ANNUAL REPORT 2001

INTERNATIONAL ATOMIC ENERGY AGENCY

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2001

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 2001.

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MEMBER STATES OF THE INTERNATIONAL ATOMIC ENERGY AGENCY

(as of 31 December 2001)

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ARMENIA
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AUSTRIA
AZERBAIJAN
BANGLADESH
BELARUS
BELGIUM
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BOLIVIA
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CANADA
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TUNISIA
TURKEY
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UKRAINE
UNITED ARAB EMIRATES
UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND
UNITED REPUBLIC OF TANZANIA
UNITED STATES OF AMERICA
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YUGOSLAVIA, FEDERAL REPUBLIC OF
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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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THE IAEA AT A GLANCE

(as of 31 December 2001)

- **133** Member States.
- **58** intergovernmental and non-governmental organizations worldwide have formal agreements and arrangements with the Agency.
- **44** years of international service in 2001.
- **2205** professional and support staff.
- **$230 million** regular budget for 2001, supplemented by extrabudgetary contributions amounting to **$27.7 million**.
- **$73 million** target in 2001 for voluntary contributions to the Agency's Technical Co-operation Fund, supporting projects involving **3422** expert and lecturer assignments, **3005** meeting and workshop participants, **2260** participants in training courses, and **1516** fellows and visiting scientists.
- **3** international laboratories and research centres.
- **2** liaison offices (in New York and Geneva) and **2** safeguards regional offices (in Tokyo and Toronto).
- **120** approved Co-ordinated Research Projects involving **1590** active research contracts and agreements.
- **225** safeguards agreements in force in 141 Member States (and with Taiwan, China) involving **2487** safeguards inspections performed in 2001. Safeguards costs in 2001 amounted to **$70 million** in regular budget and **$15.2 million** in extrabudgetary resources.
- **15** national safeguards support programmes and **1** multinational support programme (European Union).
- **500 000 plus** monthly visits to the Agency's *WorldAtom* web site.
- **2 million plus** records in the International Nuclear Information System (INIS), the Agency's largest database.
- **182** publications issued (in print and electronic form) in 2001.

NOTE

- The *Annual Report* reviews the results of the Agency's programme according to the three "pillars" of technology, safety and verification — and also management — as presented in the *Medium Term Strategy*. The introductory chapter, "The Year in Review: Major Issues and Challenges", in particular, seeks to provide a thematic analysis, based on the three pillars, of the Agency's activities in 2001 within the overall context of notable developments during the year in the 'nuclear world'.

- Tables that were previously included in the Annex on the:

  — Situation on 31 December 2001 with respect to the conclusion of safeguards agreements between the Agency and States party to the Treaty of Tlatelolco.

  — 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 2001.

  — Facilities under Agency safeguards or containing safeguarded material on 31 December 2001.

  — Main equipment and activities in support of safeguards.

  are now available on the Agency's *WorldAtom* web site (*http://www.iaea.org/worldatom/Documents/Anrep/Anrep2001/*).

- 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 NPT.

ABBREVIATIONS

ABACC	Brazilian–Argentine Agency for Accounting and Control of Nuclear Materials
AFRA	African Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology
ARCAL	Co-operation Agreement for the Promotion of Nuclear Science and Technology in Latin America and the Caribbean
BWR	Boiling water reactor
CRP	Co-ordinated Research Project
CTBTO	Comprehensive Nuclear-Test-Ban Treaty Organization
ESTRO	European Society for Therapeutic Radiology and Oncology
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	OECD Nuclear Energy Agency
OCHA	United Nations Office for the Coordination of Humanitarian Affairs
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
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
UNOPS	United Nations Office for Project Services.
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
WCO	World Customs Organization
WEC	World Energy Council
WHO	World Health Organization
WMO	World Meteorological Organization
WTO	World Trade Organization
WWER	Water cooled and moderated energy reactor (former USSR)

CONTENTS

Annex

THE YEAR IN REVIEW: MAJOR ISSUES AND CHALLENGES

The International Atomic Energy Agency continued to play an important role in 2001 under the three pillars of its mandate — *technology, safety* and *verification.* In particular, it served as a catalyst for sustainable development through the transfer of nuclear science and technology, as a key contributor to global nuclear safety and as a cornerstone for nuclear non-proliferation. The Agency's programme of activities focused on: bringing about the development and transfer of peaceful nuclear technologies; building and maintaining a global nuclear safety regime; and guarding against the proliferation of nuclear weapons and strengthening the security of nuclear material and facilities.

This chapter presents the state of the 'nuclear world' in 2001 from the perspective of the Agency, along with a summary of its major activities and achievements.

TECHNOLOGY

Sustainable development

During 2001, as before, a range of different views on nuclear power was expressed. In April, at the ninth session of the Commission on Sustainable Development (CSD-9), Parties agreed to disagree on nuclear energy's role in sustainable development. The final text noted that some countries see nuclear energy as a substantial contributor to sustainable development, while others consider the two to be fundamentally inconsistent. However, the parties did reach unanimous agreement that "the choice of nuclear energy rests with countries".

The Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) reached agreement in November on implementation rules (referred to as the "Marrakesh Accords") for the 1997 Kyoto Protocol to limit greenhouse gas (GHG) emissions. For nuclear energy this is an important step towards attaching a tangible economic value to nuclear power's avoidance of GHG emissions, even though the Marrakesh Accords exclude nuclear projects from two of the three flexible mechanisms in the Kyoto Protocol that provide credits for GHG avoidance by States: the clean development mechanism and joint implementation (the third mechanism is emissions trading).

As the expert body on nuclear science and technology within the UN family, the Agency has been active as an information resource in the continuing CSD and UNFCCC processes. For example, the Agency contributed to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), which concluded, among other things, that nuclear power plants have the highest potential for GHG mitigation in the energy sector. The Agency has also been participating in the preparatory process for the August 2002 World Summit on Sustainable Development (WSSD) in Johannesburg. Nuclear science and technologies have had much to contribute to progress on *Agenda 21* — negotiated at the 1992 UN Conference on Environment and Development (the Rio "Earth Summit") — in such areas as agriculture, food safety, public health, industrial techniques, electricity generation and water resources development and management (Box 1).

Nuclear power around the world

Nuclear power continues to be an important part of the energy mix in many countries. At the end of 2001 there were 438 nuclear power plants in operation, corresponding to a total capacity of 353 GW(e), more than 10 000 reactor-years of cumulative operating experience and about 16% of

global electricity generation. Two new plants came on line during the year. While nuclear power is being generated primarily in a broad range of industrialized countries, 31 of 32 new plants under construction are in Asia or in Central and Eastern Europe.

For existing nuclear power plants, the most significant recent trend is a steady increase in availability factors through improvements in operational practices, engineering support, strategic management, fuel supply and spent fuel disposition. These have reduced generating costs and improved safety. Their cumulative impact is substantial — during the 1990s, availability increased by an amount equivalent to building 28 new nuclear power plants of 1000 MW(e) each. Among countries for which 2001 operating data are available, Argentina, Brazil, the Czech Republic, Germany, India, the Republic of Korea, Spain, the Russian Federation, Switzerland, Ukraine and the USA all increased their production of nuclear electricity to record levels.

For new plants, the outlook is mixed. New nuclear power plants are more attractive in countries experiencing a rapid growth in energy demand, or where indigenous energy resources are scarce, energy supply security is a priority or nuclear power is seen as an important way to reduce air pollution and GHG emissions. In Western Europe and North America, the two regions with the largest number of operating nuclear power plants, there were no firm plans for new construction through the end of 2001. However, in January 2002, the Government of Finland made a favourable decision "in principle" on a utility application to build a fifth nuclear power plant. In addition, the new US "Energy Policy", released in May 2001, recommended government support for "the expansion of nuclear energy in the United States as a major component of…national energy policy". During the year, Belgium and Germany took legislative actions to phase out nuclear power at the end of the lifetimes of their currently operating reactors.

