futaba-gun, Fukushima-ken	x
	Fukushima Dai-Ichi-2	1	Futaba-gun, Fukushima-ken	x
	Fukushima Dai-Ichi-3	1	Futaba-gun, Fukushima-ken	x
	Fukushima Dai-Ichi-4	1	Futaba-gun, Fukushima-ken	x
	Fukushima Dai-Ichi-5	1	Futaba-gun, Fukushima-ken	x
	Fukushima Dai-Ichi-6	1	Futaba-gun, Fukushima-ken	x
	Fukushima Dai-Ni-1	1	Futaba-gun, Fukushima-ken	x
	Fukushima Dai-Ni-2	1	Futaba-gun, Fukushima-ken	x
	Fukushima Dai-Ni-3	1	Futaba-gun, Fukushima-ken	x
	Fukushima Dai-Ni-4	1	Futaba-gun, Fukushima-ken	x
	Genkai-1	1	Higashimatsura-gun, Saga-ken	x
	Genkai-2	1	Higashimatsura-gun, Saga-ken	x
	Genkai-3	1	Higashimatsura-gun, Saga-ken	x
	Genkai-4	1	Higashimatsura-gun, Saga-ken	x
	Hamaoka-1	1	Ogasa-gun, Shizuoka-ken	x
	Hamaoka-2	1	Ogasa-gun, Shizuoka-ken	x
	Hamaoka-3	1	Ogasa-gun, Shizuoka-ken	x
	Hamaoka-4	1	Ogasa-gun, Shizuoka-ken	x
	Ikata-1	1	Nishiuwa-gun, Ehime-ken	x
	Ikata-2	1	Nishiuwa-gun, Ehime-ken	x
	Ikata-3	1	Nishiuwa-gun, Ehime-ken	x
	Joyo	1	Higashi-gun, Ibaraki-ken	x
	Kashiwazaki-1	1	Kashiwazaki-shi, Niigata-ken	x
	Kashiwazaki-2	1	Kashiwazaki-shi, Niigata-ken	x
	Kashiwazaki-3	1	Kashiwazaki-shi, Niigata-ken	x
	Kashiwazaki-4	1	Kashiwazaki-shi, Niigata-ken	x
	Kashiwazaki-5	1	Kashiwazaki-shi, Niigata-ken	x

SAFEGUARDED FACILITIES (cont.)

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Japan (cont.)	Kashiwazaki-6	1	Kashiwazaki-shi, Niigata-ken	x
	Kashiwazaki-7	1	Kashiwazaki-shi, Niigata-ken	x
	Mihama-1	1	Mikata-gun, Fukui-ken	x
	Mihama-2	1	Mikata-gun, Fukui-ken	x
	Mihama-3	1	Mikata-gun, Fukui-ken	x
	Monju	1	Tsuruga-shi, Fukui-ken	x
	Ohi-1 and 2	2	Ohi-gun, Fukui-ken	x
	Ohi-3	1	Ohi-gun, Fukui-ken	x
	Ohi-4	1	Ohi-gun, Fukui-ken	x
	Onagawa-1	1	Oshika-gun, Miyaki-ken	x
	Onagawa-2	1	Oshika-gun, Miyaki-ken	x
	Sendai-1	1	Sendai-shi, Kagashima-ken	x
	Sendai-2	1	Sendai-shi, Kagashima-ken	x
	Shika	1	Hakui-gun, Ishikawa-ken	x
	Shimane-1	1	Yatsuka-gun, Shimane-ken	x
	Shimane-2	1	Yatsuka-gun, Shimane-ken	x
	Takahama-1	1	Ohi-gun, Fukui-ken	x
	Takahama-2	1	Ohi-gun, Fukui-ken	x
	Takahama-3	1	Ohi-gun, Fukui-ken	x
	Takahama-4	1	Ohi-gun, Fukui-ken	x
	Tokai-1	1	Tokai-Mura, Ibaraki-ken	x
	Tokai-2	1	Tokai-Mura, Ibaraki-ken	x
	Tomari-1	1	Furuu-gun, Hokkaido	x
	Tomari-2	1	Furuu-gun, Hokkaido	x
	Tsuruga-1	1	Tsuruga-shi, Fukui-ken	x
	Tsuruga-2	1	Tsuruga-shi, Fukui-ken	x
Kazakhstan	BN-350	1	Aktau	—
Korea, Republic of	Kori-1	1	Pusan	x
	Kori-2	1	Pusan	x
	Kori-3	1	Pusan	x
	Kori-4	1	Pusan	x
	Ulchin-1	1	Ulchin	x
	Ulchin-2	1	Ulchin	x
	Ulchin-3	1	Ulchin	x
	Ulchin-4	1	Ulchin	—
	Wolsong-1	1	Kyongju	x
	Wolsong-2	1	Kyongju	—
	Wolsong-3	1	Kyongju	x
	Wolsong-4	1	Kyongju	—
	Younggwang-1	1	Younggwang	x
	Younggwang-2	1	Younggwang	x
	Younggwang-3	1	Younggwang	x
	Younggwang-4	1	Younggwang	x
Lithuania	Ignalina NPP	2	Visaginas	—
Mexico	Laguna Verde 1	1	Alto Lucero	x
	Laguna Verde 2	1	Alto Lucero	x
Netherlands	Borssele	1	Borssele	x
	Dodewaard NPP	1	Dodewaard	x

SAFEGUARDED FACILITIES (cont.)

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Pakistan	KANUPP	1	Karachi	x
	Chasnupp-1	1	Kundian	—
Philippines	PNPP-1	1	Morong, Bataan	x
Romania	Cernavoda-1	1	Cernavoda	—
Slovakia	A1	1	Bohunice	x
	EMO-1	2	Mochovce	—
	V-1	2	Bohunice	x
	V-2	2	Bohunice	x
Slovenia	Krško	1	Krško	x
South Africa	Koeberg-1	1	Cape Town	x
	Koeberg-2	1	Cape Town	x
Spain	Almaraz-1	1	Almaraz	—
	Almaraz-2	1	Almaraz	—
	Asco-1	1	Asco	—
	Asco-2	1	Asco	—
	Cofrentes	1	Cofrentes	—
	José Cabrera	1	Almonazid de Zorita	—
	Santa María de Garona	1	Santa María de Garona	—
	Trillo-1	1	Trillo	—
	Vandellos 1	1	Vandellos	—
	Vandellos 2	1	Vandellos	—
Sweden	Barsebäck 1	1	Malmö	—
	Barsebäck 2	1	Malmö	—
	Forsmark 1	1	Uppsala	—
	Forsmark 2	1	Uppsala	—
	Forsmark 3	1	Uppsala	—
	Oskarshamn 1	1	Oskarshamn	—
	Oskarshamn 2	1	Oskarshamn	—
	Oskarshamn 3	1	Oskarshamn	—
	Ringhals 1	1	Göteborg	—
	Ringhals 2	1	Göteborg	—
	Ringhals 3	1	Göteborg	—
	Ringhals 4	1	Göteborg	—
Switzerland	KKB Beznau I	1	Beznau	x
	KKB Beznau II	1	Beznau	x
	KKG Gösgen	1	Gösgen-Däniken	x
	KKL Leibstadt	1	Leibstadt	x
	KKM Mühleberg	1	Mühleberg	x
Ukraine	Chernobyl NPP	3	Chernobyl	—
	Khmelnitski 1	1	Neteshin	—
	Rovno 1 and 2	2	Kuznetsovsk	—
	Rovno 3	1	Kuznetsovsk	—
	South Ukraine 1	1	Yuzhnoukrainsk	—
	South Ukraine 2	1	Yuzhnoukrainsk	—
	South Ukraine 3	1	Yuzhnoukrainsk	—
	Zaporozhe 1	1	Energodar	—

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Ukraine (cont.)	Zaporozhe 2	1	Energodar	—
	Zaporozhe 3	1	Energodar	—
	Zaporozhe 4	1	Energodar	—
	Zaporozhe 5	1	Energodar	—
	Zaporozhe 6	1	Energodar	—
Research reactors and critical assemblies				
Algeria	NUR Reactor	1	Algiers	x
	Es Salam research reactor	1	Ain Oussera	—
Argentina	Argentine reactor-1	1	Constituyentes	—
	Argentine reactor-3	1	Ezeiza	—
	Argentine reactor-4	1	Rosario	—
	Argentine reactor-6	1	Bariloche	—
	Argentine reactor-0	1	Córdoba	—
	Argentine reactor-8	1	Pilcaniyeu	—
Australia	HIFAR	1	Lucas Heights	x
	MOATA	1	Lucas Heights	x
Austria	ASTRA	1	Seibersdorf	—
	Siemens Argonaut Reactor	1	Graz	—
	Triga II	1	Vienna	—
Bangladesh	Atomic Energy Research Est.	1	Dhaka	x
Belarus	Sosny	1	Minsk	—
Belgium	BR1-CEN	1	Mol	x
	BR2-CEN-BRO2	2	Mol	x
	CEN-Venus	1	Mol	x
	Thetis	1	Gent	x
Brazil	IEA-R1	1	São Paulo	—
	RIEN-1 Argonaut RR	1	Rio de Janeiro	—
	IPR-RI-CDTN	1	Belo Horizonte	x
	IPEN Critical assembly	1	São Paulo	—
	Subcritical assembly	1	Recife	—
Bulgaria	IRT-2000	1	Sofia	x
Canada	Biology, Chemistry, Physics	2	Chalk River	x
	McMaster	1	Hamilton	x
	NRU	1	Chalk River	x
	NRX	1	Chalk River	x
	Slowpoke-AECL	1	Ottawa	x
	Slowpoke-Dalhousie Univ.	1	Halifax	x
	Slowpoke-Ecole Polytechnique	1	Montreal	x
	Slowpoke-Kingston	1	Kingston	x
	Slowpoke-Saskatchewan	1	Saskatoon	x
	Slowpoke-Univ. of Toronto	1	Toronto	x
	Slowpoke-Univ. of Alberta	1	Edmonton	x

SAFEGUARDED FACILITIES (cont.)

