ANNUAL REPORT

2000

INTERNATIONAL ATOMIC ENERGY AGENCY

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Article VI.J of the Agency's Statute requires the Board of Governors to submit "an annual report to the General Conference concerning the affairs of the Agency and any projects approved by the Agency".

This report covers the period 1 January to 31 December 2000.

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MEMBER STATES OF THE INTERNATIONAL ATOMIC ENERGY AGENCY

(as of 31 December 2000)

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ARGENTINA
ARMENIA
AUSTRALIA
AUSTRIA
BANGLADESH
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TURKEY
UGANDA
UKRAINE
UNITED ARAB EMIRATES
UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND
UNITED REPUBLIC OF TANZANIA
UNITED STATES OF AMERICA
URUGUAY
UZBEKISTAN
VENEZUELA
VIET NAM
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ZIMBABWE

The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are situated in Vienna. Its principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world".

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IAEA AT A GLANCE

(as of 31 December 2000)

- **130** Member States.
- **54** intergovernmental and non-governmental organizations worldwide have formal agreements and arrangements with the Agency.
- **43** years of international service in 2000.
- **2173** professional and support staff.
- **$199.3** million regular budget for 2000, supplemented by extrabudgetary resources amounting to $38.7 million.
- **$73** million target in 2000 for voluntary contributions to the Agency's Technical Co-operation Fund, supporting projects involving 3483 expert and lecturer assignments, 2379 meeting and workshop participants, 2263 participants in training courses and 1637 fellows and visiting scientists.
- **3** international laboratories and research centres.
- **2** liaison offices (in New York and Geneva) and 2 safeguards field offices (in Tokyo and Toronto).
- **132** active Co-ordinated Research Projects involving 2067 research contracts and agreements.
- **224** safeguards agreements in force in 140 States (and with Taiwan, China) involving 2467 safeguards inspections performed in 2000. Safeguards expenditures in 2000 amounted to $70.6 million in regular budget and $10.3 million in extrabudgetary resources.
- **15** national safeguards support programmes and 1 multinational support programme (European Union).
- **2** million plus scientific and technical bibliographic records in the International Nuclear Information System (INIS), the Agency’s largest database.

NOTE

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

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
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)

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GLOBAL PERSPECTIVES AND KEY ISSUES

The United Nations "Millennium Summit" in September 2000 highlighted a number of objectives in its "Millennium Declaration" to which it assigned special significance. These covered, among others, the areas of: peace, security and disarmament; development and the eradication of poverty; and protection of the environment. In the efforts to realize these objectives, the Agency plays a modest but important role.

In carrying out its mandate, the Agency groups its activities under the three "pillars" of *technology, safety* and *verification*. Specifically, the Agency seeks to: act as a catalyst for the development and transfer of peaceful nuclear technologies; build and maintain a global nuclear safety regime; and assist in global efforts to prevent the proliferation of nuclear weapons. This chapter reviews some of the key issues and events in 2000 as they relate to the Agency's programme of work.

TECHNOLOGY

Nuclear power around the world

Over the past 50 years, nuclear power has become an important part of the energy mix in many countries. At the end of 2000, there were 438 operating nuclear power reactors. This was equal to 351 GW(e) of installed capacity. Together they provided about 16% of global electricity generation. Six new power reactors, with a total capacity of 3056 MW(e), were connected to their respective national electricity grids in 2000. Three of these were in India, while Brazil, the Czech Republic and Pakistan each had one. One reactor was shut down — Chernobyl-3 in Ukraine.

Over 30 countries are using nuclear power to produce electricity. In 2000, its share of total electricity generation ranged from 76% in France to 1.4% in Brazil. The construction of 31 new power reactors continued in Argentina, China, the Czech Republic, the Islamic Republic of Iran, Japan, the Republic of Korea, the Russian Federation, Romania, Slovakia and Ukraine. National energy plans envisage additional reactors in China, the Democratic People's Republic of Korea, India, the Islamic Republic of Iran, Japan, the Republic of Korea and the Russian Federation. In November, the Finnish utility TVO applied for a government decision "in principle" to build a fifth nuclear power plant. This is the first such initiative in western Europe in many years. On the other hand, the German Government and utilities concluded an agreement to phase out Germany's 19 nuclear power plants. The agreement allows nuclear power plants to operate for an average lifetime of 32 years.

The coming on line of six new power reactors in 2000 still represents only about 3% of estimated total world electricity capacity *additions* in 2000. This is considerably less than nuclear power's 16% share of global electricity *generation*. Projections show that this pattern is expected to continue in the near term, in which case nuclear power's share of electricity production in the coming decade would decline.

While a survey of global nuclear power plant construction plans indicates that, in contrast to Asia, no new plants are being built or have been ordered in North America and western Europe, the economics of *existing* nuclear power plants showed improvement in 2000, particularly in North America. The USA enjoyed record capacity factors, outputs, low costs and short refuelling outages. Moreover, capacity factor improvements in the USA since 1998 have been equivalent to nine new 1000 MW(e) reactors. The US Nuclear Regulatory Commission also granted its first

two 20-year licence renewals. The licensed reactor lifetime in each case is now 60 years.

Nuclear fuel cycle and waste technology

Important initiatives were taken during the year in the areas of the nuclear fuel cycle and radioactive waste management. With regard to the fuel cycle, the Agency convened a symposium on uranium mining activities and their impact on the environment. The aim of the conference was to review changes in mining practices and compile the latest information in this field (Box 1).

An issue critical to the future of all nuclear technologies is the management and disposal of high level radioactive waste. The management of waste was the subject of the Scientific Forum at the Agency's 44th General Conference in September 2000. There was agreement at the Forum that while technological solutions for the safe management of radioactive waste existed, public acceptance of — and confidence in — these solutions were critical. As for permanent waste disposal facilities, Finland, Sweden and the USA were considered to be the farthest ahead. In the USA, the opening of the Waste Isolation Pilot Plant (WIPP) in New Mexico in 1999 was an important step towards demonstrating the geological disposal of long lived waste. In addition, the US Department of Energy intends to begin accepting commercial radioactive waste at the Yucca Mountain site in Nevada in 2010. Sweden evaluated proposals from six communities to host a spent fuel repository. In November 2000, the field was narrowed to three sites, for which detailed geological investigations should begin in 2002. And in December, the Finnish Cabinet approved a proposal by Posiva, the nuclear waste authority, to build a final repository for spent nuclear fuel in a cavern near the nuclear plants at Olkiluoto. While still requiring the approval of the Finnish Parliament, the plan, if approved, envisages the start of construction in 2010 and operation some ten years later.

Investigations also continued in 2000 on new energy production technologies that reduce actinide generation and focus on long lived waste transmutation. The Agency's role in this area included facilitating international co-operation in research and development and work on demonstration projects in underground research laboratories.

BOX 1. **URANIUM MINING AND PROTECTION OF THE ENVIRONMENT**

Environmental management at uranium mines today is different from past approaches. Improved production techniques and better planning have resulted in smaller environmental impacts. To chart some of these changes and disseminate information on good practices, the Agency held a symposium in Vienna in October 2000 entitled 'The Uranium Production Cycle and the Environment'. Addressing for the first time the environmental issues related to uranium mining and production, the meeting's principal conclusions included the following:

- Technological advances have improved exploration methods, mining practices, disposal of tailings and operational safety. They have also reduced waste, lowered the impact on the environment, enhanced safety and improved production economics.
- Waste management techniques have improved greatly. For example, increased interest is being shown in 'natural attenuation' for groundwater restoration at mine sites. This method relies on the chemical reactivity of rocks at the site to neutralize residual leach solutions remaining in the ground following in situ leach operations.
- Decommissioning and closure plans are being prepared before the start of an operation. At many sites these planning activities have become an ongoing process conducted throughout the lifetime of the project. ■

The global climate change debate

In December 1997, industrialized countries agreed to limitations on their greenhouse gas (GHG) emissions under a protocol adopted in Kyoto. They also agreed on three "flexibility mechanisms" that would establish a 'market' for GHG reductions, while leaving for later discussion the rules for implementation of the protocol. One of these three mechanisms — the "Clean Development Mechanism" (CDM) — created a means for transferring credits obtained for reducing emissions from projects in developing countries to industrialized countries that are sponsors of those projects to meet their own reduction obligations.

At the Sixth Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) (or "CoP-6"), held in The Hague in November 2000, no agreement was reached on finalizing the rules governing the three flexibility mechanisms and negotiations were suspended until the next meeting, scheduled for July 2001 in Bonn. At CoP-6, several parties pressed for nuclear power's exclusion from consideration for the flexibility mechanisms, citing concerns over radioactive waste management, proliferation, safety and economics. However, other parties argued that "it [was] not a good approach to overrule the judgement of developing countries on sustainable development by limiting the types of eligible CDM Projects".

Agency activities in 2000 in this area included co-ordination of national case studies prepared by teams in China, India, Pakistan, the Republic of Korea and Viet Nam to explore potential nuclear power CDM projects. Among electricity generation options, nuclear power generally proved to be the lowest cost GHG mitigation alternative. The mitigation costs were found to be considerably lower than the estimated marginal mitigation costs for compliance with the Kyoto Protocol. In presentations at the 2000 General Conference and at CoP-6, the Agency used these and other data to emphasize the contribution that nuclear can make — and is already making — to reducing global warming risks.

The ninth session of the UN Commission on Sustainable Development (CSD-9) was held in April 2001. The CSD was created to follow up on "Agenda 21", negotiated at the same 1992 UN Conference on Environment and Development (the Rio "Earth Summit") that produced the UNFCCC. The Agency contributed a range of preparatory materials through the UN Ad Hoc Inter-Agency Task Force on Energy, which is responsible for co-ordinating all UN system inputs. In this regard, an important activity for the Agency in 2000 was the development and field testing of 'Indicators for Sustainable Energy Development' in collaboration with other international organizations. These indicators provide a comprehensive set of benchmarks for assessing progress, or needs, related to sustainable energy development, or to the role of nuclear power.

"... studies suggest that nuclear energy will enjoy a significant share of total energy production through 2100 in most scenarios."

The future prospects for any energy technology depend increasingly not only on its economics and environmental impact, but also on its potential contribution to sustainable development. Two important studies were published in 2000, the *World Energy Assessment* by UNDP, WEC and the UN Department for Economic and Social Affairs, and the *Special Report on Emissions Scenarios* by the Intergovernmental Panel on Climate Change, both of which received substantive inputs from Agency staff. These studies suggest that nuclear energy will enjoy a significant share of total energy production through 2100 in most scenarios.

Advanced technologies and innovative designs

To ensure that nuclear power is given a fair and full hearing in the ongoing climate change and energy supply debates, it is necessary to promote greater innovation, leading to

new reactor types and fuel cycle designs that offer enhanced safety features, are proliferation resistant, and are economically competitive.

Some 25 projects, both innovative and evolutionary, are under development in France, India, Japan, the Republic of Korea, the Russian Federation, South Africa and the USA, among others. Complementing these at the international level is the Generation IV International Forum, an initiative of the USA that seeks to co-ordinate advanced R&D in nine countries — the OECD Nuclear Energy Agency (OECD/NEA) and Agency are participating as observers in this endeavour. The aim is to identify the most promising technology concepts for new designs by 2002 and then draw up an R&D plan to support deployment by 2030. Another international undertaking is a new Agency effort, the extrabudgetary International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO). The goal of INPRO is to reinforce other efforts in this area by involving all interested countries, including developing countries whose energy demands are growing fastest, and to incorporate the Agency's safeguards and safety expertise early in the design process.

"An area of concern is a possible shortage in the future of qualified, well trained personnel in all areas of nuclear power ..."

Maintenance of knowledge and competence

An area of concern is a possible shortage in the future of qualified, well trained personnel in all areas of nuclear power (including the operation of power plants, radiation protection, waste management and decommissioning). Most countries with advanced nuclear programmes report a decrease in the number of new graduates in the nuclear field. The reasons for this trend include public perceptions of a 'stagnant' industry and the consequent impression among younger people that the nuclear area offers poor career prospects. The result has been an emerging shortfall of specialized expertise and a gradual shrinking of nuclear science and engineering departments at universities and institutes.

The maintenance of knowledge and expertise in nuclear science, technology and engineering has recently received much attention at the governmental and non-governmental levels in a number of Member States. In response, a new subprogramme on this issue is being proposed by the Agency for 2002–2003. Also, the Agency has strengthened its efforts to co-ordinate international co-operation in setting up training activities.

Applications of nuclear technologies

A major part of the Agency's work in the technology area takes place in the field of nuclear science and applications. The high level Standing Advisory Group on Nuclear Applications (SAGNA), established in April 2000 to advise the Director General on the Agency's activities in the application of nuclear techniques, emphasized the important role of the Agency in supplementing the scientific and technological capacities of Member States and as a catalyst for social and economic development.

The Agency implements a wide range of nuclear technology applications in its regular programme of activities. For instance, Co-ordinated Research Projects — supported by research and service laboratories in Seibersdorf and Monaco — focus on the use of radiation and isotope techniques to increase food production, fight disease, manage water resources and protect the environment. In the area of food and agriculture, for example, insect sterilization techniques have produced significant gains in livestock production and fruit production, radiation induced mutations have been used to produce crops with greater yield and higher quality, and the irradiation of food has helped to preserve freshness and eliminate disease causing organisms.

The Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear

Weapons (NPT Review Conference) in 2000 noted the role of the Agency as the principal international organization for nuclear technology transfer. The Conference participants also confirmed the importance of the Agency's technical co-operation activities in fulfilling the obligations set forth in Article IV of the NPT.

The Agency's technical co-operation programme — running to approximately $86 million a year — is the main vehicle for the transfer of nuclear science and technology to developing countries. The emphasis here is on supporting projects that respond to the real needs of the country, produce an economic or social impact and reflect the distinct advantages of nuclear technology over other approaches.

Technology transfer has greater impact when a strong partnership exists with the end user — frequently a water authority, health ministry, or livestock or plant protection service. Moreover, Agency technology must be combined, in the recipient country, with committed resources and sustained effort (Box 2). It is also clear that government interest is decisive for projects to succeed in delivering long lasting results. The existence of a national programme financed from either domestic or external sources has been found to be the best indicator of this commitment.

Turning to the issue of human health, some of today's most important health problems are the result of the reduction in mortality from infectious diseases, especially in industrialized countries. The very successes of the past few decades have generated a 'demographic transition' from traditional societies, where almost everyone is young, to societies with rapidly increasing numbers of middle aged and elderly people. With this transition, a new set of diseases has risen to prominence, such as cancers, heart disease, stroke and mental illness. Nuclear techniques have much to offer in the diagnosis and control of these non-communicable diseases.

In recent years there have also been very effective applications for combating infectious diseases such as tuberculosis, malaria and HIV/AIDS, all of which remain major health associated constraints to economic growth. In 2000, the Agency focused on the validation of new nuclear tools for diagnosing drug resistant strains of malaria and tuberculosis. Other applications of nuclear techniques were in the

BOX 2. AFRICAN HEADS OF STATE RECOGNIZE THE SUCCESS OF TSETSE FLY ERADICATION EFFORTS

Following the successful eradication of the tsetse fly from Zanzibar Island in the United Republic of Tanzania as a direct result of a large scale Agency technical co-operation project, the sterile insect technique (SIT) has attracted greater interest and recognition of its potential by Member States. The major reason for this attention is the increasing problem of African trypanosomosis, a livestock disease caused by the tsetse fly. At the 36th Summit of African Heads of State and Government in Lomé, Togo, in July 2000, it was decided to initiate a campaign for the eradication of tsetse flies from the African continent. The Summit recognized the tsetse problem as one of Africa's most important constraints to continued socioeconomic development, affecting human and livestock health and limiting land use. Acknowledging the transboundary nature of the problem, States were urged to act collectively to eliminate this insect and mobilize the necessary human, financial and material resources required to make Africa tsetse-free within the shortest time possible.

The Summit commended those African countries that have initiated the application of SIT for their pioneering work, and welcomed the establishment of the Pan-African SIT Forum of African scientists as a mechanism through which sustainable, area wide tsetse eradication can be achieved. Following the Summit's decision, a task force of African tsetse/trypanosomosis specialists, organized by the OAU and supported by the Agency, developed an action plan for a Pan-African Tsetse and Trypanosomosis Eradication Campaign. ■

areas of paediatrics (Box 3) and cardiology, and the use of stable isotopes in malnutrition studies to track the intake of vitamins and other nutrients.

Another area of increasing worldwide concern is the management of increasingly scarce water resources. It is estimated that over one billion people in the world have no access to clean water. Dwindling supplies and unequal distribution of freshwater resources exacerbate this problem. In many countries the situation is becoming more acute as water demand rises and more people move to urban areas. In short, the need for safe, clean drinking water is growing as fast as the world's population. Experts agree that if nothing is done, two thirds of the world's population will suffer from moderate to severe lack of water by 2025. This sobering outlook is bringing more countries and international organizations together in new ways. As they forge partnerships for sustainable water development, they are pooling expertise and limited resources on several fronts, including the use of nuclear science and related technologies. In this connection, a noteworthy co-operative effort in 2000 was the launching of the Joint International Isotopes in Hydrology programme between the Agency and UNESCO, designed to co-ordinate the integration of isotope hydrology techniques into the water sector activities of States belonging to the two organizations. The two agencies have also established other areas of co-operation and dialogue, for example joint publication of teaching material on environmental isotopes in the hydrological cycle, and the holding of consultations with a view to identifying areas of common interest in their respective programmes.

SAFETY

Developments in nuclear safety in 2000

National and international efforts over the past decade have resulted in an increased level of nuclear safety in a number of countries of central and eastern Europe and the former Soviet Union. Some of these positive developments were highlighted in a report issued in 2000 by the Western European

BOX 3. NUCLEAR TECHNIQUES TO SCREEN NEWBORNS FOR THYROID DEFICIENCY

Thyroid deficiency in newborns is common in many parts of the developing world. It is most prevalent in areas of endemic iodine deficiency and its most significant effect is on the developing brain. The condition may lead to irreversible neurological impairment, deafness or loss of speech. Mental and intellectual impairment is possible even when the iodine deficiency is less severe. However, neonatal hypothyroidism is treatable if detected early, i.e. within the first few days after birth. The best method of detection is measurement of the thyroid related hormones in the baby's blood by radioimmunoassay methods. The cost of such a screening programme is insignificant compared with the cost of caring for even a limited number of people suffering from severe mental retardation. Thus, through the use of nuclear techniques, a completely treatable problem can be detected early enough to permit timely medical intervention with every hope of success.

In an Agency regional technical co-operation project for West Asia, Member States were able to establish and validate the methodology for the measurement of thyroid related hormones. The early clinical studies were followed by the extension of the method to as many peripheral laboratories as possible in order to permit them to establish screening protocols at a number of hospitals and laboratories and, at the same time, allow a longer lead time for local health authorities to improve the logistics of national screening programmes.

All participating laboratories have accepted the treatment method. In addition, the reagents used in the method are being produced locally, resulting in significantly lower costs and less reliance on imported materials. ■

Nuclear Regulators' Association (WENRA). The report identified positive developments related to regulatory regimes and bodies and to the safety status of nuclear power plants in the region.

During 2000, the Agency continued to provide nuclear safety review services and assistance to countries in central and eastern Europe and the former Soviet Union. Like WENRA, the Agency obtained a positive overall picture in the area of nuclear safety in a number of these countries while providing suggestions for further improvement. For example, the Agency's review mission to units 1 and 2 of the Bohunice nuclear power plant in Slovakia concluded that a comprehensive safety upgrading programme had been developed and implemented. Other missions gave a positive evaluation of the modernization programmes for the Kozloduy nuclear power plant in Bulgaria.

"On 15 December 2000, the last operating unit of the Chernobyl nuclear power plant was shut down."

The Temelin-1 nuclear power plant in the Czech Republic, which is a WWER-1000/320 reactor with substantial design modifications, achieved criticality on 11 October 2000. In December 2000, the Austrian and Czech Governments signed an agreement for a joint team of experts to review the safety of the plant. According to the agreement, the process of putting the plant into operation would continue, but commercial power operation would not start until the experts had reported their findings.

On 15 December 2000, the last operating unit of the Chernobyl nuclear power plant was shut down. At a donor's conference in 2000 in Berlin, more than $300 million, required for the commencement of the Chernobyl Shelter Implementation Plan, was pledged. At the request of the Government of Ukraine, the Agency has refocused its assistance projects in order to help the government in preparing a comprehensive plan for the safe decommissioning of the entire plant.

In South East Asia, the Pacific and the Far East, the Agency continued, through a special programme, to provide assistance to China, Indonesia, Malaysia, Philippines, Thailand and Viet Nam in enhancing the capabilities of regulatory bodies and technical support organizations and the safety of nuclear power plants and research reactors.

Germany, Lithuania and Ukraine were the latest among a number of European countries that have taken decisions to close some of their nuclear power plants earlier than originally intended. There are important safety issues that stem from these decisions that must be addressed. For example, operational safety must be maintained from the time of the closure decision until shutdown and decommissioning. This requires specific programmes that compensate for the organizational and technical changes that will occur during this period. Furthermore, a decision for early closure can reduce incentives for making upgrades to improve the safety of these facilities for their remaining period of operation.

One area of increasing concern is the safety of research reactors. In April 2000, the International Nuclear Safety Advisory Group (INSAG) — which advises the Agency's Director General — highlighted three major safety issues concerning research reactors: the increasing age of operating research reactors, more than half of which are over 30 years old; the large number of such reactors — well over 200 worldwide — that are shut down but not decommissioned; and the number of research reactors not under adequate regulatory control. INSAG called for immediate efforts to address these issues, and suggested that there might be benefit in the development of a legal instrument to cover the safety of these reactors.

In response to these concerns, the Agency has strengthened its activities related to the

safety of research reactors. For example, the review services now place higher priority on assessing and helping to improve regulatory effectiveness and on operational safety aspects such as the management of safety and safety culture. During 2000, the Agency organized three interregional training courses with particular relevance to research reactor safety issues and dispatched eight safety review missions to assist the operators of these reactors.

"The results of Agency reviews continue to indicate a general improvement in the safety of many nuclear power plants, ... as well as progress in enhancing the effectiveness and technical capabilities of regulatory bodies."

While ensuring a high level of safety is a national responsibility, international co-operation on safety related matters has proved to be indispensable. In this regard, the Agency advocates a global nuclear safety culture comprising three elements: conventions, internationally agreed safety standards and measures to apply those conventions and standards.

Three international conventions related to safety are currently in force: the Convention on Early Notification of a Nuclear Accident, the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency and the Convention on Nuclear Safety. A fourth convention, the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, will enter into force in June 2001.

International nuclear safety standards have to date been focused on nuclear power plants and research reactors. There are, however, some safety issues specific to other fuel cycle facilities that must be given consideration in their design and operation, such as criticality, chemical toxicity, fire and explosion hazards. During the year, the Agency began work on developing specific safety standards for fuel cycle facilities.

The Agency continued to adjust the content of its safety review services, which are a means of providing for the application of the safety standards, in order to reflect developments in these standards as well as the needs of Member States. In particular, in light of developments in safety standards for operational nuclear safety, the relevant peer review services gave greater attention to safety culture and the management of safety, and promoted the increased use of self-assessments. The results of Agency reviews continue to indicate a general improvement in the safety of many nuclear power plants and implementation of corrective safety measures, as well as progress in enhancing the effectiveness and technical capabilities of regulatory bodies.

Developments in radiation and radioactive waste safety in 2000

International efforts continued to focus during 2000 on providing assistance for upgrading national radiation and waste safety infrastructures. The Agency, through a technical co-operation Model Project, has provided technical support and assistance in the implementation of action plans in more than 50 participating States. Seventeen peer review teams visited participating States during 2000 to evaluate: the adequacy of the legal and regulatory framework; the empowerment of the regulatory authority to enforce legislation and regulations; the system of notification, authorization and control of radiation sources; existing financial and human resources; and the number of adequately trained personnel.

A Code of Conduct on the Safety and Security of Radioactive Sources was developed in 2000 as guidance for States. A resolution of the 2000 General Conference invited Member States to consider means to ensure its wide application. The Code particularly addresses the establishment of an adequate system of regulatory control, from the production of radioactive sources to their final disposal, and a system for the restoration of such control if it has been lost.

Where the amount of radioactive material used in medicine, research and industry is substantial, such as with sources used in radiotherapy or industrial radiography, extreme care is necessary to prevent accidents that may result in severe consequences for the affected individuals. In 2000, five people died in Thailand and Egypt as a result of two accidents involving radiation sources. The Agency's 'Action Plan on the Safety of Radiation Sources and the Security of Radioactive Materials' has been designed to address the problems in this area. As part of its activities in 2000 to implement this Plan, the Agency developed a simple, generally applicable system for categorizing radiation sources. The sources are ranked according to the harm they could cause, so that the controls to be applied will be appropriate to the radiological risks which the sources (and the materials contained in them) present. A related activity in the implementation of the Action Plan was a conference organized by the Agency of national regulatory authorities and hosted by the Government of Argentina in Buenos Aires, in December 2000. Various actions that States should take with a view to ensuring the safety and security of radiation sources were identified at the conference.

Environmental assessments of areas with residues of radioactive material are becoming an important activity for international organizations. The Agency, together with other relevant United Nations system organizations, has received requests for assessments of areas in the Balkans, the Gulf and the Middle East where it is known or believed that depleted uranium (DU) in ammunition has been used in the past. One example of the Agency's co-operative efforts in this area during 2000 was its participation in investigations by UNEP of the use of DU in Kosovo (Box 4).

The 2000 report by UNSCEAR on sources and effects of atomic radiation was presented to the 55th Session of the United Nations General Assembly. In addition to re-evaluations of some important parameters in radiation protection, the report also included an evaluation of the consequences of the Chernobyl accident. UNSCEAR's scientific assessments indicated that there have so far been about 1800 cases of thyroid cancer in children who were exposed at the time of the accident, primarily as a result of ingesting radioactive iodine. Although the Committee found no scientific evidence of increases to date in the incidence of any other health effects that could be related to radiation exposure, it concluded that the individuals most highly exposed as a result of the accident have an increased risk of suffering radiation associated effects in the future. UNSCEAR decided during its April

BOX 4. CO-OPERATION IN INTERNATIONAL ENVIRONMENTAL ASSESSMENTS — DEPLETED URANIUM IN KOSOVO

In November 2000, a field mission organized by UNEP visited several sites in Kosovo, Yugoslavia, where NATO had used ammunition containing DU in 1999. The mission was based on information provided by NATO in 2000 about locations at which such ammunition was used. The members of this mission, who included two experts from the Agency, made measurements of external dose rates and took samples of soil, water, vegetation and milk.

The mission report, released in March 2001, concluded that no widespread ground contamination had been found in the investigated areas and, therefore, that the corresponding radiological and chemical risks were insignificant. Although UNEP's findings show no cause for alarm, the report describes specific situations (e.g. high radiation doses as a result of prolonged contact with DU ammunition, or ingestion of small amounts of contaminated soil) where risks cannot be excluded, and the possible DU intake might be somewhat higher than the applicable standards. In addition, according to the report, some uncertainties still exist relating to the long term behaviour of DU in the environment. For these reasons, the report calls for certain precautionary actions. ■

2001 session to continue its consultations with scientists and experts from interested States to study the radiological consequences of the Chernobyl accident and prepare a further report thereon to the United Nations General Assembly.

The Agency continued to work during the year on maintaining international focus on the issue of the safe management of radioactive waste, accelerating progress towards demonstrated solutions and bridging the gap in perception between technical waste experts and the public at large. To raise international awareness of this issue, the Agency in March organized an international conference on the safety of radioactive waste management, in Córdoba, Spain. Continuing this effort, the Agency's General Conference featured a Scientific Forum on radioactive waste management.

A resolution passed at the 2000 General Conference requested the Secretariat to develop internationally agreed radiological criteria for long lived radionuclides in commodities, particularly foodstuffs and wood. Differences between national approaches and criteria have led to difficulties in international trade in such commodities.

"The seminal event of the year ... was the May 2000 Review Conference of the 187 States Parties to the Treaty on the Non-Proliferation of Nuclear Weapons ..."

The transport of radioactive materials, particularly nuclear fuel and radioactive waste, has continued to cause concern in a number of States. At the 2000 General Conference, a resolution called for several actions, including inviting States shipping radioactive materials to provide potentially affected States, upon their request, with assurances that their national regulations take the Agency's *Regulations for the Safe Transport of Radioactive Material* (the 'Transport Regulations') into account and with information on shipments. It also called for efforts to: examine and further improve measures and international regulations on the international maritime transport of radioactive material and spent fuel; and encourage Member States to ensure that they have national regulatory documents governing the transport of radioactive materials that are in conformity with the Agency's Transport Regulations. For its part, the Agency reached agreement in 2000 with other international organizations in the transport field on timetables for implementing the latest version of the Transport Regulations into the specific regulations for the air, sea and land transport of hazardous goods.

VERIFICATION

The international non-proliferation and disarmament scene

The seminal event of the year in the area of non-proliferation and disarmament was the May 2000 Review Conference of the 187 States Parties to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT). For the first time in 15 years, the parties were able to successfully conclude their discussions on a broad range of nuclear non-proliferation and disarmament issues with the adoption, by consensus, of a final document. One of the key outcomes of the Review Conference was agreement by all parties on the need for an "unequivocal undertaking by the nuclear-weapon States to accomplish the total elimination of their nuclear arsenals".

The final document reviewed the implementation and operation of the NPT from 1995 to 2000, and outlined a framework for moving ahead with nuclear disarmament and non-proliferation during the next five year period. In an effort to overcome the perceived stalemate in international arms control, the States established objectives for 2000–2005 to stimulate progress in the implementation of the obligations under the NPT. These included a number of practical steps for non-proliferation, nuclear disarmament, safeguards and export controls, peaceful nuclear co-operation, universal adherence to the treaty, and further strengthening of the review process. Moreover, the Conference agreed that there should

be more transparency on the part of the nuclear weapon States with regard to their capabilities, as well as a diminishing role for nuclear weapons in security policies.

Implementation of safeguards agreements and additional protocols

As of 31 December 2000, the Agency had 224 safeguards agreements in force with 140 States (and with Taiwan, China). Over 900 facilities and locations outside facilities were under Agency safeguards or contained safeguarded nuclear material in 2000.

Agency activities to verify the commitments of States to nuclear non-proliferation and in support of the development of peaceful uses of nuclear energy received positive attention both during the Review Conference and in the final document. In particular, States expressed their support for the Agency's continuing efforts to strengthen the safeguards system, and called upon all States that had not already done so to conclude safeguards agreements and protocols additional to those agreements. They reaffirmed that the additional protocols, in particular, greatly enhance the Agency's verification capability by providing for increased information and greater physical access. It was concluded that the combination of a safeguards agreement and an additional protocol in force for each non-nuclear-weapon State would assist the Agency in providing credible assurance not only about the non-diversion of declared nuclear material but also about the absence of undeclared nuclear material and activities in a State.

Regrettably, as of the end of 2000, 54 non-nuclear-weapon States party to the NPT had not fulfilled their legal obligation to bring into force the required safeguards agreements, and since 1997, when the Model Additional Protocol was adopted, additional protocols with only 57 States had been approved by the Agency's Board of Governors, of which only 19 had entered into force or were being provisionally applied.

Adherence to safeguards agreements and protocols additional to those agreements is a key element in international nuclear non-proliferation efforts. To this end, a General Conference resolution called upon the Director General and Member States to consider ways and means, which could include a possible plan of action, to promote and facilitate the conclusion and entry into force of such safeguards agreements and additional protocols. The Secretariat has developed a new and updated action plan with a focus on greater co-operative efforts with Member States. A number of Member States, notably Japan, Kazakhstan, New Zealand and Peru, responded positively and concretely to the action plan by developing activities with the Agency.

> ***"Adherence to safeguards agreements and protocols additional to those agreements is a key element in international nuclear non-proliferation efforts."***

In keeping with General Conference resolutions, the Agency has continued to hold consultations with the States of the Middle East region on the application of full scope safeguards to all nuclear activities in the Middle East, and the development of model agreements that would contribute to the establishment of a nuclear weapon free zone in that region. However, little progress has been achieved so far.

With regard to the current safeguards situation in the Democratic People's Republic of Korea (DPRK), the Agency is still unable to verify the correctness and completeness of the initial report of nuclear material made by the DPRK and is, therefore, unable to conclude that there has been no diversion of nuclear material in that State.

Since December 1998, the Agency has not been in a position to implement its mandate with regard to Iraq under the relevant United Nations Security Council resolutions. As a consequence, the Agency still cannot provide any assurance that Iraq is in compliance with its obligations under those resolutions. Following physical inventory verification inspections

performed under the safeguards agreement between Iraq and the Agency pursuant to NPT in January 2000 and January 2001, Agency inspectors were able to verify the presence of the nuclear material under safeguards at the Tuwaitha storage facility. However, these inspections cannot serve as a substitute for Agency activities under the relevant Security Council resolutions.

Integrated safeguards

The Agency has placed high priority on integrating traditional safeguards verification activities with a wide range of safeguards strengthening measures, especially those contained in protocols additional to safeguards agreements. As recognized by the NPT Review Conference, the aim of these efforts is to optimize the combination of all safeguards measures available to the Agency in order to meet its safeguards objectives with maximum effectiveness and efficiency.

The development of all aspects of integrated safeguards is continuing, drawing on internal resources, such as the Integrated Safeguards Working Group, as well as the Standing Advisory Group on Safeguards Implementation (SAGSI), a group of experts appointed by the Director General, and Member State Support Programmes. Considerable progress has been made, including the identification of the conditions to be met before integrated safeguards can be implemented in a State and the development of generic approaches for several specific facility types. Work will proceed on the implementation of integrated safeguards in specific States when the relevant facility type approaches have been developed and the necessary conditions for the implementation of integrated safeguards have been met in the State concerned. The rate of implementation, however, is highly dependent on the actions of the States concerned in bringing into force their respective additional protocols.

New technologies

Unattended and remote monitoring of the characteristics and movement of radioactive material are key measures of a strengthened safeguards regime. The availability of such systems enables the Agency to implement its safeguards obligations with an improved level of efficiency and effectiveness (Box 5).

Other verification activities

In the final document of the NPT Review Conference, the States Parties welcomed the efforts by nuclear weapon States to co-operate in making nuclear disarmament measures irreversible. In that context, specific reference

BOX 5. USING NEW TECHNOLOGIES TO IMPROVE THE EFFECTIVENESS OF AGENCY SAFEGUARDS

An important measure to both strengthen and maximize the effectiveness of the current safeguards regime is the use of unattended and remote monitoring. In 2000, the Agency carried out numerous activities related to the remote monitoring and transmission of data on radiation and digital image surveillance systems. More sensitive radiation detectors with better discrimination were developed and installed in radiation monitoring systems, which allow the Agency to apply instrumented safeguards where previously an inspector presence or measures intrusive to the facility were required, and to obtain more definitive measurements such as the presence of specific isotopes where earlier only detection of radioactivity was possible. In addition, reliable and secure data transmission mechanisms were developed and tested, allowing the Agency to collect and evaluate data in near real time.

The Agency also conducted studies to ascertain the potential of using commercial satellite imagery as one tool of a strengthened safeguards regime. Satellite imagery analysis has proved to be useful in investigating open source information. In this connection, the Agency began development of an imagery database of nuclear sites under safeguards. ■

was made to the completion and implementation of the "Trilateral Initiative" between the USA, the Russian Federation and the Agency as one of the practical steps for the systematic and progressive efforts to implement Article VI of the NPT and paragraphs 3 and 4(c) of the Decision on "Principles and Objectives for Nuclear Non-Proliferation and Disarmament" agreed to by the NPT parties in 1995.

The Trilateral Initiative originated in 1996, at which time the USA, the Russian Federation and the Agency agreed to establish a prototype verification system for ensuring that weapon origin and other fissile materials specified by the States as "released from defence programmes" were not used for any military purposes. In 2000, progress was made in the development of technical approaches, particularly as they concerned the verification of such material with classified characteristics, and in the negotiation of a new related Model Verification Agreement. The aim, as indicated in the NPT final document, is to have a verification regime that can assure the international community that the material has been irreversibly removed from military applications. In August–September 2000, the USA and the Russian Federation signed a bilateral "Plutonium Management and Disposition Agreement" that commits each party to the withdrawal of 34 tonnes of weapons grade plutonium from weapons programmes. In September 2000, the two States agreed to hold early consultations aimed at concluding an agreement with the Agency to allow verification measures with respect to that material.

Physical protection of nuclear material

Terrorist and other groups and individuals may try to acquire nuclear material illegally. As such groups are less likely to have the means to manufacture this material, theft is a more likely route for its acquisition. The physical protection of nuclear material against theft is, therefore, an important non-proliferation issue.

The Convention on the Physical Protection of Nuclear Material, which entered into force in 1987, is designed to avert the potential dangers posed by the unlawful taking and use of nuclear material, primarily while such material is in international transport. In addition, recommendations exist, published by the Agency, for the physical protection of nuclear material in use, storage and transport, whether domestic or international, against its unauthorized removal and/or sabotage, and for the protection of nuclear facilities against sabotage. The Expert Meeting convened by the Director General in 1999 to discuss whether there is a need to revise the Convention continued its work during 2000.

"Combating illicit trafficking is an issue that has gained prominence as such incidents continue to occur."

Illicit trafficking is a downstream consequence of the theft of nuclear and other radioactive material. Combating illicit trafficking is an issue that has gained prominence as such incidents continue to occur. The Agency has a programme of activities that embraces information exchange, assistance to regulatory bodies and training. It has also established a database intended to provide an authoritative central source of information on incidents of illicit trafficking. The overall number of incidents reflected in the database that involve either nuclear material or other radioactive materials has dropped marginally in the last year. However, after a hiatus from 1996 to 1998, during which there were no reported seizures of weapons grade nuclear material, the last two years have witnessed four such incidents, the largest being one involving 920 grams of high enriched uranium.

OUTREACH

The Agency continued in 2000 to reach out to its many constituencies, in line with its public information and outreach policy that seeks to engage both traditional and non-traditional partners. A noteworthy example of this approach was a meeting with representatives from the nuclear industry, held in January

2000. This 'Industry Forum' provided an opportunity to exchange views with a broad range of professionals, including representatives of workers in the nuclear industry. There was broad consensus on the need for intensified efforts in the fields of safety, innovation and public confidence.

Another important activity during the year was to raise public awareness of the various priority activities of the Agency. For example, non-proliferation became a subject of press attention during the NPT Review Conference in May 2000, with the Agency providing a range of background material for the press and public both in print and on its *WorldAtom* Web site. The site *(http://www.iaea.org/worldatom)*, which was revamped in 2000, attracted an ever increasing number of visitors. The Sixth Conference of the Parties to the UNFCCC, held in The Hague, was another event for which the Agency prepared public information material. Also spotlighted was the issue of radioactive waste management. As one of the most controversial issues for the nuclear power industry, the Agency worked to offer balance and substance in its treatment of this issue.

"The Secretariat in 2000 continued and accelerated its management reform initiatives ... to sharpen the process of programme formulation and maximize efficiency ..."

These activities came in addition to concerted efforts by senior management, particularly the Director General, to reach out to a wider audience in civil society, including the arms control and disarmament community, academic institutions and think-tanks.

MANAGEMENT

The Secretariat in 2000 continued and accelerated its management reform initiatives designed both to sharpen the process of programme formulation and maximize efficiency in programme delivery. In January 2000, the fourth Senior Management Conference convened by the Director General set the stage for the year. The Conference considered and formalized the practical details of introducing — within a deliberately condensed time schedule — a results based approach to programming and budgeting, and restrengthened and extended the Secretariat's ongoing review of administrative practices.

A detailed explanation of results based methodology in the context of the Agency was presented to the Programme and Budget Committee of the Board of Governors in May, together with an initial planning document outlining the proposed programme and budget parameters for the 2002–2003 biennium. In this way, Member States were consulted in the development process from the outset — much earlier in the programme formulation cycle than in any previous year. Subsequently, a comprehensive document containing the *objectives, main outputs* and *outcomes* of the substantive major programmes was issued to Member States and became the subject of detailed consultations in September.

It was on the basis of the resultant programme that the initial budget estimates were then derived. Adjustments were subsequently made to the estimates to reflect anticipated financial constraints and to comply with guidelines issued by the Director General. The resulting draft programme and budget document for 2002–2003 was submitted to Member States in December 2000.

The "outcomes" referred to above are central to the results based approach and concentrate on the responses to stated problems that a given Agency programme is expected to bring about in Member States. *Performance indicators* are derived against which the effectiveness of the programme can subsequently be judged. The advantages of this approach include: increased transparency; greater participation of Member States in programming, leading to better identification of their needs; better priority setting; and improved evaluation of performance.

On a parallel track, developments continued in improving operational efficiencies. On 1 January 2000, a new financial information and control system was successfully put into operation — despite Y2K concerns — and enhancements to it were introduced throughout the year. The system provides programme managers with more timely and extensive data, permitting more precise implementation of activities. Additionally, special attention was given to restructuring the information technology services throughout the Agency to ensure efficient support to programme activities, with full advantage taken of the new technology.

Under the one house policy emphasized by the Director General, close attention is being paid to the working conditions of the staff. In this regard, a survey was carried out during the year to gain information on the views and concerns of members of the Secretariat. The results were analysed to identify any major issues and to suggest solutions. An important development was the expansion — under the management of the Agency and with a substantial grant from the City of Vienna — of the Child Care Centre to accommodate the children of staff members of the organizations based at the Vienna International Centre (VIC). In addition, planning began, together with the Government of Austria, on a project for the removal of asbestos from the buildings in the VIC. This will be a major undertaking lasting a total of six years and involving detailed and careful project management.

CONCLUSION

The role that the Agency has played in helping to achieve the global objectives of "freedom from fear" and "freedom from want" continues to conform to the objective stated in Article II of its Statute, namely to "accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world". In this context, several principles central to the Agency's mission were reinforced during 2000, the most important of which were the following:

- Important benefits for achieving sustainable development and for improving the quality of life can derive from the peaceful application of nuclear energy and nuclear techniques. The Agency therefore has an important role in assisting developing countries to improve their scientific, technological and regulatory capabilities.
- Both national measures and international co-operation are essential for nuclear, radiation, waste and transport safety, and the Agency has a key role in the promotion of a global safety culture.
- Agency safeguards are a basic component of the non-proliferation regime and create an environment conducive to nuclear disarmament and nuclear co-operation.

[Photo: Dean Calma, IAEA]

View of the plenary session of the Agency's 44th General Conference in September 2000.

THE BOARD OF GOVERNORS AND THE GENERAL CONFERENCE

The Board of Governors oversees the ongoing operations of the Agency. Among its functions it examines and makes recommendations to the General Conference on the Agency's accounts, programme and budget and considers applications for membership; it also approves safeguards agreements and the publication of the Agency's safety standards. The Board of Governors comprises 35 Member States and generally meets five times a year (see Table I).

The General Conference comprises all Member States of the Agency and meets once a year. It considers the report of the Board of Governors on the Agency's activities during the previous year; approves the Agency's accounts and the budget; approves any applications for membership; and elects members to the Board of Governors. It also conducts a wide ranging general debate on the Agency's policies and programme and passes resolutions directing the priorities of the Agency's work (see Table II for a complete list of resolutions in 2000).

The applications of Azerbaijan, the Central African Republic and Tajikistan for membership of the Agency were approved by the General Conference upon the recommendation of the Board of Governors. At the end of 2000 these applications had not taken effect, and the Agency had a total of 130 members.

With regard to the financing of technical co-operation, as agreed by the Board in 1999 the Ambassadors of Finland and Mexico conducted joint consultations. They presented their report to the Board and their work was thereafter continued by the Chairman of the Board, H.E. Sergio de Queiroz Duarte of Brazil, with a view to arriving at a target for contributions for 2001 and 2002, and indicative planning figures for the following biennium. As proposed by the Chairman, the Board made recommendations and subsequently the Conference reached agreement on these matters and set a rate of attainment of the target designed to stimulate the flow of resources into the Technical Co-operation Fund during that period.

With regard to the financing of the safeguards component of the regular budget, as agreed by the Board in 1999, the Ambassador of Spain conducted consultations and presented a report to the Board. As proposed by the Chairman, who had continued the work of the Ambassador, the Board recommended and the Conference agreed on a set of arrangements designed to end the system of 'shielding' of certain Member States within a specified time-frame.

Pursuant to Resolution GC(42)/RES/4, which adopted criteria or guidelines for consideration of requests for the restoration of voting rights made by Member States in arrears in the payment of their financial contributions to the Agency, the Conference undertook a follow-up

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Note: This section reports on matters of a procedural nature dealt with by the Board of Governors and the General Conference during the year. Substantive programmatic issues considered by the policy making organs are covered under the relevant chapters of this report.

assessment through the Board of Governors of the usefulness and pertinence of the criteria and guidelines. The Board was of the opinion that experience thus far had been insufficient for a proper assessment and the Conference accordingly requested the Board to review the matter after November 2001 and to report to the Conference in 2002.

On the amendments to Articles VI and XIV.A of the Agency's Statute, which were approved by the Conference in 1999 and circulated to Member States for ratification as required by the Statute, the Agency was informed by the depository Government that eight Member States had ratified the amendment to Article VI and that six Member States had ratified the amendment to Article XIV.A. In accordance with the Statute, each amendment shall come into force only when accepted by two thirds of all members.

The Board agreed to the application of the new results based approach to programme development, as proposed by the Secretariat, in the preparation of the Agency's programme and budget for the years 2002–2003. The new approach emphasized the objectives to be achieved as a result of the Agency's programme and the outcomes to be attained, as opposed to the more traditional focus on inputs and outputs.

As the current term of the Director General is to expire on 30 November 2001, pursuant to the procedures for the appointment of the Director General previously approved by it, the Board began its consideration of the matter, setting the closing date for the receipt of nominations and authorizing the Chairman to send to the Governments of all Member States a circular letter on the matter.