Given low fuel costs and improved capacity factors, a well run, amortized nuclear power plant is often the least cost electricity generation option. There is thus growing interest in extending the lifetime of existing plants. By the end of 2001, six electricity plants in the USA had been granted extensions,

BOX 1. ISOTOPES — INDISPENSABLE TOOLS FOR STUDYING CLIMATE CHANGE

While it is widely accepted that recent global warming is largely a product of enhanced GHG concentrations in the atmosphere, great uncertainty remains regarding the relationships between specific parameters and climate phenomena, and regarding the impacts of climate change on the Earth's water cycle. The changes observed in the last few decades appear to be unprecedented compared with the history of changes in the Earth's climate. Understanding the causes of past climate changes is, therefore, an important part of climate change research. Isotopes are one of the most important tools to assist researchers in gaining insights into past climate changes, primarily by measuring changes in the distribution of oxygen and hydrogen isotopes in groundwater and sediments over time.

An international conference on 'The Study of Environmental Change using Isotope Techniques' was organized by the Agency in Vienna in April 2001. The conference reviewed the latest isotope techniques and their applications in global climate change research. Future research directions in the assessment of: the impacts of deforestation on water balance in the Amazon Basin; understanding of past climate variability and changes through continental and polar ice core records; characterization and understanding of the movement, mixing and residence times of oceanic water masses; and past climate changes recorded in groundwater in aquifers in Europe, Asia, Australia, Africa and the Americas were discussed. The conference recommended the establishment of a global network of isotope monitoring of large rivers along the lines of the Agency's global network for isotopes in precipitation. ■

increasing the licensed lifetime of each to 60 years. The owners of an additional 40% of operating US plants have indicated their intention of seeking license extensions — the US Nuclear Regulatory Commission expects this figure to eventually reach 85% or higher. In addition, the Ministry for Atomic Energy of the Russian Federation decided to extend the lifetimes of the Novovoronezh-3 and 4 plants by 15 years.

For nuclear power, innovation will be a key factor in closing the gap between near term scenarios that project only modest expansion (or even a decline) and most long term scenarios, which project a substantial expansion. The principal objectives of innovative concepts are low capital costs, short construction and start-up times, a very high level of safety, and proliferation resistance. Several small to medium sized designs seek to benefit from modular structures and systems for rapid on-site installation, economies of series production, easier financing and their potential appeal for countries with small electricity grids or power needs in remote locations. They may also be more appropriate for non-electric applications such as district heating, desalination and hydrogen production. Many advanced reactor designs are in various stages of development in national research programmes around the world.

There are two major international efforts on innovative reactor designs. The first is the Agency's International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO), which has a membership of 13 (i.e. Argentina, Brazil, Canada, China, Germany, India, Republic of Korea, Netherlands, Russian Federation, Spain, Switzerland and Turkey, as well as the European Commission) and is open to all interested Member States and organizations. The other is the Generation IV International Forum (GIF), which was initiated by the USA and currently has ten members. The GIF Charter was formally signed in 2001; this was also INPRO's first year of operation.

INPRO, in particular, seeks to promote innovations in nuclear reactors and fuel cycles to meet likely future needs in terms of economics, safety, environmental impacts, proliferation resistance and public acceptance. Its objectives are to ensure that nuclear energy is available to help meet 21st century energy needs and to engage both technology holders and users. The current focus is on defining user requirements, which can then be used to help design appropriate R&D strategies. Subsequently, Member States can examine innovative designs against these requirements.

Nuclear fuel cycle and waste management

The 'back end' of the fuel cycle saw important developments in Finland and in the USA. In May 2001, the Finnish Parliament ratified the Government's decision "in principle" to approve a final repository for spent fuel in a cavern near the nuclear power plants at Olkiluoto. Construction is scheduled to start in 2011, with operation scheduled to commence ten years later. Also in May, the US Department of Energy determined that the proposed Yucca Mountain disposal site in Nevada meets the Environmental Protection Agency's radiation standards set earlier in the year.

Recognizing that there are more countries interested in the science of deep underground storage and disposal, the Agency launched an 'International Network of Centres of Excellence for Demonstration and Training in Geological Disposal'. This network, which was built initially around the deep underground research laboratories made available by the Governments of Belgium and Canada, has now expanded to include Switzerland, the United Kingdom and the USA.

Turning to the 'front end' of the nuclear fuel cycle, a new edition of the "Red Book" — *Uranium 2001: Resources, Production and Demand* — was published jointly by the Agency and the OECD NEA. The Red Book is the foremost world reference on uranium supplies and includes the latest information on uranium exploration, production, resources and demand. A complementary study published by the Agency, *Analysis of Uranium Supply to 2050*, concluded that known resources are adequate to satisfy primary supply requirements through 2035 in a middle demand case, after which new resources would need to be developed.

Nuclear fusion

The world's leading fusion scientists and engineers completed a detailed engineering design for the 500 MW International Thermonuclear Experimental Reactor (ITER), which will demonstrate the scientific and technological feasibility of fusion energy. The Agency has supported activities related to the ITER project since its inception and the ITER Parties (Canada, the European Union, Japan and the Russian Federation) have asked for the Agency's continued support during the next phase leading to the construction of ITER. A site in Canada is under consideration and other offers of sites are expected from the European Union and Japan.

Technology transfer

Promoting the scientific, technological and regulatory capabilities of developing countries through technology transfer and capacity building are among the main tasks of the Agency's technical co-operation programme, with special emphasis given to technical co-operation among developing countries (Box 2). In 2001, which was a banner year for the programme, disbursements went up significantly to $73.5 million from $59.1 million in 2000. The major areas of activities were: human health (23%), safety (20%), food and agriculture (17%), applications of physical and chemical sciences such as isotope hydrology (14%), capacity building (7%), marine environment (7%), nuclear power (5%) and nuclear fuel cycle and waste management technology (4%). Of these disbursements, approximately 41% went towards equipment and 59% provided training, expert services, subcontracts, miscellaneous services and fellowships. The effectiveness of the Agency's technical co-operation programme can also be enhanced by the fostering of strategic partnerships that combine nuclear technologies and essential non-nuclear activities (Box 3).

Capacity building, which involves the promotion of local human resources development and technology transfer, has become a central theme in Agency activities directed at developing Member States. In this regard, thematic CRPs were introduced by the Agency with the purpose of combining capacity building with scientific research activities. An essential component of a thematic CRP is the pairing of senior researchers in developing and developed countries, with this pair supervising a research fellow from the same developing country in studies leading toward a doctorate or similar

BOX 2. **SERVING HUMAN NEEDS — NUCLEAR TECHNOLOGY TRANSFER FOR SUSTAINABLE DEVELOPMENT**

Technology transfer in relation to the Agency's technical co-operation activities was the focus of the Scientific Forum held in September 2001 at the 45th regular session of the General Conference. The forum provided an opportunity for dialogue between national, intergovernmental and non-governmental counterparts from different regions that share common development challenges.

The forum focused on three areas of technology transfer: promoting food security using isotopes and radiation to overcome basic ecological constraints; managing water resources by understanding aquifer dynamics; and improving human health using isotopes to develop new vaccines and diagnostic reagents. In his keynote address to the Forum, Jeffrey Sachs, Professor of International Trade at Harvard University, analysed the role of science and technology in industrialized and developing countries and pointed out that drawing leading scientists and engineers into the challenge of helping the world's poorest is a critical task that requires international donor support and action from international agencies such as the Agency. At the concluding panel discussion the experts examined ways in which "sci-tech" tools, particularly nuclear related technologies, could be better applied at national, regional and global levels to solve the pressing problems of food security, improving public health and developing clean water resources. ■

advanced degree. This will assist in building capacity in developing countries, particularly in the context of the general decline in the number of young people embarking on careers in the nuclear sciences. The individual doctoral work under the thematic CRP addresses the same research area, thereby providing a broad based approach to the research subject under investigation. In 2001, two thematic CRPs were under way in the fields of nuclear medicine and nutrition.

Sterile insect technique (SIT)

The tsetse fly is one of Africa's greatest constraints to socioeconomic development, severely affecting human and livestock health and land use. At their July 2001 summit in Lusaka, the Heads of African States and Governments approved an Action Plan for the Pan African Tsetse and Trypanosomosis Eradication Campaign (PATTEC).