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Chile	La Reina	1	Santiago	x
	Lo Aguirre	1	Santiago	x
China	HWRR	1	Beijing	x
Colombia	IAN-R1	1	Bogotá	x
Czech Republic	LR-O	1	Řež	x
	Univ. Training Reactor VR-1P	1	Prague	x
	VVR-S	1	Řež	x
Democratic People's Republic of Korea	Critical Assembly	1	Bungang-Ri, Nyongbyon	x
	IRT	1	Bungang-Ri, Nyongbyon	x
Democratic Republic of the Congo	Triga II	1	Kinshasa	x
Denmark	DR-1	1	Roskilde	x
	DR-3	1	Roskilde	x
Egypt	RR-I	1	Inshas	x
	MPR	1	Inshas	—
Finland	FIR 1	1	Otaniemi	—
Germany	BER-2	1	Berlin	x
	FH-Furtwangen	1	Furtwangen	x
	FRF-2	1	Frankfurt	x
	FRM	1	Garching	x
	GKSS-FRG1&FRG2	2	Geesthacht	x
	KFA-FRJ2	1	Jülich	x
	SUR 100	1	Bremen	x
	SUR 100	1	Hannover	x
	SUR 100	1	Kiel	x
	SUR 100	1	Hamburg	x
	SUR 100	1	Ulm	x
	SUR 100	1	Stuttgart	x
	SUR 100	1	Berlin	x
	SUR 100	1	Aachen	x
	Tech. Univ. AKR	1	Dresden	x
	Tech. Hochschule ZLR	1	Zittau	x
	Triga	1	Mainz	x
	MHH-Triga	1	Hannover	x
	DKFZ-Triga	1	Heidelberg	x
	VKT research reactor	1	Rossendorf	x
Ghana	GHARR-1	1	Legon-Accra	x
Greece	GRR-1	1	Attiki	x
Hungary	Training reactor	1	Budapest	x
	WWR-S M 10	1	Budapest	x
Indonesia	Gama	1	Yogyakarta	x
	MPR-30	1	Serpong	x
	PPTN	1	Bandung	x

SAFEGUARDED FACILITIES (cont.)

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Iran, Islamic Republic of	TRR	1	Tehran	x
	HWZPR	1	Esfahan	x
	MNSR	1	Esfahan	x
Israel	IRR-1	1	Soreq	x
Italy	AGN-201	1	Palermo	x
	Poltec.	1	Milan	x
	RTS-1	1	San Piero a Grado	x
	TAPIRO	1	Santa Maria di Galeria	x
	Triga-RC1	1	Santa Maria di Galeria	x
	Triga-2	1	Pavia	x
Jamaica	Centre for Nuclear Sciences	1	Kingston	x
Japan	DCA	1	Oarai-machi, Ibaraki-ken	x
	FCA	1	Tokai-Mura, Ibaraki-ken	x
	HTR	1	Kawasaki-shi, Kanagawa-ken	x
	HTTR	1	Higashi-gun, Ibaraki-ken	x
	JMTR	1	Higashi-gun, Ibaraki-ken	x
	JMTRCA	1	Higashi-gun, Ibaraki-ken	x
	JRR-2	1	Tokai-Mura, Ibaraki-ken	x
	JRR-3	1	Tokai-Mura, Ibaraki-ken	x
	JRR-4	1	Tokai-Mura, Ibaraki-ken	x
	Kinki University reactor	1	Higashiosaka-shi, Osaka-fu	x
	KUCA	3	Osaka	x
	KUR	1	Sennan-gun, Osaka	x
	Musashi reactor	1	Kawasaki-shi, Kanagawa-ken	x
	NCA	1	Kawasaki-shi	x
	NSRR	1	Tokai-Mura, Ibaraki-ken	x
	Rikkyo University R.R.	1	Nagasaka, Kanagawa-ken	x
	TCA	1	Tokai-Mura, Ibaraki-ken	x
	TODAI	1	Tokai-Mura, Ibaraki-ken	x
	TTR	1	Kawasaki-shi, Kanagawa-ken	x
	VHTRC	1	Tokai-Mura, Ibaraki-ken	x
Kazakhstan	Kurchatov test reactor	3	Semipalatinsk	—
	WWR-K	1	Almaty	—
Korea, Republic of	Triga II and III	2	Seoul	x
	Kyunghee Univ.	1	Suwoon	x
	Hanaro	1	Taejon	x
Latvia	IRT	1	Riga	x
Libyan Arab Jamahiriya	IRT reactor	1	Tajura	x
Malaysia	Puspati	1	Bangi, Selangor	x
Mexico	Triga Mark III	1	Ocoyoacac	x
Netherlands	HOR	1	Delft	x
	HFR	1	Petten	x
	LFR	1	Petten	x

SAFEGUARDED FACILITIES (cont.)

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Norway	HBWR-Halden	1	Halden	x
	JEEP-II	1	Kjeller	x
Pakistan	PARR-1	1	Rawalpindi	x
	PARR-2	1	Rawalpindi	x
Peru	RP-0	1	Lima	x
	RP-1O	1	Lima	x
Philippines	PRR-1	1	Quezon City, Diliman	x
Poland	Agata and Anna	2	Świerk	x
	Ewa	1	Świerk	x
	Maria	1	Świerk	x
Portugal	RPI	1	Sacavem	x
Romania	Triga II	1	Piteşti Colibaşi	x
	VVR-S	2	Magurele	x
Slovenia	Triga II	1	Ljubljana	x
South Africa	SAFARI-1	1	Pelindaba	x
Sweden	Studsvik RR	2	Studsvik	—
Switzerland	AGN 211P	1	Basel	x
	Crocus	1	Lausanne	x
	Proteus	1	Würenlingen	x
	Saphir	1	Würenlingen	x
Syrian Arab Republic	MNSR	1	Damascus	x
Thailand	TRR-1	1	Bangkok	x
Turkey	Çekmece Nuclear Research and Training Centre	1	Istanbul	x
	ITU-TRR Triga Mark II	1	Istanbul	x
Ukraine	Kiev RR	1	Kiev	—
	IR-100 RR	1	Sevastopol	—
Uruguay	Centro Investigaciones Nucleares	1	Montevideo	x
Uzbekistan	Photon	1	Tashkent	—
	WWR-SM	1	Tashkent	—
Venezuela	RV-I	1	Altos de Pipe	x
Viet Nam	Da Lat Research Reactor	1	Da Lat, Lam Dong	x
Yugoslavia Fed. Rep. of	RA-RB	2	Vinča	x

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Conversion plants, including pilot plants				
Argentina	UF_6 production facility		Pilcaniyeu	—
	UO_2 conversion plant		Córdoba	—
Canada	CAMECO		Port Hope	x
Chile	Lab. exper. de conversión		Santiago	x
Japan	JCO conv. plant		Tokai-Mura, Ibaraki-ken	x
	Ningyo R&D		Tomata-gun, Okayama-ken	x
	PCDF		Tokai-Mura, Ibaraki-ken	x
Mexico	Fuel fabrication pilot plant		Salazar	x
Romania	UO_2 powder fabrication plant		Feldioara	—
South Africa	Conversion plant		Pelindaba	x
	HEU-UF_6 production plant		Pelindaba	x
Sweden	Ranstad Mineral		Ranstad	—
Fuel fabrication plants, including pilot plants				
Argentina	Experimental plant		Constituyentes	—
	Fuel fabrication plant		Ezeiza	—
	Fuel fabrication plant		Constituyentes	—
Belgium	BN-MOX		Dessel	x
	FBFC		Dessel	x
	FBFC MOX		Dessel	—
Brazil	Fuel fabrication plant		Resende	—
	Fuel tech. co-ord. unit		São Paulo	—
Canada	CRNL fuel fabrication		Chalk River	x
	Fuel fabrication facility		Chalk River	x
	GEC, Inc.		Toronto	x
	GEC, Inc.		Peterborough	x
	Zircatec		Port Hope	x
Chile	UMF		Santiago	—
Democratic People's Republic of Korea	Nuclear fuel fabrication plant		Nyongbyon	—
Denmark	Metallurgy		Roskilde	x
Egypt	FMPP		Inshas	—
Germany	Adv. Nuclear Fuels		Lingen	x
	NUKEM		Wolfgang	x
	Siemens Uran (two units)		Hanau	x
	Siemens MOX		Hanau	x
India	Ceramic fuel fab. assembly area		Hyderabad	x
	EFFP-NFC		Hyderabad	x