TABLE I. **THE BOARD OF GOVERNORS, 2000–2001**

The composition of the Board of Governors in 2000–2001 at the conclusion of the 44th (2000) regular session of the General Conference was as follows:

- Algeria
- Argentina
- Australia
- Austria
- Belarus
- Bolivia
- Brazil
- Canada
- China
- Cuba
- Egypt
- Finland
- France
- Germany
- Ghana
- India
- Indonesia
- Ireland
- Japan
- Republic of Korea
- Libyan Arab Jamahiriya
- Mexico
- Nigeria
- Pakistan
- Peru
- Poland
- Russian Federation
- South Africa
- Spain
- Switzerland
- Syrian Arab Republic
- Thailand
- Ukraine
- United Kingdom of Great Britain and Northern Ireland
- United States of America

The Chairman of the Board for 2000–2001 was Mr. Ibrahim Halil Umar of Nigeria. The Vice-Chairmen were H.E. Ms Irene Freudenschuss-Reichl of Austria and Mr. Jerzy Niewodniczański of Poland. ■

TABLE II. **RESOLUTIONS OF THE GENERAL CONFERENCE IN 2000**

Number	Title	Date adopted (2000)
GC(44)/RES/1	Application by Tajikistan for membership of the Agency	18 September
GC(44)/RES/2	Application by Azerbaijan for membership of the Agency	18 September
GC(44)/RES/3	Application by the Central African Republic for membership of the Agency	18 September
GC(44)/RES/4	The Agency's Accounts for 1999	22 September
GC(44)/RES/5	Regular Budget appropriations for 2001	22 September
GC(44)/RES/6	Technical Co-operation Fund Allocation for 2001	22 September
GC(44)/RES/7	The Working Capital Fund in 2001	22 September
GC(44)/RES/8	The financing of Technical Co-operation: Contributions to the Agency's Technical Co-operation Fund	22 September
GC(44)/RES/9	The Financing of Safeguards: Revised arrangements for the assessment of Members' contributions towards the safeguards component of the Agency's Regular Budget	22 September
GC(44)/RES/10	Scale of assessment of Members' contributions for 2001	22 September
GC(44)/RES/11	Measures to strengthen international co-operation in nuclear, radiation and waste safety	22 September
GC(44)/RES/12	The safety of radioactive waste management	22 September
GC(44)/RES/13	Education and training in radiation protection and nuclear safety and waste management	22 September
GC(44)/RES/14	The safety of nuclear research reactors	22 September
GC(44)/RES/15	Radiological criteria for long lived radionuclides in commodities (especially foodstuffs and wood)	22 September
GC(44)/RES/16	Convention on Early Notification of a Nuclear Accident and Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency	22 September
GC(44)/RES/17	Safety of transport of radioactive materials	22 September
GC(44)/RES/18	Strengthening of the Agency's technical co-operation activities	22 September
GC(44)/RES/19	Strengthening the effectiveness and improving the efficiency of the safeguards system and application of the Model Protocol	22 September
GC(44)/RES/20	Measures against illicit trafficking in nuclear materials and other radioactive sources	22 September
GC(44)/RES/21	Strengthening the Agency's activities related to nuclear science, technology and applications	22 September
GC(44)/RES/22	Plan for producing potable water economically	22 September
GC(44)/RES/23	Strengthening co-operation between nuclear research centres in the area of the peaceful applications of nuclear technology	22 September
GC(44)/RES/24	Servicing immediate human needs	22 September
GC(44)/RES/25	Outcomes of the NPT Review Conference relevant to the activities of the IAEA	22 September
GC(44)/RES/26	Implementation of the agreement between the Agency and the Democratic People's Republic of Korea for the application of safeguards in connection with the Treaty on the Non-Proliferation of Nuclear Weapons	22 September
GC(44)/RES/27	Implementation of United Nations Security Council resolutions relating to Iraq	22 September
GC(44)/RES/28	Application of IAEA safeguards in the Middle East	22 September
GC(44)/RES/29	Examination of delegates' credentials	22 September

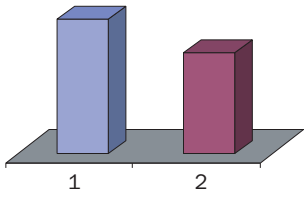
The Agency's Programme in 2000: Technology

NUCLEAR POWER

PROGRAMME OBJECTIVE

To assist Member States, at their request, in planning and implementing programmes for the utilization of nuclear power, as well as to support them in achieving improved safety, reliability and economic cost effectiveness of their nuclear power plants by promoting advanced engineering and technology, training, quality assurance and infrastructure modernization.

Regular budget expenditure: $3 903 485
Extrabudgetary programme expenditure (not included in chart): $90 194



1. Nuclear Power Planning, Implementation and Performance: $2 231 926
2. Nuclear Power Reactor Technology Development: $1 671 559

OVERVIEW

The Agency's nuclear power programme in 2000 reflected the growing emphasis on economic competitiveness arising from liberalizing electricity markets around the world. A number of documents were published and databases further expanded, containing information, recommendations and guidance formulated under the aegis of the Agency on proven engineering and management practices for achieving improved safety, reliability and economic cost effectiveness of nuclear power plants. These were also made available in electronic form and widely distributed to the end users in Member States.

Innovation is key to the future role of nuclear power, and successful innovation will require substantial investments around the world. The Agency can facilitate international exchange and co-operation in this area so that such efforts are more likely to reinforce and complement each other in a cost effective manner. The recommendation of a number of high level advisory groups and expert panels and recent programme activities on innovative concepts led in November to an agreement among a number of Member States to establish the new International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO). This project will build upon continuing programme activities on new technologies and applications, including small and medium sized reactors, evolutionary improvements in water cooled reactors, fast reactors, high temperature modular gas cooled reactors and desalination applications.

NUCLEAR POWER PLANNING, IMPLEMENTATION AND PERFORMANCE

The Agency published a number of guidebooks and monographs in 2000 to assist Member States in planning, implementing and operating nuclear power projects:

- Planning issues were dealt with in a revised edition of the guidebook *Economic Evaluation of Bids for Nuclear Power Plants*, together with upgrades to the associated computer program. The new guidebook and software reflect feedback from Member States based on experience with the 1986 edition of the guidebook.
- In the area of personnel training, *Analysis Phase of Systematic Approach to Training (SAT) for Nuclear Plant Personnel* describes alternative methods of job analysis and provides practical examples from Member States.
- *Quality Assurance Standards: Comparison Between IAEA 50-C/SG-Q and ISO 9001:1994*, produced in collaboration with FORATOM, clarifies technical differences between Agency and ISO standards to help ensure that applications of ISO standards to nuclear installations are fully compatible with regulatory requirements. A technical report, *Quality Assurance for Software Important to Safety* addresses the increasing importance of software applications in the design, testing and analysis of nuclear reactor systems, as well as in monitoring, control and safety functions. *Managing Suspect and Counterfeit Items in the Nuclear Industry* provides guidance on identifying and handling components that appear not to conform to established specifications and standards (suspect items) and may also be illegal copies or substitutes whose material, performance or characteristics are knowingly misrepresented by the vendor, supplier, distributor or manufacturer (counterfeit items).
- *Strategies For Competitive Nuclear Power Plants* provides plant managers with information and methods to identify and implement measures to remain competitive in the midst of rapid changes in electricity markets around the world. A technical report on the Agency's Nuclear Economic Performance International System (NEPIS) summarizes the major transformations occurring in the electricity generation industry that require reduced nuclear operations and maintenance costs, and resource optimization methods that nuclear plant managers can use in response. The report also identifies difficulties that existing cost accounting systems create for data collection and offers suggestions for new systems.
- *Management of Ageing of Instrumentation and Control Equipment in Nuclear Power Plants* analyses experience with ageing components around the world. In addition, using different management techniques, it presents a suggested ageing management strategy and outlines the necessary steps toward practical implementation.

In 2000, the Agency released the Power Reactor Information System (PRIS), including mapping features and the full database, on CD-ROM and through the PRIS Web page (*http://www.iaea.or.at/programmes/a2/*). Two PRIS services, MicroPRIS and PRIS-PC (the connection to PRIS through the Internet), are currently distributed to more than 600 users in Member States and international organizations.

Over the past few years, the number of technical co-operation projects has increased significantly. In 2000, two large regional projects were completed in Europe on improving operations management and in-service inspection of WWER-440/1000 reactors. Other projects provided technical support for preparations for new nuclear power plant projects in Africa, Asia, Europe and Latin America, life management of power plants in Europe and Latin America, personnel training and qualification in the Commonwealth of Independent States, and modernization of instrumentation and control in Europe and Latin America.

NUCLEAR POWER REACTOR TECHNOLOGY DEVELOPMENT

In November, senior officials from Member States and international organizations met in

Vienna to establish the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) and finalize its terms of reference. These include:

- Helping to make nuclear energy available for meeting the sustainable energy needs of the 21st century;
- Facilitating information exchange and joint consideration by interested Member States, including both technology suppliers and users, of international and national actions to advance innovations in nuclear reactors and fuel cycles that improve economics, safety, proliferation resistance and environmental soundness;
- Engaging all relevant stakeholders in a process that builds on and complements existing national and international initiatives.

INPRO will be implemented through an International Co-ordinating Group on Innovative Nuclear Reactors and Fuel Cycles (ICG), established for a period of two years. The ICG will have a steering committee and be supported by technical expert groups from Member States, with project management and administration support from the Agency.

The Agency's Technical Working Group on Advanced Technologies for Light Water Reactors focuses on technology developments to improve the economic competitiveness of LWRs while meeting stringent safety objectives. A Technical Committee meeting in Munich in October on the performance of operating and advanced LWR designs showed that technological improvements in inspection, maintenance and repair make important contributions to higher performance and better economic competitiveness of existing nuclear power plants. Similar benefits were seen from economies of scale, design optimization and standardization for new evolutionary designs.

Within the framework of the Agency's Technical Working Group on Advanced Technologies for Heavy Water Reactors (TWG-HWRs), a technical document was completed that examines the status of HWR advanced technology in the areas of fuel cycle flexibility, safety and economics, and advanced technology development needs in the coming two decades. It also forms a basis for definition of the TWG's future activities. The document addresses both evolutionary and innovative HWRs, and will provide input to INPRO.

Natural circulation phenomena play a particularly important role in the design of passive systems, a feature that can improve economics and safety in evolutionary and innovative nuclear power plants. A Technical Committee meeting assessed the current base of experimental data and the applicability of current methodologies for computing natural convection phenomena in advanced water cooled reactor designs, and developed approaches to carrying out improvements in models and supporting experimental data. The information from this meeting will form one of the many technical inputs to INPRO.

"... technological improvements in inspection, maintenance and repair make important contributions to higher performance and better economic competitiveness of existing nuclear power plants."

For sodium cooled reactors, previous Agency–European Commission joint benchmark exercises have shown that large conventional, sodium cooled fast reactor cores show reactivity increases if coolant is lost by boiling or gas intrusion. Since even a small positive reactivity effect has an important safety impact, a number of research teams around the world are investigating ways to neutralize the positive sodium void reactivity effect. Doing so through innovative core designs has the advantage of providing an additional inherently activated safety margin to prevent fuel pin failure or local boiling in the domain of operational and severe transients. Through a new joint benchmark programme, the Agency and the European Commission jointly studied the possibility of replacing the core's upper axial blanket with a sodium plenum to

enhance axial neutron leakage. This approach resulted in a strong negative reactivity effect.

In order to generalize, review and document fundamental knowledge in liquid metal cooled reactor technology, the Agency completed a technical report on the main design and technical problems that have occurred during liquid metal fast reactor operation. The report included findings on how to avoid past design errors and incorporate effective solutions to problems that have already occurred.

"A Web site launched in 2000 provides an overview of gas cooled reactor (GCR) technology development and related Agency activities ..."

International interest and activity in modular high temperature gas cooled reactors (HTGRs) increased in 2000. The Chinese HTR-10 experimental reactor went critical in December, and the HTTR in Japan continued power ascension testing. The South African ESKOM Pebble Bed Modular Reactor received active project participation from British Nuclear Fuels Ltd. in the United Kingdom and Exelon in the USA. And work on the Gas Turbine Modular Helium Reactor continued, with participation from France, Japan, the Russian Federation and the USA. A number of additional design feasibility studies are also under way.

A Web site launched in 2000 provides an overview of gas cooled reactor (GCR) technology development and related Agency activities *(http://www.iaea.org/inis/aws/htgr/index.html)*. A second related site facilitates information exchange and collaboration among the chief scientific investigators in a CRP on the evaluation of high temperature GCR performance. The CRP's objectives are to validate analytical codes and performance models, formulate code-to-experiment benchmark activities for the test programmes, demonstrate GCR safety characteristics and evaluate research synergism in the commissioning of the HTTR and HTR-10 plants.

Following General Conference Resolution GC(44)/RES/22, a software manual for the Agency's Desalination Economic Evaluation Program (DEEP) was published, including technical descriptions, flowcharts of all calculation modules and installation instructions. Available on CD-ROM, the software and manual have been distributed to 96 experts in 30 Member States. In addition, 50 licenses for DEEP had been granted by the end of 2000.

Examining the Economics of Seawater Desalination Using the DEEP Code, published in 2000, provides a comprehensive economic assessment of nuclear desalination compared with fossil options and lays the basis for future case specific evaluations for national projects and studies. *Guidance for Preparing User Requirements Documents (URDs) of Small and Medium Size Reactors and its Application in Developing Countries* addresses the possible use of such reactors for desalination in developing countries. These publications will support the Agency's objective of facilitating collaborative, interregional technical co-operation projects involving technology holders and end-users, leading to an integrated nuclear desalination system generating both power and heat.

The International Nuclear Desalination Advisory Group (INDAG) held its fourth meeting in April 2000 and reviewed recent developments both inside and outside the Agency. Among other observations, INDAG recommended strengthening the Agency's generic tools for planning and implementing nuclear desalination projects in developing countries. Based on its review of outside activities, INDAG urged more active participation by developing countries, in particular, in the interregional technical co-operation project on integrated nuclear and desalination system design. In related work, a Web page was set up that provides for INDAG information on the technology of nuclear seawater desalination, past and present projects, Agency activities, and sample calculations using DEEP.

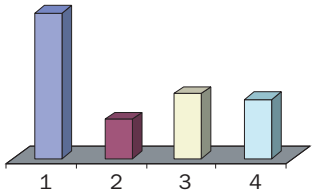
NUCLEAR FUEL CYCLE AND WASTE TECHNOLOGY

PROGRAMME OBJECTIVE

To facilitate the transfer and exchange of information and technology among Member States; to provide assistance and guidance, when requested, on the formulation and implementation of strategies in nuclear fuel cycle related activities and radioactive waste management programmes with due regard to efficiency, safety, environmental soundness and sustainability, and consistency with internationally accepted norms, where applicable, and good practices.

Regular budget expenditure:$4 686 198

Extrabudgetary programme expenditure (not included in chart): $673 718



1. Nuclear Fuel Cycle and Materials: $2 205 366
2. Sources of Radioactive Waste: $596 685
3. Implementation and Application of Radioactive Waste Management Technologies: $986 165
4. Waste Management Information and Technology Transfer: $897 982

OVERVIEW

The Agency's nuclear fuel cycle and waste technology programme covers all aspects of the fuel cycle, from uranium resources and production, through nuclear fuel performance and technology, to spent fuel management. Increasing attention has been given to how the fuel cycle affects the sustainability of nuclear power, and to spent fuel management, particularly spent fuel storage and the increasing inventory of separated plutonium. Thus, the focus this year was on uranium resources and production, including environmental issues, and on spent fuel technology, including long term storage and burnup credit. Major events in 2000 were the publication of the IAEA–OECD/NEA 'Red Book 1999', and the holding of an international symposium on the uranium production cycle and the environment.

Activities in the area of radioactive waste management emphasized waste minimization and facility decommissioning, the implementation of waste management initiatives (with a greater focus on disposal issues), and technology transfer and information exchange. The Agency placed greater emphasis on international co-operation in the geological disposal of high level and long lived wastes. Canada and Belgium offered to make their underground research laboratories available to the Agency to organize international demonstrations and training projects on geological disposal. And the scientific forum during the General Conference in September focused on the technology and safety aspects and future directions of radioactive waste management.

NUCLEAR FUEL CYCLE AND MATERIALS

In 2000, the Agency and the OECD/NEA published *Uranium 1999: Resources, Production and Demand* (the 'Red Book'), the foremost world reference on uranium. Using official information from 49 countries and including statistics on resources, exploration, production and demand as of 1 January 1999, the Red Book provides substantial new information from all major uranium producing centres in Africa, Australia, Eastern Europe, North America and the Newly Independent States, and analyses industry statistics and worldwide projections of nuclear energy growth, uranium requirements and supply.

A symposium in October on the uranium production cycle and the environment addressed long and short term uranium supply issues, impact assessment, socioeconomic effects, safety and regulatory affairs.

"In 2000, the Agency and the OECD/NEA published Uranium 1999: Resources, Production and Demand (the 'Red Book'), the foremost world reference on uranium."

One major message was that environmental issues carry with them an important social dimension. The environmental–social link is particularly significant in areas with strong traditional local cultures, but in all cases mining concerns should establish early communication with other stakeholders, particularly those communities most directly affected. Another issue that was emphasized was that the planned, progressive decommissioning of an operational site is the key to minimizing environmental impacts, satisfying public and regulatory concerns, minimizing operational and decommissioning costs, minimizing corporate liability and building public support.

A CRP on transport models of radioactive substances in primary circuits of water cooled reactors ended in 2000. Models incorporated in nine national codes were evaluated using a blind exercise based on activity measurement data provided by five countries operating PWR, WWER and CANDU power plants. The participants conducted sensitivity analyses to evaluate more specifically the different models and the precise role of each parameter, and identified important improvements that can be made in national models and codes.

The Agency also completed and published a study of stress corrosion cracking in Zircaloy fuel cladding. Pellet-clad interaction, which is a licensing concern for many water reactors, was investigated, as were the effects of creep, temperature, material condition, iodine partial pressure and texture on stress corrosion cracking rates and on the fractography of the resulting cracks. The study can be used in modelling fuel behaviour, and also contains an up to date review of iodine induced stress corrosion cracking of zirconium alloys.

Within the framework of a CRP on hydrogen and hydride degradation of the mechanical and physical properties of zirconium alloys, an Agency study of delayed hydride cracking of pressure tube material led to a very effective transfer of know-how at the laboratory level. Delayed hydride cracking can result in the failure of pressure tubes in CANDU reactors and may also contribute to fuel cladding failure in water reactors. The study participants carried out a round-robin exercise, reporting delayed hydride cracking of CANDU pressure tube material measured in different laboratories. The results show that much of the usual spread in data across laboratories can be dramatically reduced simply by careful experimental controls.

The continuing accumulation of spent fuel is an important concern for the Agency (Fig. 1). New nuclear power plants are coming on line in Asia and Eastern Europe. And in Western Europe and North America existing power plants continue to generate spent fuel. This accumulates in storage facilities and, due to limited pool capacities, has already required re-racking in many pools plus away-from-reactor (AFR) storage. Currently, only a few countries reprocess spent fuel or plan direct

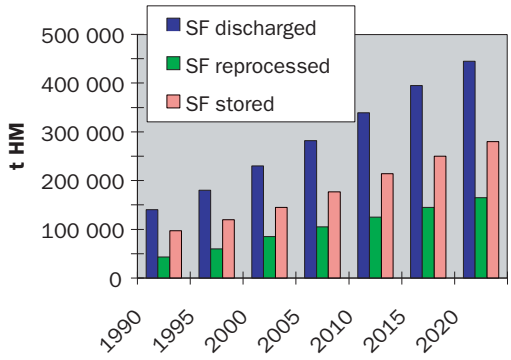


FIG. 1. Projected cumulative generation of spent fuel (SF), measured in tonnes of heavy metal (t HM).

disposal. Most have deferred such decisions and store their spent fuel. The lack of final repositories and the deferral of decisions lead to long, but uncertain, storage periods.

To address these concerns, the Agency examined the requirements for long term storage facilities in a Technical Committee meeting. In addition, a CRP on spent fuel performance assessment and research studied the behaviour of spent fuel and structural materials during long term wet and dry storage. Capacity requirements for future storage are driven by the fact that less than one third of spent fuel will be reprocessed, mainly in Europe. Design requirements for future storage, including materials, equipment and installation, must also take into account the trend to higher fuel burnup (and consequent higher enrichment of fresh fuel) and the use of plutonium in mixed oxide (MOX) fuel. These lead to changing spent fuel characteristics, i.e. higher decay heat and a flatter downward curve over time. This necessitates a longer storage period than is common in many countries with burnup lower than 40 GW·d/t.

On the issue of burnup credit, the Agency held a Technical Committee meeting to report on progress made in burnup credit implementation. Such credits take advantage of changes in the isotopic composition of fuel during burnup that reduce reactivity. The meeting participants observed that the motivation for applying credits in criticality safety applications is generally economic, but burnup credit is also applicable to assessments of public health and safety, resource conservation and environmental quality. These credits also generally make it possible to load more fuel into one transport or storage cask, thereby reducing the number of transports or amount of storage space.

The Nuclear Fuel Cycle Information System (NFCIS) completed its third year of operation. An upgraded client/server database management system was installed to allow faster and more reliable access. A newly developed Internet site allows users from the Agency and Member States to search the NFCIS database and retrieve information on nuclear fuel cycle facilities around the world. Also available is the Nuclear Fuel Cycle Simulation System (VISTA), a newly developed Agency model for calculating and estimating fuel cycle service requirements. The model has been enhanced to include estimates of MOX fuel fabrication requirements and separated civil plutonium inventories. VISTA integrates data from other Agency databases (such as PRIS and the Energy and Electricity Data Bank (EEDB)) in order to estimate fuel cycle service requirements based on various scenarios for each world region. The Agency also developed a new Internet site *(http://www.iaea.org/programmes/ne/video/menu.htm)* that features a library of video films describing nuclear power and the fuel cycle.

"Capacity requirements for future storage are driven by the fact that less than one third of spent fuel will be reprocessed, mainly in Europe."

SOURCES OF RADIOACTIVE WASTE

The large number of facilities scheduled for retirement in the near future in many Member States has made the subject of waste minimization during decommissioning

increasingly important. The Agency published a technical report on *Minimization of Radioactive Waste from Decontamination and Decommissioning of Nuclear Facilities* that analyses the current status of waste minimization during decommissioning, the principles and factors to be considered when selecting a minimization strategy, and the existing options, approaches, developments and trends in waste minimization.

Published information and guidance on the organizational dimensions of decommissioning is considerably more scarce than information on technological aspects. This lack of information may be due to perceived differences between privately operated and state owned facilities, or due to variations between countries, but it is possible to establish common rules and recommendations that can be adapted to specific cases. This is important because the lack of guidance on organizational aspects may create the impression that the availability of the required technologies is enough for successful decommissioning. For this reason, the Agency published a review of the planning and management aspects of decommissioning entitled *Management and Organization for the Decommissioning of Large Nuclear Facilities*.

"One of the most efficient [waste] minimization options is to recycle and reuse valuable materials and components from different waste streams."

Other activities related to this area included technical co-operation projects that focused on assisting Member States with the drafting and review of decommissioning plans for shutdown research reactors (see Fig. 2). These projects covered a range of strategies — from immediate dismantling (Latvia) to long term safe enclosure (Georgia). In another technical co-operation project focusing on central and Eastern Europe, the Agency brought together international experts to assist in transferring technology and know-how to Armenia, Bulgaria, the Czech Republic, Hungary, Slovakia and Ukraine. The experts first provided information on decommissioning planning and management based on national experiences and then helped draft a technical document to consolidate available information, decommissioning experience, lessons learned and guidance. The document also identifies the resources that need to be provided for decommissioning.

IMPLEMENTATION AND APPLICATION OF RADIOACTIVE WASTE MANAGEMENT TECHNOLOGIES

Waste minimization is a basic component of a modern integrated waste management strategy. One of the most efficient minimization options is to recycle and reuse valuable materials and components from different waste streams. The Agency published a technical document in 2000 that provides comprehensive information on recycling and reusing both radioactive and non-radioactive components of potential waste streams from the entire nuclear fuel cycle. The document includes 'historic waste' as a specific waste stream, and emphasizes that recycle and reuse should be a

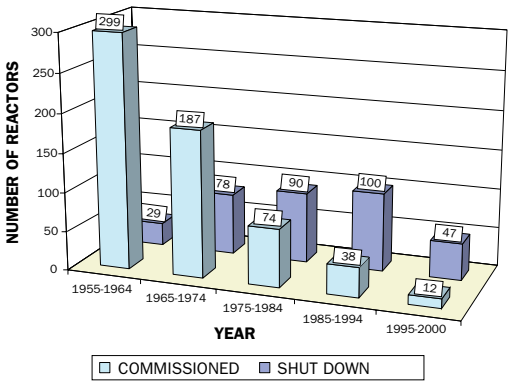


FIG. 2. Double column histogram showing the decreasing number of research reactors commissioned and the increasing number shut down in each decade between 1955 and 1994, and in the half-decade from 1995 to 2000.

consistent part of each national, site and plant specific waste management policy.

Another document, *Handling and Processing of Radioactive Waste from Nuclear Applications,* addresses the pre-disposal management of radioactive waste generated in applications of radioisotopes in research, medicine and industry. Present practices, procedures and techniques for the treatment, conditioning, packaging and storage of radioactive waste are also described, as are the basic principles and factors to be considered when selecting a waste management strategy and processing technology. Finally, the document provides technical information and reference material on different waste processing options.

Management of Radioactive Waste from the use of Radionuclides in Medicine is intended for medical and biomedical establishments and for authorities overseeing medical applications of radioisotopes. This technical document, like the previous document, sets out the principles and factors to be considered when selecting a waste management strategy and processing technology. The document also describes advanced practices implemented in facilities around the world and provides practical guidance and recommendations.

An entire generation of graphite moderated nuclear reactors will need to be decommissioned in the near future, as will other nuclear facilities using graphite for various purposes. However, the excellent mechanical properties and chemical stability of graphite, which are advantages during its lifetime, make the management of graphite waste more difficult. To foster information exchange among Member States having to address this problem, the Agency completed a review of radioactive graphite waste management from the dismantling of nuclear power plants, as well as other nuclear graphite applications.

Near surface disposal of low and intermediate level waste is an option being practised or planned in many Member States, and there is a growing need for additional information and guidance. To meet this need, the Agency assessed the scientific and technological issues involved in order to help Member States to develop, site, implement and assess the safety and performance of disposal systems. Various non-technical questions, including social, economic, institutional, local and national infrastructure, public policy and acceptance issues, were also studied. As part of these reviews, a technical document, *Inspection and Verification of Waste Packages for Near Surface Disposal* was published that describes the concepts of waste package inspection and verification, waste acceptance requirements, and the establishment of a waste package quality assurance/quality control programme.

"Near surface disposal of low and intermediate level waste is an option being practised or planned in many Member States, and there is a growing need for additional information and guidance."

Plans for high level, long lived waste disposal in deep geological repositories raise unique problems owing to the very long time-scales that must be considered. To heighten public confidence in geological disposal and refine long term predictions of the condition of such disposal systems, the Agency published a technical document on methods used to extrapolate short term observations to the longer time periods needed for analysing the isolation of long lived radioactive wastes. Analogue studies represent another approach to evaluating system performance and building confidence in the safety of geological systems. Accordingly, the Agency started a CRP on anthropogenic analogues that will study the processes that have affected ancient artifacts and materials. This can help provide an understanding of how human-made materials will behave in a repository environment over many centuries.

The contribution of monitoring to the long term safety of radioactive waste repositories was the subject of a technical document published by the Agency in 2000. Monitoring

is seen mainly as an important way to provide reassurance that a repository is fulfilling its intended purpose, i.e. to isolate waste from the human environment. The document describes possible environmental monitoring objectives at different stages of repository development, the monitoring techniques that might be applied, and the ways that the resulting information might be used.

"An important event in 2000 was the offer by Belgium and Canada to make their underground research laboratories available for international demonstration and training activities under the aegis of the Agency."

An important event in 2000 was the offer by Belgium and Canada to make their underground research laboratories available for international demonstration and training activities under the aegis of the Agency. Several Member States plan to construct such laboratories to develop expertise and hands-on experience with radioactive waste disposal in underground environments. The Belgian and Canadian offers provide an important opportunity to share expertise and promote international consensus among Member States.

WASTE MANAGEMENT INFORMATION AND TECHNOLOGY TRANSFER

Since 1996, the Agency has conducted regional demonstrations on predisposal waste management methods and procedures to provide hands-on training in processing specific kinds of radioactive waste, mostly from medical, research and industrial radioisotopes. In 2000, the first cycle covering Latin America, East Asia and the Pacific, and Eastern Europe and Middle East was completed. The series of demonstrations for the Russian Federation is still under way, and their scope is being expanded to add emphasis to quality management aspects of radioactive waste management. In the last four years, these demonstrations have reached more than 100 participants from 50 countries.

The number of radium conditioning operations increased by 50%, and several Member States provided new expert teams in 2000. In Asia, the Agency qualified new expert teams from the Republic of Korea and Pakistan, and carried out successful operations in Sri Lanka, Myanmar and Bangladesh. In Africa, operations were conducted in Madagascar, Egypt, Sudan, Mauritius and Tunisia. In Latin America, radium sources were conditioned in Venezuela. The few Latin American countries whose radium sources have not yet been conditioned still use radium for nuclear applications. Before the Agency can assist with conditioning, these countries will have to terminate such applications and collect all radium sources.

The radiation source accident in Thailand in early 2000 illustrated the continuing need for increased information and care in handling such sources. A technical document, on the *Handling, Conditioning and Storage of Spent Sealed Radioactive Sources*, was published in 2000 that provides information on both sealed source conditioning procedures and various storage options. Another document on *Management for the Prevention of Accidents from Disused Sealed Radioactive Sources* is in the process of being published.

Remaining with the subject of sealed sources, the Agency developed the computer software and began collecting and entering the data for an International Catalogue of Sealed Radioactive Sources and Devices. Member States have been asked to provide information for this resource, which will be supplemented by information from commercial catalogues and Internet databases. The catalogue, in its final form, will contain technical information about sealed sources, including design features and illustrations, and data on manufacturers and distributors, including addresses and company histories. It is intended as a tool for identifying orphan sources and old devices containing sealed radioactive sources.

The Agency serves as the Secretariat for the Contact Expert Group (CEG), which co-ordinates the management and disposition of spent fuel and radioactive waste in the Russian Federation, including waste from submarine reactors. By the end of 2000, 180 submarines had been taken out of service, of which 115 still had spent nuclear fuel on board. The rate of defuelling has increased with financial support from Japan, the USA and Western European countries. Four submarines were defuelled in 1998, eight in 1999, and 18 in 2000. Another 20–21 are scheduled for defuelling in 2001. The problem of liquid radioactive waste treatment has been solved by upgrading existing facilities at Atomflot, in the northwest part of the Russian Federation, near Murmansk, and by commissioning a new floating treatment facility in the far eastern part of Russia. With the participation of Norway and the USA, dual purpose metal–concrete casks for transportation and interim storage of spent nuclear fuel are now in use. As of October 2000, 28 casks had been manufactured. A new train has also been built to transport the spent fuel to the Mayak reprocessing plant. And in 2000, the Netherlands joined the CEG, bringing its membership to 13.

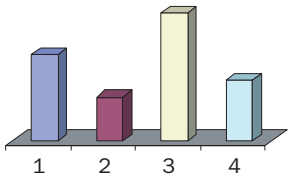
COMPARATIVE ASSESSMENT OF ENERGY SOURCES

PROGRAMME OBJECTIVE

To facilitate national and international comparative assessments of full energy source-to-service chains with the aim of supporting sustainable energy development. To explore the role of nuclear power for sustainable energy system development, and to assist Member States in making informed policy decisions about their future energy development.

Regular budget expenditure: $2 492 653

Extrabudgetary programme expenditure (not included in chart): $204 455



1. Energy Demand, Analysis, Supply Options and Indicators for Sustainable Energy Development: $677 843
2. Health and Environmental Impacts and Risks of Energy Systems: $341 812
3. Nuclear Energy in Sustainable Energy Strategies: $1 003 279
4. Support to Member States: $469 719

OVERVIEW

The Agency's programme on comparative assessment of energy sources focused in 2000 on reviewing nuclear power's future role in increasingly competitive electricity markets, and its potential contributions to furthering sustainable energy development. To this end, several new methodological tools were developed to aid in informed decision making in Member States. These include a new modelling and analytical approach to electricity system operation and expansion planning specifically designed to reflect growing competition and heightened environmental concerns in the electricity sector; a simplified model for estimating and valuing external costs associated with electricity generation; development of a system of indicators of sustainable energy development; and the update of several other Agency energy–economy–environment analytical tools. A series of reports were also produced on the impact of competition on nuclear power, and the importance of nuclear power for environmental protection and as a means of greenhouse gas mitigation. Capacity building in Member States was also emphasized, through the dissemination of methodologies and through training and information seminars. Finally, the Agency increased its interactions with other international organizations dealing with similar issues, both within and outside the United Nations system.

ENERGY DEMAND ANALYSIS, SUPPLY OPTIONS AND INDICATORS FOR SUSTAINABLE ENERGY DEVELOPMENT

Sound energy and electricity system analysis requires reliable data and information, appropriate tools and well defined analytical boundaries. Such analysis must also reflect current trends toward market liberalization, more stringent environmental constraints, the competitive allocation of scarce financial resources and rapidly changing technologies. To build and support the capacity of Member States to develop independent, sustainable energy development strategies, energy and environmental policies and investment decisions, the Agency provides a range of relevant data, information and analytical tools.

Despite the concerted emphasis worldwide on sustainable development, there remains no explicit comprehensive set of benchmarks for assessing progress, or needs, related to sustainable energy development, or to the role of nuclear power. The Agency's Indicators for Sustainable Energy Development (ISED) are intended to fill this gap. In 2000, the full set of 41 was field tested for applicability and data conformity in 15 countries. This has generated requests from several international organizations, including the International Energy Agency, UNESCO and the United Nations Economic Commission for Europe, to participate in the Agency's future work in this field. The full results of the project will be presented to the United Nations Commission on Sustainable Development for consideration during its ninth session (UNCSD-9), and to the Rio+10 meeting in 2002.

HEALTH AND ENVIRONMENTAL IMPACTS AND RISKS OF ENERGY SYSTEMS

A CRP completed in 2000 compiled data on wastes from non-nuclear fuel chains (mainly coal and oil), and developed a preferred international approach to comparing health and environmental effects from different fuel chain wastes. Specifically, at the CRP's third Research Co-ordination meeting, held in November 2000, several risk comparison methods (between nuclear and non-nuclear fuel chains) were evaluated and a preferred method based on comparisons against national regulatory standards was identified.

NUCLEAR ENERGY IN SUSTAINABLE ENERGY STRATEGIES

The development of the Agency's modelling tools over the past ten years reflects the evolution of electricity and energy markets worldwide. Early modelling work was tailored to centralized energy and electricity system planning and decision making, i.e. for national utilities with guaranteed markets and funding. More recently, the need is for decision aiding tools for choices among generation options under conditions of growing competition, a growing reliance on private capital markets, increased uncertainty and increasingly stringent environmental constraints.

"The development of the Agency's modelling tools over the past ten years reflects the evolution of electricity and energy markets worldwide."

The Agency therefore updated its established energy and electricity system models (WASP, FINPLAN, ENPEP and MAED) and introduced two new models, MESSAGE (a new electricity supply expansion model) and GTMAX, which simulates the operation of an electric system in a short-term electricity market. It also developed a simplified modelling package, B-GLAD, for estimating and valuing external costs associated with electricity generation. This software is designed to aid decision makers in weighing the health and environmental impacts of different generating technologies. The peer review and field test of B-GLAD is now in its final phase, and it will be ready for dissemination in 2001, at which time training will be made available to Member States.

To support its model development work, training and applications, the Agency introduced a Web based software package, *Business Collaborator* (BC), for most of its comparative assessment activities with Member States. BC establishes a 'virtual office' that participants can access in order to exchange and review documents and to engage in real-time 'chat room' conversations. The software has significantly reduced travel costs.

"... the Agency has taken an active role in climate change debates held by the United Nations Framework Convention on Climate Change [and the] Intergovernmental Panel on Climate Change ..."

With regard to environmental analysis, including climate change mitigation, the Agency has concentrated on framing the argument for keeping the nuclear option open at various international negotiations on definitions, guidelines and rules associated with sustainable development. Nuclear power's benefits in terms of mitigating greenhouse gas (GHG) emissions are undisputed (Fig. 1), and the Agency has taken an active role in climate change debates held by the United Nations Framework Convention on Climate Change (UNFCCC) and the Intergovernmental Panel on Climate Change (IPCC), providing background information and analyses of nuclear power's potential contributions to GHG emission reductions. Resolution GC(43)/RES/14 from the 1999 General Conference requested that the Agency help developing Member States to explore the role of nuclear power in achieving sustainable development and in mitigating GHG emissions through the Clean Development Mechanism (CDM). In response, research was initiated with Member States to estimate the potential of nuclear power projects in non-Annex I countries (essentially the developing countries) to satisfy GHG reduction commitments in developed countries, as well as sustainable development needs, through the Kyoto Protocol's CDM. In co-operation with five Member States, the Agency completed a series of case studies indicating that the CDM could indeed help advance nuclear development in Member States considering new construction, and that possible exclusions of nuclear power from the CDM would work against the interests of such nuclear development programmes.

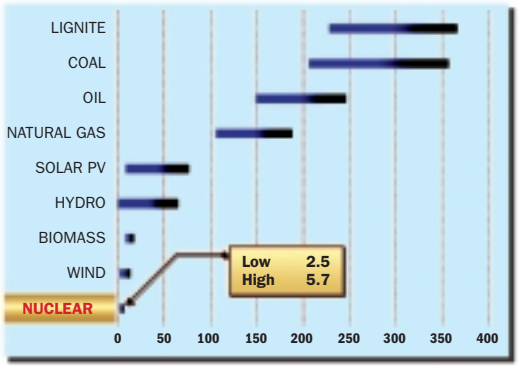


FIG. 1. Ranges of total GHG emissions from different electricity production chains, expressed in grams of carbon equivalent per kilowatt-hour of electricity generated. The ranges reflect differences in factors such as conversion efficiencies, local plant conditions, fuel transport requirements, the fuel mix assumed for electricity requirements related to plant construction and manufacturing equipment and the upstream components of the fuel cycle.

Four of these case studies (for China, India, Pakistan and Viet Nam) were presented at the 2000 General Conference in September. In the case of new capacity, coal fired power generation was the least cost baseline option in each case, except for Indian sites that were more than 1200 km from the nearest coal mine. For such sites, nuclear power was the least cost option. With that exception, each case study compared its coal fired baseline to alternatives with lower GHG emissions. In all of the comparisons, nuclear power proved to be the least cost GHG mitigation option, with mitigation costs (based on levelized generating costs) ranging from $26 to $57 per tonne of carbon (t C), a range that is considerably lower than the estimated marginal mitigation costs for compliance with the Kyoto Protocol.

The Agency then presented all five case studies at the Sixth Conference of the Parties

(CoP-6) of the UNFCCC in November 2000. The fifth study, focusing on the Republic of Korea, also concluded that coal fired power would be the least cost baseline alternative, and that nuclear power would be the most cost effective mitigation option with a GHG mitigation cost slightly over $4/t C. These presentations were especially relevant to the proposed exclusion of nuclear power from two of the flexibility mechanisms, CDM and Joint Implementation (JI). In a statement to the CoP-6 Plenary, the Agency also emphasized the low GHG emissions associated with nuclear power (see Fig. 1) and noted that the exclusion from flexibility mechanisms of any technology necessarily limits flexibility and thus, potentially, cost effectiveness. The presentation of the five case studies offered conference participants a detailed argument against the exclusion of nuclear power from the CDM and represented the only notable exploratory steps toward taking advantage of nuclear power's near-zero GHG emissions in the imminent markets for GHG reductions.

The next focal points of the debate on sustainable energy development are UNCSD-9 in April 2001, the continuation of CoP-6 in July 2001 and Rio+10 in 2002. The Agency has provided documents to UNCSD-9 and to the Committee on Energy and Natural Resource Development (CENRD) addressing nuclear power's future within the context of sustainable energy development. The Chair of CENRD asked the Agency to prepare a discussion paper on all current nuclear issues, including all applicable opinions and solutions. This involved a multi-stakeholder consultation process that solicited the full spectrum of opinions about the key facts and issues surrounding nuclear power. These were discussed and incorporated into the final discussion document. The Agency also contributed to the *World Energy Assessment*, organized jointly by the United Nations Department for Economic and Social Affairs, the United Nations Development Programme and the World Energy Council and published in September. This extensive study is intended as additional input to the UNCSD and provides the comprehensive factual background required to assess future sustainable energy development options.

A new CRP was started to quantify the actual contribution of nuclear power to date in mitigating air pollution, including GHGs. It also looks ahead to enhance mitigation assessment tools, develop methodological guidelines, and conduct national studies to better assess the potential role of different energy options, especially nuclear power, in sustainable energy strategies. All these contributions will be useful to Member States interested in designing and implementing sustainable development policies. Currently, the CRP includes national studies covering Bulgaria, China, Hungary, Pakistan, Romania, the Russian Federation and Slovakia. While all have a common goal of assessing nuclear power's role in reducing GHG emissions, each reflects country specific conditions regarding economic development, environmental regulations, international commitments to reduce GHGs, energy resource endowments, underlying technological capabilities, etc. Thus, in addition to conclusions about the role of nuclear power in different countries, these studies will, as a group, bring together valuable information on updated national GHG inventories, current and future policies on nuclear power development, and a variety of possible scenarios (and costs) of GHG reductions. Among other things, these will provide important additional factual and statistical information for future Agency contributions to the GHG mitigation debate.

"A new CRP was started to quantify the actual contribution of nuclear power to date in mitigating air pollution, including GHGs."

SUPPORT TO MEMBER STATES

The results of the various analyses and studies carried out by the Agency also serve as input for national workshops and training courses, and for working with individual

Member States to enhance their analytical capabilities in these areas. Support to Member States focuses on addressing such issues as: (i) the implications of global warming and the potential role of nuclear power in mitigation strategies; (ii) the development of sustainable energy strategies; and (iii) the trend toward greater competition and privatization within the electric power sector, and the implications for nuclear power.

The Agency completed a CRP on the DECADES modelling and database package in 2000. The purpose of this project was to enhance the capabilities of Member States, particularly developing countries, to perform comparative assessments of different energy options and strategies for electricity generation in conformity with the objectives of sustainable development. National case studies revealed that enforcement of environmental regulations has considerable implications on power system expansion in terms of investment requirements, operating costs and environmental burdens. A comparative analysis of alternative expansion options showed that the magnitude of these impacts is very much dependent on the strategies adopted to comply with the regulations. Some of the case studies conducted under the CRP showed the use of nuclear power to be part of the optimal strategy for future expansion of the electricity sector in a sustainable manner. The exchange of information and experience between national teams in the CRP also proved valuable in enhancing the Agency's energy planning tools to meet the evolving needs of electricity system planners in developing countries. The latest version of the DECADES Computer Tools was distributed to over 45 Member States, together with the requisite training in use of the package.

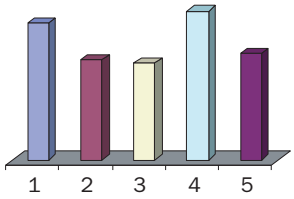
FOOD AND AGRICULTURE

PROGRAMME OBJECTIVE

To promote sustainable food security by fostering the development and transfer of nuclear and related biotechnological methods which provide significant opportunities for intensifying crop and livestock production, enhancing biodiversity and improving food quality and safety.

Regular budget expenditure: $11 770 179
(of which FAO's contribution is $ 2 216 108)

Extrabudgetary programme expenditure
(not included in chart): $2 929 469



1. Soil and Water Management and Crop Nutrition: $2 219 737
2. Plant Breeding and Genetics: $1 621 053
3. Animal Production and Health: $1 570 585
4. Insect and Pest Control: $2 413 213
5. Food and Environmental Protection: $1 729 483

OVERVIEW

Planned and implemented jointly with FAO, the Agency's food and agriculture programme helped Member States to strengthen significantly their capacities to integrate nuclear techniques into national and global efforts for overcoming some of the key constraints to sustainable food security. Efforts were also made in building awareness among political and technical decision-makers of the potential offered by nuclear technology in tackling these constraints. Examples of the many interactions and partnerships fostered during the past year included the decision of African Heads of State to move forward in using the sterile insect technique (SIT) against tsetse flies, the General Conference of the OIE adopting an accreditation procedure for animal disease diagnostic laboratories, and the Secretariat of the Global Rinderpest Eradication Programme (GREP) including the Agency on the technical body that will certify the global eradication of rinderpest.

The transfer by the Agency, through technical co-operation, of techniques and strategies developed or validated through previous research resulted in a number of achievements in dealing with problems of food security. These included the advances made by many Member States in: controlling fruit flies and improving trade through the use of SIT; eradicating rinderpest and increasing animal production and income generation with the help of immunoassay techniques; introducing better crop varieties developed through radiation and more efficient nitrogen-fixing tree species for improving soil fertility and crop production which were identified using isotopes; and adopting food irradiation to improve food safety and securing plant health. Finally, the Agency made progress in identifying and exploring, through co-ordinated research, new opportunities for harnessing nuclear techniques. In addition, important knowledge gaps and new applications were assessed critically before being recommended for wider transfer. The use of radiation to treat sewage sludge is one example; others include the development of molecular techniques for assisting plant breeders to select agronomically useful traits in crops; a technique for diagnosing trypanosomosis in livestock; and better procedures for mass rearing tsetse flies for use in SIT projects.