The Agency is playing a major role in supporting the PATTEC initiative as SIT will be an essential component of a package of technologies that will be used. In 2001, the Agency's General Conference adopted a resolution welcoming the OAU's Action Plan and requesting the Agency, in co-operation with Member States and relevant international organizations, to continue supporting African Member States in the tsetse eradication endeavour. The FAO Conference in 2001 adopted a similar resolution.

To ensure the involvement of all stakeholders within and outside Africa, and in recognition of the importance of international co-operation in supporting the PATTEC initiative, the OAU formed a Policy and Mobilization Committee, under the chairmanship of its Secretary General, to guide PATTEC. The Agency, FAO and WHO are represented on this committee.

Food irradiation

The International Consultative Group on Food Irradiation (ICGFI) is composed of 46 Member States, more than half of them developing countries. The Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture serves as its Secretariat. ICGFI has been evaluating global developments in food irradiation; providing advice on its application to Member States and to the three co-sponsoring organizations — the Agency, FAO and WHO — and providing information to the Joint FAO/IAEA/WHO Expert Committee on the Wholesomeness of Irradiated Food and the Codex Alimentarius Commission. After completing its mandate of developing policy guidelines for the

BOX 3. **BUILDING STRATEGIC PARTNERSHIPS FOR TECHNICAL CO-OPERATION**

The benefits of the Agency's nuclear technology transfer to Member States can be maximized when this technology is combined with skills and know-how in other related fields. Strategic partnerships with related technical institutions help ensure that the transferred nuclear technologies achieve the desired impact.

A good example is in the field of tissue banking. The Agency has had considerable success in establishing training courses — now available through distance learning facilities — for irradiating tissue for use in operations. However, merely producing irradiated tissue is not enough. Awareness campaigns need to be launched to encourage the donation of tissue, and surgeons need to be trained to be able to transplant it in patients. Since these non-nuclear "forward and backward linkages" are not part of its normal activities, the Agency formed a partnership with the Musculo-Skeletal Transplant Foundation, a non-profit organization that can transfer the requisite skills. This and other such strategic partnerships will help ensure that the nuclear technology transferred to Member States will not only be used to create valuable products, but will be available on a sustainable basis. ■

Agency, FAO and WHO, and successfully contributing to efforts to facilitate the acceptance and application of food irradiation techniques over the last 17 years, ICGFI decided in 2001 to phase out its activities by 2004, paving the way for the establishment of a new organization with strong involvement of the private sector, especially the food industry. The structure of this organization will be defined at the ICGFI meeting to be held in November 2002.

Nutrition

An estimated 70% of all stunted children live in Asia, where 21% of infants are born undernourished. In addition, iron and iodine deficiencies continue to be major public health issues in the region. Isotope techniques are very effective mechanisms for evaluating the nutritional status of individuals and populations, measuring nutrient requirements and studying the bioavailability of vitamins and minerals. The Agency has been supporting these activities through several of its programmes in 2001. Of special importance is a regional technical co-operation project in Asia to study the bioavailability of added micronutrients in staple foods. China, Indonesia, Malaysia, Pakistan, Philippines, Thailand and Viet Nam participate in this project. Thus, wide acceptance of nuclear technologies by several governments in the East Asia and Pacific region to test the bioavailability of fortified foods has built partnerships that have strengthened efforts to fight malnutrition in that region. In addition, the Agency initiated steps to establish a partnership with the Asian Development Bank to deal with this problem.

An international Code of Practice for dosimetry

To assist Member States in standardizing their procedures for measuring the amount of radiation used to treat cancer patients, the Agency published a new Code of Practice for dosimetry. The development of this Standard took five years, involving several eminent medical physicists and review by more than 50 scientists from 20 countries. The WHO, PAHO and the European Society of Therapeutic Radiology and Oncology have also endorsed it. This Code is unique as its calculation approach is consistent for a variety of radiation beams and it is inherently simpler than earlier methods. It is expected to benefit radiation measurement laboratories all over the world; institutes in Algeria, Greece, Finland, Norway, Sweden and Saudi Arabia have already adopted the Code.

Depleted uranium

Military conflicts during the last decade involved the use of depleted uranium (DU) ammunition. The potential and reported consequences of exposure to DU residues for the local civilian population, peacekeeping forces and the environment have been the subject of public concern and media attention. The Agency therefore decided to hold a scientific seminar and training course to provide the proper scientific basis and adequate background information to its Member States for assessing DU's radiological and toxicological risks and consequences. The seminar and training course were organized in September in co-operation with UNEP and WHO. In related work, Agency and UNEP experts, at the government's request, began an assessment of the consequences of DU residues that may be present in Kuwait since the Gulf War.

Integrating isotope applications in national water development programmes in Africa

Isotope techniques are unique tools for obtaining hydrological information for sustainable groundwater resource management. As a result of the increased interest of the Agency's Member States in the application of these techniques, technical assistance in isotope hydrology has nearly tripled in the last five years. More than 65 technical co-operation projects in isotope hydrology are presently operational in Africa, Asia and Latin America to develop appropriate approaches for integrating isotope techniques with ongoing national water resource management programmes. Several regional projects have been developed to assist major government and donor supported freshwater programmes.

A chronic shortage of water is a major constraint for the socioeconomic development of southern Madagascar, which constitutes the least developed part of the country. To increase the availability of drinking water in this area, the Government has initiated a World Bank supported "500 Wells Project". In 2001 the Agency made available to the project authorities hydrogeological data collected using isotope techniques in similar geological strata in Madagascar. These data are being used to guide site selection for the drilling of these wells.

Using isotope techniques, the Agency also assisted in identifying the sources of nitrate pollution in the aquifer that supplies water to the city of Dodoma in the United Republic of Tanzania. The Government has used this information in developing criteria for land use restrictions and groundwater protection in the area.

SAFETY

National and international efforts continued during the year to enhance the global safety of nuclear power, an attribute that is vital to the credibility of nuclear technology. In 2001, there was further confirmation that since the Chernobyl accident safety performance has continued to show significant improvement around the world. This has been established through the Agency's own safety review missions and through the collection of information on operating experience and plant performance data by the World Association of Nuclear Operators (WANO). The positive trends in nuclear safety were confirmed at the second review meeting for the Convention on Nuclear Safety, when the Contracting Parties discussed the national reports submitted by States in 2001 and concluded that significant progress had been observed since the first review meeting in 1999. Also, the Council of the European Union (EU) issued a 'Report on Nuclear Safety in the Context of Enlargement', noting that a number of States seeking membership in the EU had embarked on the implementation of major modernization and safety improvement programmes. In spite of these positive developments, much remains to be done at the national and international levels to address the varying safety practices in different countries. In addition, in the aftermath of the events of 11 September 2001, the interrelationship between the safety and security of the use of nuclear technologies has been underlined.

In the past year, there have been notable developments with regard to the work of a number of expert bodies in providing authoritative findings and recommendations on nuclear safety related topics. Their advice constitutes important inputs to the development of the Agency's safety standards and many national safety regulations. For example, the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) focused on the risk of hereditary effects from exposure to radiation and concluded that such a risk was likely to be somewhat lower than previous estimates, requiring a downward revision of the previously used risk coefficients for hereditary effects. Also in 2001, the International Commission on Radiological Protection (ICRP) continued its work on revising and making simpler its recommendations on radiological protection that would place more emphasis on individual doses than collective doses. The International Nuclear Safety Advisory Group (INSAG) completed its work on key issues in strengthening safety culture and on maintaining knowledge, training and infrastructure for research and development. INSAG's advice on the latter stressed the need for greater efforts to ensure that knowledge, human resources and R&D support needed to maintain and improve the safety of nuclear activities continue to be available in the future.

The OECD NEA continued its efforts to stimulate international co-operation in safety research. For example, its project launched on the research in the nuclear regulatory context brought together regulators, researchers and licensees to discuss current challenges. It also continued to focus on the safety aspects of the management of long lived waste, addressing such issues as the retrievability of disposed waste or the step-wise decision making in the long term implementation process for geological repositories.