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Indonesia	Experimental fuel element installation (IEBE)		Serpong	x
	Research reactor fuel element production installation (IPEBRR)		Serpong	x
Iran, Islamic Rep. of	Fuel fabrication lab.		Esfahan	—
Italy	Fabnuc		Bosco Marengo	x
Japan	JNF		Yokosuka-shi, Kanagawa-ken	x
	MNF		Tokai-Mura, Ibaraki-ken	x
	NFI (Kumatori-1)		Sennan-gun, Osaka	x
	NFI (Kumatori-2)		Sennan-gun, Osaka	x
	NFI Tokai		Tokai-Mura, Ibaraki-ken	x
	PFPF		Tokai-Mura, Ibaraki-ken	x
	PPFF		Tokai-Mura, Ibaraki-ken	x
Kazakhstan	Ulbinski Metallurgical Works		Kamenogorsk	—
Korea, Republic of	CANDU fuel fabrication plant		Taejon	x
	KNFFP		Taejon	x
Romania	Romfuel		Piteşti Colibasi	x
South Africa	MTR fuel fabrication		Pelindaba	x
	LEU fuel fabrication		Pelindaba	x
Spain	ENUSA fuel fabrication plant		Juzbado	—
Sweden	ABB		Västeras	—
Chemical reprocessing plants, including pilot plants				
Democratic People's Republic of Korea	Radiochemical Laboratory		Bungang-Ri, Nyongbyon	—
Germany	WAK		Eggenstein-Leopoldshafen	x
India	PREFRE		Tarapur	x
Italy	EURE		Saluggia	x
	ITREC-Trisaia		Rotondella	x
Japan	Tokai reprocessing plant		Tokai-Mura, Ibaraki-ken	x
In addition, the following R&D facilities and locations are associated with reprocessing technology:				
Argentina	*Fission products div.*		*Ezeira*	—
Brazil	*Reprocessing project*		*São Paulo*	—
Indonesia	*RMI*		*Serpong*	—
Japan	*SCF*		*Tokai-Mura, Ibaraki-ken*	*x*
	JAERI Tokai R&D		*Tokai-Mura, Ibaraki-ken*	*x*
	PNC Tokai R&D		*Tokai-Mura, Ibaraki-ken*	*x*
	Sumitomi Met. Mining		*Tokai-Mura, Ibaraki-ken*	*x*

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Enrichment plants, including pilot plants				
Argentina	Pilcaniyeu enrichment plant		Pilcaniyeu	—
Brazil	Enrichment plant (first cascade)		Resende	—
	Enrichment laboratory		Ipero	—
	Uranium enrichment pilot plant		São Paulo	—
	Laser spectroscopy lab.		San jose dos Campos	—
China	Shaanxi		Han Zhang	—
Germany	UTA-1		Gronau	x
Japan	Uranium Enrichment Plant		Tomata-gun, Okayama-ken	x
	Rokkasho Enrichment Plant		Kamikita-gun, Aomori-ken	x
Netherlands	URENCO		Almelo	x
South Africa	Semi-commercial enrichment plant		Pelindaba	x
	MLIS enrichment plant		Valindaba	—
United Kingdom	URENCO E22		Capenhurst	x
	URENCO A3 plant		Capenhurst	—
In addition, the following R&D facilities and locations are associated with enrichment technology:				
Brazil	*UF_6 laboratory*		*Belo Horizonte*	—
Germany	*Urenco*		*Jülich*	—
Japan	*Asahi Chemical Industry*		*Hyuga-shi, Miyazaki-ken*	*x*
	Communication Equipment Works		*Tokai-Mura, Ibaraki-ken*	*x*
	Hitachi laboratory		*Hitachi-shi, Ibaraki-ken*	*x*
	JAERI Tokai R&D		*Tokai-Mura, Ibaraki-ken*	*x*
	PNC Tokai R&D		*Tokai-Mura, Ibaraki-ken*	*x*
	Toshiba R&D Centre		*Kawasaki-shi, Kanagawa-ken*	*x*
Netherlands	*Urenco*		*Almelo*	*x*
	Ultra-centrifuge		*Almelo*	—
Separate storage facilities				
Argentina	Central store		Ezeiza	—
	Central store		Constituyentes	—
	Nuclear material store		Constituyentes	—
Australia	Vault storage		Lucas Heights	x
Belgium	Belgoprocess		Dessel	x
	Elbel		Beveren	—
	Wet Store		Tihange	—
Brazil	Aramar stores (2 units)		Ipero	—
	UF_6 production facility		São Paulo	—
Bulgaria	Long term storage		Kozloduy	x
Canada	Nuclear material		Chalk River	x
	Spent fuel canister store		Chalk River	x
	Douglas Point dry storage		Tiverton	x

SAFEGUARDED FACILITIES (cont.)

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
	Gentilly-1		Gentilly	x
	Spent fuel storage		Chalk River	x
	AECL Research		Pinawa	x
	PUFDSF		Pickering	x
Czech Republic	Storage Škoda		Bolevec	x
	HLW store		Řež	—
	ISFS Dukovany		Dukovany	—
Democratic People's Republic of Korea	Nuclear fuel storage		Bungang-Ri, Nyongbyon	—
Denmark	Risø Store		Roskilde	x
	Risø Waste		Roskilde	—
Finland	TVO-KPA store		Olkiluoto	—
France	Cogéma UP2 and UP3		La Hague	x
Germany	Bundeslager		Wolfgang	—
	ANF UF_6 Lager		Lingen	x
	KFA AVR BL		Jülich	—
	KFA AVR		Jülich	x
	BZA-Ahaus		Ahaus	—
	NCS-Lagerhalle		Hanau	—
	Energiewerke Nord GmbH		Lubmin	x
	Energiewerke Nord-ZLN		Lubmin	—
	Transportbehälterlager		Gorleben	—
	TR Halle 87		Rossendorf	—
	Kernmateriallager		Rossendorf	—
Hungary	Central radionuclide store		Budapest	x
	MVDS		Paks	—
India	AFR		Tarapur	x
Indonesia	TC and ISFSF		Serpong	—
Italy	Compes. deposito		Saluggia	x
	Essor nuclear plant		Ispra	—
	Essor storage		Ispra	x
	Research centre		Ispra	—
Japan	KUFFS		Kyoto	x
	Fukushima Dai-Ichi SFS		Futaba-gun, Fukushima-ken	—
	N. S. Mutsu		Mutsu-shi, Aomori-ken	x
	RCTS		Kamikita-gun, Aomori-ken	—
	RSFS		Kamikita-gun, Aomori-ken	x
Kazakhstan	Ulbinski Thorium Storage		Kamenogorsk	—
Netherlands	Covra Store		Vlissingen	—
Pakistan	Hawks Bay depot		Karachi	x

SAFEGUARDED FACILITIES (cont.)

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Portugal	Inst. de Armazenagem		Sacavem	x
Russian Federation	Mashinostroitel'nyi Zavod		Ehlektrostal	—
Slovakia	AFRS		Bohunice	x
South Africa	Waste storage		Pelindaba	—
	Bulk storage facility		Pelindaba	x
	HEU storage vault		Pelindaba	x
	Thabana pipe store		Pelindaba	x
Spain	CIEM		Madrid	—
Sweden	Central long term storage		Oskarshamn	—
Ukraine	Chernobyl storage		Chernobyl	—
United Kingdom	Thorp R&S		Sellafield	x
	Special nuclear material store 9		Sellafield	x
	Thorp Plutonium Store		Sellafield	—
United States of America	Pu storage vault		Hanford, WA	—
	Y-12 plant		Oak Ridge, TN	x
	Vault		Golden, CO	—
Other facilities				
Algeria	UDEC		Draria	—
	Es Salam reactor		Ain Oussera	—
Argentina	Alpha facility		Constituyentes	—
	Experimental UO_2 plant		Cordoba	—
	Enriched uranium lab.		Ezeiza	—
	Fission products div.		Ezeiza	—
	Fuel fabrication plant		Ezeiza	—
	Uranium powder fab. plant		Constituyentes	—
	Triple Altura Lab.		Ezeiza	—
Australia	Research Lab.		Lucas Heights	x
Belgium	IRMM-Geel		Geel	x
	CEN-Labo		Mol	x
	CEN-Waste		Dessel	—
	I.R.E.		Fleurus	x
	CEN-lab. Pu		Mol	x
Brazil	Isotope laboratory		São Paulo	—
	Nuclear material lab.		Ipero	—
	Safeguards store		São Paulo	x
Czech Republic	Nuclear Fuel Inst. (UJP)		Zbraslav	x
	Research Laboratories		Řež	x
Democratic People's Republic of Korea	Subcritical assembly		Pyongyang	x

SAFEGUARDED FACILITIES (cont.)