SOIL AND WATER MANAGEMENT AND CROP NUTRITION

Isotopes are playing a dynamic and growing role in monitoring and improving the nutrient and water status of soils, and thereby the sustainability of natural resource use for crop production. This was one of the main conclusions of an FAO/IAEA symposium on nuclear techniques in integrated plant nutrient, water and soil management, which was held in Vienna in October 2000. In addition to increasing the awareness among the international scientific and development communities of recent advances in methodologies and approaches, the symposium drew special attention to the substantial opportunities now available for improving the sensitivity and precision of stable and radioactive isotope determination through better instrumentation. New multiple labelling approaches with stable isotopes were identified that can follow the cycling of two or more nutrients simultaneously and which illustrate clearly the interdependence between nutrient and carbon fluxes.

"The Agency's Laboratories at Seibersdorf validated an iron oxide impregnated filter paper (Pi-strip) method for estimating plant-available soil phosphorus."

Urban societies are faced with the ever-increasing problem of managing waste materials. Modern sewage treatment plants produce large quantities of sludge that constitute a public health hazard owing to the presence of pathogenic organisms. A CRP and technical co-operation activities supported national and international efforts to identify approaches for dealing with this problem and to demonstrate the usefulness of sludges for improving soil fertility and crop production. The CRP concluded that gamma irradiated sludge was not only free of pathogenic organisms but was a valuable source of plant nutrients, increasing crop yields several fold and providing up to 50% of their nitrogen and phosphorus requirements. Moreover, by increasing water retention and decreasing soil compaction, this sludge was a valuable soil conditioning agent. Interestingly and contrary to common belief, sludges from urban areas generally had low concentrations of heavy metals. Nevertheless, the CRP recommended that the concentrations of these metals be monitored in soils and plants, and adherence to disposal guidelines and prescribed loading limits is necessary if sludge is repeatedly applied to agricultural land.

Phosphorus deficiency is a major constraint to crop production in many countries with acid soils. The use of a rapid and simple soil test to diagnose phosphorus deficiency in agricultural fields is therefore an essential first step in tackling the problem. The Agency's Laboratories at Seibersdorf validated an iron oxide impregnated filter paper (Pi-strip) method for estimating plant-available soil phosphorus. The results showed a close correlation between the Pi-strip method and the standard reference method based on isotopic exchange kinetics and hence with plant phosphorus uptake. The availability of this cheap and easy to use method improves the opportunities available to countries both to diagnose phosphorus deficiency and ameliorate its effects by applying locally produced phosphate rock fertilizers.

Overexploitation of natural vegetation and soil resources in many countries has resulted in widespread land degradation, lower crop productivity and reduced food security. A regional technical co-operation project that ended in 2000 involved nine countries in the East Asia and Pacific region in redressing this problem through agroforestry (i.e. the use of nitrogen fixing trees). Participants identified locally adapted species with high nitrogen fixing potentials using isotope methods. For example, when *Gliricidia sepium* was introduced as a shade tree in the coffee plantations of Sri Lanka and the prunings used as mulch on the soil surface, berry yields increased more than five-fold. Typically, the introduction of trees into cropping systems resulted in fast tree growth, better tolerance to drought and soil acidity, and less soil erosion on sloping

land. On-farm demonstrations of the benefits of agroforestry — better conservation of natural resources and more sustainable production of cash crops and valuable timbers — provided tangible incentives for farmers to integrate leguminous trees into their cropping systems.

PLANT BREEDING AND GENETICS

Molecular markers are playing an increasingly major role in the genetic characterization, breeding, and improvement of many crops. They have also greatly expanded the ability to assess biodiversity and understand the structure, evolution and interaction of plants with the environment. Through a CRP completed in 2000, more than 12 000 hybridization probes (both radioactive and non-radioactive), 2800 microsatellite primer pairs, and 2000 fingerprinting primers were distributed free of cost to facilitate the transfer of molecular marker technology to developing countries. In addition, information was provided on protocols describing the best methods of application and on software technology resources, troubleshooting and access to reference materials. The CRP participants made considerable progress in the development and application of amplification based DNA markers, and on introducing the robust methods of experimental design now widely used by the electronic and automotive industries to optimize experimental DNA marker protocols and conserve resources for the analysis of plants and their pathogens. They also used these materials and techniques to develop molecular maps for pearl millet, rice, barley, wheat, sorghum, and maize and for detecting fungal diseases in banana, plantain, yams and chickpeas.

Date palm plays an important role in food security and in maintaining the ecosystems of North African countries. However, date production and income generation from these trees is seriously threatened by 'Bayoud' disease, which in Morocco and Algeria has already killed over 15 million trees. A technical co-operation project on identifying new approaches for the control of this disease used low dose gamma radiation to increase the formation of somatic embryos, thereby enabling date palm trees to be rapidly multiplied. Further breakthroughs included the isolation of the toxin produced by the fungus and the identification of seven molecular marker primers that are associated with resistance or tolerance to the disease. These now make it easier to select disease resistant trees for subsequent testing in the field.

The continued use of radiation induced mutations was reflected in the inputs provided by Member States to the FAO/IAEA database on mutant varieties. During 2000, the number of mutant varieties that were officially released reached 2252 — an increase of 291 over the previous year and covering 163 species spread over 62 countries. To better quantify the impact of some of these varieties, the Agency embarked on a number of fact-finding missions to selected countries. The mutant variety 'TNDB100', which was developed from a traditional variety after radiation treatment and officially released in Viet Nam in 1997, now covers more than 200 000 hectares (ha) in the Mekong Delta. Its fast acceptance by farmers arises from its high yield (6–8 t/ha) and grain quality despite acidic soils and low input conditions, while its early maturing nature means that two or three crops can be grown per year. India provides another example. Here, the mutant variety TAU-1 of black gram is grown on over 500 000 ha, covering 95% of the area in Maharashtra State. The increased area planted and the yield achieved has contributed the equivalent of $64.7 million annually to the economy of the region.

"The continued use of radiation induced mutations was reflected in the inputs provided by Member States to the FAO/IAEA database on mutant varieties."

Lowering the cost of technology for crop improvement is vital for developing countries. Studies carried out in 2000 in the Agency's Laboratories at Seibersdorf demonstrated that natural daylight captured through

tubular skylights could replace artificial light and substantially reduce the costs of in vitro culture methods used for large scale propagation of crop plants. A prototype system to capture natural light and eliminate the need for electricity was developed which will be of major benefit in reducing the cost of micropropagation in developing countries. Using random amplified polymorphic DNAs, the Agency's Laboratories also identified four primers that are associated with specific DNA fragments of salt-tolerant rice varieties but not with those from salt-susceptible varieties. These primers are now available to assist the many Member Sates affected by soil salinity to select mutants for tolerance to saline conditions.

ANIMAL PRODUCTION AND HEALTH

Working closely with the OAU's Inter-African Bureau of Animal Resources (IBAR), FAO, the European Union, the Swedish International Development Agency and other donors, the Agency has continued to be active in its role as a catalyst and in harmonizing international and national efforts to develop immunoassay tests for monitoring the eradication of rinderpest from livestock in Africa. The results of a CRP revealed the enormous progress that has been made in eliminating this lethal virus infection from the region and underlined the critical role of FAO/IAEA technologies, strategies and capacity building for their use in securing this rollback. When the Agency first became involved, 14 African countries were infected and over a million heads of cattle were dying each year. Today only small areas in Somalia and southern Sudan remain infected and all countries in the region now use internationally standardized and validated sero-monitoring and surveillance tests backed up by quality assurance programmes and defined surveillance performance indicators monitored from the Agency's Laboratories at Seibersdorf.

"... the Agency assisted the OIE ... to develop a generic veterinary laboratory accreditation scheme to facilitate international trade in livestock and livestock products."

Equally deadly to cattle production and food security in Africa is trypanosomosis. In 2000 a CRP ended, funded by the Netherlands, that resulted in the successful development, international standardization and validation of an immunoassay test to reliably detect the disease-causing parasite in cattle populations. Already used in Zanzibar Island, United Republic of Tanzania, to confirm the eradication of the tsetse fly and in Ethiopia to provide baseline data to gauge the outcome of the Southern Rift Valley tsetse fly eradication campaign, this assay coupled with the national capacities established to use it reliably will become increasingly important as the momentum to eliminate the disease and its vectors from the region intensifies.

Using the knowledge and experience gained in developing and transferring immunoassay technology to national laboratories for animal disease diagnosis and surveillance, the Agency assisted the OIE (Organisation Internationale des Epizooties) to develop a generic veterinary laboratory accreditation scheme to facilitate international trade in livestock and livestock products. Based on an interpretation of the international standard ISO 17025, this scheme was adopted by the 154 Member States of the OIE at its annual General Conference in May 2000. Linked to the external quality assurance programme operated from the Agency's Laboratories at Seibersdorf, this provides a path for national veterinary laboratories to achieve international accreditation and conform to World Trade Organization standards for trade related laboratory testing.

Another major constraint to animal production in most developing countries is inadequate feed supplies. Building on the success of previous CRPs that identified feed supplementation strategies as being able to overcome this problem, two regional technical cooperation projects in Asia and Africa addressed the issue on a wider scale. Reviews

of both projects confirmed that the feed resources and strategies for their use identified through the CRPs led to better utilization of low quality feed for ruminant feeding in all participating Member States, and that one of the supplements developed — the urea-molasses multinutrient block (UMMB), proved particularly valuable both to smallholder as well as semi-commercial farmers. In Asia, for example, over 1.6 million kg of UMMBs were fed to over 25 000 cattle, buffalo, yaks and goats by the 6200 farmers associated with the project in 2000. In addition to stimulating livestock production, the project generated employment and income, particularly for village women. Critical to this success were the efforts made by Member States and the Agency alike to strengthen and extend the modalities and linkages between collaborating institutes, national livestock agencies, farmer organizations and non-governmental organizations for extension of the technology. Over 145 national training activities were conducted for field extension personnel and farmers, amounting to over 5000 person-days of training. Exhibitions, demonstrations, publication of leaflets in local languages and educational programmes through the mass media were also conducted. Some Member States established microfinancing schemes through revolving funds for farmer groups, while in other States commercial companies took on the production of UMMBs.

INSECT AND PEST CONTROL

Following the successful eradication of the tsetse fly from Zanzibar Island in the United Republic of Tanzania, the sterile insect technique (SIT) has continued to gain more recognition among Member States in the past year. In response to the increasing problem of African trypanosomosis, a livestock disease caused by tsetse fly, 12 affected countries formed the "Pan-African SIT Forum" under the auspices of the OAU for the development and application of SIT in area-wide programmes for tsetse fly eradication. Subsequently, the Heads of African States and Governments adopted a "Decision on Proposal for Eradication of Tsetse Flies on the African Continent" at their 36th Summit Meeting in Togo. As a result arrangements are under way to initiate a Pan-African Tsetse and Trypanosomosis Eradication Campaign.

Other developments in tsetse eradication included the development at the Agency's Laboratories at Seibersdorf of a new feeding and holding system which allows large numbers of tsetse flies to be provided with a blood meal as required and from which pupae can be efficiently collected. A field cage protocol for assessing the quality of sterile male tsetse was also developed and evaluated which will make a major contribution to the effectiveness of tsetse SIT field programmes in Africa. Furthermore, a robust and accurate protocol for the production of all male tsetse pupae was developed which eliminates two extremely time consuming processes that had to be followed during the eradication programme in Zanzibar. Taken together, these breakthroughs will reduce considerably the cost and increase the quality of mass produced tsetse flies.

"... the sterile insect technique (SIT) has continued to gain more recognition among Member States in the past year."

The Mediterranean fruit fly (medfly) is another insect pest that causes widespread economic damage. In South Africa, an SIT pilot technical co-operation project demonstrated the cost effective use of this environment friendly technology for control rather than eradication. By replacing insecticides with aerial releases of sterile flies, medfly populations were effectively suppressed throughout 2000 in the Hex River valley, a major table grape exporting area. The direct result was an approximately 60% reduction in the rejection rate of table grapes from this valley by inspectors of importing countries, representing a substantial increase in revenue to the local fruit industry.

The transnational medfly SIT technical co-operation project between Israel, Jordan and Palestinian Authority continued to make progress, resulting in the effective suppression of the pest from the Arava region and the Lower Jordan Valley. This effort allowed exports of vegetables to medfly free countries without quarantine restrictions to the value of $5 million. Based on the promising results in the first phase, the project was expanded with

"Improving the level of awareness of industry and consumers about the facts and benefits of food irradiation is key to stimulating wider acceptance and uptake of the technology."

US Agency for International Development and 'footnote-a/' support from the USA to cover other areas, including Gaza and Israel's western Negev. In addition, fruit producing areas in eastern Egypt are now being included to expand the sterile fly release area.

In another medfly SIT technical co-operation control project on the Portuguese island of Madeira, the medfly mass rearing and sterilization facility built with financial contributions from the European Union began producing an FAO/IAEA developed genetic sexing strain. Sterile male releases focused on the northern part of Madeira and neighbouring Porto Santo island have reduced fruit infestation levels. This led to a feasibility study being conducted with the aim of expanding SIT technology to major citrus production areas in Valencia, Spain and other major fruit producing areas in the Mediterranean basin.

A majority of medfly mass rearing facilities in the world are being converted to adopt the most advanced male only production technology using genetic sexing strains developed by the Agency's Laboratories at Seibersdorf. Currently, factories in Argentina, Chile, Guatemala and Portugal already produce under this system, and factories in Australia, Mexico, Peru and the USA are preparing for its introduction. The expanded El Pino facility in Guatemala reached production levels in 2000 of over 800 million sterile male medflies per week, the largest production of a male only medfly strain in the world, and sterile males produced at this facility are being used for medfly SIT programmes in Guatemala, Israel, Jordan, Mexico, South Africa and the USA.

The Agency's Laboratories at Seibersdorf made further technical and logistical improvements related to genetic sexing strains for medfly. The stability of the strain was improved by the introduction of chromosomal inversions and a procedure developed to allow the shipment of eggs between rearing facilities which could have a significant impact on the future commercialization of SIT.

As part of the strategy to increase awareness of the availability of the SIT for cost effective insect control, a video entitled *The Sterile Insect Technique: An Environment-Friendly Method of Insect Pest Suppression and Eradication* was produced under an interregional technical co-operation project, The video was distributed to entomology and ecology departments at universities, pest control research institutes and animal and plant protection organizations around the world.

FOOD AND ENVIRONMENTAL PROTECTION

Improving the level of awareness of industry and consumers about the facts and benefits of food irradiation is key to stimulating wider acceptance and uptake of the technology. A public information workshop arranged by the Agency and FAO for countries participating in RCA addressed public concerns about food safety and the benefits of food irradiation as a sanitary and phytosanitary measure. It resulted in the creation of a media network — *INFORM (Irradiation Network for the Media)* — to enhance public awareness.

Expanding the market opportunities for irradiated fruits, vegetables and other horticultural commodities requires that Member States meet the quarantine requirements for international trade. To facilitate this, an FAO/IAEA workshop involving senior food

control and plant quarantine officials from RCA countries certified irradiation as a sanitary and phytosanitary treatment for food and agricultural commodities. This highlighted the importance of taking a systematic approach to certification of food destined for international trade.

The draft certificate that was produced is intended to accompany irradiated foods and simplify inspection formalities in importing countries. At another workshop, guidelines were developed in the format required under the International Plant Protection Convention for using irradiation as a phytosanitary treatment of food. The aim is to have an international standard. In concert with these activities, a powerful information system was launched on the Internet called *IDIDAS (International Database on Insect Disinfestation and Sterilization)* to keep industry, government regulators and other relevant bodies up to date on the radiation doses used in the control of insect pests and mites.

The presence of excessive pesticide residues can result in imports being blocked, and represents a barrier to international food trade. To deal with this problem, a training course on quality assurance and control procedures for analysing foodstuffs for pesticide residues was held at the Agency's Laboratories at Seibersdorf. The participants became qualified in the skills and information required to implement food surveillance programmes and analytical quality assurance to comply with Codex Maximum Residue Limits.

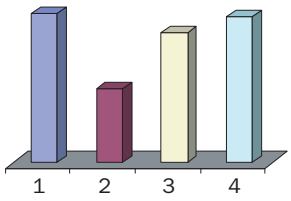
HUMAN HEALTH

PROGRAMME OBJECTIVE

To enhance the capabilities of developing Member States to address needs related to the prevention, diagnosis and treatment of health problems through the development and application of nuclear techniques.

Regular budget expenditure: $5 470 525

Extrabudgetary programme expenditure (not included in chart): $106 655



1. Nuclear Medicine: $1 639 432
2. Applied Radiation Biology and Radiotherapy: $811 609
3. Dosimetry and Medical Radiation Physics: $1 420 455
4. Nutritional and Health Related Environmental Studies: $1 599 029

OVERVIEW

The main focus of the programme was on the development of medical services for the prevention of malnutrition, detection of contaminant levels affecting humans, and diagnosis and management of cancer, nutritional, infectious and genetic disorders. In nuclear medicine there was emphasis on the use of open sources of radioactivity, which have been widely recognized in clinical practice as indispensable tools for the diagnosis and management of a large number of benign and malignant disorders. Radiotherapy techniques for the treatment of cancer were made more accessible to a greater number of Member States. While many States have the capability to ensure the proper accuracy of treatment procedures, a large group (especially those who are not members of the Meter Convention) still lack access to traceable dosimetry standards, or have no means other than the Agency to verify the quality of radiation measurements. For these Member States, the Agency remains the only organization that addresses these needs through its dosimetry programme. In the field of nutritional and environmental studies, nuclear based and related techniques were used to upgrade reference materials for studies of body composition of various elements and micronutrients for people living in Asia (the 'Reference Asian Man' project).

NUCLEAR MEDICINE

Three severe clinical problems were addressed through separate CRPs. One looked into the role of bone scintigraphy by single photon emission computer tomography (bone SPECT) in chronic back pain. Analyses of results obtained in 400 selected patients revealed that bone SPECT can give valuable information in the early diagnosis of backbone joint disease, which is a common and treatable cause of chronic back pain. Another study evaluated the correlation between recurrent urinary tract infection (acute pyelonephritis) and renal scarring (diagnosed by dimercapto succinic acid renal scintigraphy) in 310 children. The results showed a strong correlation between urinary tract infection and acute pyelonephritis. It was also observed that early and effective antibiotic therapy may lead to complete resolution of acute cortical lesions in the kidneys and reduction the incidence of delayed sequel (scars). The third study, conducted in patients with palpable breast lumps (scintimammography), showed high sensitivity and specificity in correctly diagnosing malignant lesions. It confirmed the usefulness of scintimammography as a complementary method to conventional X ray mammography in the diagnosis and management of patients with breast cancer.

In 2000, the Agency launched its first thematic CRP entitled 'Management of liver cancer using radionuclide methods with special emphasis on trans-arterial radionuclide therapy and internal dosimetry'. This is the first in a series of CRPs that will be linked to post-graduate medical education in universities in developing Member States. For the first time the CRP will have an equal number of research contract and research agreement holders working in pairs. Each pair will supervise a post-graduate student in research work leading to an MD or PhD degree awarded by the local or national university.

Under various national and regional technical co-operation projects, a number of new in vivo and in vitro nuclear medicine techniques were transferred to developing Member States. For example, molecular biology methods for the detection of drug resistant malaria, tuberculosis and Chagas disease were introduced in many countries of Africa and Latin America through two regional projects. The Agency provided an increasing number of Member States with technical support to strengthen their capabilities in the radioimmunoassay of tissue markers for breast cancer, hepatitis C, tumour markers and microalbumin, and in neonatal screening methodology. Other technical co-operation projects provided gamma cameras, SPECT systems and surgical gamma probes to developing Member States. In vivo nuclear medicine services in these countries were enhanced by the transfer of radionuclide

"Under various national and regional technical co-operation projects, a number of new in vivo and in vitro nuclear medicine techniques were transferred to developing Member States."

methods in the management of coronary artery disease, liver cancer, thyroid cancer, bacterial infection and childhood diseases. In an effort to standardize clinical practice, the Agency finalized the protocols for various nuclear nephro-urological procedures for uniform application in the Latin American region through a regional ARCAL project.

APPLIED RADIATION BIOLOGY AND RADIOTHERAPY

A number of clinical treatment protocols directed at optimizing the use of clinical resources for radiation therapy of cancer were evaluated in a CRP that ended in 2000. One of these protocols, addressing the palliation of dysphagia in oesphageal cancer, proved particularly successful. It evaluated 232 patients treated with a limited number of intralumenal insertions (two or three) of a radiation source into the oesophagus within one week (in contrast to the four or more weeks of external radiation). The protocol immediately received widespread acceptance and is now being promoted in Member States where this cancer constitutes a major clinical problem.

In another CRP involving a protocol on hemibody irradiation for disseminated bone metastatic pain resulting from various cancers (e.g. prostate and lung cancer), 72 patients were randomized between two fractions of radiation treatment doses in one day, four fractions in two days and five fractions in five days. The study's conclusions regarding the selection of patients for these regimes were that patients with prostate cancer in particular appear to respond better to the prolonged fractionation regime. However, with breast or lung cancer primaries, the shorter fractionation regimes may be used with good responses.

"Technical co-operation projects in radiotherapy have become increasingly oriented towards the provision of the entire 'package' of technology ..."

The role of radiotherapy in AIDS patients with cancer is a subject of great importance in sub-Saharan Africa, where HIV positivity can reach 35% in some population groups. The disease is also accompanied by a greater than five fold increase in many cancers. An expert group examining this issue prepared a guidelines document on decision making (including the option of not administering any treatment at all) in the radiotherapy management of cancer patients infected with HIV who have limited life expectancy attributable to AIDS.

Technical co-operation projects in radiotherapy have become increasingly oriented towards the provision of the entire 'package' of technology — equipment, dosimetry, training, protection and commissioning — necessary for coherent radiotherapy services. Other technical co-operation projects focus on cancer control management. This work is being conducted jointly with the International Agency for Research of Cancer (IARC), which provides support for cancer registries in countries where the Agency is improving treatment facilities. These registries are useful for assessing current needs of Member States and determining the impact of the national cancer management programme including the effect of radiotherapy technology supplied.

DOSIMETRY AND MEDICAL RADIATION PHYSICS

In 2000 there was a considerable increase in activities in support of X ray dosimetry. This is a result of an Agency survey showing that the calibration methods at diagnostic radiation qualities performed at Secondary Standard Dosimetry Laboratories (SSDLs) are not standardized. Following the survey, a large number of SSDLs have requested guidance on establishing calibration facilities for X ray dosimetry. The capability of the Agency's Laboratories at Seibersdorf in mammography was augmented, along with the calibration of instruments at diagnostic radiology qualities. The mammography standard of the Agency was calibrated and a calibration service was made available to SSDLs. For general diagnostic radiology, an experimental set-up used to analyse the X ray spectra was established at the Agency's Laboratories. In addition, a CRP was launched for the development of a Code of Practice for diagnostic X ray dosimetry. And a new Code of Practice developed for radiotherapy dosimetry based on absorbed dose to water standards was completed.

The IAEA/WHO network of SSDLs currently consists of 73 laboratories in 61 Member States (more than half of which are developing countries) and 20 affiliated members (international organizations and Primary Standard Dosimetry Laboratories). In 2000, three new SSDLs — in Ethiopia, Greece and a second calibration laboratory in Germany — joined the network. Co-operation and collaboration between metrology organizations is critical in ensuring standardization of measurements. Following the signing by the Agency in October 1999 of the 'Mutual Recognition of National Measurement Standards and of the Calibration and Measurement Certificates issued by National Metrology Institutes' (the 'Mutual Recognition Arrangement', or MRA) for the SSDL network, an intercomparison of measurement standards was held with SIM,

the regional metrology organization for the Americas. An intercomparison with EUROMET, the European metrology body, is planned for 2001.

A total of 56 national standards and reference ionization chambers were calibrated at the Agency for Member States: about 85% were radiotherapy level (including brachytherapy) calibrations and 15% were for radiation protection. And dose quality audits and intercomparisons were organized for SSDLs to check the traceability of their measurements and to monitor their performance. Seventeen SSDLs participated in the intercomparison of radiotherapy ionization chamber calibration factors and 30 in the thermoluminescent dosimeter (TLD) audit for radiation protection level dosimetry. Ninety-six radiation beams from cobalt-60 units and clinical accelerators operated at laboratories, or supervised by SSDLs, were monitored in the TLD audit for radiotherapy.

The Agency contributed to an international collaborative study of cancer risk among radiation workers carried out by the International Agency for Research on Cancer (IARC), in Lyon. The objective of the study is to provide an assessment of the carcinogenic effects of long term, low level radiation exposures in humans and to test the adequacy of current radiation protection recommendations. A comprehensive set of experiments was also carried out at the Agency's Laboratories at Seibersdorf to assess the response of personal dosimeters to energies and geometries similar to those existing under working conditions. The study involved irradiation of about 650 dosimeters.

The IAEA/WHO TLD postal dose assurance service for monitoring the calibration of radiotherapy beams at hospitals worldwide audited 333 beams, of which 215 were cobalt-60 and 118 were high energy X rays from clinical accelerators. The TLD programme has continued to expand, and the dosimeter return rate now exceeds 95%, with 80% of the results within the ±5% acceptance limits. An analysis revealed the limitations for hospitals that do not participate regularly in external audits: 109 radiotherapy facilities in 72 hospitals that had never been audited before were included in the IAEA/WHO TLD programme, with the finding that only 74% of the results of the first round of participation were within the ±5% limits; 11% showed large deviations (beyond 10%) in these hospitals. This compares with 83% of results within ±5%, and 6% of large deviations for hospitals that have participated more than once.

Following positive feedback on the assistance given in setting up national TLD programmes for quality assurance in radiotherapy, five more Member States received assistance. And as part of a technical co-operation project in Central American and Caribbean countries, a network for reciprocal on-site quality audit visits was established where physicists from various radiotherapy institutions in the region, supported by experienced physicists from the same region, carry out quality control measurements in other hospitals and countries.

"The Agency contributed to an international collaborative study of cancer risk among radiation workers ..."

Forty-eight cobalt-60 beam audits were performed for 23 industrial facilities and research institutes in Member States through the International Dose Assurance Service. Five results outside the acceptance limits were followed up.

NUTRITIONAL AND HEALTH RELATED ENVIRONMENTAL STUDIES

The most significant outcome of a CRP on Reference Asian Man completed in 2000 was the generation of reliable data sets for dietary intake by the participating countries. These data will help the participating Member States to resolve national problems of radiation exposure assessment, as well as facilitate

the development of the characteristics of a Reference Asian Man, the primary goal of this regional project. The CRP also strengthened the analytical quality control profile in these countries, enabling them to carry out reliable measurements for a group of trace elements of great radiological significance, namely caesium, iodine, strontium, thorium and uranium.

Differences in bone mineral density (BMD) measured using dual energy X ray absorptiometry (DEXA) in young adults across a range of countries was the subject of another CRP that ended in 2000. In examining an age stratified total of 3752 subjects selected at 11 centres in 9 countries, highly significant differences in mean weight, height, and BMD between countries ($p<0.001$) were found. Following adjustment for age, weight and height, highly significant differences existed in young adult bone mass (for both men and women) that, if they persist into old age, may contribute to a two to three fold difference in the risk of bone fracture.

"A regional UNDP/RCA/IAEA project on air pollution and its trends resulted in a network of air samplers being built to collect airborne particulate matter ..."

A regional UNDP/RCA/IAEA project on air pollution and its trends resulted in a network of air samplers being built to collect airborne particulate matter in the participating Member States. The results revealed increased levels of several toxic elements in the air of many of these countries, resulting in several undertaking legislative steps or technical countermeasures. Additionally, capacity for detecting regional air pollution episodes, such as haze due to biomass burning, was established

The application of nuclear techniques to problems of nutrition and health care took various forms in 2000. For example, technical co-operation projects in Latin America made progress in the use of isotopes for evaluating nutrition intervention programmes. A project in Chile completed a study on isotope techniques to measure iron bioavailability in fortified milk of the National Complementary Food Programme (PNAC). Another project examined body composition and energy expenditure in pre-school children using labelled water ($^2H_2{}^{18}O$).

Priority work in 2000 at the Agency's Laboratories at Seibersdorf included the first compulsory proficiency test for ALMERA, a network of 80 laboratories in 45 countries to measure environmental radioactivity. The test consisted of two sets of samples, one for the analysis of alpha and beta emitting radionuclides including plutonium, americium-241 and strontium-90, and the second for a mixture of gamma emitting radionuclides. A total of 56 sets of samples for alpha/beta analysis and 74 sets of samples for gamma analysis were distributed to 68 laboratories in 40 countries.

Related activities at the Agency's Laboratories included proficiency tests administered to other laboratories involved in the measurement of environmental radioactivity. Two tests, in particular, focused on strontium-90 in an incinerator ash matrix, and on the measurement of plutonium-239, plutonium-241 and americium-241 in soil. The results from the strontium-90 test indicate that the majority (over 80%) of laboratories still have problems determining this radionuclide. However, better results were obtained in the second test for the measurement of transuranium actinides.

The Seibersdorf Laboratories were also involved in the analysis of samples from two technical co-operation projects in Algeria and Jordan, and a follow-up activity connected with the UNEP evaluation of the military use of depleted uranium (DU) in Kosovo. Twenty-three Algerian samples gathered during a mission to former French nuclear test sites were analysed non-destructively for gamma emitting radionuclides (caesium-137, americium-241, europium-154 and barium-133), and destructively for actinides (plutonium, americium-241) and strontium-90. A summary

report of these analyses provided the basis for an Agency estimate of present and future possible doses to persons in the area. None of the sites gives rise to dose levels which might require intervention. It was, however, recommended to the Algerian Government that access continue to be restricted to the contaminated areas, and that further monitoring be continued.

A sampling and analysis mission to Jordan was intended to investigate Jordanian concern about elevated levels of fission products in their environment. In situ gamma spectrometric measurements were performed and 33 samples were analysed for gamma emitting radionuclides. The radioactivity levels found are consistent with a mixture from global fallout and contamination from the Chernobyl accident, and are generally lower than the levels found in southeast Europe.

And in Kosovo, 16 samples were taken by Agency experts and analysed at the Seibersdorf Laboratories for total uranium and uranium isotopic abundances. The results confirmed the presence of varying amounts of DU at the suspected sites, in addition to a natural uranium level of around 2 mg/kg generally in the Balkan soil. In spite of the extremely sensitive instrumental capabilities, this limits the detection of DU in the environment to about 0.1 mg/kg.

Responding to requests by Member States for environmental reference materials with reference values for primordial radionuclides (uranium, thorium, radium-226, lead/polonium-210), a potential phosphogypsum reference material for these radionuclides as well as three mineral waters for radium-226 were identified and are being analysed. The reference materials are needed to enhance the comparability of radioactivity levels measured by different laboratories on a worldwide scale.

A CRP on radiochemical, chemical and physical characterization of radioactive particles in the environment was approved in 2000. The goal is to develop techniques for identifying and investigating the characteristics of small radioactive particles, which in most cases are the primary species involved in the accidental or intentional release of radioactivity.

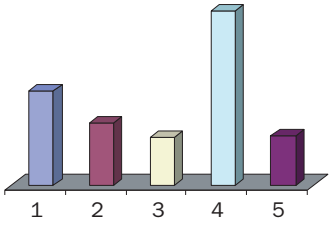
MARINE ENVIRONMENT, WATER RESOURCES AND INDUSTRY

PROGRAMME OBJECTIVE

To improve Member State capabilities to: (i) monitor and assess radioactivity in the marine environment for its protection, and use nuclear techniques and environmental isotopes to better understand and assess marine processes and pollution; (ii) integrate appropriate isotope and nuclear techniques in the planning and resource management of the whole water cycle and better understanding of human induced hydroclimatic impact on the water cycle and its interaction with other environmental systems; and (iii) adapt and utilize radiation and radiotracer technologies to improve industrial productivity and minimize environmental hazards.

Regular budget expenditure: $5 759 160

Extrabudgetary programme expenditure (not included in chart): $691 379



1. Measurement and Assessment of Radionuclides in the Marine Environment: $1 269 095
2. Transfer of Radionuclides in the Marine Environment: $832 708
3. Monitoring and Study of Marine Pollution: $638 576
4. Development and Management of Water Resources: $2 360 689
5. Industrial Applications: $658 092

OVERVIEW

Agency activities dealing with the marine environment focused on the quantification of marine levels and distributions of radioisotopes, the processes that control them and their ultimate fate and the way in which they can be used in association with other nuclear and isotopic techniques to understand broad problems of marine pollution. In addition, the work programme emphasized capacity building, quality assurance activities and education and training in marine environmental protection. New information was collected on radioactivity in several major oceanic regions using traditional and new automated techniques, and has been added to the Global Marine Radioactivity Database (GLOMARD). Laboratory and field training and research studies on the transfer of nuclear and non-nuclear contaminants in contrasting marine ecosystems were prominent. The ocean carbon dioxide cycle, a critical component of climate change, was the focus of a study of the production of particulate carbon and its removal from the oceans.

In its water resources management activities, the Agency focused on identifying and working with other partners in developing isotope methodologies and in assisting Member States through its technical co-operation programme. Specifically, an inter-agency initiative with UNESCO was launched to increase collaboration with the aim of integrating isotopes in hydrology research and education. New projects were formulated in co-operation with other agencies to develop isotope methodologies for improving global water resources assessment and understanding hydroclimatic processes. These included the estimation of submarine groundwater discharge and global monitoring of rivers. Technical co-operation projects in isotope hydrology, with a number of international agencies and the US Geological Survey as partners, were carried out in Ethiopia and Bangladesh. And research began on a new analytical technique for the isotope analysis of water that requires minimal infrastructure and operational skills.

In the area of industrial applications, the Agency assisted oil producing countries in Asia and Latin America in using radiotracers to enhance the recovery of oil from wells. At a symposium on radiation technology in emerging industrial applications, held in Beijing, the use of radiation for facilitating conventional wastewater treatment and upgrading of natural polymers to produce value added products were identified as promising applications in industry. In the field of non-destructive testing, the Agency developed protocols to determine corrosion and deposits in small diameter pipes.

MEASUREMENT AND ASSESSMENT OF RADIONUCLIDES IN THE MARINE ENVIRONMENT

A CRP on Worldwide Marine Radioactivity Studies (WOMARS) that reviewed the present sources of anthropogenic radionuclides in the marine environment and studied the open ocean distribution of radionuclides in the water column and sediment ended in 2000. The results showed that the present caesium-137 inventory in the marine environment from global fallout is approximately 158 PBq for the Pacific and Indian Oceans, and 83 PBq for the Atlantic and Arctic Oceans. The present caesium-137 inventory from local tropospheric fallout from nuclear weapon tests carried out in the Pacific Ocean is estimated to be about 72 PBq. In comparison, the current caesium-137 inventory in the Atlantic and Arctic Oceans and their marginal seas from Sellafield and Cap de la Hague nuclear fuel reprocessing plant releases is estimated to be about 24 PBq. The Chernobyl accident contributes about 11 PBq to the present inventories of caesium-137 in the European seas, mainly in the Baltic and Black Seas. Whereas the present average concentrations of caesium-137 in surface waters of these seas are estimated to be about 60 and 40 Bq/m^3, respectively, the worldwide average due to global fallout is about 2 Bq/m^3.

In related work, the world's oceans were divided into latitudinal bands to investigate changes in the average concentrations of strontium-90, caesium-137 and plutonium-239+240 over time in order to estimate the mean residence time of these radionuclides in the water column and to predict present concentrations. Such information is important for the estimation of radiation doses to humans through the consumption of seafood. The results indicate that the mean residence time for strontium-90 and caesium-137 in surface waters has been the same, about 25 years, while for plutonium-239+240 the residence time is about 13 years. The CRP was supported by extrabudgetary funding from Japan.

Through the Marine Radioactivity Studies in the World Oceans project, supported by extrabudgetary funds from Japan, IAEA-MEL analysed samples collected in the northeast Atlantic Ocean, the south Indian Ocean and the northwest Pacific Ocean. Several radionuclides (tritium, carbon-14, strontium-90, caesium-137, plutonium and americium isotopes) were analysed in water samples collected at different water depths at northeast Atlantic Ocean radioactive waste dumping sites around 46°N and 17°W. No clear evidence of radionuclide leakage from dumped containers with radioactive wastes was found. However, remarkable peaks in radionuclide concentrations were observed at medium depths between 2000 and 3000 m, which have not previously been observed. The conclusion is that high latitude injection processes must be responsible for the observed evolution of concentrations below 1000 m, downwelling high surface radionuclide concentrations to medium depths.

"No clear evidence of radionuclide leakage from dumped containers with radioactive wastes was found."

Surface and water column samples collected during an expedition to the south Indian Ocean (north of the Kerguelen Islands) were

analysed for their radionuclide constituents, as well as for salinity, density and temperature gradients. Radiotracers such as carbon-14, caesium-137, plutonium-238, plutonium-239+240 and americium-241 were used to study the evolution of anthropogenic radionuclide input at southern latitudes. Low radionuclide concentrations found in the south Indian Ocean reflect slow worldwide redistribution and mixing of global fallout radionuclides, resulting in a considerable dilution of the global fallout signal in the southern hemisphere. In addition, zooplankton (biological particulates) was collected to measure the concentration of natural polonium-210 and anthropogenic plutonium and americium isotopes. It was found that zooplankton, bearing different elemental and radionuclide compositions, can be used as a biomarker of open ocean water column processes.

"Member State radioanalytical laboratories have found Agency reference materials to be important tools for maintaining high quality assurance standards."

IAEA-MEL completed radiocarbon measurements in seawater samples taken at ten stations in the southwestern North Pacific during the Agency's 1997 Pacific Ocean expedition, in collaboration with the Japan Atomic Energy Research Institute and the University of Arizona. Five stations were located close to GEOSECS stations, and five were in the vicinity of Bikini and Enewetak Atolls, which may be influenced by former nuclear weapons testing. Compared with the GEOSECS data (from samples collected in 1973), the Agency's results show an increase of radiocarbon in intermediate waters. Furthermore, it is estimated that bomb produced carbon-14 inventories in the water column have increased by more than 20% during the last 24 years. Vertical profiles of carbon-14 at the stations near Bikini and Enewetak Atolls show a similar general trend to that found at other stations; therefore, no effect of close-in fallout from nuclear weapons tests has been found. This contradicts Agency data on plutonium-239+240 obtained from the same set of samples which showed that the Northwest Pacific Ocean has been affected both by global and close-in fallout. This latter input is in a different, more reactive, physico-chemical form, which leads to more rapid removal in the ocean.

Member State radioanalytical laboratories have found Agency reference materials to be important tools for maintaining high quality assurance standards. In the framework of the Agency's Analytical Quality Control Services (AQCS) programme for radionuclides in the marine environment, a fish sample from the Irish and North Seas (IAEA-414) was prepared, tested for any inhomogeneities and sent to almost one hundred laboratories participating in this new global intercomparison exercise, after which it will be issued as a new Certified Reference Material.

Underwater gamma ray spectrometry is a new technique that was developed by the Agency to complement or replace the traditional sampling–sample analysis approach for applications with space–time constraints, e.g. large areas of investigation, emergency response or long term monitoring. Both high efficiency sodium iodide and high resolution germanium spectrometers have been used to investigate contamination by anthropogenic radionuclides in a variety of marine environments. For example, a gamma ray survey of seabed sediment offshore from the Sellafield nuclear reprocessing plant was carried out with the aim of obtaining estimates of the distributions of caesium-137 in the area. The survey, carried out in co-operation with the Centre for Environment, Fisheries and Aquaculture Science of the United Kingdom, showed caesium-137 concentrations in surface sediment between about 100 Bq/kg to about 900 Bq/kg dry weight, with the latter value restricted to a small area some 2 km northwest of the outfall. As the recent releases from Sellafield were negligible compared with releases in the past, remobilization of caesium-137 from sediment plays a dominant role in the observed changes in caesium-137 levels.

The radionuclide levels observed at present in the marine environment are very low, thereby necessitating the use of highly sensitive analytical systems. A Monte Carlo simulation code was developed to optimize the background characteristics of low level, high purity germanium gamma spectrometers. A 15 cm thick lead shielding was found to be the optimum shielding for most gamma spectrometry applications.

Another important group of radionuclides in the marine environment is represented by long lived alpha emitters of both natural origin (such as uranium and thorium isotopes) and anthropogenic origin (such as plutonium and americium isotopes). These radionuclides have traditionally been analysed by semiconductor alpha spectrometry (SAS). However, SAS is limited in its sensitivity, resolution and mass of samples used for analysis. A new analytical method developed at IAEA-MEL using inductively coupled mass spectrometry (ICP-MS) allows much lower detection limits for plutonium and uranium isotopes and a much smaller sample size for analysis, in the case of seawater by two orders of magnitude.

"Certain nuclear techniques are unique tools for enhancing our understanding of how radionuclides and conventional pollutants move through the marine environment."

As part of a regional technical co-operation project on marine environmental assessment of the Black Sea region, the Agency organized an international scientific cruise involving six Black Sea Member States: Bulgaria, Georgia, Romania, the Russian Federation, Turkey and Ukraine. Contaminants in the marine environment were assessed, with a focus on anthropogenic radionuclides, to study oceanographic processes which control the fate of pollutants using radionuclides as tracers. The results will be used to assess the distributions and inventories of radionuclides in relation to input sources and oceanographic processes and to improve predictive models for the dispersion of contaminants and comparative assessments of natural and anthropogenic radionuclides.

TRANSFER OF RADIONUCLIDES IN THE MARINE ENVIRONMENT

Certain nuclear techniques are unique tools for enhancing our understanding of how radionuclides and conventional pollutants move through the marine environment. The Agency's new state of the art experimental aquaria facilities in Monaco continue to serve as a focal point for training and research studies on the transfer of nuclear and non-nuclear contaminants in contrasting marine ecosystems. However, a freak storm in April 2000 resulted in the complete destruction of the subsurface water pumps and intake pipes, causing major delays in the work of IAEA-MEL. Despite this setback, several experimental studies were completed during the year.

It has been shown that organisms at the base of the marine food chain are all important in governing the cycling and redistribution of elements and materials in the sea. Furthermore, we know that marine zooplankton feeding on microscopic plant life (phytoplankton) produce faecal pellets that play a major role in the biogeochemical behaviour of many radionuclides and their transfer through the water column. These zooplankton have enhanced capacities to accumulate natural polonium-210, the main deliverer of radiological dose through the marine pathway, and this high bioaccumulative capacity is particularly evident in oceanic regions of low biological productivity such as those typically found in the tropics. A collaborative project between the Australian Nuclear Science and Technology Organisation and the Agency measured the transfers of polonium-210, and its grandparent lead-210, from water to phytoplankton and from phytoplankton to zooplankton and their faecal pellets. The experimental results support the interpretation of field based results that the lead-210: polonium-210 ratios in water are greater than unity in oceanic

surface waters because of their differential removal, and that the removal is biologically mediated, primarily by zooplankton faecal pellets.

Radiotracers can be used to experimentally test the ability of certain organisms to serve as bioindicators of coastal marine contaminants, i.e. human made radionuclides and toxic heavy metals. With shrimp of growing importance in the world fisheries economy, the Agency carried out a study where edible shrimp were exposed for several months to bottom sediments contaminated simultaneously with a mixture of radiotracers of cadmium, silver, zinc and cobalt. Periodic gamma spectrometric measurements of the live shrimp clearly showed a similar direct transfer from sediments to shrimp of cadmium, silver and zinc which was, however, three times greater than that of cobalt. Comparing these transfer factors with known distribution coefficients for the same metals in sediments indicates that transfer rates from sediments to shrimp cannot be predicted solely from the relative differences in sediment–water distribution coefficients for sediments. Other factors such as sediment type, grain size and organic matter content also play a role in the transfer of the contaminant metal from sediment to the organism living on them.

"Radiotracers can be used to ... test the ability of certain organisms to serve as bioindicators of coastal marine contaminants, ..."

Bivalve molluscs are distributed throughout the world and are also an important food source. Because they filter directly from water organic particles for food, they have been proposed as potentially ideal bioindicators of water borne contaminants. Using new culture techniques developed specifically for the temperature controlled IAEA-MEL aquaria system, the bioaccumulation of americium-241, cadmium-109, caesium-134, cobalt-57, silver-110m and zinc-65 was examined from water and food in tropical mussels and oysters. The two long lived radionuclides (caesium and americium) are only weakly bioaccumulated in these warm water bivalves. When the contamination source is removed, caesium is rapidly lost from both species. In contrast, all the radiolabelled heavy metals were rapidly bioaccumulated, with generally higher concentration factors observed in the oysters than mussels. Both bivalve species accumulated more zinc and silver than the other contaminants tested, and in the case of oysters almost all the zinc accumulated was retained for several weeks after the organisms were transferred to non-contaminated sea water. This suggests that, in particular, oysters would be an ideal bioindicator of zinc contamination in tropical coastal areas.

An in-depth temporal analysis of transuranium nuclide concentrations in deep water sediment trap samples (1000–2000 m depth) from the northwest Mediterranean Sea, coupled with known changes in transuranium inventories in the overlying water column during the last two decades, indicates that sinking particles reaching the sea floor out of deep waters can account for 26–72% of the total annual plutonium loss and virtually all of the americium removal from the water column. A further observation that americium: plutonium activity ratios in unfiltered Mediterranean sea water are on average six times lower than those typically found in North Pacific waters suggests the existence of a specific mechanism for enhanced particle scavenging and removal of americium from the biologically poor waters of the open Mediterranean. Based on these oceanographic measurements and the proximity of the Mediterranean Sea to one of the world's largest desert regions, it is now believed that the unique and frequent inputs of Saharan dust particles, which are known to be active sites for americium sorption, are likely responsible for the observed rapid removal of americium to Mediterranean sediments.