Public demands for reassurance on safety issues, with calls for greater transparency and accountability, are being widely voiced in many countries. The need, therefore, for a more effective and transparent international safety regime continues to be a high priority. An international conference on topical issues in nuclear safety, held in September 2001, highlighted some of the most important challenges facing the nuclear safety community. These included the safety of research reactors, maintaining competence for safety, risk informed decision making, the influence of external factors on nuclear safety, the safety of nuclear fuel cycle facilities and safety performance indicators. The conference underlined the central importance to all aspects of safety of a strong safety culture and management of safety.

Chernobyl

In March 2001, the Ukrainian Government selected the design for a new shelter to be built around the existing Chernobyl-4 'sarcophagus'. The European Bank for Reconstruction and Development agreed to this decision, paving the way for the development of technical specifications and for obtaining tenders for the work to begin.

In April and June, two major international conferences were held in Ukraine to mark the 15th anniversary of the Chernobyl accident. Their focus was on the lessons learned and the health effects of the accident. In addition to providing an update on the incidence of radiation induced thyroid cancer in individuals who were infants or young children at the time of the accident, both conferences reflected on other health problems in the affected region. They concluded that there was some evidence — as yet not conclusive — of an excess of leukaemia cases among the "liquidators" (involved in clean-up operations at the site in 1986 and 1987), who received significant radiation doses, but no significant increase in the incidence of leukaemia in the wider population. There were also some data indicating a possible increase in the incidence of solid cancers in the affected areas, but little or no evidence of any causal link to radiation exposure.

Strengthening the global safety regime

The development and adoption of international, legally binding conventions under the Agency's auspices has significantly contributed to the enhancement of nuclear safety worldwide. To date, conventions have been developed covering the safety of power reactors, radioactive waste and spent fuel management, early notification and assistance in the case of a nuclear accident or radiological emergency, and the physical protection of nuclear material. However, many States are not yet party to these conventions, certain key areas of nuclear activity are still not subject to conventions and some of the conventions that exist are not comprehensive in their coverage. Further efforts are needed to make these conventions universal and comprehensive and to consider other areas, such as the safety of research reactors (Box 4), in which codes of conduct or other types of international undertakings could be beneficial. An important new development in 2001 was the entry into force of the Joint Convention on the Safety of Spent Fuel and on the Safety of Radioactive Waste Management.

Since the major aim of the safety related conventions is to promote adherence to internationally agreed and respected safety objectives and principles, the development and maintenance of a comprehensive body of safety standards is a second key element for the establishment of a comprehensive safety regime. Over the past few years, the Agency has been working intensively to update, complete and raise the quality and visibility of the set of safety standards that covers the entire range of nuclear activities, including nuclear, radiation, waste and transport safety. These standards define what is necessary to achieve a high level of safety. Although the number of States using the Agency's safety standards directly or as the reference basis for national nuclear safety regulations has been increasing, acceptance of the standards by all States and relevant intergovernmental organizations remains a high priority objective.

Agency safety services

The Agency continued to assist States in applying its standards by providing education and training, promoting information exchange on best safety practices, and rendering a broad range of safety services (Box 5). The nuclear safety services offered by the Agency — such as operational safety reviews, design reviews and regulatory reviews — continued to be in great demand. The main challenges here are ensuring that the advice and assistance provided by the Agency are explicitly underpinned by the safety standards and that the practical experience of applying the standards generates feedback to improve the next generation of safety standards.

The benefits of the international peer reviews and other services are demonstrated by the increasing degree to which follow-up missions find that identified safety problems have been resolved. In the past year, the Agency has begun to develop a more holistic approach — an 'integrated safety evaluation', which by drawing together results from existing appraisal services, provides a diagnosis of a State's overall nuclear safety profile and identifies those areas where safety enhancements should be focused.

During 2001, the Agency's nuclear safety review services and assistance were availed by countries of Central and Eastern Europe, the former Soviet Union, South East Asia and the Pacific and the Far East. For example, an expert team assembled by the Agency assessed the safety of the design of the Temelin-1 nuclear power plant in the Czech Republic. In China, assistance continued to be provided for the improvement of nuclear safety at the Qinshan Nuclear Power Corporation and expert missions reviewed the design of the newly constructed Tianwan nuclear power plant, providing recommendations on severe accident mitigation and the reactor protection system. Also, the Agency, at the request of the Korean Peninsula Energy Development Organization (KEDO), completed a design safety review of the LWR project that KEDO is implementing for the Democratic People's Republic of Korea (DPRK).

Safety and security of radiation sources

An important safety issue for the Agency is the safety and security of radioactive sources. In the past year, the Agency's Action Plan on these issues was revised and expanded aiming, among other things, at promoting self-assessment of national protection arrangements, provision of more guidance and assistance in locating 'orphan sources' and responding to emergencies. The revised plan foresees the development and implementation of a universal system of labelling of radiation sources so that

BOX 4. **ADDRESSING THE SAFETY OF RESEARCH REACTORS**

An area of continuing concern is the safety of research reactors. In the past year, the Agency initiated a range of measures towards the establishment of a comprehensive, internationally accepted safety regime for these reactors. In addition to work performed on safety standards, incident reporting and regulatory supervision, the Agency identified some key concerns — such as degraded equipment, inadequate fuel storage, lack of regulatory oversight as well as the absence of adequate funding and the lack of a clear plan on how to make the best use of the reactors. Responding to these concerns, the Agency decided to implement an internationally agreed action plan for research reactors that includes: an assessment survey to acquire comprehensive information on the safety status of research reactors worldwide; preparation of a Code of Conduct on the safety of these reactors; a review of the Agency's assistance programmes to ensure that priority is being given to issues of highest safety relevance; and strengthening of monitoring activities on the safety of research reactors under project and supply agreements. In implementing the latter action, for instance, the Agency conducted Integrated Safety Assessment of Research Reactors (INSARR) missions in Greece, where the operational safety aspects of the "Demokritos" research reactor were reviewed, and in Australia, where the Preliminary Safety Assessment Report for the Replacement Research Reactor to be built at Lucas Heights was examined. ■

individuals are immediately aware of the potential hazards. While concern with respect to potential malicious acts in connection with orphan sources exists, public health effects due to inadvertent exposure are an equally important concern. This was demonstrated at the end of 2001 when two powerful radioactive sources were found unshielded in a remote area of the Republic of Georgia. The Georgian incident also serves as an illustration of the much larger problem of orphan sources that deserves prompt attention.

Safe transport of radioactive material

In spite of the outstanding safety record of those transporting radioactive material, many States and regional groups, in particular small island developing States and other coastal States, have expressed concern over the impact — on people, the economy and the environment — of a potential accident during the transport of this material by sea. The 2001 General Conference adopted a resolution that called for several actions, including urging those States shipping radioactive material and spent fuel to provide assurances to potentially affected States that their national regulations are in accord with the Agency's Transport Regulations. It also called for efforts to examine and further improve measures and international regulations relevant to the international maritime transport of radioactive material, including spent fuel. The resolution welcomed the practice of some shipping States and operators of undertaking timely consultations with relevant coastal States in advance of shipments and invited others to do so. Recognizing that uniform implementation and interpretation is an important prerequisite to an international transport safety regulatory regime, the resolution also noted that during 2001 the relevant international organizations had incorporated into their respective regulatory documents the requirements of the Agency's Transport Regulations. These modal regulations (for air, sea and land transport) were all in force at the international level as of 1 January 2002.