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Germany	KFA-heisse Zellen		Jülich	x
	KFK-heisse Zellen		Eggenstein-Leopoldshafen	x
	KFK-IHCH		Eggenstein-Leopoldshafen	x
	Siemens heisse Zellen		Karlstein	x
	KFA Lab.		Jülich	x
	Transuran		Eggenstein-Leopoldshafen	x
	VKT. Tec. ZTR		Rossendorf	x
Hungary	Institute of Isotopes		Budapest	x
Indonesia	RMI		Serpong	—
Iran, Islamic Republic of	LWSCR		Esfahan	x
	GSCR		Esfahan	—
Italy	CNEN-LAB. PU.		Santa Maria di Galeria	x
Japan	JAERI-Oarai R&D		Higashi-gun, Ibaraki-ken	x
	JAERI-Tokai R&D		Tokai-Mura, Ibaraki-ken	x
	Kumatori R&D		Sennan-gun, Osaka	x
	Mitsui Iwakuni-Ohtake		Kuga-gun, Yamaguchi	x
	Mitsui Toatsu		Takai-shi, Osaka-fu	x
	NDC Fuel Hot Lab.		Tokai-Mura, Ibaraki-ken	x
	NDC fuel laboratories		Tokai-Mura, Ibaraki-ken	x
	NERL, University of Tokyo		Tokai-Mura, Ibaraki-ken	x
	NFD		Higashi-gun, Ibaraki-ken	x
	NFI Tokai-2		Tokai-Mura, Ibaraki-ken	x
	NRF Neutron Radiation Facility		Tsukuba-shi, Ibaraki-ken	x
	PNC FMF		Higashi-gun, Ibaraki-ken	x
	PNC IRAF		Higashi-gun, Ibaraki-ken	x
	PNC-Oarai R&D		Higashi-gun, Ibaraki-ken	x
	PNC-Tokai R&D		Tokai-Mura, Ibaraki-ken	x
	SCF		Tokai-Mura, Ibaraki-ken	x
	Showa-Kawasaki		Kawasaki-shi, Kanagawa-ken	x
	Sumitomo-Chiba		Sodegaura-shi, Chiba-ken	x
	Uranium Material Laboratory		Higashi-gun, Ibaraki-ken	x
Korea, Republic of	PIEF		Daejeon	x
	Acrylonitrile plant		Ulsan	—
	DFDF		Taejon	—
	HFFL		Taejon	x
	IMEF		Taejon	x
Netherlands	ECN and JRC		Petten	x
Norway	Research laboratories		Kjeller	x
Poland	Institute for Nuclear Chemistry and Engineering		Warsaw	—
	Institute of Nuclear Research		Świerk	x
South Africa	Decommissioned pilot enrichment plant		Pelindaba	x
	Decontamination and waste recovery		Pelindaba	—
	Hot Cell Complex		Pelindaba	x
	NU and DU metals plant		Pelindaba	x

SAFEGUARDED FACILITIES (cont.)

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Switzerland	EIR		Würenlingen	x
	CERN		Geneva	x
Turkey	Nuclear fuel pilot plant		Istanbul	x
Ukraine	Chernobyl unit 4		Chernobyl	—
	Khmelnitski FF Storage		Neteshin	—
	KHFTI		Kharkov	—
	Rovno FF Storage		Kuznetsovsk	—
	South Ukraine Storage		Yuzhnoukrainsk	—
	Zaporozhe FF Storage		Energodar	—
	Sevastopol subcritical assembly		Sevastopol	—
United States of America	B&W NNFD		Lynchburg, VA	—
Non-nuclear installations				
Cuba	Storage of equipment		Prov. Havana	—

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

Note: The Agency was also applying safeguards in Taiwan, China, at six power reactors, five research reactors/critical assemblies, one uranium pilot conversion plant, two fuel fabrication plants, one storage facility and one R&D facility.

Locations in Iraq containing nuclear material which are under the responsibility of the IAEA Action Team under United Nations Security Council Resolution 687

Location C	In the vicinity of Al Tuwaitha

ADDITIONAL SAFEGUARDS SUPPORT PROVIDED BY STATES

States and organizations representing groups of States having formal support programmes	States having R&D contracts and test programmes
Argentina	Argentina
Australia	Austria
Belgium	Latvia
Canada	Pakistan
EURATOM	Russian Federation
Finland	
France	
Germany	
Hungary	
Japan	
Republic of Korea	
Netherlands	
Russian Federation	
Sweden	
United Kingdom	
United States of America	

MAIN EQUIPMENT AND ACTIVITIES IN SUPPORT OF SAFEGUARDS

	1997	1998
Gamma ray measurement systems	Total in inventory	
Low resolution systems (assay probes)	78	78
High resolution systems (analysers)	43	42
Portable multichannel analysers	263	304
Detectors	629	759
Neutron measurement systems		
Detection heads for active neutron measurements	29	30
Detection heads for passive neutron measurements	32	34
Neutron coincidence counting electronics	92	102
Spent fuel measurement systems		
Cerenkov glow viewing devices	87	97
Spent fuel radiation measuring systems	143	165
Irradiated fuel measuring electronics	67	77
Other measurement systems		
Physical properties devices	134	147
Optical surveillance systems		
Photo cameras	943	891
Video single camera systems	402	456
Video multiple camera systems	30	65
Video review stations	81	86
Seals		
In situ verifiable seals	1 350	1 327
Radiation monitoring systems	57	74
Activities		
Metal cap seals issued	18 200	18 600
Metal cap seals verified	18 140	19 301
Shipment of equipment and supplies	618	554
Hand carried transport of equipment and supplies	552	656
Shipment of reference material and chemicals to facilities	161	170
Shipment of inspection samples, radioactive material standards and contaminated items to the Safeguards Analytical Laboratory	243	202
Procurement actions	1 908	1 707

Agreement on the Privileges and Immunities of the IAEA (reproduced in document INFCIRC/9/Rev. 1). In 1998, two States adhered to the Agreement. By the end of the year, there were 67 Parties.

Vienna Convention on Civil Liability for Nuclear Damage (reproduced in document INFCIRC/500). Entered into force on 12 November 1977. In 1998, 3 States adhered to the Convention. By the end of the year, there were 31 Parties.

Convention on the Physical Protection of Nuclear Material (reproduced in INFCIRC/274/Rev.1). Entered into force on 8 February 1987. In 1998, 4 States adhered to the Convention. By the end of the year, there were 63 Parties.

Convention on Early Notification of a Nuclear Accident (reproduced in INFCIRC/335). Entered into force on 27 October 1986. In 1998, 2 States adhered to the Convention. By the end of the year, there were 82 Parties.

Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (reproduced in INFCIRC/336). Entered into force on 26 February 1987. In 1998, 2 States adhered to the Convention. By the end of the year, there were 77 Parties.

Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention (reproduced in INFCIRC/402). Entered into force on 27 April 1992. Its status remained unchanged during 1998, with 20 Parties.

Convention on Nuclear Safety (reproduced in INFCIRC/449). Entered into force on 24 October 1996. In 1998, 7 States adhered to the Convention. By the end of the year, there were 49 Parties.

Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (reproduced in INFCIRC/546). Opened for signature on 29 September 1997. In 1998, 5 States adhered to the Convention. By the end of the year, there were 5 Contracting States and 37 Signatories.

Protocol to Amend the Vienna Convention on Civil Liability for Nuclear Damage (reproduced in INFCIRC/566). Opened for signature on 29 September 1997. In 1998, 1 State adhered to the Protocol. By the end of 1998, there was 1 Contracting State and 14 Signatories.

Convention on Supplementary Compensation for Nuclear Damage (reproduced in INFCIRC/567). Opened for signature on 29 September 1997. In 1998, 4 States signed the Convention. By the end of 1998, there were 13 Signatories.

Extension of the African Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (AFRA) (reproduced in INFCIRC/377). Entered into force on 4 April 1995. In 1998, 3 States adhered to the Extension. By the end of the year, there were 24 Parties.

Second Agreement to Extend the 1987 Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (RCA). Entered into force on 12 June 1997. In 1998, 4 States adhered to the Agreement. By the end of the year, there were 17 Parties.

Revised Supplementary Agreement Concerning the Provision of Technical Assistance by the IAEA (RSA). In 1998, 1 State concluded the Agreement. By the end of the year, there were 88 States that concluded RSA Agreements.

Co-operation Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean (ARCAL). Opened for signature on 25 September 1998. By the end of the year, there were 12 Signatories.

CO-ORDINATED RESEARCH PROJECTS

(with year of start and completion)

Nuclear power		
Case studies to assess and compare different energy sources in sustainable energy and electricity supply strategies	1996	2001
Assuring the structural integrity of the reactor pressure vessel	1996	1999
Nuclear power plant outage coding system	1998	2001
Design and evaluation of heat utilization systems for the high temperature engineering test reactor (HTTR)	1993	1999
Thermohydraulic relationships for advanced water cooled reactors	1994	1999
Evaluation of high temperature gas cooled reactor performance	1997	2002
Intercomparison of analysis methods for seismically isolated nuclear structures	1996	2000
Harmonization and validation of fast reactor thermomechanical and thermohydraulic codes and relations using experimental data	1996	1999
Potential of thorium based fuel cycles to constrain plutonium and to reduce long term waste toxicities	1995	1999
Use of a thorium based fuel cycle in accelerator driven systems (ADS) to incinerate plutonium and to reduce long term waste toxicities	1996	1999
Intercomparison of techniques for pressure tube inspection and diagnostics	1998	2001
Establishment of a thermophysical properties database for LWRs and HWRs	1998	2002
Optimization of the coupling of nuclear reactors and desalination systems	1998	2003
Nuclear fuel cycle and waste technology		
Treatment of liquid effluent from uranium mines and mills during and after operation (post-decommissioning/rehabilitation)	1996	1999
Stress corrosion cracking of zirconium alloy fuel cladding	1994	1999
Hydrogen and hydride induced degradation of the mechanical and physical properties of zirconium based alloys	1998	2002
High temperature on-line monitoring of water chemistry and corrosion	1995	1999
Modelling of transport of radioactive substances in the primary circuit of water cooled reactors	1996	2000
Spent fuel performance assessment and research	1997	2002
Corrosion of research reactor aluminium clad spent fuel in water	1995	2000
Evaluation of the safety, environmental and non-proliferation aspects of partitioning and transmutation of actinides and fission products	1994	1998
Chemical durability and performance assessment of spent fuel and high level waste forms under simulated repository conditions	1998	2002
Combined methods of liquid radioactive waste treatment	1997	2001
Long term behaviour of low and intermediate level waste packages under repository conditions	1997	2002
Extrapolation of short term observations to time periods for isolation of long lived radioactive waste	1995	1999