The production of particulate carbon and its removal from the surface water of the oceans has a strong bearing on understanding the

carbon dioxide cycle and resolving other questions related to global climate change. The Agency's unique time-series measurements of particle flux in the northwest Mediterranean, taken over a 13 year period from 1987 to 2000, show a clear seasonal variation of high carbon flux during winter–spring months and a much diminished flux in the summer–autumn period.

Such field experiments on organic carbon sequestration have also highlighted the influence of Saharan dust events in mediating these climate related processes. Saharan dust, which carries a high load of wind borne nutrients, is now believed to actually fertilize and enhance biological particle production in the normally nutrient starved Mediterranean waters. This process, which is highly variable over time, could account for the three to four-fold inter-annual fluctuations in carbon flux which were observed during the 1990s. Such data sets, derived from collaborative studies with other scientists, underscore the true magnitude of the seasonal changes in carbon export from surface waters to depth.

MONITORING AND STUDY OF MARINE POLLUTION

Key results from inductively coupled plasma-mass spectrometry (ICP-MS) and accelerator mass spectrometry (AMS) measurements demonstrate that these techniques effectively complement radiochemical analyses of transuranic elements. Even more importantly, the isotopic information provided by ICP-MS and AMS can be used to identify the source of an observed contaminant. Strategies to exploit the higher resolution modes afforded by the Agency's Finnigan Element double-focusing ICP mass spectrometer provided interference-free plutonium isotopic data which can be used to discriminate contamination from different weapons detonations. ICP-MS and AMS are now being used to detect the presence of uranium-236 as an indicator of nuclear activities and processes. Such data cannot be obtained by traditional radiometric methods. In addition, the greater sensitivity provided by ICP-MS and AMS for many key nuclides has resulted in the collection and processing of smaller samples to obtain the required information. Isotopic analysis is also being used for trace metal assays through isotopic dilution analysis in the characterization of Agency reference materials.

Carbon isotope studies provide information on the source of organic material in marine sediments. A newly developed procedure using high performance liquid chromatography (HPLC) effectively separates petroleum hydrocarbons and biomarker lipids for compound-specific isotopic analyses. Three isotopic carbon projects examined the origin of organic material in marine sediments in diverse locations. The first project, off the western coast of South Africa, evaluated long term changes in the carbon cycle at the ocean–atmosphere interface of the Benguela Current upwelling system. The study showed a gradual decrease in the carbon isotope ratio over the past 4.5 million years (Pliocene–Pleistocene epochs). These measurements are a key component in the ultimate objective of determining the historical carbon dioxide exchanges between the oceans and the atmosphere. Another investigation, on the eastern continental slope margin of the Faroes–Shetland Channel, found high concentrations of mid-chain ketones in sediments at one drill site. The carbon isotopic composition in these substances was markedly different from that typical of marine algae. As these types of compounds could be formed by clay-catalysed reactions of triglycerides at high temperatures, the carbon isotope measurements are indicative of contamination from drilling activities. In the third investigation, different depositional environments on the Lorca Basin (Spain) were defined on the basis of the biological inputs to each marine sediment type.

"ICP-MS and AMS are now being used to detect the presence of uranium-236 as an indicator of nuclear activities and processes."

Speciation analyses help elucidate the environmental behaviour and bioavailability of metal pollutants in the environment. Mercury contamination in the surface waters of French Guyana was investigated as part of an evaluation of the impact of gold mining. The study assessed the distribution and transport of mercury in two typical water basins affected by mercury derived from gold mining operations: the Inini River basin, and the Sinnamary River and estuary. The results indicated that methyl mercury accumulates to very high levels in deep anoxic waters of the Petit-Saut reservoir, located on the Sinnamary River, and is released downstream of the dam into the river. As a result of this contamination, carnivorous fish collected in the Sinnamary catchment basin contain excessive amounts of methyl mercury.

"... novel and sensitive methods for the analysis of organotin compounds and their degradation products in marine sediments and biota were developed at IAEA-MEL."

The use of organotin compounds containing tributyltin (TBT) and triphenyltin (TPhT) in marine paints causes pollution in the marine environment. Because these anti-fouling compounds are highly persistent in marine sediments, continuous monitoring and surveys in areas with no historical data provide information on the extent and effect of pollution. To this end, novel and sensitive methods for the analysis of organotin compounds and their degradation products in marine sediments and biota were developed at IAEA-MEL. These techniques were used to analyse samples from both Qatar and the United Arab Emirates (UAE). Oysters from the UAE contain these anti-fouling agents at concentrations that might represent an ecotoxicological risk. High ratios of TBT and TPhT over its metabolites indicate recent inputs of these active biocides in the UAE. In comparison, organotin compounds were not significantly present in the sandy sediments and fish samples from both countries.

Quality assurance programmes assist Member State national laboratories and regional laboratory networks in producing reliable environmental data. These programmes implement global intercomparison and intercalibration exercises which characterize homogenized marine samples for their ultimate use as reference standards. Two new Reference Materials (sediment sample IAEA-408 and fish sample IAEA-406) were prepared and characterized for chlorinated pesticides and petroleum hydrocarbons. Regional reference materials for chlorinated pesticides and petroleum hydrocarbons, comprising one sample of sediment and one sample of biota were prepared for the Regional Organisation for the Protection of the Marine Environment (ROPME). A reference material was also produced specifically for laboratories in the Black Sea area. This sediment sample was analysed for chlorinated pesticides, petroleum hydrocarbons (BS1/OC) and various heavy metals (BS1/TM).

Contaminant screening provides key information on environmental quality to aid in coastal zone management. Responding to a request from Monaco, IAEA-MEL analysed harbour sediment samples for chlorinated pesticides, PCBs, petroleum hydrocarbons, organotin compounds and a range of heavy metals. Contaminant levels reflected normal port activities and no notable pollution hot spots were identified. The data aided management decisions for the disposal of waste material from the extension of the harbour. In this connection, water samples from the aquarium at the Oceanographic Museum of Monaco were analysed for petroleum hydrocarbons, PCBs and chlorinated pesticides. The results refuted the hypothesis that such substances, possibly remobilized by construction activities at the adjacent port, caused the photo bleaching of coral in the aquarium.

In related work, a contaminant-screening project was undertaken in the UAE and Qatar in collaboration with ROPME. Traces of petroleum aliphatics, indicative of diesel fuel, were found in marine waters at only one site,

namely on the east coast of the UAE. These contaminants also appeared in sediments and biota from this location. Generally, sediments and biota from Qatar and the UAE exhibited insignificant concentrations of organic contaminants. The relative composition of hydrocarbons in sediments from one location (Ras Al-Nouf, Qatar) signified recent, but minor, inputs of such contaminants. High mercury levels in fish and elevated cadmium concentrations in shellfish were measured in biota from the UAE. Biological samples from Qatar had lower contents of such heavy metals.

A number of important outcomes resulted from a just concluded CRP, sponsored by the Swedish International Development Agency, on the use of radiotracers in studying the distribution, fate and effects of pesticide residues on biota in the tropical marine environment. For example, capacity building in laboratories and training in the analysis of pesticides has helped several Member States evaluate pesticide pollution and its effects in tropical marine environments. Quality control and quality assurance procedures, including regular participation in intercomparison exercises and the use of certified reference materials to ensure the quality of data, were adopted by many of these laboratories. Research using carbon-14 labelled compounds was introduced in many Member State laboratories, as was gas chromatographic techniques. In most cases, these techniques were not in use before the start of the CRP. The research contracts awarded helped augment the human resources available to evaluate pesticide problems in developing countries.

DEVELOPMENT AND MANAGEMENT OF WATER RESOURCES

The Agency's *Medium Term Strategy* calls for greater use of partnerships with other international bodies to maximize the benefits of programme activities to the Member States of both organizations (see Box 1). The pursuit of such synergies was the driving force behind the Joint International Isotopes in Hydrology Programme (JIIHP), a new IAEA–UNESCO initiative that was launched to integrate isotope hydrology techniques in the water sector of Member States. Through JIIHP, there will be greater participation by and information dissemination to a wider group of practising and research hydrologists in Member States through UNESCO's International Hydrological Programme (IHP) network. The JIIHP was endorsed by UNESCO's General Conference and a Memorandum of Understanding for its implementation is being discussed by the two organizations.

An Advisory Group meeting to evaluate the potential benefits of isotope monitoring of global rivers concluded that isotope ratios in river water are an excellent proxy for precipitation and integrate the spatial and temporal variability in the hydrological cycle. A global network of isotopes in river water, therefore, can be a powerful new tool for monitoring climate change and/or land use patterns, as well as facilitating integrated water resources management. A river network will also supplement the long running IAEA–WMO Global

BOX 1. INCREASING THE VISIBILITY OF THE AGENCY'S WORK IN SUSTAINABLE DEVELOPMENT

The Agency highlighted its activities in isotope hydrology and their contribution to global water resources management at the Third World Water Forum at The Hague and the World Bank's Water and Sanitation Forum in Washington, D.C. In the Hague, the Agency projected its role in the various water related programmes of the United Nations system as part of an exhibition that included FAO, HABITAT, the UN Department of Economic and Social Affairs, UNEP, UNESCO, UNICEF, WHO and the World Bank. At the World Bank Forum, the Agency highlighted its contribution to projects that are investigating the arsenic contamination of drinking water in Bangladesh. This presentation, in particular, provided an opportunity to communicate directly with the professional and management staff of various agencies involved in the water sector. ■

Network for Isotopes in Precipitation (GNIP) and increase the utility of isotope data for water balance and climate change studies. The Agency is formulating the next step in this area, namely a CRP in collaboration with UNESCO and WMO that will design a river monitoring network.

The role of isotopes in the assessment of submarine groundwater discharge (SGD) was reviewed at another Advisory Group meeting

"Greater integration of isotope hydrology into water resources management practices in Ethiopia was an important accomplishment in 2000."

that also had UNESCO's IHP and the Intergovernmental Oceanographic Commission as partners. Comprising as much as 50% of total terrestrial freshwater runoff, SGD constitutes a substantial freshwater resource in coastal areas, but can also be a source of pollution for the marine environment. The meeting concluded that a unique methodology based on a combination of radioactive isotopes of radium and radon, and stable isotopes of oxygen, hydrogen, and strontium, can be developed to assess and quantify SGD, something that is difficult to achieve with non-isotopic methods.

The presence of elevated arsenic concentrations in drinking water continues to be a major public health issue in Bangladesh. At the request of, and in co-operation with the Government of Bangladesh, WHO, the World Bank, UNDP and UNICEF, the Agency organized a proficiency test to evaluate the quality of arsenic measurements made by about 20 laboratories in Bangladesh. The test will not only improve the quality of the measurements, but will also provide a greater degree of confidence in the analytical surveys performed by different laboratories. This is critical, since the results of the arsenic analysis of groundwater are being used to make policy decisions regarding the continued use of individual or community water supply wells. Clearly, decisions based on inaccurate or inconsistent data would have unintended and adverse social and economic impacts on the population.

Greater integration of isotope hydrology into water resources management practices in Ethiopia was an important accomplishment in 2000. Specifically, a national plan for groundwater resources assessment was drawn up at an Agency workshop organized in co-operation with the US Geological Survey and involving the Ethiopian Science and Technology Commission, the Ministry of Water Resources, the Ethiopian Geological Survey, Addis Ababa University and consulting hydrogeologists. The plan has been submitted for government approval and, upon implementation, will guide national and international efforts for groundwater resources assessment and management over the next 10–15 years.

A CRP on the use of isotopes for the analysis of flow and transport dynamics in groundwater systems assessed the applicability of different conceptual hydrological model formulations under different geological settings and at different spatial scales. One of the main accomplishments was the development of software by selected institutes on 'lumped parameter modelling' and 'compartmental modelling–mixing cell' approaches. Both software packages, together with a user's manual for these applications, will be available on CD-ROM.

A new application of the stable isotopes of dissolved molecular oxygen was tested to estimate oxygen consumption and replenishment rates in polluted rivers in a CRP that ended in 2000. These estimates are difficult to obtain by non-isotopic means. In addition, a new technique was tested for labelling fine suspended sediments with technetium-99m. This technique allows the simultaneous measurement of water and sediment phases in water pollution studies.

Sulphur isotopes, along with other isotopes, are useful in studying the origin of geothermal acidity, the estimation of reservoir temperatures and the investigation of scale formation in geothermal installations. This was the main conclusion of a CRP on the applications

of isotope techniques to problems associated with geothermal exploitation that ended in 2000. The results of this CRP will have a strong impact on this aspect of the implementation of Agency technical co-operation projects. For example, investigation results for some geothermal fields will be used directly for improved geothermal reservoir management strategies. Other geothermal systems with similar acidic problems will benefit from the established sulphur isotope systematics and isotope-chemical models in the CRP.

In related work, an Advisory Group meeting reassessed the available Agency reference materials in the field of stable isotope measurements. Careful measurements resulted in the consistent calibration of these materials for sulphur stable isotopes. This will improve the quality assurance of sulphur isotope measurements, which are extensively used in many hydrological and geochemical studies.

In many parts of the world, increasing development and migration have led to greater demand and impact on aquifer systems in urban areas. Improved methods for the management of groundwater resources are thus issues of high priority in many cities. A recently completed CRP evaluated the usefulness of geochemical and isotopic techniques for applications in major urban aquifers. Although many of the isotope techniques were demonstrated to be useful in non-urban situations, it was not clear how they could be applied in urban situations. The CRP demonstrated that isotope techniques might be most useful for understanding changes in groundwater recharge and for distinguishing multiple sources of recharge resulting from the effects of urbanization.

Soil erosion and sedimentation represent serious global threats to sustainable agricultural production, environmental conservation and dam sustainability. An Advisory Group meeting concluded that the 'basic' nuclear techniques developed earlier in related CRPs on soil erosion were valid for sediment 'fingerprinting' studies. However, the participants agreed that further development was required to construct a framework and methodology under which the nuclear techniques would be implemented for monitoring sedimentation control strategies.

The Agency published a manual for using isotopic and chemical techniques in geothermal reservoir development and management. Providing information on essential nuclear and complementary methodologies for a multidisciplinary approach to geothermal exploration, development and monitoring, the manual provides comprehensive procedures for carrying out isotope and geochemical investigations of geothermal systems, i.e. sampling, analysis and data interpretation. It is expected to facilitate personnel development in Member States and the implementation of future Agency technical co-operation projects in this field.

"The CRP demonstrated that isotope techniques might be most useful for understanding changes in groundwater recharge ..."

Improving quality assurance procedures for chemical analyses of geothermal waters in Member State analytical laboratories was the Agency's goal in holding a third round of intercomparison exercises. Thirty-five laboratories in Asia, Africa and Latin America participated in these exercises, with five of them serving as reference laboratories. These exercises serve as a diagnostic tool for the participating laboratories to identify their performance in water chemistry analyses.

In related activities, the Agency designed and tested a vacuum distillation procedure for the preparation of environmental water samples for tritium analysis at low activity levels. The new procedure ensures a high quality of tritium analyses in spite of the steadily decreasing tritium levels in hydrological samples and the associated increasing sensitivity to laboratory contamination by local sources. A sample pyrolysis line was installed for organic and inorganic substances coupled to mass spectrometric oxygen isotope ratio analysis. This will allow long term monitoring

of the oxygen isotopic composition of the available Agency stable isotope reference materials and ensure high quality standards of materials sold around the world as part of the Agency's AQCS. And the Agency tested a simplified sample preparation method for sulphur isotope measurements in a collaborating laboratory in Poland. The method will improve conventional sample preparation techniques, thereby further enhancing the quality of sulphur isotope measurements.

"In Niger, the isotope results are being used to constrain the flow and transport model of the aquifer system and determine those most vulnerable to pollution."

A two phase technical co-operation Model Project on isotopes in groundwater development was implemented by the Agency for north and west Africa. Egypt, Ethiopia, Morocco and Senegal participated in the first phase (from 1995 to 1998) and Algeria, Mali, Niger, Nigeria, Sudan and Uganda took part in the second phase (from 1997 to 2000). In Algeria, the isotope results indicate that the aquifers in the Djanet and Tin Seririne basins and in the Tidikelt region are not being replenished by modern precipitation. These findings strongly indicate that the water supply of the city of Tamanrasset will rely more on the mobilization of local renewable resources through appropriate subsurface dams. In Niger, the isotope results are being used to constrain the flow and transport model of the aquifer system and determine those most vulnerable to pollution. In northwestern Nigeria, critical data for the various sources of recharge and replenishment of the Rima Group aquifer were obtained. This information can be used in the management of groundwater resources in the Wurno irrigation scheme area and identification of areas suitable for artificial recharge. In Uganda, isotope results provided data on the replenishment of water resources in towns north of the capital Kampala. The information can be used to better manage the available groundwater.

Nuclear techniques can be very effective in measuring environmental pollution. The Agency conducted a sediment contamination study in Montevideo Bay; the surrounding areas of the Rio de la Platathat showed that heavy metal contamination was confined only inside the bay, but did not extend to the Rio de la Plata. This is crucial information to the authorities for planning remedial actions, which are now feasible because of the limited extent of the contamination.

In an Agency technical co-operation project in Costa Rica on the sustainable management of groundwater in the Central Valley, results demonstrated that nitrate in the groundwater originates from nitrogen fertilizer in areas of coffee plantations and from human wastes in areas without adequate sewerage systems. Labelled (nitrogen-15) fertilizer was used to demonstrate that the current nitrogen fertilizer management practices in high density coffee plantations are economically and environmentally inefficient. Only 6–40% of the total amount of fertilizer applied was being absorbed by coffee plants. The data collected from this project were later disseminated through a regional Agency–National University symposium.

Technology transfer is a critical component of the Agency's technical co-operation programme. One project focused on the use of artificial tracers (krypton-85 and hydrogen-3) to determine the re-aeration rate of polluted rivers in Ecuador. Tracer determined re-aeration rates in the Quito metropolitan region were much higher than those estimated from empirical techniques and allow better design of a planned water treatment facility for the city. The Agency also trained staff from the local implementing organization in the tracer technique. The simplicity of the technique and the availability of equipment and trained personnel in the country led other municipalities to request the local organization to help them in similar experiments.

INDUSTRIAL APPLICATIONS

A CRP on radiotracer technology for engineering unit operation studies and unit process

optimization ended in 2000. Among the achievements were the development and validation of software for tracer data modelling and interpretation for problem solving in major industrial processes, including fluidized beds, sugar crystallizers, trickle bed reactors, cement rotary kilns, flotation cells, grinding mills, incinerators, wastewater treatment units and interwell communications in oil fields.

Radiotracers are very competitive tools for enhancing oil recovery in oil fields, both onshore and offshore. Secondary and tertiary recoveries are used to collect oil that remains in the pores and fissures of the rocks. An Agency CRP developed and validated new radiotracers for investigation of secondary and tertiary recoveries. And a multitracer technique was tested and put into service in Argentina, Brazil, China and Viet Nam.

Radiotracer and nucleonic gauge technologies continue to be an active component of technical co-operation national and regional projects. The Agency carried out a number of activities in these areas for use in the petroleum and petrochemical industries. For example, radiotracer and sealed source technology for troubleshooting inspection in petroleum refineries was introduced for the first time in African countries. In Ghana and Nigeria this technology is being used for problem solving through column scanning and leak detection in heat exchangers.

The papers presented and discussed at an international symposium in Beijing on radiation technology in emerging industrial applications showed the environmental friendliness of this technology. The advantages of radiation processing in upgrading naturally available macromolecules into useful products for health care and agricultural applications have reached pilot scale demonstrations. In addition, the participants noted the use of radiation technology in mitigating environmental problems, particularly in the purification of flue gases and the decontamination of industrial and municipal waste water.

The results from a CRP in the Asia–Pacific region funded by extrabudgetary contributions from Japan highlighted the unique role of radiation processing in upgrading natural polymers into useful products. Such natural polymers as chitin, chitosan, alginates and carrageenans that are abundant in the region exhibit properties that can be used in the health care industry, agriculture and wastewater treatment. For example, radiation degraded polysaccharides — chitin/chitosan, alginates and carrageenans — can induce growth and suppress environmental stress on

"Radiotracers are very competitive tools for enhancing oil recovery in oil fields, both onshore and offshore."

plants, and also enhance antimicrobial activities. Irradiated chitosan, when applied as a coating agent on fruits, can delay ripening and spoilage, thereby increasing the shelf life of the fruit. In the health care industry, radiation processed chitin/chitosan is a biocompatible, biodegradable material that is also bactericidal. Hydrogels prepared from chitosan possess antibacterial properties that prevent infection and stimulate re-epithalization. Controlled drug delivery systems have also been prepared using radiation grafted chitosan. Environmental applications include the irradiation of chitin, which can significantly improve the efficiency of recovery of chitosan from biowaste. Due to its unique chemical structure, chitosan can be used as an adsorbent to treat various aqueous effluents containing heavy metals and toxic organics and dyes.

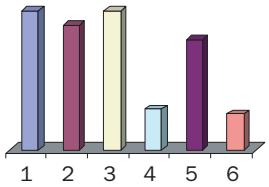
The detection and measurement of internal corrosion in industries using piping systems can help to improve the safety and reliability of industrial plants. Data from a CRP that ended in 2000 on the validation of protocols for corrosion and deposit determination in small diameter pipes by radiography will be used to draft an international standard. A major observation was that standard radiographic procedures have been validated, and protocols for identification and measurement of corrosion attack and deposits have been prepared.

PHYSICAL AND CHEMICAL SCIENCES

PROGRAMME OBJECTIVE

To promote research and development in specific applications of nuclear physical and chemical sciences for solving practical problems in the fields of energy, environment, nuclear medicine, material sciences and industry; and to enhance the utilization of existing research reactors and accelerators and help national analytical laboratories in acquiring skills in international quality in their analytical measurements.

Regular budget expenditure: $8 273 873
Extrabudgetary programme expenditure (not included in chart): $13 485



1. Nuclear and Atomic Data for Applications: $1 955 333
2. Nuclear Instrumentation: $1 747 334.
3. Theoretical Physics (contribution): $1 950 000
4. Utilization of Research Reactors and Particle Accelerators: $574 362
5. Radiochemical Applications: $1 543 047
6. Plasma Physics Applications and Controlled Fusion Research: $503 797

OVERVIEW

The Agency continued its global role of providing up to date nuclear and atomic data for use in all facets of nuclear science and technology, through the World Wide Web, CD-ROMs and Telnet retrievals. The setting up of a 'mirror site' in Brazil has been completed and this will greatly benefit scientists in the Latin American and Caribbean region. Injections of charged particle beams is a common mode of plasma heating in fusion devices, and a CRP on the topic resulted in the production of a data set for charge exchange cross sections. Special materials are used on the walls of fusion reactors that face plasma and the results of a CRP on this topic will provide valuable data on plasma-material interaction.

Individuals from Member State in East Asia and Latin America were trained in the operation and maintenance of nuclear electronics; educational kits were developed for this purpose. Two technical documents on the applications of research reactors and on strategic planning for their use will help improve the utilization of research reactors. The results of a CRP provided valuable information on the use of ion beams for optoelectronic and semiconductor materials and devices. Another CRP advanced the field of peptide based radiopharmaceuticals labelled with cyclotron produced radioisotopes. Indigenous capabilities in producing kits for the assay of prostate specific antigen (PSA), and other tumour markers, were built up in Member States through a CRP. A document on good manufacturing practices (GMP) in radiopharmaceutical production was completed and is expected to be included in a WHO manual on this subject. Radioanalytical chemistry and archaeology were combined for the first time in a CRP devoted to archaeological investigations in the Latin America region. The Agency continued to help Member States in introducing quality assurance and quality control measures in their radioanalytical laboratories and encouraged them to obtain ISO accreditation when involved in the commercial endeavours. In the field of plasma physics and controlled fusion research, steady progress is being made towards construction of the International Thermonuclear Experimental Reactor (ITER). The parties involved have requested that activities related to the phase of design adaptation to specific site conditions continue under the Agency's auspices.

NUCLEAR AND ATOMIC DATA FOR APPLICATIONS

The Agency focused its efforts on providing Member States with convenient and cost free access to the numerical nuclear and atomic data needed for the development and maintenance of nuclear technologies and applications. These applications rely on accurate and up to date data to provide a realistic description of the underlying physical processes. After dramatic annual increases in usage in the first years following the introduction of Web based on-line services for the main nuclear databases, the number of user retrievals from the Agency's nuclear data server (*http://www-nds.iaea.org/*) stabilized this year at a constant level. However, retrievals from specialized data libraries and files created in the framework of CRPs and similar projects show a steady increase in user access. There has also been steady growth in off-line requests for data products prepared by the Agency. These trends in the patterns of use of the Agency nuclear data services are summarized in Table I.

An Agency mirror site at the Nuclear and Energy Research Institute of Brazil (IPEN) began operation. Implemented through a technical co-operation project for Latin America and the Caribbean, the site has the same capabilities for nuclear data search and retrieval as the main Agency data server in Vienna and offers much faster access to data for many users in the region, especially in Brazil. With improved connectivity of Latin American and Caribbean regional networks, this site will also benefit other countries of the region. Overall, there is a clear trend in the growth of the number of users from developing countries (see Fig. 1)

Data distributed on CD-ROMs are regularly updated and interface programs have been developed that provide a quality of access to the data similar to on-line services. A test CD-ROM version of the EXFOR database of experimental reaction cross-sections implemented as a relational database, containing extended searching and interactive plotting capabilities, was prepared and distributed to co-operating data centres for evaluation. Other CD-ROMs that were distributed by the Agency include: a new version of CINDA containing a bibliographical index on microscopic neutron data; updated pre-processing codes for evaluated nuclear data files (PREPRO2000); a new release of the ENDF/B-VI library of evaluated cross-sections and the JENDL library of neutron dosimetry reaction cross-sections.

"The Agency focused its efforts on providing Member States with convenient and cost free access to ... numerical nuclear and atomic data ..."

TABLE I. **DISSEMINATION OF NUCLEAR DATA BY THE AGENCY**

	1996	1997	1998	1999	2000
Retrievals through the Web from main nuclear databases	—	23	4276	9581	9642
Telnet based nuclear data retrievals	5700	7350	2700	2180	1387
Information on CD-ROMs	—	—	205	420	648
Off-line retrievals	800	1900	1995	2290	2557
Accesses through the Web to other files and information materials	—	4400	7413	7757	11472

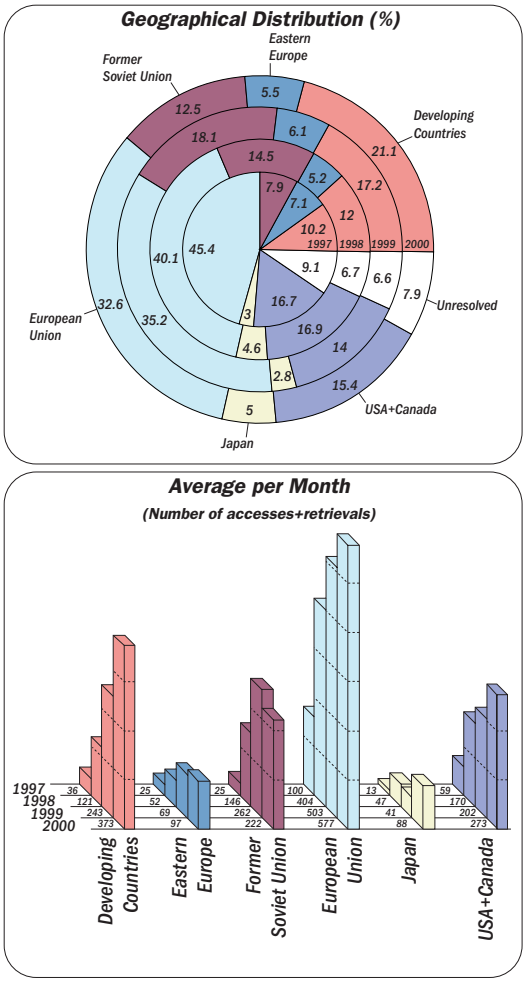


FIG. 1. Developing countries represent the second largest group of users (after the countries of the European Union) of the Agency's nuclear data server, accounting for more than 20% of all data retrievals and accesses. The figure shows Internet statistics for the Agency's nuclear data services, including the mirror server at IPEN.

A new project on the development of platform independent solutions for network shared nuclear databases began in co-operation with other data centres. The objective of this effort in database programming and data access is to broaden the participation of co-operating data centres working on different platforms (including PCs). The technology will also permit access to nuclear data services over local networks, which is important for isolated laboratories in developing countries with inadequate access to the Internet.

A large amount of data on the chemical erosion of wall materials of fusion devices was added to the on-line Atomic and Molecular (A+M) Data Information System, AMDIS. These data, the output of a recently completed CRP, are highly important in the modelling of nuclear fusion reactor experiments around the world. The results represent a major step forward in the amount and accuracy of such data. And two databases for physical sputtering and radiation enhanced sublimation for beryllium, carbon and tungsten and related compounds were completed in 2000.

A CRP on charge-exchange cross-section data for fusion plasma studies that ended in 2000 produced particularly important data in the modelling of beams injected into plasmas generated in nuclear fusion experimental devices. The data include results of experimental measurements and theoretical calculations that are especially important in validating theoretical models. A notable feature of this CRP was the use of some of the best experimental techniques available in the field.

NUCLEAR INSTRUMENTATION

The objective of a CRP that started in 2000 is to develop and foster the application of alpha particle spectrometry. Benefits will include better instrumental systems, Frisch-grid ionization chambers for large area samples, software for alpha spectrum analysis and the development of natural reference materials for alpha spectrometry.

An Advisory Group report concluded that nuclear techniques are well suited to determine whether a buried object contains an explosive. Nuclear sensors, because of their specificity to explosives, can therefore be used on a multi-sensor platform to provide confirmation of the presence of explosives. In this connection, the Agency described the possibilities and advantages of using nuclear techniques for humanitarian demining at two meetings of the Standing Committee of Experts on Technologies for Mine Action, a working group within the Ottawa Treaty.

Through its laboratories at Seibersdorf, the Agency provides essential support and transfers technology to Member States. Significant activities in 2000 included:

- New educational kits for training in nuclear electronics, including power supplies, micro-controllers and protection instruments.
- Developing power supply and control systems for portable X ray fluorescence (XRF) spectrometers.
- Developing and testing of a portable XRF spectrometer based on a low power X ray tube and thermoelectrically cooled semiconductor detector. The spectrometer can be used to study art objects.
- Developing a database to store the results of experiments obtained by using an automatic scanning system for large area detectors.
- Adapting selected commercially available information and communication technology based training tools for nuclear electronics and the maintenance/repair of surface mounted technology based instruments.
- Installing and assessing an energy dispersive XRF system based on a high voltage X ray tube.
- Assessing a backscatter fundamental parameter method for quantitative in situ XRF analysis.
- Establishing a worldwide information network for XRF laboratories

UTILIZATION OF RESEARCH REACTORS AND PARTICLE ACCELERATORS

The focus of activities in 2000 was on developing a set of documents and information services to enable the reactor manager to effectively deal with the current environment. In this regard, the Research Reactor Database included, for the first time, quantitative research reactor utilization information in order to track the effectiveness of Agency activities in this area.

The goal of an innovative new CRP is to pair mentor research reactor facilities with recipient institutions to expand the use of small angle neutron scattering (SANS). The paired facilities will work together on developing aspects of SANS to make it applicable to a broader range of facilities, such as those with lower power, or in harsher environments where support services for high technology equipment are not available.

Another new CRP will examine the use of ion beam techniques for the analysis of light elements in thin films, including depth profiling. The first Research Co-ordination meeting emphasized the importance of ion beam techniques in providing unique information in important materials research areas such as corrosion degradation, and the role of light elements like hydrogen, carbon, nitrogen and oxygen on the electrical and structural properties of advanced materials.

"The goal of an innovative new CRP is to pair mentor research reactor facilities with recipient institutions to expand the use of small angle neutron scattering ..."

Finally, a CRP on the application of MeV ion beams for the development and characterization of semiconductor materials helped the participating laboratories to significantly improve their analytical capability for materials characterization. Another benefit was greater collaboration between participating research groups, resulting in many scientific journal publications in the fields of optoelectronic characterization of semiconductor materials and devices, elemental characterization of thin semiconductor films, and defect transformations in semiconductors. In addition, several participating laboratories significantly improved their analytical capability for materials characterization.

At the Agency's Laboratories at Seibersdorf, an electronic version of the Accelerator Database was developed and is available on the

Agency's Web site (*http://www.iaea.org/worldatom/*). In addition, archaeological samples were analysed under an agreement with the Ruder Boskovic Institute in Zagreb.

RADIOCHEMICAL APPLICATIONS

Diagnostic and therapeutic radionuclides produced in cyclotrons are finding increasing use in nuclear medicine. Improved and more economical production procedures and efficient methods of target recovery will increase their availability and reduce costs. In order to realize this objective, a new CRP was started to develop improved targets for the production of iodine-123, iodine-124, palladium-103 and thallium-201.

"Assay of serum PSA (prostate specific antigen) levels is a valuable adjunct to the diagnosis and management of patients with prostate cancer ..."

A CRP on the optimization of synthesis and quality control procedures for the preparation of fluorine-18 and iodine-123 labelled peptides ended in 2000. The participants investigated improved synthetic routes for the production of prosthetic groups, including procedures for their purification and quality control. Three new peptides were identified, synthesized, radiolabelled and evaluated in vitro and in vivo. Among the radiopharmaceuticals tested, one holds significant promise and can lead to a new generation of somatostatin receptor specific agents.

Infectious diseases remain a major health problem and cause of death worldwide, particularly in developing countries. Nuclear medicine imaging, because of its sensitivity, offers an attractive option for the diagnosis of focal infections. A new CRP on the development of kits for technetium-99m radiopharmaceuticals for infection imaging has the goal of developing technetium-99m labelled compounds with better specificity and faster blood clearance, needed for clinical use

Assay of serum PSA (prostate specific antigen) levels is a valuable adjunct to the diagnosis and management of patients with prostate cancer, the second most prevalent cancer in males. Doctors recommend annual PSA tests in conjunction with digital rectal examinations in males over the age of 50. The local capability to produce PSA assay kits in sufficient quantities and at a reasonable cost is crucial for undertaking such screening programmes in developing countries. A CRP that ended in 2000 built on earlier expertise acquired in developing radioimmunometric assays for hormones generated in national laboratories. Among the main achievements: (i) a methodology was developed for the purification of PSA from seminal plasma, (ii) anti-PSA secreting hybridomas were produced; (iii) matched pair monoclonal antibodies (MoAbs) for use in the assays were obtained; and (iv) other key assay reagents including PSA standards, iodine-125 labelled MoAb tracer and MoAb coated tubes, were produced. In addition, the CRP participants developed PSA–immunoradiometric assay (IRMA) kits using reagents and validated them against imported kits. With this expertise, the participants will be able to produce IRMA kits for total and free PSA at an affordable cost to meet national and even regional demands, in addition to developing such kits for other tumour markers.

In regional technical co-operation projects in Europe and Latin America on quality assurance/quality control for nuclear analytical laboratories, counterparts were requested to submit regular progress reports, participate in proficiency tests and accept external audit inspections. The goal of these projects — to assist Member State laboratories establish a complete quality system in compliance with the ISO/IEC 17025 — was largely achieved

A recently completed CRP, carried out with the participation of the Smithsonian Institution in the USA, combined for the first time trace element analysis with archaeological investigations. A well established technique involving pattern recognition and 'fingerprint-

ing' through instrumental nuclear activation analysis was introduced to a number of laboratories in various Latin American countries to determine the provenance of ancient pottery. The CRP opened up new fields of application of nuclear sciences. Specifically, partnerships between users of the analytical data (the archaeologist) and the analyst were established. National teams were formed comprising analytical scientists and archaeologists to formulate the working hypothesis, collect and prepare samples, analyse the materials and evaluate the data sets.

In order to meet the need for reliable analytical tools in speciation analysis, isotopic and nuclear techniques must be used for validation and method development. Accordingly, a new CRP was started on the development and validation of speciation analysis using nuclear techniques for the method validation of arsenic, selenium and chromium species in aqueous media. The goal of this CRP is to establish recommended and validated speciation tools for use the laboratories of developing Member States.

PLASMA PHYSICS APPLICATIONS AND CONTROLLED FUSION RESEARCH

Through its work in plasma physics and fusion research, the Agency continued to: facilitate technical information exchange; foster co-operation between major laboratories and developing Member States; promote spin-off applications; help developing Member States strengthen their research programmes; and provide support for the ITER Engineering Design Activities (EDA). Work related to the ITER EDA facilitates execution of the ITER project and the dissemination of technical information on EDA results, which also benefits developing Member States.

Participants at the 18th Agency Fusion Energy Conference in Sorrento, Italy, reported that several tokamak experiments (DIII-D, JET, JT-60U, ASDEX-U, TEXTOR and HT-7) had exceeded the theoretical plasma density limit (the "Greenwald limit"). Such experiments also demonstrated the creation of a plasma region with reduced heat loss rate (an "internal transport barrier"), which improves the plasma energy balance. Pellets of solid hydrogen have been injected to sustain plasma density. The injection of powerful atomic beams, radio waves or microwaves has been shown to help sustain the plasma current and enhance plasma stability. Impressive results were also achieved in stellarator experiments, especially the superconducting Large Helical Device (LHD).

In inertial fusion energy (IFE) power plants, powerful laser beams or ion beams compress pea sized fuel pellets to a point where intense nuclear fusion reactions occur, resulting in small explosions. If these explosions are confined in a blast chamber and repeated

"Impressive results were also achieved in stellarator experiments, especially the superconducting Large Helical Device ..."

several times per second, heat and electricity are generated. On the basis of recent experimental success, IFE is now at the stage where significant benefits can be obtained from international co-operation. A new CRP on the elements of power plant design for IFE will help resolve such key interface issues as the:

- Driver/target interface (focusing and beam uniformity required by the target);
- Driver/chamber interface (final optics, magnet protection, shielding);
- Target/chamber interface (target survival during injection, target positioning and tracking).

This CRP will also assess the systems integration and environmental, safety and economic aspects of IFE power plants.

At a Technical Committee meeting in Chengdu, China, on the applications of fusion energy research to science and technology, various industrial and societal benefits, or

spin-offs, of fusion research were highlighted. For example:

- Hybrid diesel-electric engines first used in the Joint European Torus power supplies are now operating in the "Altrobus" in Italy;
- Patented microcalorimeters developed for fusion research are now being used in industrial plasmas;
- Electronic equipment developed for Langmuir probe diagnostics in fusion research are now being applied to space plasma research;
- Theoretical models (e.g. solution of Fokker–Planck equations) developed for plasma investigations are now being applied in financial modelling.

A Technical Committee meeting in Madrid provided a forum for the discussion of IFE target and chamber investigations worldwide. The key technical issues for successful pellet compression are the uniform illumination of the pellets by smoothed laser beams and the uniformity and sphericity of the fuel pellets. Among the topics discussed were: blast chamber technologies; chamber/laser interfaces; target injection; system integration; and safety and environmental issues. The meeting also helped to develop collaborations between small and large laboratories.

The Agency's Programme in 2000: Safety

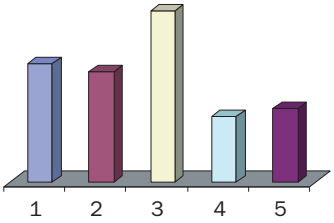
NUCLEAR SAFETY

PROGRAMME OBJECTIVE

To assist in achieving and maintaining a high level of safety of nuclear installations operating worldwide through international harmonization of safety standards and norms and the provision of advice and services.

Regular budget expenditure:$5 217 968

Extrabudgetary programme expenditure (not included in chart): $1 811 632



1. Nuclear Power Plant Safety Assessment: $1 143 373
2. Design and Engineering Safety: $1 077 237
3. Operational Safety: $1 660 428
4. Research Reactor Safety: $631 663
5. Regulatory Activities Related to Nuclear Safety: $705 267

OVERVIEW

Internationally accepted safety standards are an increasingly important element of the global nuclear safety culture, as they are adopted and applied or referred to more widely. Efforts to update the Agency's nuclear safety standards are now producing tangible results, with the publication in 2000 of Safety Requirements on the design and operation of nuclear power plants (as well as Safety Requirements on legal and governmental infrastructure for safety published in the general safety area), and three supporting Safety Guides.

The Agency provides safety services at the request of Member States as a means of facilitating the application of its safety standards and promoting good international safety practices. The services cover the areas addressed by the safety standards — the siting, design and operation of nuclear power plants, the safety of research reactors and the regulatory aspects of safety — and continue to be updated and tailored to meet Member State needs. The continuing, and in many cases increasing, demand for these services shows that Member States consider them to be beneficial to safety.

The results of Agency reviews demonstrate a general improvement in the safety of nuclear power plants and implementation of corrective safety measures, and progress in enhancing the effectiveness and technical capabilities of regulatory bodies. The number of significant events reported by nuclear power plants and regulators has steadily decreased over the last eight years, and there is a general move by utility and regulatory management towards promoting improvements in safety culture. Overall, there is evidence of a continuing general improvement in the operational safety of nuclear power plants throughout the world. However, a changing environment of increased competition from deregulation of electricity markets, social/political decision making for early plant closures and economic realignment of many countries could threaten this positive trend.

The safety of research reactors continues to cause concern. The Agency has responded to this concern with an expanded range of activities, and continues to explore options to strengthen international safety arrangements for such reactors.

NUCLEAR POWER PLANT SAFETY ASSESSMENT

Technical documents were prepared to assist in the implementation of the Agency's guidelines on accident analysis of nuclear power plants and on accident management programmes. These documents cover computer code analysis of in-vessel phenomena during severe accidents, incorporation of advanced accident analysis methodology into Safety Analysis Reports (SARs), applicability of computer codes for analysis of fuel safety criteria and training of accident management staff. In a related development, the Agency launched a new service in 2000, the Review of Accident Management Programmes (RAMP). A pilot review mission has been scheduled for 2001 at the Krško nuclear power plant in Slovenia.

"The results will help plants in achieving independent accident analysis capabilities, and are applicable to any first generation RBMK power reactor."

The first phase of an extrabudgetary project on accident analysis for the Kursk-1 nuclear power plant in the Russian Federation (an RBMK-1000 unit) ended in 2000. The analysis methodology, using both foreign and Russian computer codes, was validated through a detailed assessment of the models used. The results will help plants in achieving independent accident analysis capabilities, and are applicable to any first generation RBMK power reactor. The second phase of the project will be the development of a training programme.

In 1999, the Secretariat was requested by the Advisory Commission on Safety Standards (now the Commission on Safety Standards (CSS)) to prepare a report on the current status of national regulations and safety related issues for nuclear fuel cycle facilities other than nuclear power plants and research reactors. The report, completed in 2000, concluded that more than 250 facilities of different type and capacity are in operation worldwide, and some 60 facilities are either in the design stage or under construction. Although some of the safety hazards at reactor and non-reactor facilities are similar, there are some specific safety concerns at non-reactor fuel cycle facilities that must be given consideration in their design and operation, such as criticality, chemical toxicity, fire and explosion hazards. At the request of the CSS, the Secretariat prepared a proposal for an integrated set of safety standards to address the safety of non-reactor nuclear fuel cycle facilities. On the basis of this proposal, the CSS asked the Secretariat to proceed with the development of these standards in 2001–2003.

In addition to deterministic safety approaches, operators are making greater use — as are regulators — of probabilistic safety assessment (PSA) results in safety related decisions. A document prepared to compile the status of PSA applications in Member States and experience in its use demonstrates that in the design area the most use of PSA is made in identifying and prioritizing safety upgrades. However, PSAs are also performed to support new designs in identifying plant vulnerabilities and important intersystem dependencies. PSAs now generally form part of the SAR of a new plant or of a Periodic Safety Review of an existing plant.

In the operational safety area, PSAs are used to optimize technical specifications and maintenance schedules, control the plant configuration, and analyse the safety significance of incidents. Increasing use is also being made of PSAs by regulatory bodies. The Agency's activities in this area are therefore concentrated on promoting the quality and consistency of PSAs as a prerequisite for their application in decision making. Working groups were set up to compare PSA results from similar types of nuclear power plant and for pooling reliability data of plant components for use in PSAs. The Agency prepared guidance on carrying out PSAs for low power and shutdown conditions and on regulatory review of Level 2 PSAs.

Six International PSA Review Team missions were carried out to review PSAs and to provide guidance on the use of PSA results (see the Annex, Table A3). Though the results of these reviews are dependent on the individual studies, in general the weak areas relate to the estimation of frequencies for initiating events, the definition of system success criteria for loss of coolant events, and the identification and modelling of human errors and common cause failures. Often weaknesses have been identified in the quality assurance process for the PSA and the preparation of the supporting documentation.

A technical document on operational safety performance indicators for nuclear power plants, published in 2000, summarized the results of the Agency's work over recent years. The key operational safety attributes — the factors that most strongly determine whether a plant operates safely — were identified. For each of these attributes, measurable indicators were established at the overall, strategic and specific levels. The proposed framework was tested by means of pilot studies at four plants, with each plant adapting the general framework to reflect plant specific considerations. The Agency and the OECD/NEA also jointly organized a specialists' meeting on the subject. Both the report and the meeting indicated that additional work is needed in a number of areas. Some of these are being addressed through a CRP on methodological topics and data collection and analysis, and the feasibility of an international system of safety performance indicators will be discussed in a session of the international conference on topical issues in nuclear safety that the Agency is hosting in September 2001.

An extrabudgetary programme on the safety of nuclear installations in South East Asia, the Pacific and Far East countries is strengthening regulatory bodies and the safety of nuclear power plants and research reactors in China, Indonesia, Malaysia, the Philippines, Thailand and Viet Nam. Some of the measures taken include the establishment of licensing processes and systems of inspection and enforcement for research reactors. Following guidance and training provided to Indonesia's regulatory body, a system for the qualification of inspectors is being prepared. Several regional and national training events were organized, and the participants — regulators and operators of nuclear power plants and research reactors — indicated that they found these events very beneficial in enhancing nuclear safety knowledge and technical competence.