Radiological protection of patients

Medical practice involving the use of ionizing radiation accounts for about 95% of human exposure from human made sources of radiation. Accidents during medical treatment with radiation continue to occur, frequently with severe consequences. The increasing importance of the issue of radiological protection of patients is, among other things, witnessed by the fact that during 2001 four major

BOX 5. **UPGRADING RADIATION, WASTE AND TRANSPORT SAFETY INFRASTRUCTURES**

Providing assistance for upgrading national radiation, waste and transport safety infrastructures continued to be a priority for the Agency in 2001. Radiation Safety Regulatory Infrastructure peer review missions were sent to Niger, Philippines, Thailand and Venezuela. Based on an assessment of its interregional Model Project on Upgrading Radiation Protection Infrastructure, which was implemented between 1995 and 2000 in 52 States, the Agency concluded that, despite the progress made in many countries, the situation in many other countries remained unsatisfactory. The development of legislative and regulatory infrastructures will still require years of national effort in many States, with continuous government commitment, in order to comply with the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (BSS). To achieve this objective, full implementation of national work plans agreed to by the relevant governments is a prerequisite. In 2001, two new Model Projects were started to allow some 30 more States to upgrade existing radiation protection infrastructures with the Agency's assistance. It is expected that, through the establishment of a national notification, authorization, inspection and enforcement system for the control of radiation sources and materials, the regional Model Projects will contribute to enhanced protection and security of the public. It is further expected that the successful implementation of these projects will improve the level of compliance by States with the principal requirements of the BSS and, consequently, contribute to a safety based approach to the application of nuclear technologies. ■

publications of the ICRP were devoted to various aspects of radiation protection in medicine. During the year, the Agency investigated accidental exposures of radiotherapy patients in Panama and Poland, where, due to human errors in the data entry of the treatment plans and an electrical fault, a number of patients were treated with doses up to 100% higher than those prescribed. To highlight this concern, the Agency, together with the European Commission, PAHO and WHO, organized a conference in Málaga, Spain, on the radiological protection of patients in diagnostic and interventional radiology, nuclear medicine and radiotherapy.

VERIFICATION

Strengthening the safeguards system

Since the early 1990s, the Agency has been involved in strengthening its safeguards system, bearing in mind the importance of achieving the universal application of the Agency's safeguards system, consistent with the respective safeguards undertakings of Member States. In 2001, this effort took several forms. Additional protocols were concluded, comprehensive State level evaluations became a more central feature of the system and technological improvements had a positive impact on the implementation of safeguards measures (Box 6).

The Model Additional Protocol, approved by the Board of Governors in May 1997, is the key tool for strengthening the safeguards system. By concluding an additional protocol a State undertakes to provide a broad range of information about all aspects of its nuclear fuel cycle and nuclear related activities, and to provide more access rights for Agency inspectors. This enables the Agency to provide credible assurances not only about the non-diversion of declared nuclear material, but on the absence of undeclared nuclear material and activities. During the year the number of States for

BOX 6. CHALLENGES FACING SAFEGUARDS AND NUCLEAR MATERIAL SECURITY

The Agency's ninth safeguards symposium, 'International Safeguards: Verification and Nuclear Material Security', was held in Vienna in October–November 2001. The topics covered the full range of current nuclear security interests, such as nuclear non-proliferation and disarmament, physical protection of nuclear material, illicit trafficking and future Agency verification roles.

The symposium addressed both proliferation challenges and opportunities for further progress in safeguards and nuclear material security. The challenges included: implementation and universalization of additional protocols; early implementation of integrated safeguards; and finding ways to meet the legitimate demands of the international community in ensuring adequate and reliable physical protection of nuclear material. Opportunities for strengthening safeguards and nuclear material security covered: developing new tools and capabilities; new concepts and approaches; increasing the role of technology in meeting the challenge of an expanding mandate in combination with the continued reality of financial constraints imposed on the Agency's budget; making more effective use of satellite imagery; and evolving new randomized inspection strategies.

Symposium participants noted that there was a need for: a stronger and better financed safeguards system; many more States with comprehensive safeguards agreements and Additional Protocols in force; integration of new safeguards measures with the traditional methods in a way that strengthens the entire system; a dramatic increase in national and international efforts, to ensure that all potential nuclear weapons material worldwide was secure and accounted for; and an amendment to the CPPNM.

In view of the 11 September attacks in the USA, a special session on combating nuclear terrorism was organized to discuss the potential threats posed by nuclear terrorism and outlined the activities already under way at the Agency to deal with such threats. ■

which additional protocols were concluded increased from 57 to 61, and the number of additional protocols in force rose from 18 to 24 (with one more being applied provisionally). Progress, however, remains slow. With regard to comprehensive safeguards agreements, in 2001 the number of States Party to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) that have not fulfilled their legal obligation to bring into force the required NPT safeguards agreement stood at 52 (54 at the end of 2000).

Evaluation of information about a State's nuclear programme for safeguards purposes is becoming an integral part of the process of deriving safeguards conclusions. The information collected is periodically updated and evaluated. This evaluation is critical to enabling the Agency to draw and maintain its conclusions about the State's compliance with its safeguards and non-proliferation obligations.

Technological developments have always had an impact on the way safeguards have been applied. During 2001 major progress was made in increasing remote monitoring.

Integrated safeguards

The measures contained in the Model Additional Protocol were meant to be "integrated" with existing ones to ensure the optimum combination — in terms of effectiveness and efficiency — of the measures available to the Agency under comprehensive safeguards agreements and additional protocols thereto. During 2001, a major achievement was the development of a conceptual framework for integrated safeguards, designed to ensure consistency in their implementation in States with similar fuel cycles, but at the same time to provide flexibility so that in each State the combination of safeguards measures can be chosen to ensure maximum effectiveness and efficiency. Integrated safeguards can be applied once the Agency, on the basis of its activities under the comprehensive safeguards agreement and the additional protocol, has drawn a positive conclusion about the non-diversion of declared nuclear material *and* the absence of undeclared nuclear material and activities in the State concerned. For the first time, an integrated safeguards approach was applied in a Member State, namely in Australia.

Implementation of safeguards agreements and additional protocols

The implementation of additional protocols was initiated in a number of countries, including some with large nuclear fuel cycles. Substantial resources were utilized for increased information collection, analysis and evaluation activities, such as the review of declarations pursuant to additional protocols. Complementary access under additional protocols was conducted 88 times in 13 States, in most instances in conjunction with inspections.

Iraq. For more than three years the Agency has not been in a position to implement its mandate in Iraq under UN Security Council Resolution 687 (1991) and related resolutions. As a consequence, the Agency cannot provide any assurance that Iraq is in compliance with its obligations under those resolutions. Since January 2000, the Agency has carried out annual inspections, pursuant to Iraq's NPT safeguards agreement, of the declared nuclear material remaining under safeguards in Iraq. These inspections do not serve as a substitute for the verification activities required by the relevant resolutions of the Security Council, nor do they provide the assurances sought by the Council. The Agency remains prepared to resume its Security Council mandated verification activities in Iraq at short notice.

DPRK. The Agency remains unable to verify the completeness and correctness of the DPRK's initial 1992 declaration, and is therefore unable to conclude that there has been no diversion of nuclear material. The work required to verify that all nuclear material subject to safeguards in the DPRK has been declared and placed under safeguards could take three to four years, with the full co-operation on the part of the DPRK.

Nuclear security

In the week immediately following the tragic events of 11 September 2001, the Agency's General Conference adopted a resolution that requested the Director General to initiate a thorough review of Agency activities and programmes relevant to preventing acts of terrorism involving nuclear and other radioactive materials. The response by the Secretariat has been immediate, with concrete measures being taken to expand the scope and reach of many of its security related and safety services.

The Agency has been engaged for a number of years in a variety of activities relevant to the prevention of acts of nuclear terrorism, including programmes to promote the physical security of nuclear facilities and nuclear and other radioactive material, help prevent and respond to illicit trafficking in this material, strengthen the emergency response systems of the Agency and Member States and enhance the safety and security of nuclear facilities. In these areas of activity, the Agency developed norms and guidelines, promoted international co-operation, provided expert advice, training and equipment. It also provided an expanding array of advisory services to States to better protect nuclear and other radioactive material against theft; as well as nuclear facilities against sabotage, and to manage and safely dispose of radioactive sources.

Through an ongoing regional technical co-operation project in Europe, the Agency has devoted significant efforts to the training of customs officials, border guards and police in detection techniques, use of equipment and response mechanisms for combating illicit trafficking in nuclear and other radioactive materials.

The first international conference on the security of nuclear material was organized by the Agency in Stockholm in May. The conference concluded that a comprehensive approach to security of material was warranted, considering both the risks for nuclear proliferation and possible radiation and health effects. The conference encouraged States to become parties to the Convention on the Physical Protection of Nuclear Material (CPPNM). It also highlighted the Agency's role in supporting measures at the national level through the development of norms and guides, and co-ordination of technical development and assistance to States in implementing security measures.