Anthropogenic analogues for geological disposal of high level and long lived radioactive waste	1998	2002
New methods and techniques for optimization of decontamination for maintenance or decommissioning	1994	1998
Decommissioning techniques for research reactors	1997	2002
Site characterization techniques used in environmental restoration activities	1995	1999
Comparative assessment of energy sources		
Case studies to assess and compare different energy sources in sustainable energy and electricity supply strategies	1997	1999
Formulation of approaches to compare the potential impacts of waste from electricity generation technologies (FACTS)	1997	2001
Comparative health and environmental impacts of nuclear and other energy systems	1994	1998
Food and agriculture		
Use of nuclear techniques for optimizing fertilizer applications under irrigated wheat to increase the efficient use of fertilizers and consequently reduce environmental pollution	1993	1998
Use of nuclear and related techniques in the management of nutrients and water in rainfed arid and semi-arid areas for increasing crop production	1998	2002
Use of nuclear techniques for developing integrated nutrient and water management practices for agroforestry systems	1998	2004
Use of nuclear and related techniques for evaluating the agronomic effectiveness of phosphate fertilizers, in particular rock phosphates	1993	1998
Use of irradiated sewage sludge to increase soil fertility and crop yields and to preserve the environment	1995	1999
Use of isotope techniques in studies on the management of organic matter and nutrient turnover for increased, sustainable agricultural production and environmental preservation	1996	2001
Assessment of soil erosion through the use of caesium-137 and related techniques as a basis for soil conservation, sustainable production and environmental protection	1996	2001
Induced mutations in connection with biotechnology for crop improvement in Latin America	1993	1998
Induced mutations for sesame improvement	1993	1998
Induced mutations and other advanced technology for the production of crop mutants suitable for environmentally sustainable agriculture	1993	1998
In vitro techniques for the selection of radiation induced mutants adapted to adverse environmental conditions	1993	1998
Radioactively labelled DNA probes for crop improvement	1994	1999
Improvement of new and traditional industrial crops by induced mutations and related biotechnology	1994	1999

Cellular biology and biotechnology, including mutation techniques for creation of new useful banana genotypes	1994	1999
Genetic improvement of underutilized and neglected crops in low income food deficit countries through irradiation and related techniques	1998	2003
Development of feed supplementation strategies for improving the productivity of dairy cattle on smallholder farms in Africa	1993	1998
Use of immunoassay methods for improved diagnosis of trypanosomosis and monitoring of tsetse and trypanosomosis control programmes in Africa	1993	1999
Use of radioimmunoassay and related techniques to identify ways of improving artificial insemination programmes for cattle reared under tropical and subtropical conditions	1994	1999
Use of immunoassay technologies for the diagnosis and control of foot and mouth disease in South East Asia	1994	1999
Use of nuclear and colorimetric techniques for measuring microbial protein supply from local feed resources in ruminant animals	1996	2001
Rinderpest seromonitoring and surveillance in Africa using immunoassay technologies	1997	1999
Development and validation of standardized methods for using polymerase chain reaction and related molecular technologies for rapid and improved animal disease diagnosis	1997	2001
Monitoring of contagious bovine pleuropneumonia in Africa using enzyme immunoassays	1997	2002
Use of nuclear and related techniques to develop simple tannin assays for predicting and improving the safety and efficiency of feeding ruminants on tanniniferous tree foliage	1998	2003
Assessment of the effectiveness of vaccination strategies against Newcastle Disease and Gumboro Disease using immunoassay based technologies for increasing farmyard poultry production in Africa	1998	2004
Evaluation of insect population suppression by irradiated lepidoptera and their progeny	1992	1998
Development of female medfly attractant systems for trapping and sterility assessment	1993	1998
Medfly mating behaviour studies under field cage conditions	1993	1999
Improved attractants for enhancing the efficiency of tsetse fly suppression operations and barriers systems used in tsetse control/eradication campaigns	1994	1999
Enhancement of the sterile insect technique (SIT) through genetic transformation of arthropods using nuclear techniques	1994	2000
Molecular and genetic approaches to develop sexing strains for field application in fruit fly SIT programmes	1994	2000
Automation in tsetse mass rearing for use in sterile insect technique pogrammes	1994	2000
Application of genetics to improve the SIT for tsetse control/eradication	1997	2002
Impact of long term pesticide usage on soil properties using radiotracer techniques	1995	1999
Use of nuclear and related techniques in studies of the agroecological effects resulting from the use of pesticides in Central America	1993	1998
Use of nuclear and immunochemical methods for pesticide analysis	1993	1998

Validation of thin layer chromatographic screening methods for pesticide residue analysis (in vegetables)	1996	2001
Standardized methods to verify absorbed dose in irradiated fresh and dried fruits, and tree nuts in trade	1994	1998
Determination of the profiles of human bacterial pathogens in foods for export by the introduction of quality assured microbiological assays	1998	2002
Irradiation as a public health intervention measure to control foodborne diseases (cysticercosis/taeniasis and *Vibrio* infections) in Latin America and the Caribbean	1993	1998
Public acceptance and market development of irradiated food in Asia and the Pacific	1995	1998
Human health		
Local production and evaluation of primary reagents for the radioimmunoassay of alpha feto protein	1997	2000
Diagnosis of genetic disorders using radionuclide based molecular methods	1995	1998
Molecular typing of mycrobacteria strains in multi-drug resistant tuberculosis	1997	2000
Genotype/phenotype correlation in thalassemia and muscular dystrophy	1998	2000
Diagnosis and followup of prostatic cancer by radioimmunoassay	1996	1998
Standardization of iodine-131 treatment for hyperthyroidism with an intent to optimize radiation dose and treatment response (RCA)	1995	2000
Efficacy and toxicity of samarium-153 radiopharmaceuticals in the treatment of painful skeletal metastases	1996	1999
Diagnosis and management of patients with 'unexplained' back pain using bone single photon emission computer tomography	1997	2000
Study of the relationship between vesicoureteral reflux, pyelonephritis and renal scarring in children with urinary tract infection using nuclear medicine techniques	1997	2001
Nuclear imaging for infection and inflammation	1996	1999
Evaluation of technetium-99m based radiopharmaceuticals in the diagnosis and management of breast cancer patients	1997	2000
Research and certification of quality control and preventive maintenance of instruments in nuclear medicine centres (Asia and the Pacific)	1993	1998
Research and certification of quality control and preventive maintenance of instruments in nuclear medicine centres in Latin America	1995	1998
Validation of personal computer interface with gamma cameras and software for data processing of clinical studies (related to ARCAL)	1995	1998
Development and validation of an Internet based clinical and technical study communication system for nuclear medicine	1998	2002
Radiation responsiveness criteria for human tumours as determinant for therapeutic modality planning	1993	1998
Modern techniques in brachytherapy of cancer with special reference to the developing countries	1993	1999
Clinical application of radiosensitizers in cancer radiotherapy	1994	2001

Randomized clinical trial of radiotherapy combined with Mitomycin C in the treatment of advanced head and neck tumours	1994	2003
Quality assurance in radiotherapy for Latin America	1995	1998
Use of radiotherapy in advanced cancers	1995	2001
Regional hyperthermia combined with radiotherapy for locally advanced cancers	1997	2002
Aspects of radiobiology applicable in clinical radiotherapy: Increase of the number of fractions per week	1998	2005
Characterization and evaluation of high dose dosimetry techniques for quality assurance in radiation processing	1995	1999
Development of a quality assurance programme for Secondary Standard Dosimetry Laboratories (SSDLs)	1996	1999
Development of a quality assurance programme for radiation therapy dosimetry in developing countries	1995	2000
Dose determination with plane parallel ionization chambers in therapeutic electron and photon beams	1996	1999
Development of a Code of Practice for dose determination in photon, electron and proton beams based on measurement standards of absorbed dose to water	1997	2000
Electron paramagnetic resonance biodosimetry	1998	2000
Application of stable isotope tracer methods to studies of amino acid, protein, and energy metabolism in malnourished populations of developing countries	1993	1998
Comparative international studies of osteoporosis using isotope techniques	1994	2000
Development and application of isotopic techniques in studies of vitamin A nutrition	1995	1999
Isotopic evaluations of maternal and child nutrition to help prevent stunting	1996	1999
Isotopic evaluations in infant growth monitoring	1998	2000
Application of nuclear techniques in the prevention of degenerative diseases (obesity and non-insulin dependent diabetes) in ageing	1998	2001
Reference Asian Man Project (Phase 2): Ingestion and organ content of trace elements of importance in radiological protection (RCA)	1995	2000
Applied research on air pollution using nuclear related analytical techniques in the Asia and Pacific Region (RCA)	1995	1998
Assessment of levels and health effects of airborne particulate matter in mining, metal refining and metal working industries using nuclear and related analytical techniques	1996	2000
Validation and application of plants as biomonitors of trace element atmospheric pollution, analysed by nuclear and related techniques	1997	2002
Marine environment, water resources and industry		
Use of radiation processing to prepare biomaterials for applications in medicine	1995	1999
Improvement of physical properties of radiation vulcanized natural rubber latex (RCA)	1998	2000
Radiation processing of indigenous natural polymers (RCA)	1995	1999
Radiotracer technology for engineering unit operation studies and unit process optimization	1998	2001