The Agency began work in a number of countries to improve the scope and technical quality of SARs for research reactors. China was assisted in reviewing the SAR for the WWER-1000 nuclear power plant being built at Tian-

"The Agency began work in a number of countries to improve the scope and technical quality of SARs for research reactors."

wan, particularly in the areas of PSA, component integrity and conceptual design of the instrumentation and control systems, and in initiating a periodic safety review of the Qinshan-1 nuclear power plant.

Based on the Country Nuclear Safety Profiles that were developed in recent years and feedback from assistance missions, Nuclear Safety Action Plans were developed jointly by the Agency and the countries receiving nuclear safety support through the technical co-operation programme. These plans indicate priorities for establishing and maintaining a nuclear safety infrastructure that meets the requirements of the Agency's safety standards.

DESIGN AND ENGINEERING SAFETY

Revised Safety Requirements for the design of nuclear power plants were published in 2000. These specify internationally agreed design requirements for structures, systems and components important to safety that must be met for the safe operation of a nuclear power

plant, and for preventing or mitigating the consequences of events that could jeopardize safety. They also specify requirements for a comprehensive deterministic and probabilistic safety assessment of operating nuclear power plants and take into account the most recent developments in safety approaches. They supersede the 1988 *Code on the Safety of Nuclear Power Plants: Design*.

The first of a series of supporting Safety Guides was also published in 2000 on software for computer based systems important to safety. Two other Safety Guides, on instrumentation and control systems important to safety and on safety assessment and verification, have been approved for publication, and nine other revised Safety Guides on design safety are being prepared.

"Both of these reviews demonstrated the significant progress in the safety of WWER nuclear power plants over the past decade."

The Agency published guidelines for the conduct of software safety review services. This is the fourth of the five areas of Engineering Safety Review Services for which guidelines have been published: guidelines for ageing management assessment teams, design safety review services and fire safety review services have already been published, and those for seismic safety review services will be published shortly.

A design safety review carried out by the Agency of the South African Pebble Bed Modular Reactor (PBMR) resulted in several key recommendations to improve the safety of the design and to make the demonstration of safety more complete, but did not identify any fundamental flaws in the safety area that would preclude a successful project. To overcome the lack of well established safety standards for this type of reactor, the Agency initiated an in-depth investigation of all safety aspects of modular high temperature gas cooled reactors and their implications for current safety standards. A team also reviewed the safety of, and regulatory requirements and guidance for, the Korean Next Generation Reactor (KNGR) design. The impact of Agency safety reviews of new designs has been very significant both to the States developing them and to the international community. The acceptance of innovative designs and design standards internationally hinges on the effective solution of design safety issues and Agency reviews provide a technical and unbiased basis for this assessment. The experience gained from these reviews will allow the Agency to be a focal point for the development of safety approaches for reactors of evolving or innovative design.

Through its technical co-operation programme, the Agency organized a review mission to units 1 and 2 of the Bohunice nuclear power plant in Slovakia, which are of first generation WWER-440/230 design. After reviewing documentation and conducting plant walkdowns, the reviewers concluded that a comprehensive and well justified safety upgrading programme had been developed and was being implemented. The programme defines a new safety case that satisfies national requirements and, in some cases, goes beyond the Agency's recommendations for the safety upgrading of reactors of this vintage. Another mission reviewed the modernization programme for units 5 and 6 of the Kozloduy nuclear power plant in Bulgaria. Both of these reviews demonstrated the significant progress in the safety of WWER nuclear power plants over the past decade.

Over the past five years, the Agency has sent about a dozen missions to the Islamic Republic of Iran to address various aspects of the safety of the Bushehr nuclear power plant. The design of this plant is unique: the civil engineering structures from a partially built PWR plant are being used to house a WWER-1000 reactor. The structures have also suffered war damage and been repaired, which makes the project even more challenging. In 2000, the Agency carried out a safety review of selected chapters of the Preliminary

Safety Analysis Report (PSAR) of unit 1 to assess the safety and provide comments and recommendations to improve the compliance of the design with its safety standards. A separate mission visited the Iranian Safety Authority to assist it in its review of the PSAR.

Intergranular stress corrosion cracking in stainless steel pipes is a recognized safety issue for water cooled reactors. An extrabudgetary programme on the mitigation of such cracking in the austenitic stainless steel piping of RBMK reactors aims to assist countries operating such reactors in establishing effective mitigation programmes, through technology transfer, training and guidance. Among the first activities under this programme, were two training courses on risk based inspection and on advanced ultrasonic testing for the detection, characterization and repair of cracking. In addition, a comprehensive information package developed in the USA on repair and mitigation techniques was given to the countries operating RBMK reactors.

OPERATIONAL SAFETY

A publication containing revised Safety Requirements for the operation of nuclear power plants was issued in 2000. It specifies internationally agreed requirements that, in the light of experience and the present state of technology, must be satisfied to ensure the safe operation of nuclear power plants. This publication supersedes the 1988 *Code on the Safety of Nuclear Power Plants: Operation.* The first two of the series of supporting Safety Guides were also published in 2000 on fire safety in operation and on operational limits and conditions and operating procedures. Two other Safety Guides, on plant modifications and on the operating organization, have been approved for publication, and seven other new or revised Safety Guides on operational safety are being prepared.

The process involving Operational Safety Review Team (OSART) missions now typically includes a self-assessment seminar well in advance of the mission, which enables the operator to begin the improvement process up to two years before the evaluation mission. Seven such seminars have been carried out to date. For most plants the improvement in operational and management standards over the period between the self-assessment seminar and the OSART follow-up mission is visible and demonstrable (see the Annex, Table A4).

Some Member States, such as France, Germany, India and the United Kingdom, carry out their own internal reviews of plant operational performance. At the invitation of France, the Agency attended an internal review at the Dampierre nuclear power plant to monitor and comment on the French process and test the guidelines developed by the Agency for the external assessment of national review processes. The French process was found to be both comprehensive and effective. Based on the lessons learned, the Agency's guidelines will be completed in early 2001 and a service offered to Member States for effectiveness assessments of national review processes.

"The management of operational safety and safety culture needs a comprehensive and balanced set of assessment tools and performance indicators ..."

The management of operational safety and safety culture needs a comprehensive and balanced set of assessment tools and performance indicators that can be used by both operators and regulators. The Agency held three meetings in 2000 with those experienced in the successful application of safety culture assessment processes and tools in order to exchange experience and to publish successful practices. In light of the potential distraction of management from safety as a result of the competitive, financial and political pressures facing the industry, many utilities and regulators are now adopting a more comprehensive

set of indicators such as those developed by the Agency over the last three years and published in 2000.

Operating experience has been used successfully over many years in improving operational performance. The Agency has continued to develop its new comprehensive method for co-operation with Member States in assessing the effectiveness of and enhancing a nuclear power plant's entire operating experience and corrective action programme. Guidelines for a new service — the Peer Review of Operating Safety Performance Experience (PROSPER) — were developed in 2000, and a pilot mission carried out in the United Kingdom. Seven introductory seminars and workshops in five Member States prompted requests for further missions (see the Annex, Table A5).

"The Agency has a particular responsibility for the safety of research reactors under Project and Supply Agreements with Member States."

Three visits were made to the Chashma nuclear power plant in Pakistan to assist in enhancing the competence of plant managers in safely operating the plant. In addition, a joint Agency–Pakistani advisory committee was established to oversee the effectiveness of the management of plant operation. The Chashma unit has now been started up and taken over by the Pakistani operators, and the Agency is continuing co-operation.

As part of its increased collaboration with WANO, the Agency made presentations in both Ukraine and the Russian Federation to senior utility, plant and regulatory management. The presentations focused on the capabilities of the Agency for co-operation in such areas as self-assessment, operating experience, management of safety and safety culture. The Russian Federation subsequently requested Agency assistance in developing a utility wide self-assessment programme based on Agency standards. It has also requested that the Agency lead a seminar on self-assessment at the Kalinin nuclear power plant.

RESEARCH REACTOR SAFETY

In a letter to the Agency's Director General in April 2000, the Chairman of the International Nuclear Safety Advisory Group (INSAG) summarized "three major safety issues" concerning research reactors: the increasing age of operating research reactors; the large number of these reactors that are shut down but not decommissioned; and the number of research reactors not under adequate regulatory control. INSAG also suggested investigating the possibility of developing a legal instrument to cover the safety of these reactors. The Agency has taken steps to strengthen its research reactor safety activities in response to these concerns. For example, the review services now place higher priority on assessing and helping to improve regulatory effectiveness, and on operational safety aspects such as the management of safety and safety culture.

The Agency has a particular responsibility for the safety of research reactors under Project and Supply Agreements with Member States. General Conference resolution GC(44)/RES/14 requested the Secretariat to continue to explore options to strengthen international arrangements for research reactor safety, taking account of input from INSAG and others, and to continue to monitor closely those reactors subject to such agreements. Accordingly, eight safety review missions visited research reactors under agreement during 2000. Some reactors have specific safety problems requiring urgent solutions, and the Agency has taken an active role in dealing with these cases. In this regard, missions during 2000 to Colombia, the Democratic Republic of the Congo and Nigeria found the situation in each case significantly improved.

And finally, the first meeting of the Incident Reporting System for Research Reactors was held in 2000. This system aims to provide for

such reactors similar benefits to those provided by the Incident Reporting System for nuclear power plants. At present, 27 Member States are participating in the system.

REGULATORY ACTIVITIES RELATED TO NUCLEAR SAFETY

The International Regulatory Review Team (IRRT) service focuses on the regulation of nuclear power plants and research reactors (see the Annex, Table A10). However, the service now addresses, on request from Member States, the regulation of radiation, radioactive waste and transport safety. Following observations made by the First Review Meeting of the Convention on Nuclear Safety, special attention is being given to the de jure and de facto independence of the regulatory body and to financial and human resources. Many of the recommendations for improvement made during IRRT missions are specific to the particular national circumstances. However, some issues of more general interest are:

- The need for legislation to provide clear definition of the roles and responsibilities of all governmental bodies involved in the regulatory process, and to give the bodies the appropriate authority to meet these responsibilities;
- The need to ensure that the resources allocated to the regulatory body are adequate for it to function effectively;
- The importance of effective co-ordination between different regulatory bodies responsible for different aspects of a facility or activity;
- The role that the regulatory body plays in the development of safety culture in the plant operating organizations.

"... special attention is being given to the de jure and de facto independence of the regulatory body and to financial and human resources."

The Incident Reporting System (IRS), operated jointly with the OECD/NEA, was established in the early 1980s to exchange information on unusual events at nuclear power plants, as well as increasing awareness of actual and potential safety problems. As shown in Fig. 1, participating countries submitted 68 reports in 2000. The reporting rate appears to be stabilizing at about 100 events per year or fewer. This number is also influenced by the fact that repetitive events that do not provide new insights are not reported to the system.

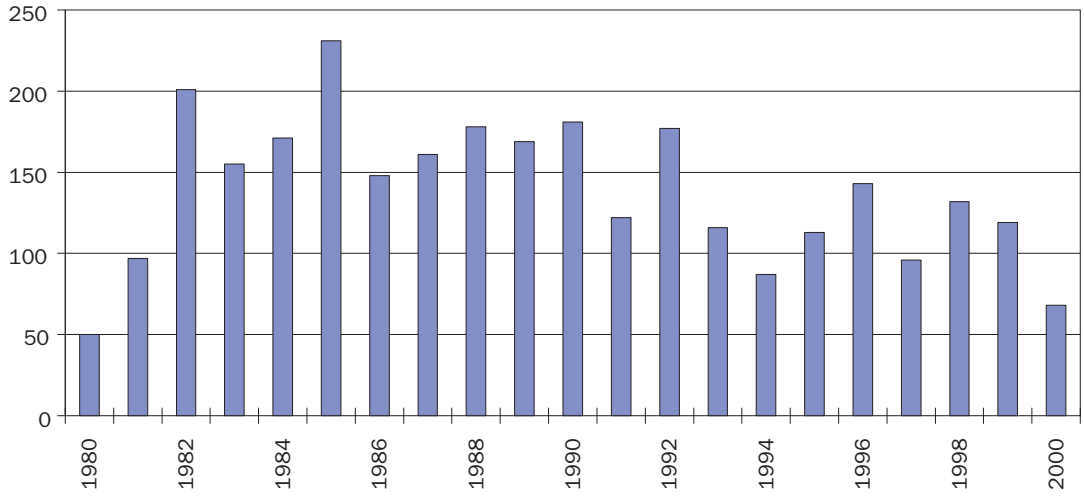


FIG. 1. Events reported to the IRS, 1980–2000.

Uncertainty about the future of nuclear power in many countries and the consequent lack of interest on the part of qualified individuals to work in the nuclear field is a major international concern. The situation is particularly worrying because higher educational opportunities in the field of nuclear engineering are greatly reduced with the elimination of nuclear engineering departments in many universities and the ageing of research facilities. On top of this the existing work force is ageing and this attrition is not being covered. In view of this situation, and in response to a resolution of the General Conference, the Agency is strengthening its training activities in the field of nuclear safety. Several new courses are being offered covering basic nuclear safety, design and operational safety, regulatory infrastructure and accident analysis. In 2000, courses were held at centres in Brazil, Germany, Slovenia and the USA. Educational modules for distance learning in nuclear safety, reactor physics and thermal hydraulics are also being prepared. In addition, a technical document was prepared on developing training programmes for staff that will assist in the systematic development of competence and training in regulatory organizations. Finally, the Agency is a member of an international task force organized by the OECD/NEA to propose actions to address this problem.

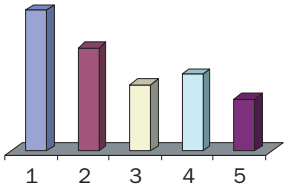
RADIATION SAFETY

PROGRAMME OBJECTIVE

To promote radiation safety through the establishment of relevant safety standards, the application of these standards, the implementation of the Agency's radiation protection rules and requirements, as well as the provision of advice and services to Member States in the framework of the technical co-operation programme and the Convention on Early Notification of a Nuclear Accident and on Assistance in the case of a Nuclear Accident or Radiological Emergency.

Regular budget expenditure: $3 394 319

Extrabudgetary programme expenditure (not included in chart): $284 662



1. Radiation Protection: $1 083 924
2. Safety of Radiation Sources and Security of Radioactive Material: $795 155
3. Safe Transport of Radioactive Material: $513 855
4. Radiation Emergencies: $597 696
5. Operational Services for Radiation Monitoring and Protection: $403 689

OVERVIEW

The regulatory infrastructure for radiation safety continues to be a major area of work for the Agency. Peer reviews of national radiation safety infrastructure were conducted in a total of 24 Member States during 2000. Implementation of the action plan on the safety of radiation sources and the security of radioactive materials continued: a categorization system was agreed which will help national regulators prioritize their activities; an international Code of Conduct was agreed to encourage good practices in Member States; and an international conference provided an opportunity for national regulators to exchange information and experiences. The framework for response to radiological emergencies was upgraded to improve the Agency's capability to meet Member State information needs in the case of events not covered by the Early Notification Convention. The results of international intercomparison exercises completed in 2000 demonstrated the progress being made by national radiation monitoring services in countries participating in the technical co-operation Model Project.

RADIATION PROTECTION

A Safety Guide on radiation protection in medical exposure was approved. The publication provides Member States with guidance on national approaches and arrangements to facilitate compliance with the requirements of the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources. These arrangements include involvement of professional bodies in developing protocols related to the protection of patients to be implemented in medical institutions.

The Secretariat established a new service to review radiation safety regulatory infrastructures of Member States. This service is available to all Member States but is particularly aimed at States that do not have a nuclear power programme, and will therefore complement the International Regulatory Review Team (IRRT) service, which includes the regulation of radiation and waste safety but focuses on States that produce nuclear power. One peer review of this type was conducted in 2000, in Ireland. Peer reviews of the effectiveness of national radiation safety infrastructure were also conducted in China, Indonesia, Republic of Korea, Malaysia, Pakistan and Singapore.

"... the Agency developed a simple, generally applicable system for categorizing radiation sources."

A technical co-operation Model Project on upgrading radiation and waste safety infrastructures that has been providing assistance to 52 Member States ended in 2000. During the year, the Agency sent peer review missions to 17 participating States to evaluate progress towards reaching the first two Model Project milestones: a system of control for radiation sources and a monitoring system for occupational exposure. In all of the countries visited, good progress has been made and action plans drafted to facilitate implementation of the project.

A CRP on radiation protection in diagnostic radiology ended in 2000. The primary objective was to initiate optimization programmes in the participating hospitals by introducing a quality control system for measurements, assessment of patient doses and image quality. Considerable reductions in patient dose were achieved without compromising image quality through simple and inexpensive actions such as added filtration, higher voltages, lower currents and the use of appropriate screen–film combinations. The CRP promoted awareness about practical implementation of quality control protocols and created a pool of expertise in each country in patient radiation protection. It also promoted close interaction and co-operation with the different professionals involved in health care delivery in a radiology department (darkroom technicians, radiographers, medical physicists and radiologists).

A CD-ROM with full search features was produced containing the full text of all of the Agency's current safety standards relevant to occupational radiation protection: the Safety Fundamentals publication on radiation protection and the safety of radiation sources, the International Basic Safety Standards and three Safety Guides on occupational radiation protection The CD-ROM is co-sponsored by the International Labour Office.

SAFETY OF RADIATION SOURCES AND SECURITY OF RADIOACTIVE MATERIAL

As part of its activities to implement the Action Plan on the Safety of Radiation Sources and the Security of Radioactive Materials — approved by the Board of Governors and endorsed by the General Conference in September 1999 — the Agency developed a simple, generally applicable system for categorizing radiation sources. The sources are ranked according to the harm they could cause, so that the controls to be applied will be commensurate with the radiological risks which the sources (and the materials

contained in them) present. The ranking is as follows:

- *Category 1 (higher risk):* industrial radiography sources, teletherapy sources, irradiators;
- *Category 2 (medium risk):* brachytherapy sources (with both high and low dose rates), fixed industrial gauges with high activity sources, well logging sources;
- *Category 3 (lower risk):* fixed industrial gauges with lower activity sources

The Board of Governors and General Conference endorsed the system, and a technical document describing the ranking system has been published.

Another activity related to the implementation of the Action Plan was a conference of national regulatory authorities organized by the Agency and hosted by the Government of Argentina in Buenos Aires, in December 2000. High level officials, senior experts from national authorities and senior policy and decision makers exchanged views and experience on the administrative, technical and managerial aspects of ensuring the regulatory control of radiation sources and radioactive materials by national authorities. The problems of establishing an effective regulatory authority, supported by several government agencies in each State, and on the procedures for the effective control of radiation sources and radioactive materials were emphasized. In particular, the steps involved in generating a regulatory control system where it does not exist, preventing sources from 'escaping' from the control system and locating and regaining control over 'orphan' sources were discussed. The Conference produced 16 "major findings", including a set of eight "immediate future actions" that States should take with a view to ensuring the safety and security of radiation sources. Many of the findings reinforced the activities already in the Agency's Action Plan. Three of the further actions identified in the findings were:

- Consideration should be given to a universal system for the labelling of radiation sources in such a way that members of the public would immediately recognize them as hazardous (using symbols and/or text in the local language). The Conference noted that the trefoil symbol used to identify radiation sources was not sufficient warning of the hazard and was often not recognized;
- Measures to prevent criminal misuse of radiation sources should be seen as complementary to measures to increase their safety and security. A distinction should be made between, on the one hand, criminal activities involving an intent to expose people to radiation and, on the other hand, breaches of safety and security where there is no malicious intent. This distinction has implications for border monitoring in particular; and
- States should develop proactive national strategies for locating orphan sources, including actions to bring orphan sources or vulnerable sources (e.g. those in inadequate storage) under proper control.

"... the steps involved in generating a regulatory control system where it does not exist, preventing sources from 'escaping' from the control system and locating and regaining control over 'orphan' sources were discussed."

The Agency prepared a Code of Conduct on the Safety and Security of Radioactive Sources. The General Conference, in Resolution GC(44)/RES/11, invited Member States "to take note of the Code of Conduct" and "to consider, as appropriate, means of ensuring its wide application". The objective of the Code is to achieve and maintain a high level of safety and security of radioactive sources through the development, harmonization and enforcement of national policies, laws and regulations, and through the fostering of international co-operation. In particular, it addresses the establishment of an adequate system of regulatory control from the production of radioactive sources to their final disposal, and a system for the restoration of such control if it has been lost.

An international reporting system for unusual radiation events (RADEV) was developed under the Action Plan and underwent internal trials. External trials will be carried out in 2001. The database will contain summaries of reports giving the results of detailed reviews of the causes and consequences of serious radiological accidents and the lessons learned. The system provides a narrative of each event and allows data to be sorted by practice, type of source, the people exposed, if any (workers, patients or public), the outcome (deterministic effects if any) and cause.

A Safety Report was issued on lessons learned from accidental exposures in radiotherapy. The report includes descriptions of 92 events, their causes and the remedial actions taken, and an analysis of lessons learned and measures for the prevention of accidents. This information is aimed at encouraging professionals working in radiotherapy facilities to consider whether such events could occur in their facilities and how they can be prevented.

"The Agency, in co-operation with other relevant international organizations and Member States, upgraded its system for responding to radiation emergencies."

SAFE TRANSPORT OF RADIOACTIVE MATERIAL

The process for producing the next substantive revision of the *Regulations for the Safe Transport of Radioactive Material* started, with a target date of 2003 for publication of a new edition. Member States and international organizations provided more than 200 proposals for change. These were placed on the Agency's Web site, together with standard electronic forms to provide comments on the "proposed changes" and "identified problems". The Revision Panel reviewed and acted upon the proposals.

At the request of the General Conference, the Secretariat conducted a survey among Member States on the national implementation of the Agency's Transport Regulations. A questionnaire was sent to all Member States and responses were received from 72, including all 30 States with operating nuclear power plants. Of those responding, 60 indicated that their national systems for regulating domestic and international transport of radioactive material were based on the Agency's regulations and, in addition, about a dozen (11 for domestic transport, 13 for international) were already based on the most recent (1996) edition.

In December 1998, the United Nations Committee of Experts on the Transport of Dangerous Goods approved complete integration of the requirements of the Agency's Transport Regulations into the United Nations Recommendations on the Transport of Dangerous Goods (also known as the 'Model Regulations'). In 2000, the Agency, the International Civil Aviation Organization, the International Maritime Organization and the Inland Transport Committee of the UN Economic Commission for Europe agreed on a timetable for entry into force in 2001 of new transport-mode-specific regulations consistent with the Model Regulations (and hence with the Agency's 1996 edition of the Transport Regulations).

During 2000, two requests for Transport Safety Appraisal Service missions were received from Brazil and Turkey. A pre-mission visit to Brazil was completed, and efforts are under way to schedule these two missions during 2001.

RADIATION EMERGENCIES

The Agency, in co-operation with other relevant international organizations and Member States, upgraded its system for responding to radiation emergencies. The existing notification system focused on transboundary emergencies of the type specified in the Convention on Early Notification of a Nuclear Accident (only one of which had occurred since the Convention entered into force). However, with

recent events such as the criticality accident at Tokaimura in Japan, accidents in Thailand, Peru and Turkey involving orphan sources, the Acerinox incident of 1998 in Spain, and the fact that the Agency is frequently asked by official contact points to verify reports of ongoing events, it has become clear that official requests for information on such events are within the scope of the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency. Member States were therefore encouraged to report to the Agency, in the form of 'warning messages', information about emergencies that were outside the scope of the Notification Convention but that might nevertheless be of concern to other Member States. The Agency will then convey such messages as appropriate to all Member States and post such messages on a Web site. To facilitate this procedure, the Agency issued a completely new edition of the *Emergency Notification and Assistance Technical Operations Manual,* together with performance requirements for an Emergency Response Network and, with FAO, OECD/NEA, United Nations Office for the Coordination of Humanitarian Affairs, WHO and WMO, prepared a Joint Radiation Emergency Management Plan of the International Organizations.

Following a fatal accident involving a cobalt-60 radiotherapy source in a suburb of Bangkok, the Thai authorities requested assistance from the Agency under the terms of the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency. A team, comprising two radiation protection experts from the Agency and three Japanese doctors specializing in the treatment of radiological accident victims, went to Thailand to advise the Thai authorities.

In recent years, the Agency has provided assistance to Georgia in dealing with 'orphan' radiation sources in the country. In May–June 2000, an Agency mission, supported by the Commissariat à l'Energie Atomique in France, carried out an aerial radiological survey of about 1200 km^2 of Georgian territory, focusing on centres of population and areas with abandoned military bases. One caesium-137 source was located in Poti, western Georgia, and three other areas with slightly elevated radiation levels were identified for further investigation by the Georgian authorities.

A common feature of some recent events involving 'orphan' sources has been the initial misdiagnosis by physicians of the symptoms of acute radiation exposure, leading to delays in response and unnecessary exposure. In an effort to raise awareness and knowledge, the Agency and WHO jointly issued a leaflet for physicians and hospital emergency departments on recognizing and initially responding to an accidental radiation injury. The Agency also issued a technical document containing practical procedures for assessment and response to radiological emergencies.

"The Agency is required by its statute to provide for the application of safety standards."

OPERATIONAL SERVICES FOR RADIATION MONITORING AND PROTECTION

The demand for radiation monitoring and protection services for Agency staff and technical co-operation experts continues to increase. In 2000, the Secretariat provided monitoring for almost 500 staff on a regular basis and a further 700 technical co-operation experts and trainees on an ad hoc basis.

The Agency is required by its statute to provide for the application of safety standards. A basic prerequisite is the ability to monitor radiation exposure accurately and consistently, and hence there is a need to harmonize the use of dosimetric quantities and techniques in Member States. To this end, the Agency completed two international intercomparisons: one on measurements of personal dose equivalent and the other on measurement of activity in bioassay samples. Two

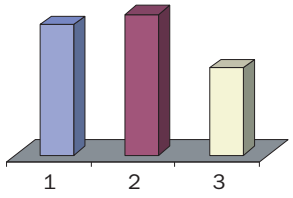
regional Asia–Pacific intercomparison exercises were also carried out: one covering the determination of ambient dose equivalent from measurements with survey equipment used in radiation protection and one on the measurement of activity of radionuclides in food and environmental samples. In these intercomparisons, monitoring services in more than ten Member States receiving Agency assistance under the technical co-operation Model Project on upgrading radiation protection infrastructures obtained results that were considered excellent, given the status of those Member States' infrastructures when the Model Project started. This is an indication both of the success of the Model Project in helping to improve safety infrastructure and of the value of intercomparison exercises in helping monitoring services to identify their strengths and weaknesses.

RADIOACTIVE WASTE SAFETY

PROGRAMME OBJECTIVE

To promote the safe management of radioactive waste, including the safety of disposable, dischargeable and residual waste, through the establishment of relevant safety standards, the application of these standards, as well as the support and service, as required, of relevant international agreements

Regular budget expenditure: $1 823 867
Extrabudgetary programme expenditure (not included in chart): $253 480



1. Safety of Disposable Waste: $662 405
2. Safety of Dischargeable Waste: $717 114
3. Safety of Residual Waste: $444 348

OVERVIEW

Key developments during the year included the publication of safety standards on the predisposal management of radioactive waste and on the regulatory control of radioactive discharges. There was also progress on the establishment of new consensus standards on geological disposal. A conference on the safety of radioactive waste management made a significant contribution towards building the necessary consensus. In addition, a new service was launched to provide technical advice to Member States on applying the safety standards. And the Agency continued to provide advice to the London Convention 1972, and in so doing completed another step towards a comprehensive database on radioactive materials in the marine environment as a result of human activities.

SAFETY OF DISPOSABLE WASTE

Safety Requirements on the predisposal management of radioactive waste, including decommissioning, were published in 2000. These establish internationally agreed requirements relating to waste arising from: the operation and decommissioning of nuclear facilities; the use of radionuclides in industry, medicine and research; the processing of raw materials containing naturally occurring radionuclides; and the cleanup of contaminated sites. They include provisions required to bring radioactive waste into a state suitable for storage or disposal in designated facilities and to ensure the safety of the facilities.

An obvious gap in the current programme to update the Agency's safety standards is the absence of standards for the geological disposal of radioactive waste. Efforts to close this gap took a step forward in 2000 when the Waste Safety Standards Committee approved an outline for a Safety Requirements publication. The Committee also identified specific topics on which consensus still needs to be developed.

As a follow-up to a conference held in Córdoba on the safety of radioactive waste management (see Box 1), the Agency's Scientific Forum during the 2000 General Conference was devoted to the topic of "Radioactive Waste Management: Turning Options into Solutions". Several of the themes from the Córdoba conference were revisited at the Forum. For example, there were discussions on various technical issues, including a number of presentations on national programmes, and some reflection on the prospects for future technological developments. There was also the same recognition that waste management cannot be treated as an exclusively technical matter, and that the technology that exists can only be put to use if the issues of public confidence and acceptance are addressed. And, as at the Córdoba conference, there was

BOX 1. BUILDING PUBLIC TRUST IN THE TECHNOLOGY TO HANDLE RADIOACTIVE WASTES

In March 2000, the Agency organized an international conference on the safety of radioactive waste management, in Córdoba, Spain. The conference, co-sponsored by the European Commission, the OECD/NEA and WHO and hosted by the Government of Spain, covered:

- The siting of radioactive waste management facilities,
- Legislative and general safety aspects,
- The predisposal management of radioactive waste,
- Near surface disposal,
- Geological disposal,
- The management of disused radioactive sources,
- The transboundary movement of radioactive waste.

Although areas were identified in which improvements could be made, there was general consensus that the technology is available to manage radioactive waste safely and reliably, and that these technological solutions should be implemented. However, a recurring theme of the conference was the importance of non-technical issues, such as building public trust in the technology and, just as importantly, in its practitioners. In particular, it was noted that progress in some areas of radioactive waste management, such as the siting of geological repositories, appeared to be best served by carefully structured, inclusive decision making processes in which all interested parties (or "stakeholders") had a recognized role.

In Resolution GC(44)/RES/12, the Agency's General Conference requested the Secretariat to prepare a report assessing the implications of the Córdoba conference's conclusions and recommendations for the Agency's programme of work. The report will be presented to the Board of Governors in 2001. ■

general acknowledgement of a 'perception gap' between technical experts and the public on the safety of radioactive waste disposal, and therefore of the pressing need to expand the dialogue on waste management issues to include all stakeholders.

The Agency launched a new safety and technical advisory service on radioactive waste management. The objective of this service is to assist Member States in the application of the Agency's waste safety standards and ensure that all waste is managed in a manner that is safe and which also protects individuals and the environment. An example was an expert mission to Brazil that reviewed arrangements for processing low and intermediate level waste from units 1 and 2 of the Angra nuclear power plant. The review also covered the on-site storage arrangements for the waste.

"The Agency is also co-operating with the OECD/NEA in conducting a peer review of the Yucca Mountain performance assessment as a whole."

Two CRPs on methodologies for assessing radioactive waste disposal practices ended in 2000. The first one led to the development and documentation of agreed procedures for the safety assessment of several types of near surface facility, including earth trenches, concrete vaults and boreholes. The second CRP, on biosphere models for assessments (BIOMASS), focused on promoting international harmonization on a range of issues: the use of 'reference biospheres' — stylized representations of hypothetical future environments — for long term safety assessments of geological repositories; modelling the impact of environmental remediation at sites affected by residual radioactive material; reconstruction of radiation doses from past releases; the transfer of radionuclides in forest ecosystems and fruit trees; and the environmental behaviour of tritium.

Partly on the basis of work done in the BIOMASS project on reference biospheres, the Agency was invited to peer review the biosphere component of the United States Department of Energy's performance assessment for the planned high level waste repository at Yucca Mountain, Nevada. The review team observed that satisfying the regulators of the safety of the facility will be necessary, but not sufficient, and that the assessment will also need to be presented to other interested parties. The team therefore divided its recommendations and suggestions into two classes: (a) those aimed at improving the biosphere assessment capability while remaining focused on satisfying regulatory requirements; and (b) those aimed at gaining the confidence of other stakeholders and making the DOE's biosphere assessment methodology more consistent with international guidance and practice. The Agency is also co-operating with the OECD/NEA in conducting a peer review of the Yucca Mountain performance assessment as a whole.

SAFETY OF DISCHARGEABLE WASTE

A Safety Guide on regulatory control of radioactive discharges to the environment was issued. This provides guidance on controlling the discharge of liquid and gaseous effluents to the environment from normal controlled operation of practices in which radioactive material is used. A complementary safety report on environmental dose assessments provides models and data for conducting assessments in the context of implementing the recommendations in the Safety Guide.

The London Convention 1972 prohibits the disposal at sea of radioactive material. The Agency published definitions and criteria to determine levels of activity below which materials would not be regarded as "radioactive" under the Convention. Following up on this, it developed guidance on radiological assessment procedures to determine whether materials for disposal at sea meet the criteria specified in the earlier document. The Contracting Parties approved this report at their meeting

in September 2000, and it will be published by the Agency in 2001.

The Agency also prepared for the London Convention a report on accidents and losses at sea involving radioactive materials. This was a follow-up to a 1999 report on the disposal of radioactive materials at sea. A database of radioactive discharges from land based sources to the marine environment was established and data collection is under way. These three sets of information constitute a comprehensive database of radioactive materials in the marine environment as a result of human activities. This information will be one input into the Agency's clearinghouse on radioactive substances, which is being developed as part of the United Nations Global Programme of Action (GPA) for the Protection of the Marine Environment. The clearinghouse will also contain information on: levels of natural and artificial activity in the world's oceans; monitoring techniques; assessments of the impact of radioactive releases to the marine environment; and international and regional conventions and standards.

"The safe decommissioning of nuclear power plants, research reactors and nuclear fuel cycle facilities is an expanding field of work for the Agency."

Radiation protection has historically focused on the protection of people, but an increasing number of Member States have expressed interest in the protection of the environment as well. A meeting of specialists organized by the Agency in August–September 2000 agreed on the overall objectives of environmental protection, the meaning of harm in the context of environmental protection, the basis for approaches for assessment and compliance, and greater co-operation with international organizations such as the International Commission on Radiological Protection and the International Union of Radioecologists, which also have work programmes in this area.

SAFETY OF RESIDUAL WASTE

The safe decommissioning of nuclear power plants, research reactors and nuclear fuel cycle facilities is an expanding field of work for the Agency. Two projects began in 2000 to assist in planning for the decommissioning of unit 1 of Ignalina in Lithuania and units 1, 2 and 3 of Chernobyl in Ukraine. These are in addition to an ongoing project dealing with the decommissioning of the BN-350 nuclear power plant in Kazakhstan.

In co-operation with the Ministry of the Russian Federation for Atomic Energy, the Agency organized an international conference entitled the 'Radiation Legacy of the 20th Century: Environmental Restoration'. Held in Moscow in October–November 2000, the conference was to some extent a follow-up to an Agency symposium on the restoration of environments with radioactive residues, held in Arlington, USA, in 1999. However, the focus of the Moscow conference was on the radioactive legacy in the countries of the former Soviet Union, Central and Eastern Europe, and the issues arising from this legacy. A key observation from both meetings was that environmental restoration decisions continue to be made on the basis of radiological criteria for the control of practices, despite international recommendations that intervention criteria are more appropriate for such situations.

Measures were taken in the immediate aftermath of the Chernobyl accident to control the international movement of foodstuffs affected by radioactive fallout. However, these measures were designed for the short term and did not address the long term issue of commodities produced in areas with persistent radioactive contamination. Areas affected by the Chernobyl accident have experienced difficulties in exporting commodities such as wood because there are no internationally accepted criteria by which to judge whether use of the commodities would pose a significant hazard. In response, the Agency's General Conference

requested the Secretariat to develop, in collaboration with the competent organs of the United Nations and with the specialized agencies concerned, radiological criteria for long lived radionuclides in commodities, particularly foodstuffs and wood.

The Agency completed a radiological assessment of sites in Algeria used in the past for nuclear weapon testing. A report on the assessment has been delivered to the Algerian Government.

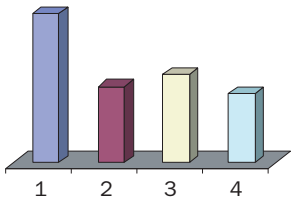
Agency experts participated in a mission to Kosovo, Yugoslavia, organized by UNEP in November 2000. The mission was part of a UNEP assessment to determine whether the use of ammunition containing depleted uranium during the 1999 Kosovo conflict has resulted in any current or future health or environmental risks. The team made external dose rate measurements and took samples of soil, water, vegetation and milk at 11 locations where NATO confirmed that such ammunition had been used. The UNEP report concluded that no widespread ground contamination had been found in the investigated areas. Therefore, the corresponding radiological and chemical risks were considered insignificant. Although the mission findings showed no cause for alarm, the report described specific situations where risks could be significant. It was also noted that there were scientific uncertainties related to the longer term behaviour of depleted uranium in the environment.

CO-ORDINATION OF SAFETY ACTIVITIES

PROGRAMME OBJECTIVE

To ensure technical consistency of the Agency's safety related functions, as well as coherence with corresponding safety activities carried out by Member States and other international organizations by promoting the co-ordination of such activities, in issuing standards, servicing conventions, providing information about safety policies and standards and supporting their implementation in Member States through technical co-operation programmes.

Regular budget expenditure: $2 480 753
Extrabudgetary programme expenditure (not included in chart): $116 774



1. Safety Policies and Standards: $963 728
2. Safety Conventions: $495 346
3. Safety Information Exchange: $571 647
4. Support to the Technical Co-operation Programme: $450 032

OVERVIEW

Over the past few years the Agency has been engaged in a substantial programme of work to update its set of safety standards, involving the preparation of about 80 new or revised standards. These are now being published at an increasing rate, with nine issued in 2000. Through its technical co-operation programme, the Agency implemented numerous projects in the areas of nuclear, radiation and waste safety. This assistance took the form of training courses and workshops, fellowships and scientific visits, and training for safety professionals in Member States. In particular, the Agency's preparation of training materials for the courses has assisted national and regional centres in their development of self-sustaining training capabilities.

SAFETY POLICIES AND STANDARDS

In the course of updating its safety standards, the Agency published nine revised or new standards (see Table I). Among these was the first in the general safety area, which covers topics that are common to nuclear, radiation, radioactive waste and transport safety. The Safety Requirements on legal and governmental infrastructure for safety specify the basic requirements for the legal framework for establishing a regulatory body. They also detail the other actions necessary to achieve effective regulatory control of all facilities and activities, from the use of a limited number of radiation sources to a major nuclear power programme. Other responsibilities are also covered, such as those for developing the necessary support for safety and emergency preparedness.

Eight more Safety Guides were endorsed by the Commission on Safety Standards (CSS) for publication, and an additional 65 safety standards are in preparation. A summary of the current status of all of the safety standards is available at *http://www.iaea.org/ns/CoordiNet/safetypubs/sftypub.htm*. Detailed information on the activities of the Radiation Safety Standards Committee (RASSC), Waste Safety Standards Committee (WASSC) and the Transport Safety Standards Committee (TRANSSC) is also available at this site. Pages on the Nuclear Safety Standards Committee (NUSSC) and CSS are under construction.

The terms and definitions used in the Agency's safety standards and other safety related publications have not always been consistent between documents, and particularly between nuclear, radiation, radioactive waste and transport safety. The Secretariat prepared a Safety Glossary with the aim of harmonizing the use of terminology and to resolve inconsistencies. Although the Safety Glossary is intended primarily for use within the Agency, it is available to interested parties outside the Agency for information and comment, in hard copy and also on the Internet at the site *http://www.iaea.org/ns/CoordiNet/safetypubs/iaeaglossary/glossaryhomepage.htm*.

For several years the Agency has organized Peer Discussions on Regulatory Practices, a forum where senior regulators can exchange information and experiences on current issues. The topic for the 2000 round of discussions was 'Regulatory Control of the Use of Contractors by Operating Organizations'. The Agency published a report by the regulators, summarizing the conclusions of the

TABLE I. **SAFETY STANDARDS PUBLISHED IN 2000**

Safety Requirements

- Legal and Governmental Infrastructure for Nuclear, Radiation, Radioactive Waste and Transport Safety, GS-R-1
- Safety of Nuclear Power Plants: Design, NS-R-1
- Safety of Nuclear Power Plants: Operation, NS-R-2
- Predisposal Management of Radioactive Waste, including Decommissioning, WS-R-2
- Regulations for the Safe Transport of Radioactive Material, TS-R-1 (ST-1, Revised)

Safety Guides

- Software for Computer Based Systems Important to Safety in Nuclear Power Plants, NS-G-1.1
- Fire Safety in the Operation of Nuclear Power Plants, NS-G-2.1
- Operational Limits and Conditions and Operating Procedures, NS-G-2.2
- Regulatory Control of Radioactive Discharges to the Environment, WS-G-2.3

discussions and giving examples of good practices.

SAFETY CONVENTIONS

The Convention on Early Notification of a Nuclear Accident was not formally invoked during the year. However, the procedures established by the Agency for response under the terms of the Convention were used in relation to less severe events, such as the discovery that the wristbands of some watches being sold in a French supermarket had components made from contaminated steel. The Islamic Republic of Iran and Luxembourg ratified the Convention during 2000, bringing the total number of Contracting Parties to 86 (83 States and three international organizations).

"And with the co-operation of the OECD/NEA, WANO and the United States Nuclear Regulatory Commission, the Agency developed an Internet based system to communicate nuclear events."

The Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency was invoked once in 2000, by Thailand in relation to an accident involving a cobalt-60 radiotherapy source. The Islamic Republic of Iran, Lithuania and Luxembourg ratified the Convention during 2000, bringing the total number of Contracting Parties to 82 (79 States and three international organizations).

The Convention on Nuclear Safety had no meetings during 2000; the next Review Meeting will be held in April 2002. Euratom became the first organization to accede to the Convention in 2000, bringing the total number of Contracting Parties to 53.

Finally, the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management moved closer to entry into force by the end of 2000. Only two more ratifications are needed. Two States ratified the Convention early in 2001 and it will enter into force on 18 June 2001.

SAFETY INFORMATION EXCHANGE

The International Nuclear Event Scale (INES) information service is operated by the Agency to collect event reports and disseminate them among participating States. During 2000, the Agency received 24 event rating forms. One event was rated at level 4: a fatal accident in Egypt involving an industrial radiography source. In all, 13 of the reported events occurred at nuclear power plants. Of the other 11 events reported, 10 involved either lost sources or the transport of sources. As can be seen from Fig. 1, the annual number of events reported has fallen by about half over the past decade.

At their annual meeting, the INES national officers approved the 2001 edition of the *INES User's Manual*. And with the co-operation of the OECD/NEA, WANO and the United States Nuclear Regulatory Commission, the Agency developed an Internet based system to communicate nuclear events. *NEWS* (Nuclear Events Web-based System) is intended to offer more flexible and faster exchange of information between participants. The system is currently undergoing trials and will be in full operation in 2001.

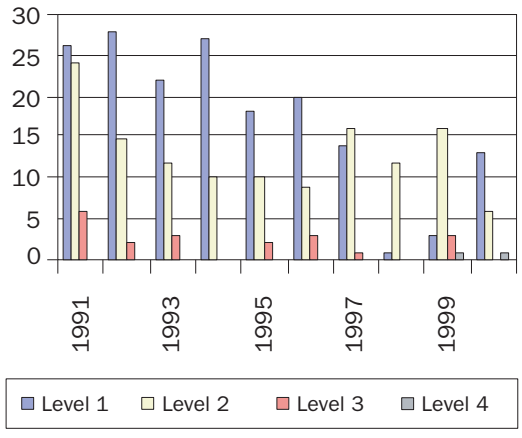


FIG. 1. Events reported to the INES information service, 1991–2000.

SUPPORT TO THE TECHNICAL CO-OPERATION PROGRAMME

During 2000, the Agency assessed 115 new safety related technical co-operation project requests for 2001–2002 and prepared corresponding project work plans. In addition, it supported the implementation of 110 ongoing technical co-operation projects, corresponding to an adjusted budget of about $16 million, in the areas of nuclear, radiation and waste safety.

Country radiation and waste safety profiles have been used in the technical co-operation Model Project on upgrading radiation protection infrastructure to consolidate and update data on a country receiving Agency assistance. The profiles cover: organizational infrastructure; the legal and regulatory framework; extent of practices involving ionizing radiation; occupational, medical and public exposure control; planning and preparedness for radiation emergencies; quality assurance; and education and training. Each profile is compared with the requirements for an adequate infrastructure, using Agency safety standards as a reference, to establish an action plan for the country to create an infrastructure commensurate with its existing and planned applications of ionizing radiation. This has been extended to States not participating in the Model Project, and the Agency has now established 66 profiles.

Country *nuclear safety* profiles serve a similar function in planning nuclear safety assistance, but take account of the much more advanced level of safety infrastructure needed to operate and regulate a nuclear power programme. These profiles have been particularly useful in planning assistance in the extrabudgetary programme on the safety of nuclear installations in South East Asia, the Pacific region and the Far East, particularly for those countries that do not currently have nuclear power programmes but are considering the nuclear option.

More than 100 Agency educational and training courses and workshops were held in 2000. The majority of these were supported through the technical co-operation programme, but a significant number were conducted under extrabudgetary programmes. In addition, some training seminars and workshops were conducted as part of safety review services, and almost 350 fellowships and scientific visits were supported through the Agency's technical co-operation programme.