In November the Agency prepared a report outlining plans to expand and strengthen programmes for nuclear security. It also addressed the Agency's response to threats from acts of nuclear terrorism and highlighted the need for additional resources to cope with this newly emerging threat (Box 7).

The informal open ended expert meeting, first convened in November 1999, to discuss whether there was a need to revise the CPPNM completed its work in May. In response to the experts' recommendations, the Director General convened in December a group of legal and technical experts to prepare a well defined draft amendment to the Convention.

OUTREACH

In keeping with a new policy aimed at informing and engaging both existing and new constituencies, the Agency expanded its outreach activities. For instance, many more non-governmental organizations (NGOs) were invited to participate in the Scientific Forum at the Agency's 2001 General Conference, and more systematic contacts are being maintained with these NGOs and with other parts of civil society. In addition, efforts continued to optimize synergies with other international organizations. A notable example was the Revised Arrangements between the Food and Agriculture Organization and the Agency for the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, concluded in December 2001.

The visibility of the Agency increased significantly during the year. In part, this was due to CNN's broadcast throughout the second half of the year of public service announcements describing the Agency and its main areas of activity. Moreover, in response to public interest in nuclear matters after the 11 September attacks in the USA, the Agency conducted a public information and media campaign on combating nuclear terrorism. Complementing these activities, the Agency's *WorldAtom* web site was redesigned.

MANAGEMENT

Over the past four years the Agency has conducted a comprehensive review of its management structure and operations. Of particular importance in this process has been the introduction of "results based programming and budgeting" — involving the formulation of programmes and budgets driven by a number of desired results that are articulated at the outset of the process, and against which actual performance is measured at the end of the programme and budget cycle. This has been accompanied by a proposed change to full *biennial* programming and budgeting. In this respect, 2001 was a transitional year for the Agency, which was marked by the incorporation of the initial components of the results based approach in the Agency's programme and budget. The consequence of the transitional year is that the Agency's fiscal cycle is now synchronized with those of other UN organizations.

As described in the *Medium Term Strategy,* the Agency's activities in 2001 were integrated under the three broad "pillars" of technology, safety and verification, and were distributed among six major programmes (increasing to seven starting in 2002). Often, the objectives to be achieved by these activities cut across programme and organizational structures. 'Matrix management' is the optimal

BOX 7. ENHANCING PROTECTION AGAINST NUCLEAR TERRORISM

United Nations Security Council Resolution 1373 (2001) of 28 September 2001 noted with concern the close connection between international terrorism and the illegal movement of nuclear material and, in that regard, emphasized the need to enhance co-ordination of efforts at the national, subregional, regional and international levels in order to strengthen a global response to this serious challenge and threat to international security. The Council also called upon all States to find ways of intensifying and accelerating the exchange of operational information, especially regarding, among others, the threat posed by the possession of weapons of mass destruction by terrorist groups, and to become parties as soon as possible to the relevant international conventions and protocols relating to terrorism.

In the same vein, the Agency's General Conference adopted a resolution on 21 September 2001 noting the importance of physical protection in preventing the unauthorized removal of nuclear material and the sabotage of nuclear facilities and nuclear materials by individuals or groups. The conference called on the Agency to thoroughly review its programmes relevant to preventing acts of terrorism and to report to the Board of Governors as soon as possible. In response to this request, the Director General prepared an initial report on protection against nuclear terrorism outlining plans for substantially expanding and strengthening the Agency's programmes in the areas of: physical protection of nuclear material and nuclear facilities; detection of malicious activities (such as illicit trafficking) involving nuclear and other radioactive materials; strengthening of State systems for nuclear material accountancy and control; security of radioactive material other than nuclear material; improving the security of nuclear facilities; response to malicious acts or threats thereof; the adherence to international agreements and guidelines; and enhancement of programme co-ordination and information management for nuclear security related matters. The report emphasized that the proposed activities were not a substitute for national measures, nor could they diminish the primary responsibility of the State for all matters of security. Rather, they were designed to assist Member State efforts in areas where international co-operation is indispensable to the strengthening of nuclear security. ■

mechanism for planning and implementing activities that require the application of different fields of expertise and multi-disciplinary approaches. As more cross-cutting areas are identified, the roles, responsibilities and accountability of the staff involved need to be clearly defined, and procedures for monitoring implementation and periodic reporting have to be established. Work was under way in 2001 to set up the necessary mechanisms and procedures for effective and efficient matrix management.

The reform process has been characterized by considerable restructuring within the Secretariat, and by the introduction of a corporate, 'one house' approach with the aim of improving co-ordination, efficiency and programme delivery. For example, new offices for policy co-ordination and for programme support were created. In addition, a new Office of Internal Oversight Services was established to consolidate and rationalize evaluation, management services, internal audit and investigation into one entity. And to improve 'customer focus' and streamline the information technology (IT) structure, a new IT Division and an IT Committee were established.

The preparation of the Agency's first full biennial programme and budget document, covering the period 2002–2003, entailed far more extensive and earlier consultations with Member States to establish their needs at the outset and obtain their views on programme content. This resulted in a revised and more focused programme structure.

Although the budgetary proposals for 2002–2003 cover the two years of the biennium, the Secretariat could only present a budget resolution for 2002. This was because the amendment to the Agency's Statute to enable the change to biennial budgeting can only take effect after the required number of Member States has formally accepted it. At the end of 2001, only 26 States had deposited their instruments of acceptance — well short of the required two thirds of the Agency's members.

Extensive consultations were conducted in the first half of the year owing to the need for increased funding for the technical co-operation and safeguards programmes, compounded by a compulsory cost of living increase in Vienna. After intensive discussions, a consensus was reached on funding for the 2002 budget.

CONCLUSION

The peaceful uses of nuclear energy will continue to be an important factor in economic development and in improving human welfare. In this regard, a capacity in nuclear science and technology is often an asset in its own right, contributing to broader technological development. Many challenges face the world today, including understanding and combating climate change, preserving the environment, feeding and protecting the health of the world's growing population, and supplying the water and energy needed for sustainable economic growth and development. Responding to these challenges requires concerted, collaborative efforts by Member States, international organizations and civil society. It also requires flexibility — the ability to adapt to changing circumstances to achieve common goals.

In 2001, the Agency remained active in fostering international co-operation for the peaceful uses of nuclear technologies, and in transferring these technologies to developing countries — but adequate investment and continuing innovation are essential to ensure that nuclear technologies remain viable. It continues to press for a comprehensive and effective nuclear safety regime — but, again, such a regime will be effective only if States adhere to it and invest in its necessary infrastructure. It has been laying the groundwork for a state of the art verification system — but such a system must be subscribed to, and above all must be underpinned by other parts of the non-proliferation regime. For the Agency's Secretariat and Member States to be able to move forward on all these fronts, active partnership is indispensable. The Agency is committed to reinforcing this partnership.

[Credit: Dean Calma, IAEA]

A view of the plenary session at the 45th regular session of the General Conference, which was held in the Austria Center Vienna from 17 to 21 September 2001.

[Credit: Dean Calma, IAEA]

As a mark of respect for the victims of the tragic events of 11 September 2001 in the USA, the Vienna Boys Choir gave a performance at the opening of the General Conference on 17 September.

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 and its 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 Box 1).

The General Conference comprises all Member States of the Agency and meets once a year. It considers the annual 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 pro-gramme and passes resolutions directing the priorities of the Agency's work (see Box 2 for a complete list of resolutions in 2001).

The applications of the Federal Republic of Yugoslavia and the Republic of Botswana for membership of the Agency were approved by the General Conference upon the recommendation of the Board of Governors. At the end of 2001 the application by the Federal Republic of Yugoslavia had taken effect, and the Agency had a total of 133 members.

The Board of Governors decided to appoint Mohamed ElBaradei as Director General of the Agency by acclamation for a further term of office of four years, until 30 November 2005. His appointment was approved by the General Conference in accordance with Article VII.A of the Statute.