Use of radiation processing for sterilization or decontamination of pharmaceuticals and pharmaceutical raw materials	1998	2000
Irradiation treatment of water, wastewater and sludge	1995	1999
Validation of protocols for corrosion and deposit evaluation in pipes by radiography	1997	2000
Physical and chemical sciences		
Development of agents for imaging CNS receptor based on technetium-99m	1996	1999
Technetium-99m labelled peptides for imaging peripheral receptors	1996	1999
Development of kits for radioimmunometric assays of tumour markers	1997	2000
Optimization of production and quality control of therapeutic radionuclides and radiopharmaceuticals	1994	1998
Optimization of synthesis and quality control procedures for iodine-123 and fluorine-18 labelled peptides	1996	1999
Validation of nuclear techniques for the analysis of precious and rare metals in mineral concentrates	1996	1999
Nuclear analytical techniques in archaeological investigations	1996	1999
Establishment of an international reference data library of nuclear activation cross-sections	1993	1998
Development of a reference input parameter library for nuclear model calculations of nuclear data (Phase I: starter file)	1994	1998
Development of a reference charged particle cross-section database for medical radioisotope production	1995	1998
Atomic and plasma wall interaction data for fusion reactor divertor modelling	1995	2000
Compilation and evaluation of photonuclear data for applications	1996	1999
Fission product yield data required for transmutation of minor actinide nuclear waste	1997	2001
Charge exchange cross-section data for fusion plasma studies	1997	2002
Plasma material interaction data for mixed plasma facing materials in fusion reactors	1997	2002
Nuclear model parameter testing for nuclear data evaluation (Reference input parameter library: Phase II)	1998	2002
Update of X and gamma ray decay data standards for detector calibration	1998	2002
Specialized software utilities for gamma ray spectrometry	1996	2000
Bulk hydrogen analysis using neutrons	1997	2000
Development of computer based troubleshooting tools and instruments	1996	2000
Application of MeV ion beams for the development and characterization of semiconductor materials	1997	2000
Analysis of research reactor transients	1995	1999
WIMS-D library update	1998	2000
Engineering, industrial and environmental applications of plasma physics and fusion technologies	1996	1999
Comparison of compact toroidal configurations	1998	2002

Nuclear safety		
Development of methodologies for optimization of surveillance testing and maintenance of safety related equipment at nuclear power plants	1996	1999
Investigation of methodologies for incident analysis	1997	2000
Round robin exercise of WWER-440 reactor pressure vessel weld metal irradiation embrittlement and annealing	1996	1999
Management of ageing of in-containment instrumentation and control cables	1992	1998
Application of non-destructive testing and in-service inspection to research reactors	1995	1998
Safety of RBMK nuclear power plants in relation to external events	1997	2000
Validation of accident and safety analysis methodology	1995	1999
Radiation safety		
Intercomparison for individual monitoring of external exposure from photon radiation	1996	2000
Intercomparison and biokinetic model validation of radionuclide intake assessment	1997	2000
Development of relevant accident data for quantifying risks associated with the transport of radioactive material	1994	1998
Development of a radiological basis for the transport safety requirements for low specific activity materials and surface contaminated objects	1997	2001
Accident severity during air transport of radioactive material	1998	2001
Regional personal dosimetry intercomparison	1996	1998
Limitations of radioepidemiological assessments for stochastic radiation effects, in relation to radiation protection	1994	1998
Cytogenetic biodosimetry	1998	2000
Radiation protection in diagnostic radiology in Asia and the Far East	1994	1998
Radiation protection in diagnostic radiology in Eastern European countries	1994	1998
Radioactive waste safety		
Biosphere Modelling and Assessment methods (BIOMASS)	1996	2002
Improvement of safety assessment methodologies for near surface disposal facilities for radioactive waste	1997	2000
Formulation of approaches to compare the potential impacts of wastes from electricity generation technologies	1997	2000

Nuclear power	
Regional workshop on upgrading and modernization of instrumentation and control of WWER 440/213 nuclear power plants	Czech Republic
Regional workshop on the organization and management of the technical support for nuclear power plant operation	Slovakia
Regional workshop on flaw discrimination and sizing methods and techniques	Spain
Regional workshop on on-line testing of nuclear plant temperature and pressure instrumentation and other critical plant equipment	Slovakia
Regional workshop on planning and management support for nuclear power plant personnel systematic approach to training based programmes	Hungary
Regional workshop on ageing and life management of nuclear power plants	Finland
Interregional course on training and qualification of nuclear power plant personnel and management responsibilities	Germany; Spain
International seminar on nuclear power in developing countries: Its potential role and strategies for its deployment	India
Regional course on nuclear power plant maintenance	Hungary; Spain
Regional workshop on optimization of nuclear power plant maintenance	India
Regional course on modernization of instrumentation and control in nuclear power plants	Germany
Regional East Asia and Pacific workshop on co-operation among the RCA Member States in the region on nuclear power planning and implementation	Rep. of Korea
Nuclear fuel cycle and waste technology	
Interregional course on spatial data integration for uranium exploration, resource assessment and environmental studies	Slovenia
Interregional course on decontamination and decommissioning of research reactors and other small nuclear facilities	USA
Regional course on quality assurance in fuel fabrication	France
Regional workshop on implementation of the WWER version of the TRANSURANUS code and safety criteria	Bulgaria
National workshop on quality assurance of nuclear fuel	China
Regional workshop on planning and management of decommissioning for WWER reactors	Austria; Japan
Regional workshop on the use and management of the Agency's sealed radiation sources registry	South Africa
Regional course on the management of radioactive waste from the medical use of radionuclides	Tunisia
Regional workshop to formulate guidance on management of radioactive waste from nuclear applications and guidance on consumer products containing radioactive substances	Nigeria
Comparative assessment of energy sources	
Interregional course on electric system expansion planning (WASP-IV/DECPAC)	USA
Regional course on economic analyses of nuclear electricity generation costs and comparison with other energy sources	Philippines
Regional course on comparative assessment of nuclear power and other energy sources in support of sustainable energy development	Rep. of Korea

National seminar on the use of the DECADES tools for the comparative assessment of energy sources	Israel
National workshop on the use of the DECADES tools for the comparative assessment of energy sources	Egypt
National seminar on the comparative assessment of options and strategies for electricity generation	China
Workshop on enhanced electricity system planning	Portugal
Seminar on the future energy outlook	Headquarters
Regional course on externalities associated with electricity generation: Concepts and estimation	Rep. of Korea
Regional workshop on the analysis of the economic and financial aspects of nuclear power programmes using the Agency's FINPLAN model	Croatia
Food and agriculture	
FAO/IAEA workshop on the use of nuclear techniques for developing sustainable soil, water and nutrient management practices	France
FAO/IAEA advanced regional workshop on quality assurance for nitrogen-15 analysis	Uruguay
FAO/IAEA workshop on external quality assurance for nitrogen-15 analyses by optical emission spectrometry	Mexico
FAO/IAEA in-country workshop for the interregional project on sustainable utilisation of saline groundwater and wastelands for plant production	Morocco; Tunisia
FAO/IAEA national course on the use of nuclear techniques in studies of soil fertility, fertilizers and water management	Guatemala
FAO/IAEA national course/workshop on the use of nuclear techniques to evaluate the dynamics of nutrients and water in cropping and tillage systems	Venezuela
FAO/IAEA course on water and soil sampling, analytical techniques and use of neutron moisture probes	Pakistan
FAO/IAEA course on hydrological studies on the project site, with particular reference to isotopic techniques	Pakistan
FAO/IAEA course on nuclear and related techniques used in the study of soil physical, chemical and biological parameters and the effects of salinity and plant growth on these parameters	Pakistan
FAO/IAEA regional course for West Asia on the use of nuclear techniques in water and nutrient management practices	Syrian Arab Republic
FAO/IAEA third co-ordination workshop for East Asia and the Pacific on nuclear techniques for the promotion of agroforestry systems	Malaysia
FAO/IAEA second co-ordination workshop for Latin America on plant nutrition, soil and water management (ARCAL XXII)	Chile
FAO/IAEA group fellowship training on water use efficiency (AFRA III)	Agency's Laboratories, Seibersdorf
Selection methods for drought tolerance in cereals and legumes	South Africa
Regional AFRA workshop to review results of experiments	Egypt

Regional course on basic mutation and in vitro culture techniques for the improvement of vegetatively propagated crops for sustainable crop production in Africa	South Africa
Second working group on rice multi-location trials	Uruguay
Third regional workshop on improving animal production through the application of feed supplementation strategies and immunoassay techniques	Viet Nam
FAO/IAEA/PARC subregional workshop on emergency preparedness and the surveillance of Rinderpest in East Africa	Uganda
Regional workshop on external quality assurance for progesterone radioimmunoassay	Zambia
FAO/IAEA workshop on emergency preparedness and disease surveillance for southern Africa	Zimbabwe
Task force meeting on strategies for future sustainability of the applications of progesterone RIA for improving livestock production in developing Member States	Headquarters
Seminar on feasibility assessment for fruit fly eradication using the sterile insect technique	South Africa
National course on integrated area wide control of fruit flies	Thailand
Group course on plant quarantine procedures against fruit flies for quarantine inspectors and supervisors	Peru
Group course on integrated control of fruit flies, with emphasis on the sterile insect technique	Peru
Second national workshop on advances in research support for national fruit fly programme	Argentina
FAO/IEAEA/SIDA workshop on implementation of quality assurance and quality control measures in residue analysis laboratories	Hungary
Human health	
Seminar on nuclear medicine: The global perspectives	Germany
Seminar on upgrading and distribution of gamma cameras in developing countries	Germany
Regional course for nuclear medicine technologists on diagnostic and therapeutic applications of radionuclide methods	Uruguay
Regional course for nuclear medicine physicians	Hungary
Regional course on advanced molecular biology techniques for Latin America on the diagnosis of Chagas' disease and leishmaniasis	Brazil
Regional course on serological markers for hepatitis infection and its sequel	Chile
Regional course on assessing viability of myocardium using nuclear medicine techniques	Australia
Regional course on the production of basic reagents for radioimmunoassay of tumour markers and optimal diagnostic uses of the assay	Zimbabwe
Regional course on molecular biology techniques and radionuclide tracers in the control of malaria and tuberculosis	Kenya
Regional workshop on the treatment of thyroid cancer with iodine-131	Pakistan
Regional course for tumour marker assay	Pakistan