In Resolution GC(44)/RES/13, the 2000 General Conference stressed the special importance of education and training in radiation protection, nuclear safety and waste management, and urged the Secretariat to strengthen its efforts in these areas. In particular, the resolution called for the Agency to assist Member States in conducting such education and training at regional and national training centres in the relevant official languages of the Agency. In response, the Agency established the needs for education and training in radiation protection over the next two years and prepared an action plan to meet them. This plan includes mechanisms to oversee all training activities, whether post-graduate education and training, specialized training, initial medical training, distance learning or on the job training. The action plan also involves the preparation of lecture materials and the establishment of a network of training centres in Member States with a view to providing sustainable training programmes in radiation protection and source safety in Member States.

"... the Agency established the needs for education and training in radiation protection over the next two years and prepared an action plan to meet them."

The Agency revised the standard syllabus of the post-graduate educational course in radiation protection. This course will be held in each geographical region about once every two years. In 2000, the course was held in Buenos Aires, Argentina (in Spanish) and in Johannesburg, South Africa (in English).

In related developments, the CSS approved a Safety Guide on building competence in radiation protection and the safe use of radiation sources. A complementary Safety Report on training in radiation protection and the safe use of radiation sources is being published

A regional technical co-operation programme on nuclear safety training for 2001–2002 was finalized, with emphasis on safety review and assessment, operational safety and regulatory effectiveness. The programme was developed in close consultation with regulatory bodies and utilities in Member States.

Further Agency efforts in promoting training activities in Member States included a new policy and strategy to assist Member States in standardizing educational and specialized courses in nuclear safety and to develop appropriate training materials. Additionally, a set of standardized courses for regulatory staff was introduced, including textbooks, test questionnaires and practical exercises.

The Agency's Programme in 2000: Verification

SAFEGUARDS

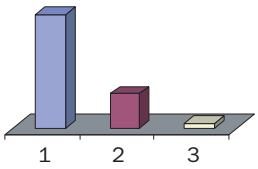
PROGRAMME OBJECTIVE

To determine, through the application of the Agency's safeguards system, whether States are complying with the undertakings in their safeguards agreements with the Agency.

Regular budget expenditure: $70 617 231

Extrabudgetary programme expenditure (not included in chart): $10 311 459

Note: Verification activities in Iraq pursuant to UN Security Council resolutions included extrabudgetary expenditures of $1 639 859



1. Operations: $52 532 674
2. Development and Support: $15 972 980
3. Management: $2 111 577

OVERVIEW

In fulfilling the safeguards obligations of the Agency in 2000, the Secretariat — having evaluated all the information acquired in implementing safeguards agreements and all other information available to the Agency — found no indication of diversion of nuclear material placed under safeguards or of misuse of facilities, equipment or non-nuclear material placed under safeguards. On this basis, the Secretariat concluded that the nuclear material and other items placed under safeguards remained in peaceful nuclear activities or were otherwise adequately accounted for.

In 2000, in respect of seven States, the Secretariat — having evaluated all the information obtained through activities pursuant to these States' comprehensive safeguards agreements and additional protocols as well as all other information available to the Agency — found no indication either of diversion of nuclear material placed under safeguards or of the presence of undeclared nuclear material or activities in those States. On this basis, the Secretariat concluded that all nuclear material in those States had been placed under safeguards and remained in peaceful nuclear activities or was otherwise adequately accounted for. In the case of the 12 other States with comprehensive safeguards agreements and additional protocols in force, the Secretariat's evaluations had not yet reached the stage where such a conclusion could be drawn.

The Agency is still unable to verify the correctness and completeness of the initial report of nuclear material made by the Democratic People's Republic of Korea (DPRK) and is, therefore, unable to conclude that there has been no diversion of nuclear material in that State. The DPRK remains in non-compliance with its safeguards agreement. Although the safeguards agreement between the DPRK and the Agency remains binding and in force, the Agency is able to implement only some of the required safeguards measures in the DPRK. The Agency has, however, been able to monitor 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 Framework" of October 1994 between the United States of America and the DPRK.

The Agency continued to implement protocols additional to safeguards agreements. The first steps of implementation in several Member States in 2000 have been to review initial State declarations and request any necessary clarifications or amplifications.

As of 31 December 2000, 224 safeguards agreements were in force with 140 States (and with Taiwan, China). At the end of 2000, safeguards agreements, which satisfy the requirements of the NPT, were in force with 128 States.

Safeguards agreements were signed with The Former Yugoslav Republic of Macedonia and with the Republic of Yemen. These agreements had not entered into force by the end of the year. A safeguards agreement with Andorra was approved by the Board of Governors.

By the end of 2000, protocols additional to safeguards agreements for 57 States had been approved by the Board of Governors and 53 had been signed. Eighteen such protocols were in force with Australia, Azerbaijan, Bulgaria, Canada, Croatia, the Holy See, Hungary, Indonesia, Japan, Jordan, Lithuania, Monaco, New Zealand, Norway, Poland, Romania, Slovenia and Uzbekistan. Furthermore, an additional protocol with Ghana was being implemented provisionally pending entry into force.

"One of the Agency's priorities in 2000 was the continued development of concepts for integrating traditional nuclear material verification activities with new safeguards strengthening measures ..."

One of the Agency's priorities in 2000 was the continued development of concepts for integrating traditional nuclear material verification activities with new safeguards strengthening measures as foreseen in the Model Additional Protocol. Integrated safeguards will allow the redistribution of resources from inspection activities to other measures, such as State evaluations and complementary accesses, designed to detect undeclared nuclear material or activities, and thereby enhance the level of assurance the Agency provides to Member States with respect to nuclear non-proliferation. Substantial progress was made on developing an integrated safeguards conceptual framework in 2000, as reported in two information papers prepared for the Board of Governors in March and December.

In 2000, approaches under integrated safeguards were prepared for three generic facility types: LWRs without mixed oxide (MOX) fuel, research reactors and spent fuel storage facilities. In addition, the first State level approach under integrated safeguards was prepared for Australia — which has an additional protocol in force — for implementation in 2001.

The Agency used satellite imagery data to support the evaluation of both open source information and additional protocol declarations for several countries. Investigations continued on setting up an imagery unit to establish the Agency's own analytical capabilities and expertise in this area, thereby lessening the dependence on Member State capabilities.

Important management measures were implemented during the year. The restructuring of two operational divisions resulted in greater work efficiencies, thus allowing better use of the experience of inspectors in particular types of facilities. Furthermore, the Agency's safeguards technical services were restructured with an emphasis on project management. Through this re-organization, managers were given full control and responsibility over specific product lines which will be of benefit for inspectors as well as developers. Other important measures included upgrading of the regional offices in Tokyo and Toronto to section level.

Activities in nuclear weapon States were reviewed to ensure that the Agency is carrying out only essential activities in the most efficient manner. In addition, travel cost reductions were initiated by agreeing with Euratom to reduce by half the number of High Level Liaison Committee meetings and agreeing with Argentina, Brazil and ABACC to increase the number of meetings at Headquarters rather than in the respective countries.

The Agency continued to investigate the possibilities for further savings offered by the

creation of new regional offices and increased co-operation with State Systems of Accounting and Control. In preparing a results based programme for the 2002–2003 biennium, needs exceeding $110 million were nevertheless identified to cover the Agency's mandated activities as compared with a zero real growth budget of $82.1 million. It should be noted that under the constraints of a zero real growth budget, the costs of safeguards equipment required for the Rokkasho reprocessing plant (Japan) would not be covered.

OPERATIONS

Since 1997, the number of activities related to the negotiation and implementation of additional protocols has steadily increased. Additional protocols were signed by Azerbaijan, Estonia, Namibia, Peru, the Russian Federation, Switzerland, Turkey and Ukraine, and entered into force in Azerbaijan, Canada, Croatia, Bulgaria, Hungary, Lithuania, Norway, Poland, Romania and Slovenia, bringing the total number of additional protocols in force to 18 by the end of 2000.

Of the Euratom non-nuclear-weapon States, Finland, Germany, Greece and Sweden notified the Agency that additional protocols had been ratified by their respective governments, bringing the total number of European Union States having ratified additional protocols to six (Netherlands and Spain ratified in 1999). Ratification by all 15 member countries is required before any European Union additional protocol can enter into force. Pending entry into force, field trial preparatory activities began in Finland and in the Netherlands. The purpose of these trials is to test selected elements of the Model Additional Protocol, in particular site definition, Article 2 declaration submissions, complementary access, reporting of results and development of modalities for the division of responsibility between the Agency, Euratom and their respective Member States.

The Agency has maintained a continuous inspector presence in the Nyongbyon area since May 1994 and has been monitoring a "freeze" on the graphite moderated reactors and related facilities in the Democratic People's Republic of Korea (DPRK) since November 1994.

Technical discussions and working group meetings were held in 2000 between the Agency and the DPRK. During the technical discussions, the Agency presented its generic requirements for the verification of the correctness and completeness of the DPRK's initial declaration. The Agency was permitted to identify some of the documents that need to be preserved; however no agreement could be reached on how to preserve the information.

The Agency also explained to DPRK representatives that the work required to verify that all nuclear material subject to safeguards in the DPRK had been declared to the Agency and placed under safeguards would take three to four years, and would require full co-operation on the part of the DPRK, which at that stage was not forthcoming.

"Since 1997, the number of activities related to the negotiation and implementation of additional protocols has steadily increased."

The Agency's safeguards activities in Iraq under the comprehensive safeguards agreement concluded pursuant to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) were implemented as part of the activities carried out by the Agency in Iraq pursuant to UN Security Council Resolution 687 (1991) and related resolutions between 1991 and 1998. However, since December 1998, and in spite of the adoption of Resolution 1284 (1999) which confirms the Agency's mandate in Iraq, the Agency has not been in a position to implement its mandate.

In the absence of any resumption of Security Council mandated activities, the Agency conducted a physical inventory verification in January 2000 (related to the 1999 programme) and in January 2001 (related to

the 2000 programme) under the safeguards agreement between Iraq and the Agency pursuant to the NPT. Agency inspectors were able to verify the presence of the nuclear material under safeguards at the Tuwaitha storage facility.

Activities of the Agency's Action Team for Iraq focused on improving its computer based inspection and analytical tools, as well as analysing the information accumulated during inspection activities, including those prior to 2000.

"Major developments with regard to the implementation of additional protocols included the conclusion of Subsidiary Arrangements ... with Indonesia and Japan."

Further progress was made in the negotiation of Subsidiary Arrangements in connection with safeguard agreements: 21 new and 5 revised Facility Attachments entered into force, namely for facilities in Argentina (8), Brazil (8), Czech Republic (3), Hungary (1), Indonesia (1), Islamic Republic of Iran (1), Japan (1), Norway (1), Romania (1) and Spain (1). In addition, draft Facility Attachments for Ukrainian facilities were discussed with the State authorities.

Major developments with regard to the implementation of additional protocols included the conclusion of Subsidiary Arrangements for the implementation of these protocols with Indonesia and Japan. A proposal for Subsidiary Arrangements pursuant to an additional protocol for Poland was received and is being reviewed.

Initial declarations pursuant to additional protocols were received and evaluated by the Agency for Hungary, Indonesia, Japan, Jordan, Monaco, and Norway. The initial declarations from the remaining States for which additional protocols entered into force in 2000 are expected in the early part of 2001. Annual Article 2 declaration updates from Australia, Ghana, New Zealand, Holy See and Uzbekistan were received and evaluated in 2000.

State evaluation reports were prepared by the Agency for review by the Information Review Committee (IRC) for 28 States compared with 18 in 1999 and 10 in 1998. Among the 28 States, the following have signed an additional protocol: Austria, Bulgaria, Canada, Denmark, Ghana, Greece, Hungary, Indonesia, Japan, Jordan, Lithuania, Netherlands, Monaco, Norway, Philippines, Poland, Slovenia, Turkey, Republic of Korea and Uruguay. Evaluations for Ghana, Jordan and Monaco considered information declared under Article 2.

The Agency conducted complementary access visits to confirm the absence of undeclared nuclear material and activities in Australia, Ghana, Indonesia, Japan and Uzbekistan. In addition, two visits were made to clarify certain aspects of past nuclear activities in Uzbekistan. Furthermore, a visit to New Zealand was carried out for the purpose of evaluating the content of nuclear material holdings at the Institute of Geological and Nuclear Sciences.

A report documenting the additional protocol implementation trial with Japan was published (EPR-66) and sent to all Member States.

In addition, the Agency implemented measures foreseen under the Model Additional Protocol in Taiwan, China. These included the receipt and review of declarations pursuant to Article 2 of the Model Additional Protocol and complementary access.

In November, a seminar was held in Minsk, Belarus, on technical, legal and policy aspects concerning the conclusion and implementation of additional protocols. The seminar was arranged by the Agency at the request of Belarus and other States in the region. Those participating in the seminar included Belarus, Estonia, Latvia, Lithuania and Ukraine.

The Agency implemented strengthened safeguards through a number of measures, includ-

ing the installation or replacement of equipment. In addition to already operating remote monitoring (RM) systems, RM is now in use at five facilities in South Africa, one facility in Switzerland and two LWR facilities in Japan, bringing the total number of RM systems in routine use to 21 at the end of 2000. In Ukraine, the installation of an unattended monitoring system at Chernobyl Unit 2 completed the safeguards approach for this facility. Replacement of analogue by digital surveillance systems was completed at a further 15 LWRs in Japan and at 12 LWRs and one on-load reactor (OLR) in the Republic of Korea. In the latter State, six LWRs have digital surveillance data remotely transmitted to the Agency. With regard to the implementation of safeguards in LWRs in the Republic of Korea, a working group concluded its final report. It contains a cost–benefit analysis of data transfers from LWRs to the Agency, showing significant savings in favour of a safeguard approach based on remote data transmission. The installation of RM devices was based on site specific cost–benefit analyses.

Unattended radiation monitoring (URM) systems were installed in two experimental prototype plutonium fuelled reactors in Japan to monitor flows into and out of areas that are difficult to access and verify. Also, URM systems were installed to monitor core loading and discharge of a fast breeder reactor in Japan. A URM system is now in routine use at the spent fuel dry store at Paks, Hungary.

Unattended non-destructive assay (NDA) measurement systems are now in routine use at two MOX fabrication plants in Belgium, this system being an essential component of the New Partnership Approach (NPA) arrangements with Euratom. In addition, an unattended NDA measurement system for the verification of spent fuel flow into transport containers for long term dry storage is in use at one reactor facility in Germany.

With regard to the verification of spent fuel transfers, tests were carried out on unattended monitoring systems for spent fuel transfers to medium term storage in Belgium and Germany. Furthermore, a new safeguards approach for spent fuel transfer to dry storage from a CANDU type reactor was implemented in India. This approach is based on establishing a database for the fingerprints of canisters with spent fuel. In the same context, enhanced spent fuel measurements were also applied for the verification during spent fuel transfers to the dry storage of an Armenian nuclear power plant. In Ukraine, preparatory activities were carried out for the verification of spent fuel transfers from Zaporozhe. Spent fuel transfers to dry storage facilities continued for the greater part of the year in the Czech Republic, Hungary and Lithuania.

"The safeguards approach for Japan Nuclear Fuel Ltd. (JNFL), which will be the largest reprocessing facility under Agency safeguards, was further developed."

New techniques and procedures were used in the course of the Agency's verification activities related to the spent fuel canning campaign at the BN-350 fast breeder reactor in Kazakhstan. For example, a spent fuel Multi-Integrated Monitoring System enables inspectors to continuously maintain knowledge over movements of nuclear material in a complex environment. A Spent Fuel Coincidence Counter is used for quantitative (partial defects) verification of irradiated fuel and blanket items. The reactor core unloading activities were monitored throughout the campaign, and the canning of all core fuel was completed by mid-October 2000, bringing the total number of spent fuel assemblies conditioned into canisters to nearly 2800 items. The core emptiness was verified successfully by mid-November 2000. All canning activities for the BN-350 are planned for completion by May 2001.

The safeguards approach for Japan Nuclear Fuel Ltd. (JNFL), which will be the largest reprocessing facility under Agency safeguards, was further developed. Material Balance Area (MBA) boundaries and corre-

sponding Key Measurement Points were identified. The Agency participated in the planning and design of the on-site laboratory (OSL), which is under construction. A list of the equipment required for the facility and the OSL, together with their preliminary costs for a budgetary estimate, was established and conceptual specifications were prepared for the design, procurement, installation, testing and acceptance of the safeguards equipment hardware. In that context, a method for the determination of impurity elements in uranium materials using inductively coupled plasma mass spectrometry was validated. The total cost for the Agency's "removable" safeguards equipment to be purchased and installed during 2002–2005 for the reprocessing facility and the OSL is estimated to be in the order of $9 million, out of a total of $36 million.

Enhanced safeguards measures were introduced at the reprocessing facility in Tokai, Japan, to maintain the continuity of knowledge of safeguards samples from the time of sample taking until receipt in the Agency's Safeguards Analytical Laboratory (SAL). Swipe samples were taken outside of cells to contribute to establishing a baseline for the facility. Routine inspection activities were introduced at Other Strategic Points to confirm operational status of the facility. Quarterly Design Information Verifications (DIV) were initiated in fulfillment of the agreed DIV Plan. Two short reprocessing test campaigns were completed under a continuous inspection regime. In this respect, 323 person-days of inspection (PDI) were spent. In addition, during 2000:

- Safeguards were implemented at a new 10 MW High Temperature Gas Cooled Reactor in Nankou, China;
- A dual containment/surveillance (C/S) safeguards approach was implemented for the receipt and storage of MOX scrap that will be used in the Solution Critical Facility in Japan;
- A Short Notice Random Inspection (SNRI) scheme was implemented at four low

TABLE I. **VERIFICATION ACTIVITIES**

	1998	1999	2000
Inspections performed	2507	2495	2467
Person-days of inspection	10 071	10 190	10 264
Seals applied to nuclear material or safeguards equipment, detached and subsequently verified (including seals applied jointly with EURATOM)	26 824	28 044	25 484
Optical surveillance films reviewed	932	1271	873
Video tapes reviewed	4884	5033	5226
Nuclear material samples analysed	645	664	626
Nuclear material analytical results reported	1610	1587	1401
Environmental samples analysed	497	511	246
Nuclear material under safeguards (tonnes)			
Plutonium contained in irradiated fuel	593	628	642.8
Separated plutonium outside reactor core	62.4	73.1	72.2
Recycled plutonium in fuel elements in reactor cores	7.2	8.0	10.7
High enriched uranium	21.4	21.2	21.8
Low enriched uranium	49 483	51 191	48 974
Source material	90 622	92 150	91 677

enriched uranium (LEU) fuel fabrication and conversion facilities in Japan and at one such facility in Spain;
- Rehearsals of the new unannounced inspection regime were conducted at Australian facilities.

The Agency's co-operation with regional or State authorities included two Safeguards Implementation Review Group (SIRG) meetings with Ukraine addressing safeguards implementation issues. Of particular importance, furthermore, was the ASEAN workshop held in Bangkok in August 2000 to discuss the Agency's role in implementation of the South East Asian Nuclear Weapons Free Zone Treaty.

The Agency's R&D co-operation with Euratom — within the framework of the NPA — resulted in the development of a new generation of electronic seals and, in the establishment of specifications for a new generation of digital multi-camera surveillance systems. Furthermore, a working group for material balance evaluations was established and began reviewing the accountancy procedures and quality of the operator and inspector measurement systems in bulk handling facilities. A common resource sharing approach focused on equipment purchase, analytical capabilities and training. In the sphere of training, a new training course for Agency and Euratom inspectors on the NPA safeguards arrangements for specific facility types was developed.

With regard to the Agency's safeguards activities in nuclear weapon States, nuclear material specified as no longer required for military purposes was inspected at plutonium and high enriched uranium (HEU) storage facilities placed by the USA under Agency safeguards (Table I). Technical discussions on a safeguards approach for the stabilization of safeguarded plutonium resulted in the planning of a stabilization campaign in 2001, after which plutonium will be stored at another long term storage under Agency safeguards. Unless and until an agreement between the USA and the Agency enters into force under the "Trilateral Initiative", it is envisaged to apply safeguards to plutonium at this facility, under the Voluntary Offer Agreement. In France, the continuity of knowledge on MOX fuel from Belgium was maintained during its re-packing for shipment to Japan. The United Kingdom continued to provide voluntarily Article 2 declaration submissions throughout 2000, pending the entry into force of the Additional Protocol between it, the Agency and Euratom.

"In the sphere of training, a new training course for Agency and Euratom inspectors on the NPA safeguards arrangements for specific facility types was developed."

The Agency took environmental samples to complete baselines, implement routine sampling, and as part of complementary access activities under additional protocols. It also initiated discussions with two Member States for hosting environmental sampling field trials to test elements of sampling, analysis and evaluation that would be applicable to both location specific and wide area environmental sampling. The environmental sampling database became operational.

In SAL and the Network of Analytical Laboratories (NWAL), 635 samples of nuclear materials and heavy water were analysed, and 1401 results for the material accountancy verification of facility operators' declarations were provided. An additional 17 samples were measured for other safeguards purposes. SAL staff received and carried out gamma spectrometry and X ray fluorescence (XRF) screening measurements on 538 environmental samples taken by Agency inspectors to allow conclusions on the absence of undeclared nuclear activities. Both bulk and particle analyses for environmental samples were performed at the Clean Laboratory and the NWAL. Approximately 420 clean swipe sampling kits for use in routine environmental sampling were also prepared at SAL.

Improved techniques for analysing microscopic particles taken from environmental samples were developed using the secondary ion mass spectrometry (SIMS) and scanning

electron microscopy techniques. A 'fast track' method for SIMS analysis was worked out which streamlines the analysis of samples from enrichment facilities. A new XRF spectrometer system was constructed to screen environmental swipe samples for the presence of uranium with sensitivity ten times greater than the earlier system. In a related activity, laboratory space was leased from the Austrian Research Centre Seibersdorf for the ashing and chemical preparation of radioactive environmental swipe samples taken from hot cell facilities. And a highlight in the area of quality assurance was the attainment of ISO 9002 certification for the Agency's Clean Laboratory.

DEVELOPMENT AND SUPPORT

With regard to the support and development of unattended monitoring systems, RM equipment was installed and tested with positive results at storage facilities in Ukraine and Belarus. For both facilities satellite transmission of data is used; however, some aspects need clarification prior to routine transmission of data to Agency Headquarters. Under a joint support programme, field trials of a complex RM system for verification of CANDU spent fuel transfer to dry storage were undertaken in Argentina. Feasibility studies were carried out for application of RM involving a fresh fuel (HEU) store at a research reactor facility in Poland. RM tests were carried out in co-operation with Euratom at one reactor facility in Sweden and one storage facility in Germany in the framework of the Swedish and German Member State Support Programmes. The results of the tests are considered important for the development of future safeguards approaches as potential problems with seals were identified and corrected.

Three on-line enrichment monitors have been installed in a down-blending facility in the USA to provide accurate information on the enrichment and concentration of uranium. In the same facility, a flow monitor was installed to measure the flow volume of the input and product outputs and a Near-Real-Time Accountancy System for on-site evaluations was implemented.

By the end of 2000, the Agency had installed digital image surveillance systems in 24 countries. More specifically, 138 systems operating 208 cameras were in use, including 38 systems capable of operating in a remote monitoring mode. A further 53 systems were purchased for installation in 2001. Testing began of a portable surveillance system and a multiple camera system based on the same technology. New hardware is being developed to improve the robustness of the camera module in radiation environments. In addition, 24 unattended radiation monitoring systems operating 65 detector assemblies were transmitting data to the Agency.

The Agency inaugurated a Safeguards Equipment Support Facility at its Headquarters where evaluation, testing and support of surveillance systems, radiation monitoring systems and RM systems will be carried out. This facility also allows for the safe storage of safeguards equipment.

"And a highlight in the area of quality assurance was the attainment of ISO 9002 certification for the Agency's Clean Laboratory."

In an effort to ensure secure communications, a standard procedure was developed for processing nuclear material accounting reports received as encrypted e-mail attachments. This procedure is also used for processing data received via e-mail from ABACC, Euratom and Canada. In this context, enabling inspectors in the field to remotely access computing facilities at headquarters has long been an Agency goal. Consequently, a 'Virtual Private Network' (VPN) was developed that provides a secure,

cost effective and reliable link between inspectors in the field and the Agency. VPN allows inspectors to immediately access the Agency's local area network in Vienna for the retrieval of information. To date, over 50 inspectors have been trained in the technical and security aspects of this technology and are using the service.

The Agency has conducted exhaustive studies to ascertain the potential of the limited use of commercial satellite imagery as one tool of a strengthened safeguards regime. In 2000, the Agency established an imagery database of nuclear sites. Also, an international team of Member State supplied imagery analysts and consultants provided substantial assistance to the Agency.

A new software tool has been developed which supports the organization of open source information. The tool will bring about significant advantages for the State evaluation process, such as assistance in analysis and the creation and storage of electronic State files.

Regarding the development of concepts for integrated safeguards, the Agency prepared guidelines defining the conditions to be met by a State and activities to be performed by the Agency considered adequate for drawing a conclusion of the absence of undeclared nuclear material and activities in a State. These guidelines were reviewed by the Standing Advisory Group on Safeguards Implementation (SAGSI) and are in provisional use. Further to integrated safeguards, the Agency developed approaches for three generic facility types: LWRs without MOX fuel; research reactors; and spent fuel storage facilities. In addition, requirements were identified that must be met in order for unannounced inspections to be successfully undertaken. The Agency received support in integrated safeguards development from several Member State Support Programmes and a Group of Experts designated by the Director General.

The necessary infrastructure for implementing complementary access was further developed through the establishment of internal guidelines for all types of locations specified in additional protocols. These guidelines are being implemented on a provisional basis. Also, the Agency issued guidelines for the processing of complementary access data packages and established a database on complementary access activities.

Based on experience previously gained in reviewing State declarations, the Agency prepared guidelines for these reviews that are now in use. In support of the declaration review and State evaluation process, new elements were added to the Physical Model.

"The Agency received support in integrated safeguards development from several Member State Support Programmes and a Group of Experts designated by the Director General."

Moreover, a report was issued on the optimum use of the Physical Model and, a new chapter on spent fuel storage and disposal was released for use in the Agency. Additional chapters on hot cell facilities and waste management facilities were prepared with the assistance of Member State Support Programmes. Two meetings were held for consultation with Member States on safeguards for geological repositories and conditioning plants for spent fuel disposal.

The quality of the seals verification system was monitored through the inclusion of deliberately altered examples (blind seals) in the seals supplied to inspectors. In addition, the quality of surveillance review was monitored through repeated reviewing of randomly selected recording media and checking of the pertinent surveillance review records.

The safeguards training curriculum was further enhanced with new training courses that addressed the need for increased skills and knowledge of safeguards staff and Member State personnel. In addition to courses for inspectors on 'traditional' safeguards, training in the implementation of

strengthened safeguards was conducted, particularly in:

- Conducting environmental sampling;
- Evaluating information and preparing State Evaluation Reports;
- Protecting confidential information through the use of encrypted e-mail and the use of the VPN;
- Conducting complementary access and fulfilling security requirements for information;
- Updating and upgrading inspector knowledge of strengthened safeguards principles and practices;
- Enhancing inspector knowledge of nuclear fuel cycle and proliferation indicators. On this topic, the first course specifically designed for Agency country officers was organized and conducted in co-operation with the United Kingdom Support Programme.

The Agency provided training to Member State personnel to assist States in fulfilling their safeguards obligations. International and regional training courses were conducted for personnel involved in the State System for Accounting and Control (SSAC). Topics included: nuclear material accounting; basic safeguards activities; strengthened safeguards with a focus on the Model Additional Protocol; Member State requirements arising from Articles 2 and 3 of the Model Additional Protocol; and other related subjects.

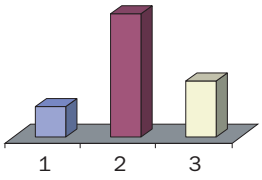
Finally, the Agency conducted the Safeguards Traineeship Programme, which is designed to give young professionals from Member States with limited nuclear infrastructure the opportunity to gain adequate experience to be considered for positions in the Agency. Of the six participants who completed the nine month course, four have been offered positions as safeguards inspectors.

SECURITY OF MATERIAL

PROGRAMME OBJECTIVE

To assist Member States, through training, expert assistance, equipment and exchange of information, in the protection of nuclear and other radioactive materials against forcible seizure, theft and other criminal activities and to provide them with the knowledge and tools for detecting and responding to incidents of trafficking should they occur.

Regular budget expenditure: $861 111
Extrabudgetary programme expenditure (not included in chart): $847 885



1. Information: $126 732
2. Protection of Nuclear Material: $503 441
3. Protection of Other Radioactive Material: $230 938

OVERVIEW

The Agency focused on providing assistance to Member States and establishing systems to prevent the diversion of nuclear material for illegal or unauthorized purposes. Information exchange continued and was enhanced through the use of new software; the number of States participating in the Illicit Trafficking Database (ITDB) Programme increased. Training activities for Member States included regional seminars, conducted in co-operation with the World Customs Organization (WCO) and INTERPOL, and through national seminars. The Agency completed the final report of the Illicit Trafficking Radiation Detection Assessment Programme (ITRAP) in October 2000. Recognizing the need of countries for detection and monitoring equipment, the Agency formulated a follow-up programme on technology development in co-operation with Member States and private industry. Finally, the Agency contributed to efforts aimed at improving international standards for the physical protection of nuclear material by Member States.

INFORMATION

The effective and accurate exchange of information is of paramount concern to the Agency and Member States. Accordingly, the Agency redesigned the Illicit Trafficking Database (ITDB) — which contains 531 incidents of which 345 were confirmed, including 175 confirmed incidents involving nuclear material. A demonstration version was distributed to Member State representatives at the ITDB Programme Review meeting in November 2000, and to selected international organizations.

Software upgrades will allow access to more comprehensive information than was previously possible. Future access to the ITDB through a Web based application was also discussed and will be evaluated in 2001. Seven new Member States joined the ITDB Programme in 2000, increasing the total number of members to 68.

PROTECTION OF NUCLEAR MATERIAL

Three meetings of a working group of the Expert Meeting "to consider whether there is a need to revise the Convention on the Physical Protection of Nuclear Material" took place. At the request of the working group, the Secretariat prepared a number of papers on: Analysis of Illicit Trafficking of Nuclear Materials; IAEA Physical Protection Recommendations and Guidance and their Use; IAEA International Physical Protection Advisory Service (IPPAS) Programme; IAEA Physical Protection Training Programme; Other IAEA Support to Member States in the Area of Physical Protection; Physical Protection Objectives and Fundamental Principles; Co-ordinated Technical Support Programme; and Bilateral Physical Protection Support Compilation of Input from Member States. The group identified several initial recommendations intended to promote further the effective implementation and improvement of physical protection worldwide. The recommendations included a spectrum of measures, initiatives and actions related to: the strengthening of the existing Convention; the need for Member States to draft a resolution at the 45th General Conference; and improving the logical hierarchy of physical protection documents to guide States in designing, implementing and regulating their national systems of physical protection. The Expert Meeting is expected to consider the final recommendations of the working group and report its conclusions thereon to the Agency's Director General in the course of 2001.

Continuing its support to Member States in evaluating their physical protection arrangements, the Agency conducted International Physical Protection Advisory Service (IPPAS) missions to Belarus and the Democratic Republic of the Congo. Revised recommendations for the physical protection of nuclear material and facilities underlined the need to use threat assessments as a basis for physical protection arrangements. In this regard, the Agency finalized the curriculum of a Design Basis Threat (DBT) workshop, developed to assist States in reviewing their threat assessments.

"Revised recommendations for the physical protection of nuclear material and facilities underlined the need to use threat assessments as a basis for physical protection arrangements."

PROTECTION OF OTHER RADIOACTIVE MATERIAL

Experience with the Illicit Trafficking Radiation Monitoring Assessment Programme (ITRAP), as well as with its own test results, led the Agency to propose a CRP to improve technical means for the detection of illicit trafficking. One of these techniques, the use of CdZnTe (cadmium–zinc–telluride) detectors in hand-held isotope identifiers, necessary for characterizing seized radioactive items at borders, proved useful in the detection of shielded and mixed sources.

In a related activity, ITRAP was completed and the results of the evaluation were

presented in October 2000. The certification of various types of monitoring and detection equipment will enable Member States to more effectively select equipment for different applications.

A technical document was prepared in co-operation with INTERPOL and WCO. Various aspects of trafficking are examined, including the range of detection and monitoring equipment available, and the responses to incidents of illicit trafficking.

A CRP was proposed with the aim of enhancing Member State capabilities for border monitoring and the use of detection equipment. The CRP will draw on the expertise of the Agency, contractors and manufacturers to design and produce the next generation of detection and identification equipment.

The Agency, through Member State Support Programmes, developed software for a commercial hand-held digital gamma spectrometer and began field testing. The instrument is a multi-purpose device for such activities as the detection of trafficking of nuclear material and radioactive sources, for the characterization of nuclear waste, and for use in nuclear verification.

The Agency's Programme in 2000: Management and Outreach

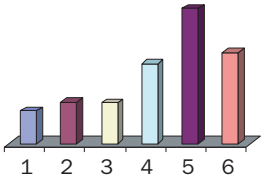
MANAGEMENT, CO-ORDINATION AND SUPPORT

PROGRAMME OBJECTIVE

To provide overall direction, policy guidance, legal advice, co-ordination and administrative support to effectively and efficiently implement the Agency's mandate as reflected in the approved programme.

Regular budget expenditure: $56 727 552

Extrabudgetary programme expenditure (not included in chart): $567 141



1. Executive Management: $4 357 622
2. Services for Policy Making Organs: $5 594 290
3. Legal Activities, External Relations and Public Information: $ 5 486 896
4. Administration: $10 735 438
5. General Services: $18 260 762
6. Information Management and Support Services: $12 292 544

LEGAL ACTIVITIES

As in previous years, the Agency provided legislative assistance to Member States to enable them to further develop their nuclear legislation. In particular, it provided assistance to 20 countries by means of written comments or advice on specific national legislation submitted to it for review. In addition, at the request of five Member States, the Agency trained individuals in various aspects of nuclear legislation. Further to the decision of the Board of Governors in December 1999 on implementation of the Model Project on upgrading radiation protection infrastructures, the Agency assisted those Member States that are still required to establish a legislative and regulatory framework for the application of adequate health and safety standards to Agency projects, including technical co-operation projects. It also advised Member States on:

- Legislation and regulations for radiation protection (for French speaking African countries);
- Legislative issues related to the development of a legal framework governing the safety of radioactive waste management and the safe transport of radioactive material (for countries of East Asia and the Pacific);
- Development of a legal framework governing emergency preparedness and response and civil liability for nuclear damage (for countries of Latin America);
- Assessment of legislative and regulatory infrastructure for radiation safety (for countries of West Asia and South East Asia);
- Drafting of nuclear legislation for individual Member States.

PUBLIC INFORMATION

One of the first events in the plan of action to implement the new public information and outreach policy was an 'Industry Forum' in January 2000. Convened with the aim of broadening and enhancing the Agency's contacts with non-traditional partners, the forum provided an opportunity for representatives of the private sector to exchange views with the Secretariat on the future prospects for nuclear power and related applications.

To heighten the visibility of its activities, the Agency posted a series of information pages on its *WorldAtom* Web site (*http://www.iaea.org/worldatom*) and issued special booklets. These dealt with the NPT Review Conference in spring 2000, the Sixth Conference of Parties (CoP-6) to the United Nations Framework Convention on Climate Change in The Hague, and the Scientific Forum on waste issues at the General Conference in September. The latter event received additional coverage through multimedia features, including extensive photo coverage and video news clips.

"One of the first events in the plan of action to implement the new public information and outreach policy was an 'Industry Forum' in January 2000."

In the publications field, the Agency's information and outreach efforts included a special emphasis on human health issues. For example, it issued a brochure on combating infectious diseases in developing nations.

Some 800 public information video products were distributed to governmental, non-governmental and other bodies, including public and commercial television channels. And in order to highlight its major emphasis in 2000 on waste management issues, the Agency produced a video for the Scientific Forum during the General Conference.

Regional public information seminars were held at regular intervals throughout the year in Brazil, Finland, Hungary, Romania and Thailand. Additionally, a number of exhibits were staged at various locations, including one on Hiroshima and Nagasaki at the Vienna International Centre (VIC).

FINANCIAL MANAGEMENT

The new Agency Financial Information Management System (AFIMS) became operational on 1 January 2000. As is typical with the introduction of a brand new system, particularly one using a new technological platform, substantial efforts were devoted to stabilizing the system, improving its use and enhancing its electronic interface with satellite systems. During the latter part of the year, much of the effort centred on testing the year end closing features of the new software to ensure a smooth process, since the closing of accounts for 2000 would be the first use of the new system.

For 2000, the General Conference appropriated an amount of $226.3 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 $221.7 million was related to Agency programmes. The latter amount was adjusted to $195.2 million to account for the average United Nations exchange rate (14.8635 Austrian Schillings to one US dollar) actually experienced during the year.

The Regular Budget for 2000, at an exchange rate of 14.8635 Austrian Schillings to one US dollar, amounted to $199.3 million, of which $191 million was to be financed from contributions by Member States on the basis of the 2000 scale of assessment, $4 million from income from reimbursable work for others and $4.3 million from other miscellaneous income.

The actual expenditures for the Agency's Regular Budget in 2000 amounted to $196.4 million, of which $192.3 million was related to the Agency's programmes (see the Annex, Table A1). The unused budget from the Agency's programmes amounted to $2.9 million, while the total unused budget was $2.8 million when reimbursable work for others was taken into account.

A total of $38.7 million of extrabudgetary resources were actually available for Agency programmes. This total consisted of a $15.1 million unused balance carried forward from 1999 and $23.6 million additional extrabudgetary funds made available in 2000. The 2000 expenditure amounted to $20.9 million (see the Annex, Table A2), of which 50% was spent from US funds, mostly to support Agency programmes for safeguards activities. About 14% of the 2000 expenditure came from funds provided by Japan and were mainly used to support work on the safety of nuclear installations in countries of South East Asia, the Pacific and the Far East. Another 13% came from funds provided by European Union Member States, which basically financed verification activities in Iraq pursuant to United Nations Security Council resolutions. The remaining 23% of 2000 expenditures was covered by funds from other donors, and predominantly financed verification activities in Iraq and work in food and agriculture.

PERSONNEL MANAGEMENT

As part of its human resources planning, the Agency developed a 'Forecast of Vacancies' that has provided flexibility in the redefinition of job profiles to meet programme needs. It also provides Member States with information on future employment opportunities. Not only will it enable national recruitment centres to begin searching early for candidates to facilitate the recruitment of staff from developing and under- or non-represented countries, it will also lead to the hiring of more women.

> ***"As part of its human resources planning, the Agency developed a 'Forecast of Vacancies' that has provided flexibility in the redefinition of job profiles to meet programme needs."***

To instill a common approach to management throughout the house, the Agency established the Management Certificate Curriculum (MCC) training course. The MCC is also closely linked to ongoing reforms, particularly in the areas of programme planning and implementation, prioritization of financial

resources and streamlining of human resources management procedures. The Agency conceives the MCC as an interactive process that permits managers to actively participate in and influence the broader reform effort. By the end of 2000, over 100 managers had completed the course.

At the end of 2000, there were 2173 staff members in the Secretariat — 912 in the Professional and higher categories and 1261 in the General Service category. These figures represent 1629 regular, 284 temporary assistance and 172 extrabudgetary staff, as well as 59 cost free experts and 20 consultants. Ninety-three nationalities were represented among the 670 staff members in posts subject to geographical distribution.

INFORMATION MANAGEMENT

In order to improve *GovAtom*, the Agency's restricted access Web site containing documents of the policy making organs, a questionnaire was distributed to Member States and their permanent missions in Vienna to solicit user comments and suggestions. An analysis of the results indicated overall satisfaction with *GovAtom*, with recommendations for improving the timeliness of documents, broadening their scope and making it easier to find them. As a result, a subset of the Official Records of the Board of Governors (GOV/OR) has been added to *GovAtom*.

COMPUTER SERVICES

The considerable time and effort invested in 1999 by the Agency to deal with the Y2K computer problem resulted in a very smooth transition of all central computer services into 2000. In particular, special software and hardware upgrades allowed the Financial Information and Control System (which was not Y2K compliant) to run as required in 2000.

The Agency's current firewall system was replaced with upgraded fault tolerant software. The new security concept also includes intrusion detection and subsystems for encrypted remote access to the Agency's computer resources through the Virtual Private Network (VPN).

A new service provider was selected for the Agency's Internet line. This has resulted in an increase of capacity with no increase in costs. The connection can now support additional services such as video conferencing and the VPN, and with 50% utilization has ample room for expansion in the next biennium.

During the year the Agency devoted considerable effort to implementing the recommendations of the Information Technology Task Force Implementation Group. On the basis of an action plan, the main objective of which is to streamline central computer services in the house, training, administration and peripheral functions such as procurement, invoicing and inventory control were rationalized. Additional cost savings from further a streamlining of services were also identified for the next two years.

LIBRARY SERVICES

A continuing Agency priority is to increase user access to information in electronic formats using the Internet, Intranet and CD-ROMs. In this connection, *VICLNET*, the VIC Library's Web site, offered users on-line access to 244 subscribed electronic journals, 208 free Internet journals and 5 commercial electronic information services. Additionally, a CD-ROM network operated as an integrated part of *VICLNET*, allowing access to 31 reference books, handbooks, directories, dictionaries, encyclopaedias and databases from the offices of VIC staff.

> ***"The considerable time and effort invested in 1999 by the Agency to deal with the Y2K computer problem resulted in a very smooth transition of all central computer services into 2000."***

To make full use of the Library's electronic information services and resources, the

Agency set up a training programme for the staff of the VIC based organizations. In 2000, 258 staff members attended 50 training courses offered by the Library.

In addition to the traditional services it provides, such as answering user queries, carrying out external database searches and loaning materials, the Library expanded its services to Member States in a number of areas. Particularly noteworthy was a document delivery service for the Permanent Missions in Vienna and for the staff of the VIC based organizations.

The Agency implemented all necessary actions related to UNIDO's withdrawal from the common VIC Library services, in accordance with a plan developed by the Joint IAEA–UNIDO Working Group. This included reorganizing the Library's information, human and financial resources.

CONFERENCE, PRINTING, PUBLISHING AND TRANSLATION SERVICES

The rapid evolution and spread of electronic publishing and the need to provide the most efficient and cost effective services to Member States led to the adoption of new policies on the outsourcing of translation, publishing and printing work, and on publishing activities in the Agency. The new publishing policy, in particular, provides a broad set of guidelines that promotes an integrated approach to the Agency's electronic and paper based publishing programme, establishing a uniform standard of quality, enhancing customer service, increasing overall efficiency and reducing duplication of effort throughout the house. In this regard, a new Intranet Web site was set up to improve user access to the Agency's conference, translation, printing and publishing services.

In addition to effecting economies in staffing through the use of streamlined work process, the Agency introduced important technological improvements in 2000, particularly the use of computer assisted translation software — designed to improve consistency and efficiency — for the preparation of English translations. This software is also being introduced for translations into the Agency's other official languages.

Advances in technology mean that requests for colour and black and white printing can now be transmitted electronically; a hard copy original is no longer necessary to print a publication. To take full advantage of this improved process, the Agency acquired new equipment that will result in better colour printing quality and faster production times. Additionally, displays and large format printing equipment were purchased for the production of standardized materials for use in Agency seminars and conferences. The total number of page impressions in 2000 was 66 788 206, down from 75 016 012 in 1999.

"The new publishing policy ... provides a broad set of guidelines that promotes an integrated approach to the Agency's ... publishing programme."

A report was prepared that simplified the definition of the types of Agency meetings, and proposed measures to rationalize and reduce the number of meetings and improve their planning and organization. Specific activities designed to support these objectives focused on developing an Agency-wide, centralized 'meeting system', modernizing facilities and encouraging the greater use of videoconferencing.

Publishing activities included the production of 163 books, reports, journal issues, CD-ROMs and leaflets in English. In addition, there was one publication in Chinese and one in Spanish.

INTERNATIONAL NUCLEAR INFORMATION SYSTEM

The objective of the International Nuclear Information System (INIS) is to collect and distribute bibliographic information on nuclear literature published in Member

States, as well as the full texts of non-conventional literature (NCL) — reports, dissertations, etc. — which is not readily available through commercial channels. The current number of participating members is 122, and includes 103 countries and 19 international organizations. A total of 65 714 bibliographic records were added during the year.

The Agency signed agreements with the Institute of Physics Publishing, Nuclear Technology Publishing and the British Nuclear Energy Society for the acquisition of their bibliographic records in electronic format. These records will be upgraded to INIS standards and added to the collection of articles from core scientific journals. In this connection, the Agency concluded an agreement with 39 INIS members to input these records.

"In a significant milestone, the Agency launched the INIS Distance Learning Program on the Internet."

As of the end of 2000, there were 1157 paid and free registrations for a total of 3292 users, in addition to Internet provider registrations, which cover 46 302 users. The INIS Database on CD-ROM had 448 paid and free subscriptions.

The Agency continued its co-operative arrangement with the OECD/NEA Data Bank. In 2000, 366 computer programs (out of 3594) were distributed to users in Member States that are not members of the OECD; eight computer programs (out of 149) were contributed from Member States that are not OECD Member Countries.

In a significant milestone, the Agency launched the INIS Distance Learning Program on the Internet. Aimed at the staff of national INIS Centres, the program contains two courses and includes instructions on all aspects of input preparation.

The Agency transfers NCL onto CD-ROM and microfiche for users in Member States. In 2000, 2683 NCL documents were imaged by the INIS Clearinghouse, for a total of 239 038 pages scanned. Scans from a further 2400 documents were also sent by Member States for a total of 112 781 pages. A total of 5083 documents were added to the NCL collection in 2000. This represents 29 CD-ROMs, for a total of 160 CD-ROMs since imaging began (over 2 000 000 pages). All NCL CD-ROMS are duplicated in-house, resulting in significant savings to the Agency.