The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management entered into force on 18 June 2001, the required number of States having deposited their instruments of ratification. In December 2001, a meeting was held for the purpose of preparing for the first review meeting of the Contracting Parties, which is to take place in 2003.

The General Conference reappointed the Comptroller and Auditor General of the United Kingdom as the External Auditor to audit the Agency's accounts for 2002 and 2003.

The General Conference took note of a report by the Secretariat, made pursuant to General Conference Resolution GC(43)/RES/19, on progress made towards the entry into force of the amendment to Article VI of the Statute (concerning the size and distribution of seats on the Board of Governors, by which membership of the Board was expanded from 35 to 43 seats). The report stated that, as of 16 July 2001, the Director General had been informed by the depositary Government that 26 Member States had accepted the amendment in accordance with their respective constitutional processes. In accordance with the Statute, entry into force of the amendment requires acceptance by two thirds of all members (see Table A22 in the Annex for the status as of 31 December 2001).

Note: This chapter 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.

During the General Conference the President of the Conference made the following statement on terrorism:

> "During the Conference, widespread condolences were expressed to the victims and their families as well as to the Government of the United States of America for the terrorist acts that took place on 11 September 200l in New York, Washington, DC, and Pennsylvania. The Delegates were unequivocal in their condemnation of these terrorist acts. As called for in UNGA RES 56/1 (2001) and UNSC RES 1368 (2001), the urgent need of working together to bring to justice the per-petrators, organizers, and sponsors of these terrorist attacks and to hold accountable those responsible for aiding, supporting, or harbouring the perpetrators, organizers, and sponsors of these acts was supported. With particular regard to the Agency's mandate, the Conference expressed its concern about the possible impact of terrorism on the security of nuclear material and other radioactive materials. In this regard, the Conference requested the Director General to review thoroughly the activities and programmes of the Agency with a view to strengthening the Agency work relevant to preventing acts of terrorism involving nuclear materials and other radioactive materials. It further urged all Member States to co-operate fully with the Director General and to support the Agency's efforts in this regard."

In December, the Board considered the Director General's initial response to the statement and to the request of the General Conference in Resolution GC(45)/RES/14B.

BOX 1. **THE BOARD OF GOVERNORS, 2001–2002**

Chairman of the Board:	H.E. Mr. Max Hughes Ambassador	Australia
Vice-Chairmen:	H.E. Mr. Sameh Hassan Shoukry Selim Ambassador	Egypt
	Mr. Vadym V. Gryshchenko Head, State Nuclear Regulatory Committee	Ukraine

Composition of the Board of Governors
at the conclusion of the 45th (2001) regular session of the General Conference

- Argentina
- Australia
- Brazil
- Bulgaria
- Burkina Faso
- Canada
- Chile
- China
- Colombia
- Egypt
- Finland
- France
- Germany
- Ghana
- India
- Iran, Islamic Republic of
- Ireland
- Japan
- Kuwait
- Libyan Arab Jamahiriya
- Mexico
- Morocco
- Pakistan
- Peru
- Philippines
- Romania
- Russian Federation
- South Africa
- Spain
- Switzerland
- Thailand
- Turkey
- Ukraine
- United Kingdom of Great Britain and Northern Ireland
- United States of America

BOX 2. **RESOLUTIONS ADOPTED BY THE GENERAL CONFERENCE DURING ITS 45th REGULAR SESSION (17–21 SEPTEMBER 2001)**

Title of resolution	Resolution number
• Applications for membership of the Agency	
— Application by the Federal Republic of Yugoslavia	GC(45)/RES/1
— Application by the Republic of Botswana	GC(45)/RES/2
• Approval of the appointment of the Director General	GC(45)/RES/3
• The Agency's accounts for 2000	GC(45)/RES/4
— Regular budget appropriations for 2002	GC(45)/RES/5
— Technical Co-operation Fund Allocation for 2002	GC(45)/RES/6
— The Working Capital Fund in 2002	GC(45)/RES/7
• Scale of assessment of members' contributions towards the regular budget	GC(45)/RES/8
• Rules regarding the acceptance of voluntary contributions	GC(45)/RES/9
• Measures to strengthen international co-operation in nuclear, radiation, transport and waste safety	GC(45)/RES/10
• Strengthening of the Agency's technical co-operation activities	GC(45)/RES/11
• Strengthening the Agency's activities related to nuclear science, technology and applications	GC(45)/RES/12
• Strengthening the effectiveness and improving the efficiency of the safeguards system and application of the Model Additional Protocol	GC(45)/RES/13
• Measures to improve the security of nuclear materials and other radioactive materials	GC(45)/RES/14
• Implementation of the NPT safeguards agreement between the Agency and the Democratic People's Republic of Korea	GC(45)/RES/16
• Implementation of United Nations Security Council resolutions relating to Iraq	GC(45)/RES/17
• Application of IAEA safeguards in the Middle East	GC(45)/RES/18
• Personnel	GC(45)/RES/15
• Examination of delegates' credentials	GC(45)/RES/19

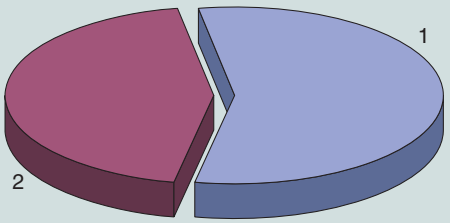
The Agency's Programme in 2001: Technology

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: $4 124 557
Extrabudgetary programme expenditure (not included in chart): $589 175



1. Nuclear Power Planning, Implementation and Performance: $2 298 347
2. Nuclear Power Reactor Technology Development: $1 826 210

KEY ISSUES AND HIGHLIGHTS

- Publications were issued on quality assurance standards, risk management, managing change in nuclear utilities, economic performance indicators, personnel training and evaluating outside contractors.
- Updated versions of Agency databases and the Power Reactor Information System (PRIS) were released to Member States. In addition, a third module on steam generators was added to the Agency's database on nuclear power plant life management.
- A major international seminar was convened in Cairo to review innovative small to medium sized reactor (SMR) designs.
- CRPs on seismic features and thermal-hydraulic codes for metal cooled reactors were completed, and a new CRP was started on the economics of selected nuclear desalination projects.
- The first full year of the extrabudgetary International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) was completed.

NUCLEAR POWER PLANNING, IMPLEMENTATION AND PERFORMANCE

Global electricity demand is projected to more than triple in the next 50 years. Figure 1 shows the increase in the global energy availability factor in the last decade. Individual plant availability increased in many cases by some 30 percentage points. From 1990 to 2000, global energy availability increased from 73% to over 82% — the equivalent of adding 28 GW(e) of new generating capacity. The data for 2001 indicate that a new record was again set. Currently, the energy availability factors at the most successful nuclear power plants are well above the 2000 average of 82%. However, for most of the world's nuclear plants there is still much room for improvement.

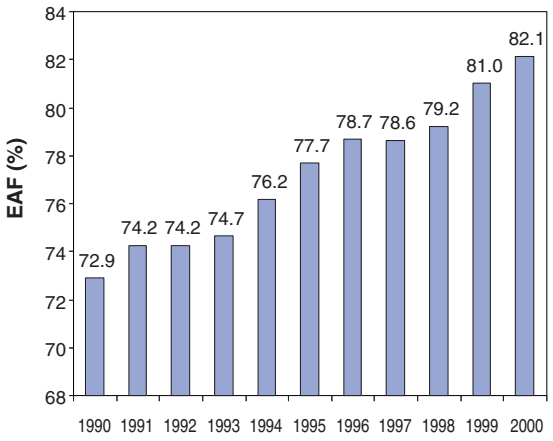


FIG. 1. Global average energy availability factor (EAF).

The Agency assists Member States in planning and implementing nuclear power projects and managing the performance and service life of nuclear power plants. The Agency used 'Internet Virtual Office' to facilitate collaboration and the dissemination of information to experts in Member States involved in projects.