Regional workshop on scintimammography techniques	India
Regional course on nuclear cardiology	Singapore
National course on radioimmunoassay	Zambia
National course on advanced radioimmunoassay techniques	Sudan
National course on radioimmunoassay	Dem. Rep. of the Congo
Regional course on quality control and preventive maintenance of radiotherapy equipment	Jordan
Regional workshop on repair and maintenance of MEDISO gamma cameras and associated computer systems	Zambia
Regional workshop on preventive maintenance and quality control of gamma camera computer systems	Ukraine
Regional workshop on the quality control of single and multi-head single photon emission computer tomography systems	Mexico
Regional workshop on upgrading of analogue gamma camera with personal computers and relevant clinical software	Kazakhstan
Regional workshop on servicing and maintenance of medical linear accelerators	Egypt
Regional course on recommended systems for upgrading	Mexico
Regional training course on treatment planning techniques and quality assurance (AFRA)	South Africa
Regional course on quality assurance in radiation oncology	Ghana
Regional course for therapeutic radiographers in clinical quality assurance (RCA)	Singapore
Regional workshop on radiotherapeutic management of head and neck tumours (AFRA)	Cameroon
Regional workshop on mould room techniques (AFRA)	Tunisia
Regional course for therapeutic radiographers in clinical quality assurance (ARCAL XXIV)	Colombia
Regional course on radiation sterilization of tissue grafts (RCA)	Philippines
Regional course on intracavitary brachytherapy	Brazil
Regional course on clinical quality assurance for radiotherapy technicians (ARCAL)	Dominican Rep.
Regional course on intraluminal and interstitial brachytherapy (RCA)	India
Workshop on self-assessment review and public awareness in tissue banking	Malaysia
Regional course for radiotherapy technicians in clinical quality assurance (ARCAL)	Brazil
Regional course on clinical and physical aspects of quality assurance in radiation oncology	Ghana
National course on quality assurance in radiation therapy dosimetry	China
Regional course on dosimetry and treatment planning of radiotherapy treatments	Mexico
Regional course on implementation of the ARCAL XXX protocol for quality assurance in radiotherapy (physical aspects)	Cuba
Monitoring radionuclides in food and the environment	Austria; Germany
Group training fellowship on radiochemical analysis of strontium-90 and actinides in environmental samples	Austria
Marine environment, water resources and industry	
Organochlorides and organophosphates	Malaysia
Chlorinated pesticides	Cote d'Ivoire

Trace metals	Cote d'Ivoire
Pesticides for MEDPOL countries	Monaco
Trace metals for MEDPOL countries	Monaco
IAEA/PAGES–ISOMAP workshop on reconstructing the isotopic composition of past precipitation from continental archives	Headquarters
Workshop on the use of isotopes in Caspian Sea investigations	Headquarters
Interregional course on analytical techniques and quality assurance in environmental isotope techniques	Headquarters
Workshop for AFRA specialized teams	Tunisia
Regional course on technical quality management of an isotope hydrology laboratory	Headquarters
Regional workshop on training personnel in the safe operation of radiation facilities (AFRA)	Egypt
Regional workshop on radiation treatment of wastewater and drinking water (RCA)	China
Regional workshop to assess national in-service inspection needs and priorities and establish appropriate programmes and methods (AFRA)	Kenya
Regional workshop on the fabrication of non-destructive testing test pieces (RCA)	Japan
Regional workshop and course on condition monitoring of civil engineering concrete structures (AFRA)	Tunisia
Regional workshop and course on in-service inspection in the petroleum industry (RCA)	Indonesia
Regional course on radioisotope sealed source and radiotracer applications in the oil and gas industries (RCA)	Malaysia
Regional course on design, calibration and quality control of nucleonic gauges (RCA)	Viet Nam
Physical and chemical sciences	
National course on gamma ray spectrometric survey in mineral resource assessment and environmental monitoring	Portugal
Regional workshop on electronics for research reactors (ARCAL)	Argentina
National course on repair and maintenance of switch mode power supplies used in personal computers and monitors	Zambia
Regional workshop on nuclear instrumentation in Africa	Kenya
Regional course on troubleshooting, maintenance and repair of analog nuclear systems and quality control of nuclear instruments	Tunisia
Regional course on personal computer interfacing of nuclear instruments	Ghana
Workshop on industrial and environmental applications of nuclear analytical methods	Austria
Workshop on performance of portable X ray fluorescence and gamma spectroscopy systems	Austria
Regional workshop on measurements of reactor physics parameters (AFRA)	Egypt
Regional course on research reactor instrumentation technology and trends (AFRA)	Nigeria
Regional course on quality control in hospital radiopharmacy	Ghana
Workshop on production of technetium-99m radiopharmaceuticals based on human albumin and immunoglobulin (RLA)	Cuba
Course on preparation of radiopharmaceuticals based on fluorine-18 and iodine-123 (RLA)	Argentina
Workshop on quality assurance and quality control in analytical laboratories I (RLA)	Mexico

Workshop on quality assurance and quality control in analytical laboratories II (RLA)	Uruguay
Nuclear safety	
Interregional course on operator regulator interface for nuclear power plants	USA
Interregional course on advances in monitoring, assessment and enhancement of the operational safety of nuclear power plants	USA
Regional course on regulatory aspects of safety documentation of research reactors	Czech Republic
Interregional course on safety in the operation of research reactors for operators	USA
Regional workshop on human factors in nuclear safety	Slovenia
Regional workshop on modelling of external hazards in probabilistic safety analysis	Russian Federation
Regional workshop on format and content of the safety analysis report	Bulgaria
Regional workshop on safety analysis of plant modifications	Slovenia
Regional workshop on analytical methods and computational tools for nuclear power plant safety assessment	Russian Federation
Regional workshop on application of plant simulators and analysis for validating EOPs	Romania
Regional workshop on monitoring operational performance through operating experience	Czech Republic
Regional workshop on operational safety performance indicators	Slovenia
Regional workshop on severe accident management	Slovenia
Regional course on regulatory control of nuclear power plants	Germany
Regional workshop on regulatory review of plant safety analysis reports	Slovakia
Regional workshop on regulatory use of probabilistic safety analysis methods	Finland
Regional workshop on radiation protection issues in nuclear power plants	Slovenia
Regional workshop on establishment of training programmes for the regulatory staff	Finland
Regional workshop on decommissioning	Slovenia
Regional workshop on training the trainers in nuclear safety	Rep. of Korea
Regional workshop on operating organization and self-assessment of safety culture	Rep. of Korea
Regional workshop on operating experience feedback	China
Regional management workshop on operational and safety issues of nuclear power plants	China
Regional workshop on definition and maintenance of the safe operating envelope	Canada
Regional workshop on operational experience feedback and self-assessment of operational safety	Pakistan
Regional workshop on maintenance optimization	India
Radiation safety	
Regional basic professional course on radiation protection	India; Morocco
Regional basic professional course on radiation protection and nuclear safety	Argentina
National course on radiation protection	Albania; Ethiopia
Regional seminar on approaches and practices in strengthening radiation protection and waste management infrastructures in Eastern European countries	Slovakia
Regional course on techniques for external and internal dose assessment	China

Regional workshop on radiation protection in mining and milling	Zambia
Regional (Europe) workshop on the implementation and management of the 'as low as reasonably achievable' concept in nuclear power plant operation	Headquarters
National training course on radiation protection for medical personnel	Bosnia and Herzegovina
National workshop on radiation protection in radiodiagnostics, radiotherapy and nuclear medicine	Uzbekistan
Regional course on radiation protection and safety in medicine: Protection against occupational, medical and public exposure	India
National course on radiation protection and quality assurance in diagnostic radiology and safety in therapy	Latvia
Regional workshop on notification, authorization, inspection and enforcement	Thailand
Regional course on notification, authorization, inspection and enforcement	Australia; Cuba; South Africa
Regional combined workshop on the Regulatory Authority Information System (RAIS) and implementation of a regulatory programme	Lebanon
National workshop on the system of authorization and inspection of radiation sources for regulators	Viet Nam
Regional workshop on the Regulatory Authority Information System (RAIS)	Slovakia
Regional course on notification, registration, licensing and control of radiation sources	Belarus
National course on industrial radiography	The Former Yugoslav Rep. of Macedonia
National course on radiation protection in the medical use of radiation and radionuclides	Cyprus
Regional course on safe transport of radioactive materials	Germany
Regional workshop on emergency planning and preparedness	South Africa
Regional workshop on assistance in case of a nuclear accident or radiological emergency	China
Regional West Asia group training on medical emergencies in case of radiological emergencies	France
Regional course on medical education and interregional harmonization programme for nuclear accident preparedness – Echo II	Russian Federation
Regional course on medical education and interregional harmonization programme for nuclear accident preparedness – Echo III	Republic of Moldova
Regional course on medical education and interregional harmonization programme for nuclear accident preparedness – Echo IV	Estonia
Regional course on medical education and interregional harmonization programme for nuclear accident preparedness – Echo V	Ukraine
Regional train the trainers workshop on planning and preparedness, accident assessment and response to reactor accidents	Belarus; Slovakia
Regional workshop on the accident classification scheme	Headquarters
Regional workshop on the application of indirect methods for individual dosimetry of internally deposited radionuclides	Japan