In a key decision at the 28th Annual Consultative Meeting of INIS Liaison Officers, held in June in Karlsruhe, Germany, the participants agreed on a new definition of membership arrangements for INIS, and on a pilot programme to determine the minimum level of input records for each member. Another important event was the 6th INIS/Energy Technology Data Exchange (ETDE) Joint Technical Committee meeting in November 2000. Two noteworthy outcomes of this meeting were: completion of the Joint INIS/ETDE Thesaurus, planned for publication in 2001; and definition of a minimum record format to ensure compatibility between INIS, the US 'Dublin Core' format and the electronic formats of various publishers whose records are being acquired by INIS to complement current input.

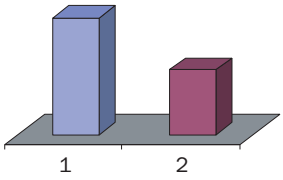
MANAGEMENT OF TECHNICAL CO-OPERATION FOR DEVELOPMENT

PROGRAMME OBJECTIVE

To provide management support to effectively and efficiently design, implement and evaluate the technical co-operation programme.

Regular budget expenditure: $11 070 820

Extrabudgetary programme expenditure (not included in chart): $364 905



1. Technical Co-operation Programme: $7 133 877
2. Planning, Co-ordination and Evaluation: $3 936 943

OVERVIEW

The Agency is guided in the management of technical co-operation by its Technical Co-operation Strategy, which aims at contributing to the sustainable socioeconomic development of Member States by raising the quality standards of project design, focusing country programmes on priority development needs and promoting the use of nuclear and isotopic techniques with clear cost–benefit advantages. A major achievement during the year was the finalization and approval of the technical co-operation programme for the coming biennium. Other achievements included: expanding outreach through the creation of *TC Web* as part of *WorldAtom*, the Agency's Web site, and providing detailed project information on-line to registered users of *TC-PRIDE* in Member States; and evaluating the technical co-operation projects of the past decade in radioactive waste management.

TECHNICAL CO-OPERATION PROGRAMME

The technical co-operation programme was finalized for the 2001–2002 biennium. As mandated in the Technical Co-operation Strategy, the focus was on identifying and formulating projects that promote socioeconomic impact by contributing to the achievement of major sustainable development priorities of each country using nuclear applications. This was achieved by an intensive dialogue with Member States, greater co-operation with United Nations agencies and other international organizations and measures to increase the potential impact through improved synergies with Agency activities funded by the regular budget. The proposals received were subjected to rigorous assessment, and programme priorities were established according to a central criterion, focusing on projects that either involved the core competencies of the Agency or were in thematic areas in countries where there are national programmes with solid financial support. Furthermore, for all Model Projects, performance indicators were identified, which will make it possible to monitor progress in achieving project objectives more effectively.

The technical co-operation programme approved for 2001–2002 reflects the current priorities of Member States. As seen in Fig. 1, the largest single area of the programme, nearly 21%, is devoted to safety related projects: radiation safety, nuclear safety and radioactive waste safety. The second major area is human health (19%) and the third largest is food and agriculture (15%). Within these areas, the concentration on development projects, rather than the nuclear institution building projects that were a large part of the Agency's technical co-operation programme in earlier years, shows the increasing appreciation in Member States of the potential for applying nuclear techniques to solve national developmental problems.

The intensified programming process was carried out during the year without sacrificing the quality of implementation of the 2000 technical co-operation programme. Not only was implementation higher — net new obligations increased to $66 million — but the

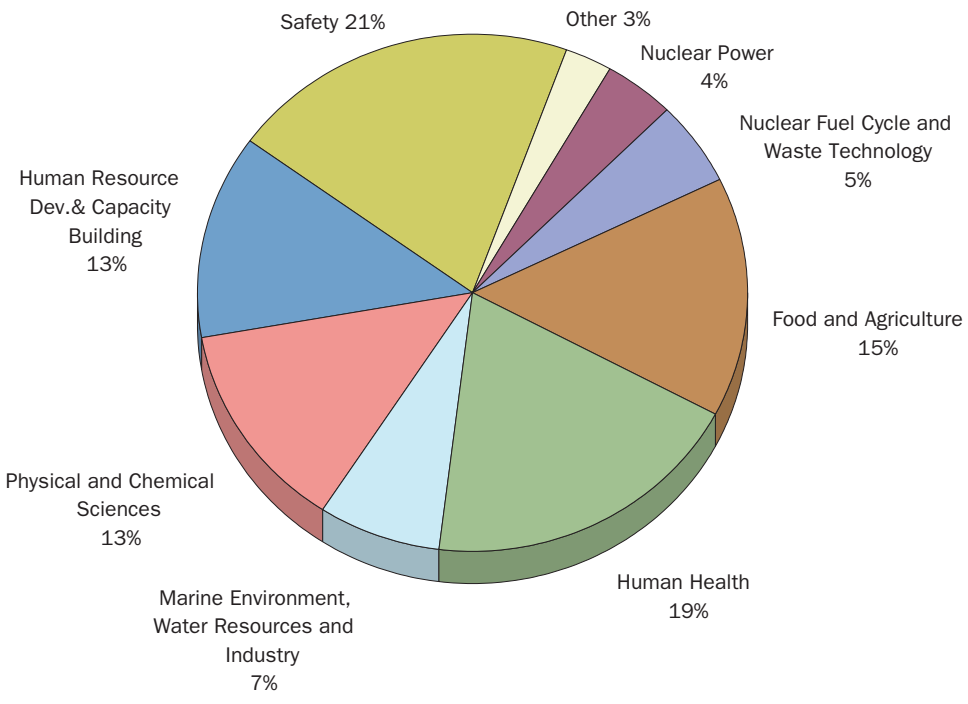


FIG. 1. Distribution of the 2001–2002 technical co-operation programme by Agency area of activity.

quality improved as well. However, the efforts over the past years to improve the quality of the programme through intensified upstream work, the growing number of recipient countries and the increasing size and complexity of the programme have added significantly to the Agency's workload in this area. Recognizing this problem — and as an interim measure — the Board of Governors at its meeting in December 2000 approved an amount of up to $1 million to be taken from the Technical Co-operation Fund (TCF) to finance additional human resources to manage the programme. It also requested the Director General to look into various options for a medium and longer term solution to the problem in consultation with Member States.

The use of isotope hydrology applications for water resource assessment and management in Ethiopia represents a good example of a successful partnership between the Agency and central government authorities. The programme began with a few activities in geothermal studies and localized groundwater assessment. Positive results led to further projects in this field, successively involving more aspects and leading to an awareness on the part of the Government of Ethiopia of the importance of taking a comprehensive approach to water resources management, including the use of isotope hydrology as a standard tool. These efforts culminated in October 2000 in a national workshop, supported by the Agency, which brought together all parties involved to discuss the country's future strategy for water resource development. It was decided to create a 12 year national master plan for the Ethiopian Groundwater Resource Assessment Programme. This is the first time that the government of a recipient country has co-operated with the Agency to make such a concrete national master plan. It is expected that 'upstream' work in this field in other countries, such as China and Namibia, will lead to similar positive results in the future.

During the year the Agency intensified its co-operation with other international and regional organizations in areas of common interest to take advantage of the valuable synergies created. One example is the strengthened relationship with the Organization for African Unity, with which the Agency now has a formal agreement to carry out joint activities to combat the tsetse fly using the sterile insect technique.

Another instance of co-operation with international organizations was the Agency's support of WHO's "Stop TB" and "Roll Back Malaria" initiatives. In collaboration with the national disease control programmes of 11 African countries and WHO, the Agency has embarked on a three year project to validate new diagnostic tools for drug resistant strains

"During the year the Agency intensified its co-operation with other international and regional organizations in areas of common interest to take advantage of the valuable synergies created."

of malaria and tuberculosis, and assist in their integration into national programmes. Molecular techniques using radionuclide tracers that have been developed under Agency projects over the past four years have reduced the time needed for identification of drug resistant strains from the four to six weeks required by conventional procedures to less than one week. Nuclear techniques have also proven to be more sensitive and reliable than conventional methods and have important applications, both for decision makers in selecting which drugs should be used, and at the clinical level in making treatment more effective.

The environment is another area that brought the Agency closer to other international organizations. For example, it participated in the First Global Environment Facility (GEF) Biennial International Waters Conference in Budapest in October 2000. A follow-up to the Global Environment Conference held in Rio de Janeiro in 1992, the GEF is the largest grant based funding mechanism addressing high priority global environment problems. The Budapest conference brought together organizations involved in implementing GEF's $400 million international waters project portfolio (such as FAO, OAU, UNDP, UNEP and the

World Bank), as well as Member States. One of the topics at the meeting was the possibility of linking relevant Agency technical co-operation projects with specific international water programmes, as well as to demonstrate the Agency's potential role in solving global water problems. Such partnerships have the advantage of potentially increasing project impact, expanding awareness of national counterparts' capacities, enhancing the integration of nuclear techniques with conventional ones, and thus increasing the sustainability of the results achieved.

In addition to advances in fields where nuclear techniques have proven their effectiveness, the Agency moved into new areas, supporting the development of new applications for nuclear and isotope technologies. One example was the preparatory work that was carried out in Europe for humanitarian demining. An Advisory Group met to review possible nuclear methods and select the most promising for field testing. This resulted in a regional project in Europe that will adapt an existing instrument for the identification of land mines and demonstrate its suitability under field conditions. If the trials are successful, the technique can be applied in other locations as well.

"During the past year, the Agency made major efforts to raise public awareness of its technical co-operation activities ..."

As mentioned above, the benefits of forging international partnerships — such as with WHO in its "Roll Back Malaria" campaign — can maximize the impact of technical assistance projects. A multi-year regional project in Africa that began in 2000 supports a global research and development initiative to investigate the feasibility of applying the sterile insect technique (SIT) to control the anopheles mosquito, which carries malaria, in selected target areas in sub-Saharan Africa. Successes gained in area wide SIT programmes against the screwworm, tsetse and fruit flies provided the basis for starting research into its use for mosquito control. This Agency initiative also responds to a request for support expressed by African Governments at the 'Abuja Summit' held in Nigeria in April 2000, where 48 Heads of State and Government adopted the 'Abuja Declaration' to halt the spread of malaria in Africa.

The policy and operational aspects of outsourcing technical co-operation projects were discussed at a regional workshop of National Liaison Officers from Latin America and the Caribbean in Lima, in November 2000. Five pilot bilateral outsourcing agreements will be implemented to strengthen technical co-operation between developing countries in the region.

At a regional seminar for the East Asia and Pacific region held in Kuala Lumpur in August, participants analysed strategies and approaches towards self-reliance and sustainability of national nuclear institutions. The main conclusion of the seminar, which was planned, developed and conducted for the Agency by the Malaysian authorities under an outsourcing agreement, was that bringing nuclear technologies to the marketplace is essential if nuclear institutions are to survive, especially in non-nuclear-power States. Such efforts are necessary to preserve and further develop nuclear expertise for the next generation.

PLANNING, CO-ORDINATION AND EVALUATION

During the past year, the Agency made major efforts to raise public awareness of its technical co-operation activities and to improve information sharing on its projects with Member States. Information for the general public is contained in a new and detailed section on the technical co-operation programme, *TC Web (www-tc.iaea.org)*, on the Agency's *WorldAtom* Web site *(www.iaea.org/worldatom)*. Government authorities and authorized officials can obtain information from the Web based *TC-PRIDE* (Technical Co-operation Project Information

Dissemination Environment) system. It provides on-line access to detailed project information and was released to registered users from Agency Member States during the 44th session of the General Conference in 2000.

The financial resource picture for technical co-operation was more predictable during 2000 than in 1998 or 1999. One Member State, the Russian Federation, rejoined the ranks of donors with a multi-million dollar payment at the end of 2000. New developing country contributors that had not pledged in 1999 but pledged in 2000 included Côte d'Ivoire, Ghana, Indonesia, Kuwait, Latvia, Madagascar, Saudi Arabia, Yemen and The Former Yugoslav Republic of Macedonia.

During the early part of the year the Agency refined the "due account" regime and established precise criteria for evaluating the payment record of both developing and developed Member States. The objective of applying due account is to increase the level of contributions to the TCF and to improve the level of payment of Assessed Programme Costs by providing incentives for Member States to pay. Due account was followed in upgrading 'footnote-a/ projects' (i.e. projects approved but awaiting funding) from TCF resources and in the programming process.

In preparation for the new cycle, the Board of Governors conducted intensive consultations and negotiations in order to agree on the TCF target for 2001–2002. The compromise reached, which was approved by the General Conference, maintained the target at $73 000 000 for both years. In addition, a new principle of "rate of attainment" was introduced, which measures the payments from Member States against the target for the year in question. The minimum rate of attainment foreseen for 2001 is 80% and 85% for 2002. With this new principle it is expected that net TCF resources will increase during the current 2001–2002 cycle, as those countries not paying their full assessed share will be encouraged to pay at least the amount corresponding to the rate of attainment.

Evaluation is an essential part of the programme cycle as it enables the Agency to learn from the experience gained in implementing projects and to apply this to future projects. In 2000, technical co-operation projects and associated regular programme activities from 1990–1999 related to radioactive waste management were reviewed. The evaluation concluded that there was uneven attainment from country to country of the objectives of these activities. The projects in this area were seen to be highly relevant; their effectiveness was more than adequate; and efficiency was acceptable with regard to quality, though less so in terms of timeliness and sufficiency of inputs. It was noted, however, that greater government commitment was needed to assure the impact and sustainability of the results. A second, more narrowly focused, evaluation examined Model Projects related to Mediterranean fruit fly eradication using SIT in three Latin American countries. The evaluation found that the economic impact of the projects, through expanded fruit production and export markets, is large and growing, and is highly sustainable.

Annex

TABLE A1. **ALLOCATION AND UTILIZATION OF REGULAR BUDGET RESOURCES IN 2000**

Programme	2000 budget GC(43)/6 (at AS 12.70) (1)	2000 adjusted budget (at AS 14.8635) (2)	2000 total expenditure Amount (3)	2000 total expenditure % of revised budget (3) / (2) (4)	Unused (overexpended) budget (2) – (3) (5)
Nuclear Power	4 399 000	3 913 000	3 903 485	99.76%	9 515
Nuclear Fuel Cycle and Waste Technology	5 310 000	4 745 000	4 686 198	98.76%	58 802
Comparative Assessment of Energy Sources	2 805 000	2 499 000	2 492 653	99.75%	6 347
Subtotal	**12 514 000**	**11 157 000**	**11 082 336**	**99.33%**	**74 664**
Food and Agriculture	10 685 000	9 656 000	9 554 071	98.94%	101 929
Human Health	6 035 000	5 474 000	5 470 525	99.94%	3 475
Marine Environment, Water Resources and Industry	6 553 000	5 836 000	5 759 160	98.68%	76 840
Physical and Chemical Sciences	8 845 000	8 097 000	8 273 873	102.18%	(176 873)
Subtotal	**32 118 000**	**29 063 000**	**29 057 629**	**99.98%**	**5 371**
Nuclear Safety	5 724 000	5 041 000	5 217 968	103.51%	(176 968)
Radiation Safety	3 576 000	3 164 000	3 394 319	107.28%	(230 319)
Radioactive Waste Safety	2 199 000	1 939 000	1 823 867	94.06%	115 133
Co-ordination of Safety Activities	3 101 000	2 772 907[a]	2 480 753	89.46%	292 154
Subtotal	**14 600 000**	**12 916 907**	**12 916 907**	**100.00%**	**0**
Safeguards	80 486 000	70 608 000	70 617 231	100.01%	(9 231)
Security of Material	1 082 000	950 000	861 111	90.64%	88 889
Subtotal	**81 568 000**	**71 558 000**	**71 478 342**	**99.89%**	**79 658**
Management of Technical Co-operation for Development	12 851 000	11 234 000	11 070 820	98.55%	163 180
Subtotal	**12 851 000**	**11 234 000**	**11 070 820**	**98.55%**	**163 180**
Management, Co-ordination and Support					
Executive Management	5 137 000	4 492 000	4 357 622	97.01%	134 378
Policy-making Organs	6 461 000	5 681 000	5 594 290	98.47%	86 710
Legal Activities, External Relations and Public Information	6 888 000	6 047 093[a]	5 486 896	90.74%	560 197
Administration	12 808 000	11 203 000	10 735 438	95.83%	467 562
General Services	22 770 000	19 621 000	18 260 762	93.07%	1 360 238
Information Management and Support Services	14 003 000	12 262 000	12 292 544	100.25%	(30 544)
Subtotal	**68 067 000**	**59 306 093**	**56 727 552**	**95.65%**	**2 578 541**
TOTAL — Agency Programmes	**221 718 000**	**195 235 000**	**192 333 586**	**98.51%**	**2 901 414**
Plus: Reimbursable Work for Others	4 609 000	4 028 000	4 091 275	101.57%	(63 275)
Total Regular Budget	226 327 000	199 263 000	196 424 861	98.58%	2 838 139

[a] Based on Board of Governors document GOV/1999/15, an amount of $45 907 was transferred from Programme Q "Legal Activities, External Relations and Public Information" to Subprogramme K.2 "Safety Conventions" in order to cover the cost of emergency assistance provided to Peru, Thailand and Japan (Tokaimura).

TABLE A2. **EXTRABUDGETARY FUNDS IN 2000 — RESOURCES AND EXPENDITURES**

Programme	2000 extrabudgetary budget figures GC(43)/6 (1)	Resources available[1] in 2000 (2)	Expenditure during 2000 (3)	Unused balance as at 31 December 2000 (2) – (3) (4)
Nuclear Power	360 000	327 019	90 194	236 825
Nuclear Fuel Cycle and Waste Technology	350 000	1 201 244	673 718	527 526
Comparative Assessment of Energy Sources	0	321 989	204 455	117 534
Subtotal	**710 000**	**1 850 252**	**968 367**	**881 885**
Food and Agriculture	3 994 000[2]	3 374 896	2 929 469	445 427
Human Health	40 000	398 812	106 655	292 157
Marine Environment, Water Resources and Industry	782 000	1 732 553	691 379	1 041 174
Physical and Chemical Sciences	0	98 900	13 485	85 415
Subtotal	**4 816 000**	**5 605 161**	**3 740 988**	**1 864 173**
Nuclear Safety	2 030 000	5 152 280	1 811 632	3 340 648
Radiation Safety	185 000	524 142	284 662	239 480
Radioactive Waste Safety	0	408 383	253 480	154 903
Co-ordination of Safety Activities	128 000	190 440	116 774	73 666
Subtotal	**2 343 000**	**6 275 245**	**2 466 548**	**3 808 697**
Safeguards	3 674 000	19 205 235	10 311 459	8 893 776
Security of Material	893 000	1 597 507	847 885	749 622
Verification in Iraq pursuant to UNSC Resolutions	3 000 000	2 139 077	1 639 859	499 218
Subtotal	**7 567 000**	**22 941 819**	**12 799 203**	**10 142 616**
Management of Technical Co-operation for Development	200 000	654 052	364 905	289 147
Subtotal	**200 000**	**654 052**	**364 905**	**289 147**
Management, Co-ordination and Support				
Services for Policy Making Organs	0	8 554	3 110	5 444
Legal Activities, External Relations and Public Information	620 000	1 392 445	562 024	830 421
Administration	0	4 711	2 007	2 704
Subtotal	**620 000**	**1 405 710**	**567 141**	**838 569**
Agency's Programmes	16 256 000	38 732 239	20 907 152	17 825 087

[1] The column "Resources available in 2000" includes cash contributions received as well as the unused balances as at 1 January 2000 and cash due from UNEP for approved activities.

[2] The FAO budget includes $893 952 estimated costs for FAO professional staff working in the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture. The salaries of the staff members are paid by FAO and are not included in columns 2 and 3.

TABLE A3. **INTERNATIONAL PROBABILISTIC SAFETY ASSESSMENT REVIEW TEAM (IPSART) MISSIONS IN 2000**

Review Type	Nuclear power plant	Country
Updated level 1/2 PSA	Krško	Slovenia
Level 1and 2 PSA	Jose Cabrera	Spain
Level 1 PSA	South Ukraine	Ukraine
Level 1 PSA	Ignalina	Lithuania
Risk scoping study	High Flux Research Reactor	Netherlands
Follow-up	Tianwan WWER 1000 (China)	Russian Federation

TABLE A4. **OPERATIONAL SAFETY REVIEW TEAM (OSART) MISSIONS IN 2000**

Type	Nuclear power plant	Type	Country
Full OSART	Belleville	PWR	France
Full OSART	Muehleberg	BWR	Switzerland
Full OSART	North Anna	PWR	USA
Reduced scope OSART	Temelin	WWER	Czech Republic
OSART follow-up	Golfech	PWR	France
OSART follow-up	Asco	PWR	Spain
OSART follow-up	Khmelnitsky	WWER	Ukraine

TABLE A5. **PEER REVIEW OF OPERATIONAL SAFETY PERFORMANCE EXPERIENCE (PROSPER) MISSIONS IN 2000**

Type	Plant/location	Country
Pilot mission	Hartlepool	United Kingdom
Workshop	Kanupp	Pakistan
Workshop	Khmelnitsky	Ukraine
Workshop	VATESI	Lithuania
Introductory seminar	VNIIAES	Russian Federation

TABLE A6. **SAFETY CULTURE ENHANCEMENT PROGRAMME (SCEP) ACTIVITIES IN 2000**

Type	Plant/location	Country
Workshop	Mochovce	Slovakia
Workshop	KFKI, Budapest	Hungary
Workshop	Daya Bay	China
Assistance visit	Laguna Verde	Mexico
Workshop	Laguna Verde	Mexico
Seminar	INB, Resende	Brazil
Seminar	SKI, Stockholm	Sweden

TABLE A7. **ENGINEERING SAFETY REVIEW SERVICE (ESRS) MISSIONS IN 2000**

Service	Site/plant	Country
Design safety review	Koeberg PBMR	South Africa
Design safety review	Bushehr	Is. Rep. of Iran
Site safety review preparatory mission	Roopur	Bangladesh
Site safety review follow-up	Muria	Indonesia
Instrumentation and control review mission	Tianwan	China
Review of regulatory/safety aspects of feasibility study for desalination	El-Dabaa	Egypt
Review of safety and regulatory requirements and guidance	Korea Next Generation Reactor	Korea, Rep. of
Seismic safety review follow-up	Maamora Centre d'Etudes Nucléaires	Morocco
Seismic safety review follow-up	TR-2 research reactor	Turkey
Seismic safety review	Cernavoda	Romania
Seismic safety review follow-up	Yerevan	Armenia
PSAR review assistance	Bushehr	Is. Rep. of Iran
Review of modernization programme	Units 5 and 6 of Kozloduy	Bulgaria

TABLE A8. **INTEGRATED SAFETY OF RESEARCH REACTORS (INSARR) MISSIONS IN 2000**

Research reactor	Country
HOR Research Reactor, Delft	Netherlands
Maria Research Reactor, Warsaw	Poland

TABLE A9. **SAFETY REVIEW MISSIONS IN 2000 TO RESEARCH REACTORS UNDER PROJECT AND SUPPLY AGREEMENTS**

Research reactor/location	Country
IAN-R1, Bogota	Colombia
Trico II, Kinshasa	Democratic Republic of the Congo
TRIGA Mark II, Bandung	Indonesia
Triga Puspati (RTP), Kuala Lumpur	Malaysia
MA-R1, Rabat	Morocco
PRR-1, Quezon City	Philippines
TRR-1/M1, Bangkok	Thailand
Dalat	Viet Nam

TABLE A10. **INTERNATIONAL REGULATORY REVIEW TEAM (IRRT) MISSIONS IN 2000**

Type of mission	Country
Reduced scope	Czech Republic
Full scope	Finland
Full scope	Hungary
Full scope	China
Preparatory meeting	Mexico

TABLE A11. **PEER REVIEWS OF RADIATION SAFETY INFRASTRUCTURE**

Country	Type of mission
Albania	Review of Model Project milestones
China	RCA review
Dominican Republic	Review of Model Project milestones
Estonia	Review of Model Project milestones
Ghana	Review of Model Project milestones
Guatemala	Review of Model Project milestones
Indonesia	RCA review
Ireland	Radiation safety regulation infrastructure mission
Jordan	Review of Model Project milestones
Kazakhstan	Review of Model Project milestones
Korea, Republic of	RCA review
Latvia	Review of Model Project milestones
Lithuania	Review of Model Project milestones
Malaysia	RCA review
Mongolia	Review of Model Project milestones
Myanmar	Review of Model Project milestones
Namibia	Review of Model Project milestones
Niger	Review of Model Project milestones
Pakistan	RCA review
Panama	Review of Model Project milestones
Singapore	RCA review
Sri Lanka	Review of Model Project milestones
Sudan	Review of Model Project milestones
Yemen	Review of Model Project milestones

TABLE A12. **NUMBER OF STATES HAVING SIGNIFICANT NUCLEAR ACTIVITIES AT THE END OF 1998, 1999 AND 2000**

	Number of States		
	1998	**1999**	**2000**
States with safeguards applied under NPT or NPT/Tlatelolco agreements	58[a]	60	60
States with safeguards applied under Tlatelolco agreements	1	1	1
States with safeguards applied pursuant to other comprehensive safeguards agreements	0	0	0
States with safeguards applied under INFCIRC/66/Rev.2-type agreements[b]	4	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	71	71

[a] This excludes Iraq, where safeguards activities 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.

TABLE A13. **SITUATION ON 31 DECEMBER 2000 WITH RESPECT TO THE CONCLUSION OF SAFEGUARDS AGREEMENTS BETWEEN THE AGENCY AND NON-NUCLEAR-WEAPON STATES IN CONNECTION WITH NPT**

Non-nuclear-weapon Stateswhich have signed, ratified, acceded to or succeeded to NPT[a] (1)	Date of ratification, accession or succession (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	7 June 1996	Approved 7 December 2000	
Angola	14 October 1996		
Antigua and Barbuda[c]	27 November 1968	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	In force: 29 April 1999	580
Bahamas[c]	10 July 1973	In force: 12 September 1997	544
Bahrain	3 November 1988		
Bangladesh	31 August 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[d]	18 September 1998	In force: 20 September 1999	435/Mod.3
Brunei Darussalam	26 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	In force: 17 December 1999	586
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[h]	25 May 1995	In force: 9 September 1996	476/Mod.1
Colombia[i]	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[j]	1 January 1993	In force: 11 September 1997	541
Democratic People's Republic of Korea	12 December 1985	In force: 10 April 1992	403

TABLE A13. **(cont.)**

Non-nuclear-weapon Stateswhich have signed, ratified, acceded to or succeeded to NPT[a] (1)	Date of ratification, accession or succession (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Democratic Republic of the Congo	4 August 1970	In force: 9 November 1972	183
Denmark[k]	3 January 1969	In force: 21 February 1977	193
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: 13 June 1986	
Eritrea	16 March 1995		
Estonia	7 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[l]	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[m]	2 May 1975	In force: 21 February 1977	193
Ghana	4 May 1970	In force: 17 February 1975	226
Greece[n]	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

TABLE A13. **(cont.)**

Non-nuclear-weapon Stateswhich have signed, ratified, acceded to or succeeded to NPT[a] (1)	Date of ratification, accession or succession (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Kuwait	17 November 1989	Signed: 10 May 1999	
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
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	8 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		
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[o]	2 May 1975	In force: 21 February 1977	193
New Zealand[p]	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	Approved: 20 September 1999	
Palau, Republic of	14 April 1995		
Panama[c,q]	13 January 1977	Signed : 22 December 1988	
Papua New Guinea	13 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

TABLE A13. **(cont.)**

Non-nuclear-weapon Stateswhich have signed, ratified, acceded to or succeeded to NPT[a] (1)	Date of ratification, accession or succession (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Poland	12 June 1969	In force: 11 October 1972	179
Portugal[r]	15 December 1977	Accession: 1 July 1986	193
Qatar	3 April 1989		
Republic of Moldova	11 October 1994	Signed: 14 June 1996	
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
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[s]	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[t]	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	30 March 1995	Signed: 10 October 2000	
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		

TABLE A13. **(cont.)**

Non-nuclear-weapon Stateswhich have signed, ratified, acceded to or succeeded to NPT[a] (1)	Date of ratification, accession or succession (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
United Republic of Tanzania	31 May 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]	25 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	Signed: 21 September 2000	
Yugoslavia[u], Federal Republic of	4 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 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 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] 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.

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

[j] 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.

[k] 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.

[l] 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.

[m] 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.

[n] 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.

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

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

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

[r] 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.

[s] 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 and signed on 27 September 1999.

[t] 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.

[u] 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.

TABLE A14. **SITUATION ON 31 DECEMBER 2000 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	Signed: 26 September 2000	
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.

TABLE A15. **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 2000[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
(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

TABLE A15. **(cont.)**

Party(ies)[b]	Subject	Entry into force	INFCIRC
	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).

(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

TABLE A15. **(cont.)**

Party(ies)[b]	Subject	Entry into force	INFCIRC
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[f]/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.

[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/288.

TABLE A16. **SITUATION ON 31 DECEMBER 2000 WITH RESPECT TO THE CONCLUSION OF PROTOCOLS ADDITIONAL TO SAFEGUARDS AGREEMENTS**

State	Status of the protocol	INFCIRC
Andorra	Approved 7 December 2000	
Armenia	Signed 29 September 1997	
Australia	In force 12 December 1997	217/Add.1
Austria	Signed 22 September 1998	
Azerbaijan	In force 29 November 2000	580/Add.1
Bangladesh	Approved 25 September 2000	
Belgium	Signed 22 September 1998	
Bulgaria	In force 10 October 2000	178/Add.1
Canada	In force 8 September 2000	164/Add.1
China	Signed 31 December 1998	
Croatia	In force 6 July 2000	463/Add.1
Cuba	Signed 15 October 1999	
Cyprus	Signed 29 July 1999	
Czech Republic	Signed 28 September 1999	
Denmark	Signed 22 September 1998	
Ecuador	Signed 1 October 1999	
Estonia	Signed 13 April 2000	
Finland	Signed 22 September 1998	
France	Signed 22 September 1998	
Georgia	Signed 29 September 1997	
Germany	Signed 22 September 1998	
Ghana*	Signed 12 June 1998	226/Add.1
Greece	Signed 22 September 1998	
Holy See	In force 24 September 1998	187/Add.1
Hungary	In force 4 April 2000	174/Add.1
Indonesia	In force 29 September 1999	283/Add.1
Ireland	Signed 22 September 1998	
Italy	Signed 22 September 1998	
Japan	In force 16 December 1999	255/Add. 1
Jordan	In force 28 July 1998	258/Add.1
Korea, Republic of	Signed 21 June 1999	
Latvia	Approved 7 December 2000	
Lithuania	In force 5 July 2000	413/Add.1
Luxembourg	Signed 22 September 1998	
Monaco	In force 30 September 1999	524/Add.1
Namibia	Signed 22 March 2000	
Netherlands	Signed 22 September 1998	
New Zealand	In force 24 September 1998	185/Add.1
Nigeria	Approved 7 June 2000	
Norway	In force 16 May 2000	177/Add.1
Peru	Signed 22 March 2000	
Philippines	Signed 30 September 1997	
Poland	In force 5 May 2000	179/Add.1
Portugal	Signed 22 September 1998	
Romania	In force 7 July 2000	180/Add.1
Russian Federation	Signed 22 March 2000	
Slovakia	Signed 27 September 1999	
Slovenia	In force 22 August 2000	538/Add.1
Spain	Signed 22 September 1998	
Sweden	Signed 22 September 1998	
Switzerland	Signed 16 June 2000	
Turkey	Signed 6 July 2000	
Ukraine	Signed 15 August 2000	

TABLE A16. **(cont.)**

State	Status of the protocol	INFCIRC
United Kingdom	Signed 22 September 1998	
United States of America	Signed 12 June 1998	
Uruguay	Signed 29 September 1997	
Uzbekistan	In force 21 December 1998	508/Add.2

* Pending entry into force of the protocol, it is applied provisionally in this State with effect from the date of signature.

TABLE A17. **APPROXIMATE QUANTITIES OF MATERIAL SUBJECT TO AGENCY SAFEGUARDS AT THE END OF 2000**

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	534.4	27.9	80.5	80 360
Separated plutonium outside reactor cores	12.5	0.1	59.7	9 031
Recycled plutonium in fuel elements in reactor cores	10.3	0.4	0	1 340
HEU (equal to or greater than 20% ^{235}U)	11.0	0.1	10.7	604
LEU (less than 20% ^{235}U)	42 147	2 786	4 041	13 204
Source material[d] (natural or depleted uranium and thorium)	78 942	1 646	11 089	6 990
Non-nuclear material[e]				
Heavy water	0	493	0	25
Total significant quantities				111 554

[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 90 t (11 199 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.

TABLE A18. **NUMBER OF FACILITIES UNDER SAFEGUARDS OR CONTAINING SAFEGUARDED MATERIAL ON 31 DECEMBER 2000**

A full list of facilities by individual State is available on the Agency's WorldAtom Web site. A printed copy is available, on request, from the Agency's Division of Public Information.

	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	147	(160)	8	(8)	1	(1)	156	(168)
Conversion plants	12	(12)	1	(1)	0	(0)	13	(13)
Fuel fabrication plants	38	(39)	4	(4)	0	(0)	42	(43)
Reprocessing plants	5	(5)	1	(1)	0	(0)	6	(6)
Enrichment plants	9	(9)	0	(0)	2	(4)	11	(13)
Separate storage facilities	62	(63)	4	(4)	7	(8)	73	(75)
Other facilities	82	(92)	1	(1)	2	(2)	85	(95)
Subtotals	**539**	**(600)**	**30**	**(33)**	**13**	**(16)**	**582**	**(649)**
Other locations	316	(413	3	(31)	0	(0)	319	(444)
Non-nuclear installations	0	(0)	1	(1)	0	(0)	1	(1)
Totals	855	(1013)	34	(65)	13	(16)	902	(1094)

[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.

TABLE A19. **MAIN EQUIPMENT AND ACTIVITIES IN SUPPORT OF SAFEGUARDS**

	1999	2000
	Total in inventory	
Gamma ray measurement systems		
Low resolution systems (assay probes)	75	75
High resolution systems (analysers)	39	39
Portable multichannel analysers	280	355
Detectors	908	995
Neutron measurement systems		
Detection heads for active neutron measurements	32	37
Detection heads for passive neutron measurements	35	38
Neutron coincidence counting electronics	92	91
Spent fuel measurement systems		
Cerenkov glow viewing devices	96	109
Spent fuel radiation measuring systems	175	184
Irradiated fuel measuring electronics	75	75
Other measurement systems		
Physical properties devices	150	144
Optical surveillance systems		
Photo cameras	715	715
Video single camera systems	505	516
Video multiple camera systems	134	158
Video review stations	142	142
Seals		
In situ verifiable seals	1 328	1 389
Radiation monitoring systems	81	101
Activities		
Metal cap seals issued	21 300	22 262
Metal cap seals verified	19 718	18 848
Shipment of equipment and supplies	534	467
Hand carried transport of equipment and supplies	514	748
Shipment of reference material and chemicals to facilities	289	293
Shipment of inspection samples, radioactive material standards and contaminated items to the Safeguards Analytical Laboratory	232	235
Procurement actions	1 423	1 439

TABLE A20. **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, Australia, Belgium, Canada, European Union, Finland, France, Germany, Hungary, Japan, Republic of Korea, Netherlands, Russian Federation, Sweden, United Kingdom, United States of America	Austria, Israel, Latvia, Pakistan, Russian Federation

TABLE A21. **CONVENTIONS NEGOTIATED AND ADOPTED UNDER THE AUSPICES OF THE AGENCY AND FOR WHICH THE DIRECTOR GENERAL OF THE AGENCY IS THE DEPOSITARY (STATUS AND RELEVANT DEVELOPMENTS)**

Agreement on the Privileges and Immunities of the IAEA (reproduced in INFCIRC/9/Rev. 2). In 2000, one State accepted the Agreement. By the end of the year, there were 67 Parties.

Vienna Convention on Civil Liability for Nuclear Damage (reproduced in INFCIRC/500). Entered into force on 12 November 1977. Status remained unchanged during 2000, with 32 Parties.

Optional Protocol Concerning the Compulsory Settlement of Disputes (reproduced in INFCIRC/500/Add.3). Entered into force on 13 May 1999. Status remained unchanged during 2000, with two Parties.

Convention on the Physical Protection of Nuclear Material (reproduced in INFCIRC/274/Rev.1). Entered into force on 8 February 1987. In 2000, four States adhered to the Convention. By the end of the year, there were 68 Parties.

Convention on Early Notification of a Nuclear Accident (reproduced in INFCIRC/335). Entered into force on 27 October 1986. In 2000, two States adhered to the Convention. By the end of the year, there were 86 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 2000, three States adhered to the Convention. By the end of the year, there were 82 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. In 2000, one State adhered to the Protocol. By the end of the year, there were 21 Parties.

Convention on Nuclear Safety (reproduced in INFCIRC/449). Entered into force on 24 October 1996. In 2000, one State adhered to the Convention. By the end of the year, there were 53 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 2000, ten States adhered to the Convention. By the end of the year, there were 23 Contracting States and 41 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 2000, one State adhered to the Protocol. By the end of the year, there were 3 Contracting States and 14 Signatories.

Convention on Supplementary Compensation for Nuclear Damage (reproduced in INFCIRC/567). Opened for signature on 29 September 1997. In 2000, one State adhered to the Convention. By the end of the year, there were 3 Contracting States and 13 Signatories.

African Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (AFRA) (Second Extension) (reproduced in INFCIRC/377). Entered into force on 4 April 2000. By the end of 2000, there were 20 Parties.

Second Agreement to Extend the 1987 Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology (RCA) (reproduced in INFCIRC/167/Add. 18). Entered into force on 12 June 1997. Its status remained unchanged during 2000, with 17 Parties.

Revised Supplementary Agreement Concerning the Provision of Technical Assistance by the IAEA (RSA). In 2000, three States concluded the Agreement. By the end of the year, there were 92 States that concluded RSA Agreements.

Co-operation Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean (ARCAL) (reproduced in INFCIRC/582). Opened for signature on 25 September 1998. In 2000, one State adhered to the Agreement. By the end of the year, there were 1 Contracting State and 14 Signatories.

TABLE A22. **CO-ORDINATED RESEARCH PROJECTS — NEW OR COMPLETED IN 2000**

A full list of all current CRPs is available on the Agency's WorldAtom Web site.
A printed copy is available, on request, from the Agency's Division of Public Information.

Nuclear Power

Conservation and application of high temperature gas cooled reactor technology: 2000–2005
Information management solutions for systematic approach to training (SAT) applications: 2000–2003
Intercomparison of analysis methods for seismically isolated nuclear structures: 1996–2000
Mechanism of nickel effect in radiation embrittlement of reactor pressure vessel materials: 2000–2003
Nuclear power plant outage coding systems: 1999–2000
Potential of thorium based fuel cycles to constrain plutonium and to reduce long term waste toxicities: 1995–2000
Surveillance programme results application to reactor pressure vessel integrity assessment: 2000–2003
Use of a thorium based fuel cycle in accelerator driven systems to incinerate plutonium and to reduce long term waste toxicities: 1996–2000

Nuclear Fuel Cycle and Waste Technology

Corrosion of research reactor aluminium clad spent fuel in water: 1995–2000
Evaluation of the safety, environmental and non-proliferation aspects of the partitioning and transmutation of actinides and fission products: 1996–2000
Technological development and practice in on-line monitoring of water chemistry related to fuel behaviour and activity transport: 1995–2000
Technologies and methods for long term stabilization and isolation of uranium mill tailings: 2000–2004

Comparative Assessment of Energy Sources

Case studies to assess and compare different energy sources in sustainable energy and electricity supply strategies: 1996–2000

Food and Agriculture

Development of improved attractants and their integration into fruit fly sterile insect technique management programmes: 2000–2005
Improvement of tropical and subtropical fruit trees through induced mutations and biotechnology: 2000–2005
Quality control of pesticide products: 2000–2005
Rinderpest seromonitoring and surveillance in Africa using immunoassay technologies: 1997–2000
Use of isotope techniques in studies on the management of organic matter and nutrient turnover for increased, sustainable agricultural production and environmental preservation: 1995–2000

Human Health

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
Bone single photon emission computer tomography in the management of patients with unexplained back pain: 1997–2000
Comparative evaluation of ictal brain single photon emission computer tomography, magnetic resonance imaging and X ray computerized tomography of the brain in the management of patients with refractory seizures: 2000–2003
Comparison of international studies of osteoporosis using isotope techniques: 1994–2000
Development of a quality assurance programme for radiation therapy dosimetry in developing countries: 1995–2000
Development of techniques at SSDLs for the dissemination of absorbed dose to water standards: 2000–2003
Dosimetry in X ray diagnostic radiology: An international Code of Practice: 2000–2005
Electron paramagnetic resonance biodosimetry: 1998–2000
Evaluation of technetium-99m based radiopharmaceuticals in the diagnosis and management of breast cancer patients: 1997–2000

TABLE A22. **(cont.)**

Genotype/phenotype correlation in thalassemia and muscular dystrophy: 1998–2000
In vivo imaging for infection and inflammation: 1997–2000
Intravascular radionuclide therapy using beta emitting radiopharmaceuticals for the prevention of re-stenosis following percutaneous transluminal coronary angioplasty: 2000–2004
Local production and evaluation of primary reagents for the radioimmunoassay of alpha feto protein: 1997–2000
Management of liver cancer using radionuclide methods with special emphasis on trans-arterial radioconjugate therapy and internal dosimetry: 2000–2005
Molecular typing of mycobacteria strains in the management of multi-drug resistant tuberculosis: 1997–2000
Radiochemical, chemical and physical characterization of radioactive particles in the environment: 2000–2005
Radioimmunoassay of advanced glycation end products in the long term management of diabetes mellitus: 2000–2004
Reference Asian Man Project (Phase 2): Ingestion and organ content of trace elements of importance in radiological protection (RCA): 1995–2000
Relationship between vesico-ureteral reflux, pyelonephritis and renal scarring in children with recurrent urinary tract infection using nuclear techniques: 1997–2000
Use of radiotherapy in advanced cancer: 1995–2000

Marine Environment, Water Resources and Industry

Application of isotope techniques to the assessment of aquifer systems in major urban areas: 1997–2000
Application of isotopes to the assessment of pollutant behaviour in the unsaturated zone for groundwater protection: 2000–2003
Isotope techniques for the assessment of slow moving deep ground water and their potential application for the assessment of waste disposal sites: 1997–2000
Isotopic composition of precipitation in the Mediterranean Basin in relation to air circulation patterns and climate: 2000–2004
Origins of salinity and impacts on fresh groundwater resources: Optimization of isotopic techniques: 2000–2005
Radiation synthesis of stimuli-responsive membranes, hydrogels and adsorbents for separation purposes: 2000–2004
Radiotracer technology for engineering unit operation studies and unit process optimization: 1998–2000
Sedimentation assessment studies by environmental radionuclides and their application to soil conservation measures: 1995–2000
Use of isotope techniques in investigating acidic fluids in geothermal exploitation: 1997–2000
Use of tracers and stable isotopes in surface water pollution studies: 1997–2000
Validation of protocols for corrosion and deposit evaluation in pipes by radiography: 1997–2000

Physical and Chemical Sciences

Application of MeV ion beams for development and characterization of semiconductor materials: 1997–2000
Applications and development of small angle neutron scattering: 2000–2003
Atomic and plasma–wall interaction data for fusion reactor diverter modelling: 1995–2000
Bulk hydrogen analysis using neutrons: 1997–2000
Development and application of alpha particle spectrometry: 2000–2004
Development of agents for imaging central neural system receptors based on technetium-99m: 1995–2000
Development of computer based troubleshooting tools and instruments: 1996–2000
Development of kits for radioimmunometric assay of tumour markers: 1998–2000
Development of kits for technetium-99m radiopharmaceuticals for infection imaging: 2000–2003
Elements of power plant design for inertial fusion energy: 2000–2005
In situ applications of X ray fluorescence techniques: 2000–2004
Nuclear analytical techniques in archaeological investigations: 1996–2000

TABLE A22. **(cont.)**

Optimization of synthesis and quality control procedures for the preparation of fluorine-18 and iodine-123 labelled peptides: 1997–2000
Standardized high current solid targets for cyclotron production of diagnostic and therapeutic radionuclides: 2000–2003
Use of ion beam techniques for the analysis of light elements in thin films, including depth profiling: 2000–2003
Validation of nuclear techniques for the analysis of precious and rare metals in mineral concentrates: 1997–2000

Nuclear Safety

Investigation of methodologies for incident analysis: 1997–2000

Radiation Safety

Investigation of appropriate methods and procedures to apply probabilistic safety assessment techniques of large radiation sources: 2000–2003
Limitations of radioepidemiological assessments for stochastic radiation effects in relation to radiation protection: 1994–2000

Radioactive Waste Safety

Formulation of approaches to compare the potential impacts of wastes from electricity generation technologies: 1997–2000
Improvement of safety assessment methodologies for near surface disposal facilities for radioactive waste: 1997–2000
Use of selected safety indicators (concentrations, fluxes) in the assessment of radioactive waste disposal: 2000–2005

TABLE A23. **TRAINING COURSES, SEMINARS AND WORKSHOPS IN 2000**

Nuclear Power

Courses

Interregional course on management for excellence in nuclear power plant performance — France
Interregional course on qualification of nuclear power plant personnel and the role of management — Germany; Republic of Korea
Regional course on modernization of instrumentation and control in nuclear power plants — Germany
Regional course on nuclear power project management — Republic of Korea
Regional course on strengthening nuclear power project management — Spain