Regional course on design, implementation and management of national individual monitoring service	Germany
Regional seminar on exchange of experience among thermoluminescent dosimeter RADOS users in the Baltic region	Lithuania
Regional workshop on external occupational dosimetry systems	Brazil
Radioactive waste safety	
Regional course on operational safety for near surface disposal facilities	United Kingdom
Regional workshop on analytical procedures for foodstuff contamination	Egypt
Regional workshop on environmental radiation measurements using spectrometric methods	USA
Safeguards	
Safeguards traineeship programme for junior professionals	Headquarters
Seminar on nuclear science and technology for diplomats	Headquarters
International course on State's System of Accounting and Control of Nuclear Material	Russian Federation
Regional course on State's System of Accounting and Control of Nuclear Material	Brazil
Technical workshop on safeguards, verification technologies and other related experiences	Headquarters
International seminar on safeguards information reporting and processing	Vienna
Security of material	
Regional course on physical protection of nuclear facilities and materials	Argentinia; China
Workshop on nuclear export/import controls	Headquarters
Workshop on familiarization of safeguards activies and non-destructive analysis measurement techniques	Belarus
IAEA/WCO/INTERPOL course on nuclear smuggling	Headquarters
Policy making, co-ordination and support	
Seminar on information security issues	Headquarters

Nuclear power	
Nuclear desalination of sea water	Proceedings Series
Nuclear fuel cycle and reactor strategies: Adjusting to new realities	Proceedings Series
Choosing the nuclear power option: Factors to be considered	Special publication
Decommissioning of nuclear facilities other than reactors	Technical Reports Series No. 386
Design measures to facilitate implementation of safeguards at future water cooled reactors	Technical Reports Series No. 392
Energy, electricity and nuclear power estimates for the period up to 2020: July 1998 edition	Reference Data Series No. 1
Nuclear power reactors in the world: April 1998 edition	Reference Data Series No. 2
Country nuclear power profiles	IAEA-CNPP
Advances in fast reactor technology	IAEA-TECDOC-1015
Modernization of instrumentation and control in nuclear power plants	IAEA-TECDOC-1016
Design measures for prevention and mitigation of severe accidents at advanced water cooled reactors	IAEA-TECDOC-1020
Selection, competency development and assessment of nuclear power plant managers	IAEA-TECDOC-1024
Energy and nuclear power planning study for Pakistan (covering the period 1993–2023)	IAEA-TECDOC-1030
Influence of high dose irradiation on core structural and fuel materials in advanced reactors	IAEA-TECDOC-1039
Technologies for gas cooled reactor decommissioning, fuel storage and waste disposal	IAEA-TECDOC-1043
Nuclear power plant organization and staffing for improved performance: Lessons learned	IAEA-TECDOC-1052
Technologies for improving the availability and reliability of current and future water cooled nuclear power plants	IAEA-TECDOC-1054
Nuclear heat applications: Design aspects and operating experience	IAEA-TECDOC-1056
Good practices with respect to the development and use of nuclear power plant procedures	IAEA-TECDOC-1058
Options identification programme for demonstration of nuclear desalination	IAEA-TECDOC-898
Potential for nuclear desalination as a source of low cost potable water in North Africa	IAEA-TECDOC-917
Planning for environmental restoration of uranium mining and milling sites in Central and Eastern Europe	IAEA-TECDOC-982
Advances in heavy water reactor technology	IAEA-TECDOC-984
Accelerator driven systems: Energy generation and transmutation of nuclear waste	IAEA-TECDOC-985
High temperature gas cooled reactor technology development	IAEA-TECDOC-988
Selection, specification, design and use of various nuclear power plant training simulators	IAEA-TECDOC-995
Introduction of small and medium reactors in developing countries	IAEA-TECDOC-999

Nuclear fuel cycle and waste technology	
Interim storage of radioactive waste packages	Technical Reports Series No. 390
Review of fuel failures in water cooled reactors	Technical Reports Series No. 388
Safe handling and storage of plutonium	Safety Reports Series No. 9
Spent fuel management: Current status and prospects 1997	IAEA-TECDOC-1006
Durability of spent nuclear fuels and facility components in wet storage	IAEA-TECDOC-1012
Implementation of burnup credit in spent fuel management systems	IAEA-TECDOC-1013
Characterization of radioactively contaminated sites for remediation purposes	IAEA-TECDOC-1017
Technical, institutional and economic factors important for developing a multinational radioactive waste repository	IAEA-TECDOC-1021
New methods and techniques for decontamination in maintenance or decommissioning operations	IAEA-TECDOC-1022
Factors for formulating strategies for environmental restoration	IAEA-TECDOC-1032
Critical review of uranium resources and production capability to 2020	IAEA-TECDOC-1033
Classification of uranium reserves/resources	IAEA-TECDOC-1035
Advances in fuel pellet technology for improved performance at high burnup	IAEA-TECDOC-1036
Management of small quantities of radioactive waste	IAEA-TECDOC-1041
Poolside inspection, repair and reconstitution of LWR fuel elements	IAEA-TECDOC-1050
Management of radioactive waste from molybdenum-99 production	IAEA-TECDOC-1051
Guidebook on good practices in the management of uranium mining and mill operations and the preparation for their closure	IAEA-TECDOC-1059
Comparative assessment of energy sources	
Guidelines for integrated risk assessment and management in large industrial areas	IAEA-TECDOC-994
DECADES tools user's manual for version 1.0	DECADES Project Document No. 3
Food and agriculture	
Towards livestock disease diagnosis and control in the 21st century	Proceedings Series
Combination processes for food irradiation	Panel Proceedings Series
Evaluation of genetically altered medflies for use in sterile insect technique programmes	Panel Proceedings Series
Research and development on procedures to stabilize acaricides in livestock dips	IAEA-TECDOC-983
Management of nutrients and water in rainfed arid and semi-arid areas	IAEA-TECDOC-1026
Improving yield and nitrogen fixation of grain legumes in the tropics and subtropics of Asia	IAEA-TECDOC-1027
Use of caesium-137 in the study of soil erosion and sedimentation	IAEA-TECDOC-1028
Use of nuclear techniques in the management of nitrogen fixation by trees to enhance fertility of fragile tropical soils	IAEA-TECDOC-1053
Application of DNA based marker mutations for improvement of cereals and sexually reproduced crops	IAEA-TECDOC-1010

Use of novel DNA fingerprinting techniques for the detection and characterization of genetic variation in vegetatively propagated crops	IAEA-TECDOC-1047
Plant breeding and genetics newsletter	Nos 1, 2
Animal production and health newsletter	Nos 28, 29
Diagnosis and epidemiology of animal diseases in Latin America	IAEA–TECDOC–1055
Genetic engineering technology for the improvement of the sterile insect technique	IAEA-TECDOC-993
The South American fruit fly *Anastrepha fraterculus* (Wied): Advances in artificial rearing, taxonomic status and biological studies	IAEA-TEDCDOC-1064
Insect and pest control newsletter	Nos 51, 52
Use of isotopic tracers in studies of herbicide performance on grasses and sedges	IAEA-TECDOC-1003
Human health	
In vitro radionuclide techniques in medical diagnosis	IAEA-TECDOC-1001
Quality assurance in radiotherapy	IAEA-TECDOC-989
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RIPL, Reference Input Parameters Library (CD-ROM)	IAEA-NDS-CD-02
FENDL-2, Fusion Evaluated Nuclear Data Library (CD-ROM)	IAEA-NDS-CD-03
ENDF: Five comprehensive evaluated nuclear data libraries (CD-ROM)	IAEA-NDS-CD-04
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ABBREVIATIONS

ABACC	Brazilian–Argentine Agency for Accounting and Control of Nuclear Materials
AFRA	African Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology
AGRIS	Agricultural Information System
ARCAL	Regional Co-operative Arrangements for the Promotion of Nuclear Science and Technology in Latin America
BWR	Boiling water reactor
CRP	Co-ordinated Research Project
CTBTO	Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization
EURATOM	European Atomic Energy Community
FAO	Food and Agriculture Organization of the United Nations
FORATOM	Forum atomique européen
HWR	Heavy water reactor
IAEA-MEL	IAEA Marine Environment Laboratory
ICTP	International Centre for Theoretical Physics
IIASA	International Institute for Applied Systems Analysis
ILO	International Labour Organisation
IMO	International Maritime Organization
INDC	International Nuclear Data Committee
IOC	Intergovernmental Oceanographic Commission (UNESCO)
ISO	International Organization for Standardization
LWR	Light water reactor
NEA	Nuclear Energy Agency of the OECD
OECD	Organisation for Economic Co-operation and Development
OLADE	Organización Latinoamericana de Energía
OPANAL	Organismo para la Proscripción de las Armas Nucleares en América Latina y el Caribe
PAHO	Pan American Health Organization/WHO
PHWR	Pressurized heavy water reactor
PWR	Pressurized water reactor
RAF	Regional Africa
RAS	Regional East Asia and Pacific
RAW	Regional West Asia
RBMK	Light boiling water cooled graphite moderated pressure tube reactor (former USSR)
RCA	Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology
SQ	Significant quantity
t HM	tonnes heavy metal
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organization
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
WCO	World Customs Organization
WEC	World Energy Council
WHO	World Health Organization
WTO	World Trade Organization
WWER	Water cooled and moderated energy reactor (former USSR)