Workshops

IAEA–FORATOM workshop on integrated management systems of nuclear installations — Slovenia
Regional workshop on evaluation of non-destructive testing results for remaining lifetime assessment — Czech Republic
Regional workshop on good practices in national approaches to nuclear power plant life management — Slovenia
Regional workshop on impact of privatization and market deregulation on nuclear power plant operation — Hungary
Regional workshop on in-service inspection effectiveness improvement through inspection qualification — Bulgaria
Regional workshop on internal and external inspection of the reactor pressure vessel — Croatia
Regional workshop on managing the early termination of nuclear power plant operations — Germany
Regional workshop on modern approaches in computer based control system design in nuclear power plant — China
Regional workshop on on-line testing of nuclear power plant temperature and pressure instrumentation and other critical plant equipment — Mexico
Regional workshop on operational and safety issues of nuclear power plants — Republic of Korea
Regional workshop on steam generator tube integrity — Russian Federation
Workshop on nuclear reaction data and nuclear reactors: Physics, design and safety — Abdus Salam International Centre for Theoretical Physics, Trieste

Seminars

National seminar on nuclear power project management — China
Seminar on accelerator driven systems and transmutation of nuclear waste: Options and trends — Abdus Salam International Centre for Theoretical Physics, Trieste

Nuclear Fuel Cycle and Waste Technology

Courses

Interregional course on decommissioning of research reactors and other small nuclear installations — USA

Comparative Assessment of Energy Sources

Courses

Regional course on case studies to assess nuclear power as a Clean Development Mechanism under the Kyoto Protocol — Republic of Korea
Regional course on the use of the Agency's methodologies and tools to analyse priority environmental issues — Indonesia
Role of nuclear energy and other energy options in greenhouse gas mitigation — Austria

Seminar

National co-ordinators' seminar to exchange experiences of comparative assessment of electricity options — Republic of Korea

Food and Agriculture

Courses

Course on differential diagnosis of the Old World Screwworm and other myiosis fly larvae — United Kingdom

TABLE A23. **(cont.)**

Course on food irradiation process control — USA
FAO/IAEA course on implementation of quality assurance/quality control measures in residue analysis laboratories — Austria
FAO/IAEA regional course on the Old World Screwworm — Islamic Republic of Iran
FAO/IAEA regional course on the sterile insect technique as a component for integrated area wide tsetse and trypanosomosis management — United Republic of Tanzania
Regional Asia course on new frontiers of developing and handling mutants — China
WHO/IAEA course on African trypanosomoses — France

Workshops
AFRA workshop on adoption of appropriate selection techniques for the development of drought tolerant germplasm — Nigeria
AFRA workshop on production of standards and internal quality control (IQC) materials for self-coating radioimmunoassay of progesterone — Mauritius
AFRA/ARCAL/RCA workshop on the development of an international protocol on irradiation as a quarantine treatment for food and agricultural commodities — Morocco
CLAM/FAO/IAEA workshop on peach fruit fly (*Bactocera zonata*) — Spain
FAO regional workshop on screwworm strategies in the Caribbean — Panama
FAO/IAEA regional workshop on in vitro mutagenesis, tissue culture and molecular markers — Thailand
FAO/IAEA regional workshop on public information on the use of irradiation as sanitary and phytosanitary treatment of food — Malaysia
FAO/IAEA study tour/workshop on the red palm weevil and peach fruit fly — Egypt
FAO/IAEA workshop on certification of irradiation as a sanitary and phytosanitary treatment for food and agricultural commodities — Australia
FAO/IAEA workshop on developing standardized training material to assist Member States to establish quality systems for veterinary diagnostic laboratories — Austria
FAO/IAEA workshop on genetic sexing and population genetics of the screwworm — Austria
FAO/IAEA workshop on improvement of the sterile insect technique for the codling moth to facilitate expansion of field application — Austria
FAO/IAEA workshop on improving and harmonizing rinderpest diagnosis and surveillance — Mali
FAO/IAEA workshop on in vitro protocols and mutant selection using Bayoud toxin — Morocco
FAO/IAEA workshop on the development of cost effective diets for the mass production of tsetse flies — Austria
FAO/IAEA workshop on the development of quality assurance for mycotoxin analysis of food and feed for Eastern European countries — Austria
FAO/IAEA workshop on the supply of sterile flies for medfly sterile insect technique in the Mediterranean Basin — Austria
FAO/IAEA/AFRA workshop on the industrial and public acceptance of food irradiation — Ghana
FAO/IAEA/UCR workshop on in vitro culture techniques for the improvement of vegetatively propagated tropical food crops — Costa Rica
RCA workshop on production of iodinated tracer for self-coating radioimmunoassay of progesterone — Thailand
Regional Asia workshop on food irradiation — China
Regional West Asia workshop on phosphorus fertilizers in fertigation — Austria
Regional West Asia workshop on the use of low quality irrigation water in fertigation — Lebanon
Workshop on trade opportunities for irradiated food — USA

Human Health

Courses
Course on basic clinical radiobiology (IAEA–ESTRO) — Slovakia
Course on clinical research in radiation oncology (IAEA–ESTRO) — United Kingdom
Course on evidence based radiation oncology — Singapore
Course on evidence based radiation oncology principles and methods (IAEA–ESTRO) — Spain
Course on imaging for target volume determination in radiotherapy (IAEA–ESTRO) — Italy
Course on physics for clinical radiotherapy (IAEA–ESTRO) — Belgium

TABLE A23. **(cont.)**

Course on radiotherapy treatment planning: Modern brachytherapy techniques (IAEA–ESTRO) — Italy
Course on radiotherapy treatment planning: Principles and practices (IAEA–ESTRO) —Netherlands
Group activity on in vivo bioavailability measurements of trace elements — China
Interregional course on molecular biology techniques and radionuclide tracers in the control of infectious diseases — Thailand
Project co-ordinators' meeting on quality assurance in the radiation sterilization of tissue grafts — Indonesia
Regional course on application of radionuclide methods in the management of infection and inflammation — Algeria
Regional course on applications of the manual of rules and procedures in nuclear nephro-urology — Cuba
Regional course on cardiac brain single photon emission computer tomography — Cuba
Regional course on cardiac single photon emission computer tomography and scintimammography techniques for nuclear medicine technologists — Bangladesh
Regional course on cell irradiation in clinical nuclear medicine practice — France
Regional course on interventional nuclear medicine — Bulgaria
Regional course on laboratory automation for radioimmunoassay — Syrian Arab Republic
Regional course on myocardial perfusion scintigraphy using single photon emission computer tomography — India
Regional course on paediatric nuclear medicine — South Africa
Regional course on physical aspects of quality assurance in radiotherapy — Australia
Regional course on production of basic reagents for radioimmunoassay of tumour markers — Tunisia
Regional course on proton emission tomography in clinical practice — China
Regional course on quality assurance in single photon emission computer tomography system imaging — Saudi Arabia
Regional course on radioimmunoassay of free prostatic specific antigen and human chorionic gonadotrophin — Jordan
Regional course on radionuclide techniques in the management of diabetes — Philippines
Regional course on radiotherapeutic management of paediatric tumours — Egypt
Regional course on servicing medical linear accelerators — Jordan
Regional course on the effective use of AMRA equipment — Morocco
Regional course on the physical aspects of quality assurance in radiotherapy — Syrian Arab Republic
Regional course on the physical aspects of quality assurance in radiotherapy — Australia

Workshops
International workshop on BioMAP — Portugal
National workshop on overview of the UNDP/RCA/IAEA subproject on air pollution and its trends: Neutron activation analysis and air pollution studies using nuclear analytical techniques in Slovenia — Philippines
Regional workshop on advanced single photon emission computer tomography technologies — Brazil
Regional workshop on effective use of PIP software — United Arab Emirates
Regional workshop on isotopic technique applications in human nutrition with emphasis on micronutrient intervention programmes — China
Regional workshop on quality control of single photon emission computer tomography systems — Algeria
Regional workshop on radionuclide treatment of liver cancer — Singapore
Regional workshop on scintimammography and application of surgical gamma probes in the management of breast cancer — Indonesia
Research workshop on monitoring of natural and human-made radionuclides and heavy metal waste in environment — Russian Federation
Workshop on maintenance and quality control of radiotherapy cobalt-60 machines — Kenya
Workshop on micronutrients and health: Molecular biological mechanisms — Malaysia
Workshop on standardization of dose measurements at calibration facilities — Algeria
Workshop on the use of stable isotopes for evaluating nutrition intervention programmes in Latin America — Argentina

Seminars
Seminar on calibration procedures and traceability of radiation measurements in the Baltic States — Lithuania
Seminar on analytical techniques in monitoring the environment — India

TABLE A23. **(cont.)**

Marine Environment, Water Resources and Industry

Courses

Advanced regional course on site specific numerical flow and transport modelling for water resources — Thailand
Course on chlorinated pesticides and PCBs — IAEA-MEL, Monaco
Course on determination of trace elements in marine environmental samples — Morocco
Course on determination of trace metals in marine samples — IAEA-MEL, Monaco
Course on petroleum hydrocarbons and chlorinated pesticides in environmental samples — Ukraine
Regional course on application of tracers to study transport processes and sedimentation rates in the marine environment — Thailand
Regional course on geochemical modelling for water resources management — Philippines
Regional course on isotopes and geochemical modelling for groundwater resources management — Zimbabwe
Regional executive course for water resources managers on breakthroughs in isotope applications in water resources management in Asia and the Pacific — Republic of Korea

Workshops

Assessment workshop for project RAS/8/084 — Philippines
Workshop on in situ marine radioactivity monitoring — Ireland
Workshop on isotopes in climate and GNIP Scientific Steering Committee — Germany

Physical and Chemical Sciences

Courses

Group fellowship training in the maintenance of nuclear spectroscopy instruments — Agency's Laboratories, Seibersdorf
Group fellowship training in the methodology and applications of the X ray fluorescence technique — Agency's Laboratories, Seibersdorf
National course on accelerators — Indonesia
National course on building and repair of personal computers and local area networks — Zambia
National course on microprocessor based nuclear instruments — Myanmar; Sri Lanka
National course on power conditioning for safe and reliable operation of electronic systems — United Republic of Tanzania
Regional course and examination on surface methods testing, level 2 — Jordan
Regional course on design and application of portable nucleonic gauges — New Zealand
Regional course on fabrication of non-destructive testing test pieces — Jordan
Regional course on hospital radiopharmacy — Cyprus
Regional course on industrial digital radiography — Republic of Korea
Regional course on model level 3 examination in eddy current testing — Pakistan
Regional course on non-destructive testing in railways — South Africa
Regional course on non-destructive testing of concrete structures — Singapore
Regional course on process, quality control and safety in radiation processing — Chile
Regional course on quality control and quality assurance in radiochemistry and nuclear related analysis — Egypt
Regional course on radiation processing of natural polysaccharides — Viet Nam
Regional course on radiation sterilization for medical and pharmaceutical applications — Tunisia
Regional course on radiographic testing, level 3 — Syrian Arab Republic
Regional course on radiotracer and sealed source techniques and applications in industry and environment — South Africa
Regional course on radiotracers in mineral ore processing — Indonesia
Regional course on standard software for tracer applications and nucleonic gauge design and calibration — Viet Nam
Regional course on tracers in oil fields — Argentina
Regional course on ultrasonic testing, level 3 — Islamic Republic of Iran
National course on repair and maintenance of microprocessor and microcontroller based instruments — Sudan

TABLE A23. **(cont.)**

National course on research and development for advanced technology — Indonesia
National course on thermoluminescent detector readers — El Salvador
National course on X ray equipment — Bolivia; Ecuador; El Salvador
Regional course on digital signal processing — Cuba
Regional course on liquid scintillation counters — Malaysia
Regional course on maintenance, troubleshooting and repair of instruments constructed with surface mount devices — Morocco
Regional course on troubleshooting of nuclear instruments based on advanced technology — Malaysia

Workshops
Regional expert workshop on quality assurance and cobalt-60 brachytherapy source production — China
Regional management workshop to review the good manufacturing practices guidebook and project self-assessment — Republic of Korea
Regional workshop on detectors — Mexico
Regional workshop on digital electronics — Brazil
Regional workshop on electron treatment of paper pulp for the viscose rayon industry — India
Regional workshop on gamma cameras — Venezuela
Regional workshop on good manufacturing practices in clean area operations for the production of technetium-99m kits and radiopharmaceuticals — Indonesia
Regional workshop on instrumentation for nuclear medicine — Peru
Regional workshop on maintenance and repair of electrometers and chambers — Brazil
Regional workshop on nucleonic gauge design, calibration and applications — Brazil
Regional workshop on quality assurance in biological control of technetium-99m kits and technetium-99m radiopharmaceuticals — Malaysia
Regional workshop on quality assurance of technetium-99m kits and ingredients — Thailand
Regional workshop on radiation processing of agro-wastes — Malaysia
Regional workshop on radiotracers for efficiency testing of wastewater treatment plants — Republic of Korea
Regional workshop on the application of gamma scanning and neutron gauge techniques in petrochemical industry — Venezuela
Second regional workshop on quality assurance/quality control of nuclear analytical techniques — Latvia
Second regional workshop on radiation treatment of industrial wastewater — Czech Republic
Task force workshop in non-destructive testing in industry — South Africa
Workshop on nuclear reaction data and nuclear reactors: Physics, design and safety — Italy

Nuclear Safety

Courses
Course on management for excellence in nuclear power plant performance — France
Interregional course on advances in monitoring, assessment and enhancement of operational safety of nuclear power plants — USA
Interregional course on regulatory aspects and safety documentation of research reactors — USA
Interregional course on the safety of spent fuel storage — USA
National basic professional course on nuclear safety — Romania
Regional basic professional training course on nuclear safety — Brazil
Regional course on nuclear fuel/ core management — Republic of Korea
Regional course on nuclear power plant siting — Indonesia
Regional course on nuclear safety information for decision makers —Malaysia
Regional course on operational safety of nuclear power plants including management — Germany
Regional course on operational safety of research reactors — Japan
Regional course on prerequisites of institutional requirements for deployment of nuclear power — Headquarters
Regional course on regulatory control of nuclear power plants — Germany
Regional course on risk based inspection: theory and applications — Lithuania
Regional course on safety assessment of nuclear power plants to assist in decision making — Finland
Regional course on safety in the operation and utilization of research reactors — Indonesia

TABLE A23. **(cont.)**

Regional course on the use of system computer codes for accident analysis — Croatia
Regional course on ultrasonic testing for detection, characterization and repair of intergranular stress corrosion cracking, flaw sizing and weld overlay examination — Russian Federation

Workshops
Regional workshop on configuration management and managing safety during planned outages —Republic of Korea
Regional workshop on operational and safety issues for nuclear power plants with special focus on management of operational safety — Republic of Korea
Workshop on design, evaluation and licensing of nuclear power plant modifications — Slovenia
Workshop on development and validation of emergency operating procedures — Czech Republic
Workshop on emergency action levels for nuclear power plants — China
Workshop on fire protection in nuclear power plants — China
Workshop on integrated regulatory enforcement and inspection — Indonesia
Workshop on management of safety and safety culture — Slovenia
Workshop on modelling of external hazards in probabilistic safety analysis — Bulgaria
Workshop on nuclear safety analysis of research reactors — Viet Nam
Workshop on nuclear safety and risk assessment — Indonesia
Workshop on operating experience feedback on human factors — Bulgaria
Workshop on operational safety monitoring and assessment — Slovenia
Workshop on operational safety performance indicators — China
Workshop on operational safety standards implementation and best practices — Headquarters
Workshop on periodic safety review — China
Workshop on periodic safety reviews and ageing — Czech Republic
Workshop on probabilistic approach to regulatory decision making — Belgium
Workshop on probabilistic safety assessment applications — China
Workshop on regulatory experience with nuclear power plant commissioning — Headquarters
Workshop on regulatory information for the public and media — Slovenia
Workshop on regulatory requirements and practices for ageing management — Slovakia
Workshop on research reactor safety assessment, standards and conduct of inspection — Headquarters
Workshop on safety assessment and regulatory control for research reactors — Viet Nam
Workshop on safety culture and research reactors — Hungary
Workshop on severe accident policy and safety goals — China
Workshop on strengthening nuclear power plant management — China
Workshop on the characterization, management and storage of spent fuel — Poland
Workshop on the decommissioning process: regulatory, technical and management aspects — Slovenia
Workshop on the role of risk monitors in operational safety — Czech Republic

Radiation Safety

Courses
Group training on assessment of legislative and regulatory infrastructure — Czech Republic
Group training on radiation and waste safety in the oil and gas industry — Syrian Arab Republic
Group training on radiation protection, waste management and quality assurance in nuclear medicine — Sweden
Group training on radiation safety in industrial irradiators — Canada
Joint IAEA/WCO/ICP–INTERPOL awareness course on combating the illicit trafficking of nuclear and other radioactive material — Austria
National course on combating illicit trafficking of nuclear and other radioactive materials — Belarus; Ukraine
National course on dosimetry in radiotherapy — Lithuania
National course on radiation protection for radiation protection officers — Costa Rica
National course on radiation protection in diagnostic radiology — The Former Yugoslav Republic of Macedonia
National course on radiation protection in diagnostic radiology and nuclear medicine — Estonia
National course on radiation protection in industrial radiography — Republic of Moldova

TABLE A23. **(cont.)**

National course on radiation protection in medical facilities — Georgia
National course on radiation protection in medical practices — Albania; Armenia; Latvia; Republic of Moldova
National course on thermoluminescent dosimetry system service and maintenance — Finland
Post-graduate group training on radiation protection and safety of radiation sources — Malaysia
Professional training pilot course on radiation protection — Belarus
Radiation protection in medical exposure — Singapore
Regional course for inspectors on the application of the guides for a system for an initial response to radiological events — Brazil
Regional course on calibration of dosimeters and survey instruments for radiation protection — Latvia
Regional course on medical response in radiological accidents — Argentina
Regional course on planning, organization and implementation of a regulatory programme for radiation protection — South Africa
Regional course on radiation protection in diagnostic and interventional radiology — Panama
Regional course on regulatory control of radiation sources — Slovakia
Regional course on response and preparedness for radiological emergencies — Cuba
Regional course on safe transport of radioactive material — Argentina; Australia; Belarus
Regional post-graduate diploma course on radiation protection — Syrian Arab Republic
Regional post-graduate educational course on radiation protection and nuclear safety — Argentina
Regional post-graduate educational course on radiation protection and safety of radiation sources — South Africa
Regional train the trainers course for instructor trainees: Medical education for nuclear accident preparedness — Ukraine

Workshops
National workshop on licensing and inspection — Uzbekistan
National workshop on radiation and waste safety in industrial practices — Bangladesh
National workshop on radiation protection and quality assurance in radiotherapy — Bangladesh
National workshop on radiation protection for radiologists and radiographers — Albania
National workshop on radiation protection in radiodiagnostics — Sri Lanka
Regional workshop on calibration of personal dosimeters and survey instruments for radiation protection — Japan
Regional workshop on developing radiation safety capabilities for response to nuclear accidents or radiological emergencies and a legal framework covering emergency preparedness and response and civil liability for nuclear damage — Brazil
Regional workshop on radiation protection and safety in radiotherapy — Philippines
Regional workshop on radiation protection in diagnostic and interventional radiology — France
Regional workshop on safety of radiation sources and materials — Viet Nam
Regional workshop on standardization of dose measurements at calibration — Algeria
Regional workshop on the Regulatory Authority Information System (RAIS) — South Africa
Workshop on practical response to a radiological emergency — Slovenia
Workshop on practices and optimization during maintenance outages — China
Workshop on public information procedures for nuclear emergencies — Viet Nam

Radioactive Waste Safety

Courses
Regional course on discharge control and environmental monitoring of radioactive material associated with medical and industrial practices — Chile
Regional course on discharge control and environmental monitoring under the Model Project on upgrading radiation and waste safety infrastructure in Europe — Estonia
Regional course on effluent monitoring and environment assessment — Japan
Regional course on safety assessment methodologies for near surface disposal facilities — Spain

Workshops
Regional workshop on radiation protection principles applied to waste management — Republic of Korea
Regional workshop on safety assessment methodologies for near surface disposal — Hungary

TABLE A24. **MAJOR PUBLICATIONS ISSUED IN 2000**

Only a selection of the Agency's scientific publications issued in 2000 is presented here.
A full list of all publications is available on the Agency's WorldAtom Web site.
A printed copy is available, on request, from the Agency's Division of Public Information.

Nuclear Power

Economic evaluation of bids for nuclear power plants — Technical Reports Series No. 396
Nuclear power reactors in the world ¯ Reference Data Series No. 2
Quality assurance for software important to safety — Technical Reports Series No. 397

Nuclear Fuel Cycle and Waste Technology

MOX fuel cycle technologies for medium and long term deployment — C&S Papers Series CSP-3/P
Uranium 1999: Resources, production and demand (jointly with OECD/NEA)
Waste management database profiles, No. 3 (CD-ROM)
Waste management research abstracts, Vol. 25 (CD-ROM)

Comparative Assessment of Energy Sources

Energy, electricity and nuclear power estimates for the period up to 2020 (2000 edition) — Reference Data Series No.1

Physical and Chemical Sciences

Bulletin on atomic and molecular data for fusion, Nos 58 and 59
CINDA 1999 (1988–1999): Index to literature and computer files on microscopic neutron data — Special publication
CINDA 2000 (1998–2000): Index to literature and computer files on microscopic neutron data — Special publication
Nuclear Fusion
Nuclear Fusion — Yokohama special issue 3
Research reactors of the world — Reference Data Series No. 3

Nuclear Safety

Fire safety in the operation of nuclear power plants — Safety Standards Series NS-G-2.1
Legal and governmental infrastructure for nuclear, radiation, radioactive waste and transport safety — Safety Standards Series GS-R-1
Operational limits and conditions and operating procedures for nuclear power plants — Safety Standards Series NS-G-2.2
Safety of nuclear power plants: Design — Safety Standards Series NS-R-1
Safety of nuclear power plants: Operation — Safety Standards Series NS-R-2
Software for computer based systems important to safety in nuclear power plants — Safety Standards Series NS-G-1.1

Radiation Safety

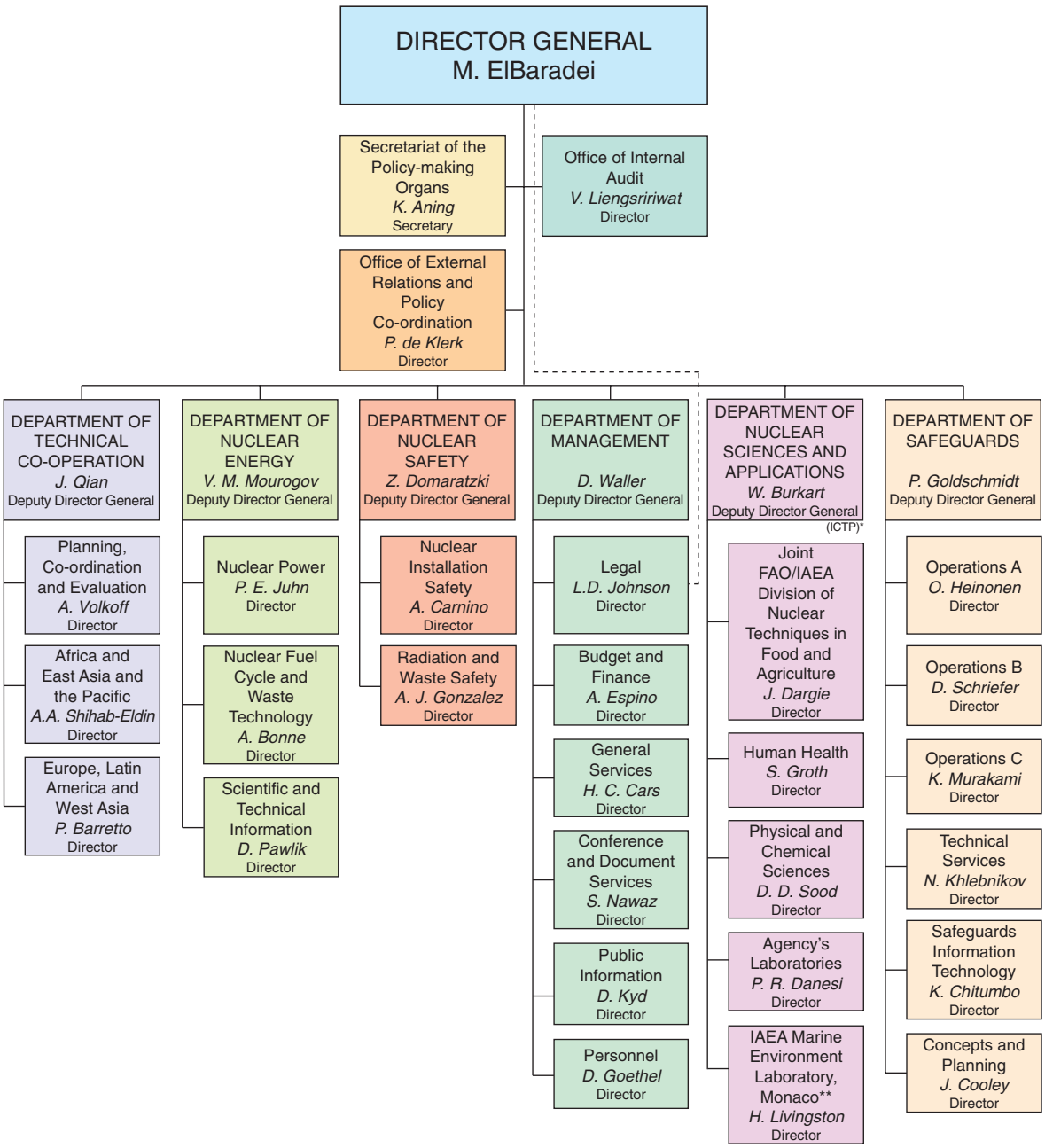
Calibration of radiation protection monitoring instruments — Safety Reports Series No. 16
Indirect methods for assessing intakes of radionuclides causing occupational exposure — Safety Reports Series No. 18
Lessons learned from accidental exposures in radiotherapy — Safety Reports Series No. 17
National competent authorities responsible for approvals and authorizations in respect of the transport of radioactive material, List No. 31. 2000 Edition — IAEA-NCAL-31
Regulations for the safe transport of radioactive material, 1996 edition (revised) — Safety Standards Series No. TS-R-1 (ST-1, Revised)
The radiological accident in Istanbul — Special Publication
The radiological accident in Lilo — Special Publication
The radiological accident in Yanango — Special Publication

TABLE A24. **(cont.)**

Radioactive Waste Safety
Predisposal management of radioactive waste, including decommissioning — Safety Standards Series No. WS-R-2
Regulatory control of radioactive discharges to the environment — Safety Standards Series No. WS-G-2.3
Safety of radioactive waste management — Proceedings Series

ORGANIZATIONAL CHART

(as of 31 December 2000)



* The Abdus Salam International Centre for Theoretical Physics (Abdus Salam ICTP), legally referred to as "International Centre for Theoretical Physics", is operated as a joint programme by UNESCO and the Agency. Administration is carried out by UNESCO on behalf of both organizations. The Agency's involvement in the Centre is managed by the Department of Nuclear Sciences and Applications.

** With the participation of UNEP and IOC.

www.iaea.org

International Atomic Energy Agency
P.O. Box 100, Wagramer Strasse 5
A-1400 Vienna, Austria
Telephone: (+43-1) 2600-0
Fax: (+43-1) 2600-7
E-Mail: Official.Mail@iaea.org

FACILITIES UNDER AGENCY SAFEGUARDS OR CONTAINING SAFEGUARDED MATERIAL ON 31 DECEMBER 2000

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Power reactors				
Argentina	Atucha NPP[b]	1	Lima	—
	Embalse NPP[b]	1	Embalse	—
Armenia	Armenia NPP[b]	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 (Angra-1)	1	Angra dos Reis	x
	Admiral Alvaro Alberto (Angra-2)	1	Angra dos Reis	—
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 GS[c]	4	Bowmanville	x
	Gentilly-2	1	Gentilly	x
	Pickering GS[c]	8	Pickering	x
	Point Lepreau GS[c]	1	Point Lepreau	x
China	Qinshan NPP[b]	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	—
	TVO I	1	Olkiluoto	—
	TVO II	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
	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

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
	KRB II Gundremmingen C	1	Gundremmingen	x
	KKS Stade	1	Stade	x
	KKU Unterweser	1	Unterweser	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-Sabotino	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
	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

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
	Sendai-1	1	Sendai-shi, Kagoshima-ken	x
	Sendai-2	1	Sendai-shi, Kagoshima-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	x
	Wolsong-1	1	Kyongju	x
	Wolsong-2	1	Kyongju	x
	Wolsong-3	1	Kyongju	x
	Wolsong-4	1	Kyongju	x
	Younggwang-1	1	Younggwang	x
	Younggwang-2	1	Younggwang	x
	Younggwang-3	1	Younggwang	x
	Younggwang-4	1	Younggwang	x
Lithuania	Ignalina NPP[b]	2	Visaginas	x
Mexico	Laguna Verde 1	1	Alto Lucero	x
	Laguna Verde 2	1	Alto Lucero	x
Netherlands	Borssele	1	Borssele	x
	Dodewaard NPP[b]	1	Dodewaard	x
Pakistan	KANUPP	1	Karachi	x
	Chasnupp-1	1	Kundian	—
Philippines	Bataan NPP[b]	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	x
	Almaraz-2	1	Almaraz	x
	Asco-1	1	Asco	x
	Asco-2	1	Asco	x
	Cofrentes	1	Cofrentes	x
	José Cabrera	1	Almonazid de Zorita	x

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
	Santa María de Garona	1	Santa María de Garona	x
	Trillo-1	1	Trillo	x
	Vandellos 1	1	Vandellos	—
	Vandellos 2	1	Vandellos	x
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[b]	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	—
	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	—
	Es Salam research reactor	1	Ain Oussera	—
Argentina	Argentine reactor-1	1	Constituyentes	x
	Argentine reactor-3	1	Ezeiza	x
	Argentine reactor-4	1	Rosario	x
	Argentine reactor-6	1	Bariloche	x
	Argentine reactor-0	1	Córdoba	x
	Argentine reactor-8	1	Pilcaniyeu	x
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	At. Energy Res. Est.	1	Dhaka	x
Belarus	Sosny	1	Minsk	—

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
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	x
	IPR-RI-CDTN	1	Belo Horizonte	x
	IPEN Critical assembly	1	São Paulo	x
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 Alberta	1	Edmonton	x
	DIF	1	Chalk River	—
Chile	La Reina	1	Santiago	x
	Lo Aguirre	1	Santiago	x
China	HTGR	1	Nankou	—
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	—
Estonia	Paldiski reactor	1	Paldiski	—
Finland	FIR 1	1	Espoo	—
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	Kiel	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

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
	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	PPNY	1	Yogyakarta	x
	RSG-GAS	1	Serpong	x
	PPTN	1	Bandung	x
Iran, Islamic	TRR	1	Tehran	x
Republic of	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 Nucl. 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
Norway	HBWR-Halden	1	Halden	x
	JEEP-II	1	Kjeller	x

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Pakistan	PARR-1	1	Rawalpindi	x
	PARR-2	1	Rawalpindi	x
Peru	RP-0	1	Lima	x
	RP-10	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
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		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				
Algeria	UDEC		Draria Nuclear Site	—
Argentina	Experimental plant		Constituyentes	—
	Fuel fabrication plant		Ezeiza	x
	Fuel fabrication plant		Constituyentes	—

State[a]	Abbreviated name of facility	Location	Subsidiary arrangements in force
Belgium	BN-MOX	Dessel	x
	FBFC	Dessel	x
	FBFC MOX	Dessel	—
Brazil	Fuel fabrication plant	Resende	x
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	x
Democratic People's Republic of Korea	Nuclear fuel fabrication plant	Nyongbyon	—
Denmark	Metallurgy	Roskilde	x
Egypt	FMPP	Inshas	—
Germany	Adv. Nuclear Fuels	Lingen	x
	Siemens MOX	Hanau	x
India	Ceramic fuel fab. assembly area	Hyderabad	x
	EFFP-NFC	Hyderabad	x
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 Colibaşi	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	Lapep	Buenos Aires	—
	Fission products div.	Ezeira	—

State[a]	Abbreviated name of facility	Location	Subsidiary arrangements in force
Brazil	Reprocessing project	São Paulo	—
Indonesia	RMI	Serpong	—
Japan	SCF	Tokai-Mura, Ibaraki-ken	x
	JAERI Tokai R&D	Tokai-Mura, Ibaraki-ken	x
	JNC Tokai R&D	Tokai-Mura, Ibaraki-ken	x
	Sumitomi Met. Mining	Tokai-Mura, Ibaraki-ken	x
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
United Kingdom	URENCO E22, E23 & A3 plant	Capenhurst	x
In addition, the following R&D facilities and locations are associated with enrichment technology:			
Brazil	UF6 laboratory	Belo Horizonte	—
Germany	Urenco	Jülich	—
Japan	Asahi Chemical Industry	Hyuga-shi, Miyazaki-ken	x
	Hitachi laboratory	Hitachi-shi, Ibaraki-ken	x
	JAERI Tokai R&D	Tokai-Mura, Ibaraki-ken	x
	NDC U-Lab.	Tokai-Mura, Ibaraki-ken	x
	JNC Tokai R&D	Tokai-Mura, Ibaraki-ken	x
	Toshiba R&D Centre	Kawasaki-shi, Kanagawa-ken	x
	CTF	Kitakami-gun, Amori-ken	x
Netherlands	Urenco	Almelo	x
Separate storage facilities			
Argentina	Central store	Ezeiza	x
	Central store	Constituyentes	x
	Nuclear material store	Constituyentes	—
Armenia	Dry Spent Fuel Storage	Metsamor	—
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
	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	—

State[a]	Abbreviated name of facility	Location	Subsidiary arrangements in force
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	x
India	AFR	Tarapur	x
Indonesia	TC and ISFSF	Serpong	—
Iraq	Tuwaitha Location C	Tuwaitha	—
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	x
	JAERI Mutsu	Mutsu-shi, Aomori-ken	x
	RSFS	Kamikita-gun, Aomori-ken	x
Kazakhstan	Ulbinski Thorium Storage	Kamenogorsk	—
Lithuania	Spent Fuel Dry Storage	Visaginas	—
Netherlands	Covra Store	Vlissingen	—
Pakistan	Hawks Bay depot	Karachi	x
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
	Z - Plant	Pelindaba	x
	E – building	Valindaba	—
	Koeberg Castor Storage Facility	Cape Town	—
Sweden	Central long term storage	Oskarshamn	—
Ukraine	Chernobyl storage	Chernobyl	—
United Kingdom	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	—

State[a]	Abbreviated name of facility	Location	Subsidiary arrangements in force
Other facilities			
Argentina	Alpha facility	Constituyentes	—
	Experimental UO_2 plant	Cordoba	—
	Enriched uranium lab.	Ezeiza	—
	Fission products div.	Ezeiza	x
	Fuel fabrication plant	Ezeiza	—
	LFR	Buenos Aires	—
	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	Fuel tech. co-ord. unit	São Paulo	x
	Isotope laboratory	São Paulo	—
	Metal. uran. project	São Paulo	—
	Nuclear material lab.	Ipero	—
	Nuclear fuel & instr. dev. lab.	São Paulo	—
	Reconversion project	São Paulo	—
	Reprocessing project	São Paulo	x
	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
Estonia	Balti ES	Narva	—
Germany	KFA-heisse Zellen	Jülich	x
	KFK-heisse Zellen	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	x
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

State[a]	Abbreviated name of facility	Location	Subsidiary arrangements in force
	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	Taejon	x
	Acrylonitrile plant	Ulsan	x
	DFDF	Taejon	x
	DUF 4	Taejon	—
	HFFL	Taejon	x
	IMEF	Taejon	x
	KAERI R&D	Taejon	—
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	x
	Hot Cell Complex	Pelindaba	x
	NU and DU metals plant	Pelindaba	x
Switzerland	EIR	Würenlingen	x
	CERN	Geneva	x
Turkey	Nuclear fuel pilot plant	Istanbul	x
Ukraine	Chernobyl unit 4 shelter	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	—
	BWXT Facility 179	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.

[b] NPP: nuclear power plant.

[c] GS: generating station.

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, two storage facilities and one R&D facility.

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CO-ORDINATED RESEARCH PROJECTS

Nuclear Power

Establishment of a thermophysical properties database for materials of LWRs and HWRs: 1999–2003
Evaluation of high temperature gas cooled reactor performance: 1998–2002
Information management solutions for systematic approach to training (SAT) applications: 2000–2003
Intercomparison of techniques for pressure tube inspection and diagnostics: 1998–2001
Mechanism of nickel effect in radiation embrittlement of reactor pressure vessel materials: 2000–2003
National approaches to correlate nuclear power plant performance targets and operation and maintenance budget: 1999–2003
Nuclear power plant outage coding systems: 1999–2000
Optimization of the coupling of nuclear reactors and desalination systems: 1998–2001
Potential of thorium based fuel cycles to constrain plutonium and to reduce long term waste toxicities: 1995–2000
Scientific basis and engineering solutions for cost effective assessments of software based instrumentation and control systems: 1999–2003
Surveillance programme results application to reactor pressure vessel integrity assessment: 2000–2003
Updated codes and methods to reduce the calculational uncertainties of liquid metal fast reactor reactivity effects: 1999–2003
Use of a thorium based fuel cycle in accelerator driven systems (ADS) to incinerate plutonium and to reduce long term waste toxicities: 1996–2000

Nuclear Fuel Cycle and Waste Technology

Ageing of materials in spent fuel storage facility: 1999–2003
Anthropogenic analogues and their use in confidence building with regard to the disposal of high level, long lived radioactive waste: 1999–2003
Chemical durability and performance assessment of spent fuel and HLW forms under simulated repository conditions: 1998–2002
Combined methods of liquid radioactive waste treatment: 1997–2001
Corrosion of research reactor aluminium clad spent fuel in water: 1995–2000
Decommissioning techniques for research reactors: 1997–2001
Evaluation of the safety, environmental and non-proliferation aspects of the partitioning and transmutation of actinides and fission products: 1996–2000
Hydrogen and hydride induced degradation of the mechanical and physical properties of zirconium based alloys: 1998–2003
Long term behaviour of low and intermediate level waste packages under repository conditions: 1997–2002
Modelling of transport of radioactive substances in primary circuit of water cooled reactors: 1996–2001
Spent fuel performance assessment and research (SPAR): 1997–2002
Technological development and practice in on-line monitoring of water chemistry related to fuel behaviour and activity transport: 1995–2000
Technologies and methods for long term stabilization and isolation of uranium mill tailings: 2000–2004
Treatment of liquid effluent from uranium mines and mills during and after operation: 1996–2001

Comparative Assessment of Energy Sources

Estimating external costs of electricity generation in developing countries using simplified approaches: 1999–2001
Impact of infrastructural requirements on the competitiveness of nuclear power: 1999–2002
Role of nuclear power and other options in meeting international goals on greenhouse gas emission reductions: 1999–2001

Food and Agriculture

A molecular and genetic approach to develop sexing strains for field application in fruit fly sterile insect technique programmes: 1994–2001
Alternative methods to gas and high performance liquid chromatography of pesticide residues in grains: 1997–2002
Assessment of soil erosion through the use of caesium-137 and related techniques as a basis for soil conservation, sustainable production and environmental protection: 1995–2001

Assessment of the effectiveness of vaccination strategies against Newcastle Disease and Gumboro Disease using immunoassay based technologies for increasing farmyard poultry production in Africa: 1998–2002
Automation in tsetse mass rearing for use in sterile insect technique programmes: 1994–2001
Cellular biology and biotechnology including mutation techniques for the creation of new useful banana genotypes: 1994–2001
Classification of soil systems on the basis of transfer factors of radionuclides from soil to reference plants: 1998–2003
Determination of profiles of human bacterial pathogens in food for export by introduction of quality assured microbiological assays: 1998–2003
Developing, validating and standardizing methodologies for the use of PCR and PCR-ELISA in the diagnosis and monitoring of control and eradication programmes for trypanosomosis: 1999–2004
Development and validation of standardized methods for using polymerase chain reaction and related molecular technologies for rapid and improved animal disease diagnosis: 1997–2001
Development of improved attractants and their integration into fruit fly sterile insect technique management programmes: 2000–2006
Development of management practices for sustainable crop production systems on tropical acid soils through the use of nuclear and related techniques: 1999–2004
Enhancement of the sterile insect technique through genetic transformation of arthropods using nuclear techniques: 1994–2002
Evaluating the use of nuclear techniques for the colonization and production of natural enemies: 1999–2004
Evaluation of methods of analysis for determining mycotoxin contamination of food and feed: 1998–2003
Genetic applications to improve the sterile insect technique for tsetse control/eradication: 1997–2003
Genetic improvement of underutilized and neglected crops in low income food deficit countries through irradiation and related techniques: 1998–2003
Improved attractants for enhancing the efficiency of tsetse fly suppression operations and barriers systems used in tsetse control/eradication campaigns: 1994–2002
Improvement of tropical and subtropical fruit trees through induced mutations and biotechnology: 2000–2005
Irradiation as a phytosanitary treatment of food and agricultural commodities: 1998–2003
Management of nutrients and water in rainfed arid and semi-arid areas for increasing crop production: 1997–2002
Molecular characterization of mutated genes controlling important traits for seed crop improvement: 1999–2004
Monitoring of contagious bovine pleuropneumonia in Africa using enzyme immunoassays: 1997–2002
Mutational analysis of root characters in annual food plants related to plant performance: 1999–2004
Quality assurance of mass produced and released fruit flies: 1999–2004
Quality control of pesticide products: 2000–2005
Use of isotope techniques in studies on the management of organic matter and nutrient turnover for increased, sustainable agricultural production and environmental preservation: 1995–2000
Use of non-structural protein of the foot and mouth disease virus to differentiate between vaccinated and infected animals: 1999–2004
Use of nuclear and colorimetric techniques for measuring microbial protein supply from local feed resources in ruminant animals: 1996–2001
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
Use of nuclear techniques for developing integrated nutrient and water management practices for agroforestry systems: 1998–2005
Validation of thin layer chromatographic screening methods for pesticide residue analysis (in vegetables): 1996–2001

Human Health

Application of nuclear techniques in the prevention of degenerative diseases (obesity and non-insulin dependent diabetes) in ageing: 1998–2002
Aspects of radiobiology applicable in clinical radiotherapy: Increase of the number of fractions per week: 1998–2005

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
Bone single photon emission computer tomography in the management of patients with unexplained back pain: 1997–2000
Clinical application of radiosensitizers in cancer radiotherapy: 1994–2001
Comparison of clinical applications software between nuclear medicine laboratories by software phantoms developed by the IAEA and COST-B2: 1999–2003
Comparative assessment of teletherapy modalities: 2001–2002
Comparative evaluation of ictal brain single photon emission computer tomography, magnetic resonance imaging and X ray computerized tomography of the brain in the management of patients with refractory seizures: 2000–2003
Comparative international studies of osteoporosis using isotope techniques: 1994–2000
Development and validation of an Internet based clinical and technical study communication system for nuclear medicine: 1998–2001
Development and validation of an Internet based clinical and technical study communication system for nuclear medicine: 1998–2001
Development of a Code of Practice for dose determination in photon, electron and proton beams based on measurement standards of absorbed dose to water: 1997–2002
Development of a quality assurance programme for radiation therapy dosimetry in developing countries: 1995–2000
Development of an improved serological kit for Chagas diagnosis using radionuclide methods: 1999–2001
Dosimetry in X ray diagnostic radiology: An international Code of Practice: 2000–2003
Electron paramagnetic resonance biodosimetry: 1998–2000
Evaluation of technetium-99m based radiopharmaceuticals in the diagnosis and management of breast cancer patients: 1997–2000
Genotype/phenotype correlation in thalassemia and muscular dystrophy: 1998–2000
Health impacts of mercury cycling in contaminated environments studied by nuclear techniques: 1999–2004
Human immunodeficiency virus markers in patients treated with radiotherapy for cervical cancer: 1999–2001
In vivo imaging for infection and inflammation: 1997–2000
Intravascular radionuclide therapy using beta emitting radiopharmaceuticals for the prevention of re-stenosis following percutaneous transluminal coronary angioplasty: 2000–2004
Isotopic evaluations in infant growth monitoring: 1999–2002
Local production and evaluation of primary reagents for the radioimmunoassay of alpha feto protein: 1997–2000
Management of liver cancer using radionuclide methods with special emphasis on trans-arterial radioconjugate therapy and internal dosimetry: 2000–2005
Molecular typing of mycobacteria strains in the management of multi-drug resistant tuberculosis: 1997–2000
Radiochemical, chemical and physical characterization of radioactive particles in the environment: 2000–2005
Radioimmunoassay of advanced glycation end products in the long term management of diabetes mellitus: 2000–2003
Randomized clinical trial of radiotherapy combined with mitomycin C in the treatment of advanced head and neck tumours: 1994–2003
Reference Asian Man Project (Phase 2): Ingestion and organ content of trace elements of importance in radiological protection (RCA): 1995–2000
Regional hyperthermia combined with radiotherapy for locally advanced cancers: 1997–2002
Relationship between recurrent lower respiratory tract infection, gastro-esophageal reflux and bronchial asthma in children: 1999–2003
Relationship between vesico-ureteral reflux, pyelonephritis and renal scarring in children with recurrent urinary tract infection: 1997–2000
Significance of viral load and virus type in hepatitis B and C for pathogenesis and treatment efficacy: 1999–2002

Use of isotopic techniques to examine the significance of infection and other insults in early childhood to diarrhoea morbidity, mal-assimilation and failure to thrive: 1999–2003
Use of radiotherapy in advanced cancer: 1995–2000
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

Application of isotope techniques to the assessment of aquifer systems in major urban areas: 1997–2000
Application of isotopes to the assessment of pollutant behaviour in the unsaturated zone for groundwater protection: 2000–2003
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