Contractor personnel provide many essential services to nuclear utilities and individual nuclear power plants during planned outages, for refuelling, for major upgrade projects, for specialized maintenance and for routine non-nuclear services such as security, administrative support, facility management, buildings maintenance and catering. An issue of great importance with respect to contractor personnel is that of ensuring, in a cost effective manner, that they are competent and qualified to perform the assigned tasks. A technical document on *Assuring the Competence of Nuclear Power Plant Contractor Personnel* (IAEA-TECDOC-1232) assists utility and nuclear power plant managers, and other relevant organizations, in identifying the required technical and professional competence of contractor personnel, and includes specific tools for contractor assessment and evaluation.

A technical report comparing the ISO-9901:2000 quality standards and the Agency's 50-C/SG-Q safety codes was completed. Prepared in response to numerous requests and a high level of interest in Member States, this publication is a follow-on to *Quality Assurance Standards: Comparison between IAEA 50-C/SG-Q and ISO-9001:1994*, which was jointly developed in 2001 with FORATOM. Both publications assist Member States in developing quality assurance policies and programmes and are considered especially useful to the utility/supplier interface in the nuclear industry. The current quality standard ISO-9001:1994 is in force until December 2003, when it will be replaced by the revised ISO-9001:2000 that was published in December 2000.

In the field of integrated management of nuclear power plant operations, a new publication — *Risk Management: A Tool for Improving Nuclear Power Plant Performance* (IAEA-TECDOC-1209) — helps operators identify and implement appropriate measures to remain competitive. It provides a structure for risk management, along with examples of how operating organizations are using this tool to help integrate the assessment of safety, operational and economic related risks in a changing environment.

Managing Change in Nuclear Utilities (IAEA-TECDOC-1226) analyses the experience of Member States in adapting nuclear power production to changing market, economic and regulatory environments. It identifies the important factors for maintaining a successful safety conscious, continuous improvement management culture in the midst of change.

Properly managed, changes can enhance nuclear safety, plant reliability and cost competitiveness, from the design stage to decommissioning. The document provides guidance to all levels of management involved in developing and implementing changes within their areas of responsibility.

The use of resources can be optimized by minimizing operations and maintenance (O&M) costs. A new publication, *Developing an Economic Performance International System to Enhance Nuclear Power Plant Competitiveness* (Technical Reports Series No. 406), provides guidance on this subject, using information from the Agency's NEPIS (Nuclear Economic Performance International System) database, which contains cost data provided by utilities from 15 countries. Performance targets and O&M costs are also correlated with the objective of identifying major economic performance indicators.

In the past, much of the focus of formal nuclear power plant training and development programmes has been on technical skills, particularly those of control room operators. The changing market environment in which such plants operate places new emphasis on increased efficiency and operator effectiveness, while still maintaining high levels of safety. A report published in 2001, *A Systematic Approach to Human Performance Improvement in Nuclear Power Plants: Training Solutions* (IAEA-TECDOC-1204), provides guidance on training nuclear power plant personnel in non-technical skills. It also presents an integrated approach that incorporates training as one of several co-ordinated approaches to achieving desired levels of human performance.

Staying with the area of training, the Agency supported an initiative on 'Co-operation among Nuclear Training Centres in the European Region' to improve both the quality and cost effectiveness of training activities in Member States in this region. In April, the Paks Nuclear Power Plant Maintenance Training Centre in Hungary hosted an initial meeting with representatives from 12 Member States. Activities under this initiative will include: development of training centre dossiers and an Internet database of available training tools; as well as collection and sharing of benchmarking information; and exchange of staff.

New releases of Agency databases included a CD-ROM version of PRIS (Fig. 2) incorporating both mapping features and the full database. PRIS data were also released to the public through the Internet *(http://www.iaea.org/programmes/ne/nenp/npes/index.htm)*. The

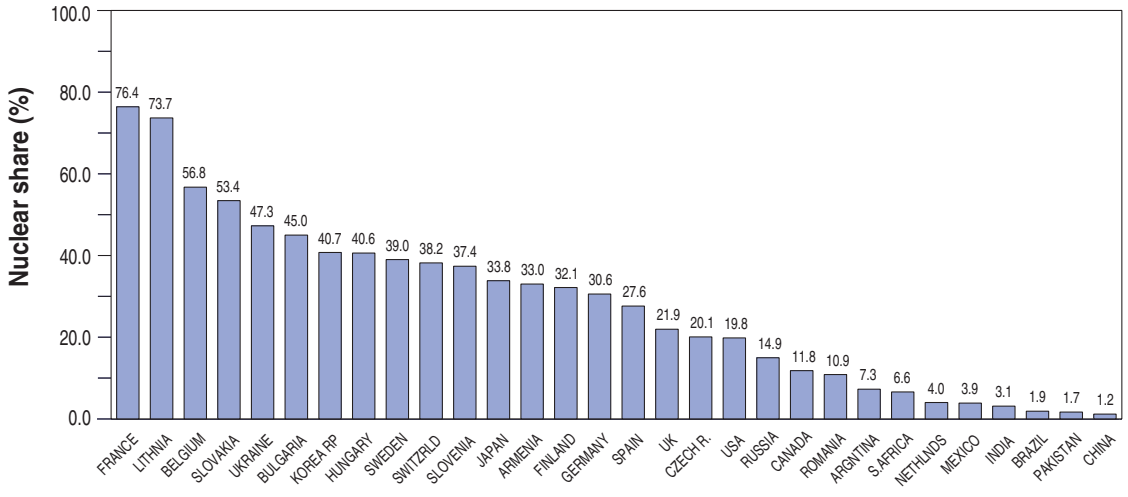


FIG. 2. The percentage of electricity generated by nuclear power in 30 countries in 2000 (based on data from PRIS and Energy, Electricity and Nuclear Power Estimates for the Period up to 2020, *Reference Data Series No. 1, IAEA, Vienna (2001)).*

other two PRIS services to Member States, MicroPRIS and PRIS-PC (the connection to PRIS through the Internet), are currently being distributed to more than 700 users in Member States and international organizations. PRIS contains multiple modules covering different aspects of nuclear power plants, including operating experience and outages, reactor design characteristics, non-electrical applications and decommissioning. Data on delayed nuclear power projects will be added in the near future.

A third module on steam generators has been added to the Agency's Nuclear Power Plant Life Management database. This module will make it easier to monitor and analyse the state of steam generators in different countries on the basis of information acquired during their accumulated operating years. Such results are important for steam generator life optimization, and are helpful in the scheduling of timely decisions on necessary repairs and replacements.

Requests from developing Member States for technical co-operation missions are given high priority and influence significantly the content and structure of the Agency's programme in nuclear power. In addition, direct outputs of the regular programme (e.g. standards, CRP results, documents, reports and databases) are used in planning, designing and implementing technical co-operation projects. Wherever possible, activities within regular and technical co-operation projects are implemented jointly to take advantage of synergies and have a greater impact in recipient Member States. In 2001, support was provided to a range of technical co-operation projects in such areas as:

— Engineering aspects of life management of nuclear power plants;
— Planning and management of the first/new nuclear power project;
— Integrated approaches to improving operations management;
— Planning, management and implementation of nuclear power plant decommissioning;
— Personnel training and qualification.

A total of 135 people received training through training courses, 535 through workshops and technical meetings, 9 through fellowships and 19 through scientific visits.

NUCLEAR POWER REACTOR TECHNOLOGY DEVELOPMENT

In addition to support for continuous performance improvements in current nuclear power plant facilities and projects, the Agency also provides support for R&D on new and modified designs that promise lower costs, better performance, a higher level of safety and greater proliferation resistance (Box 1).

Global interest in modular high temperature gas cooled reactors (HTGRs) continues, driven by their promising safety and economic features. The Agency's 'Knowledge Base' web site on HTGR technology *(http://www.iaea.org/inis/aws/htgr)* continued to draw global attention as a source of information and publications. The following achievements were recorded in 2001:

— The Chinese HTR-10 reactor underwent operational tests;
— The Japanese HTTR reached 30 MW(th) of full power;
— Design studies were carried out on the proposed Pebble Bed Modular Reactor project in South Africa, with a planned upgrade of power from 268 to 302 MW(th);
— Studies were carried out in the Russian Federation on the proposed international plutonium burning GT-MHR design project;
— The European High Temperature Reactor Technology Network was actively engaged in co-ordinated research related to HTGRs within the 5th EURATOM framework programme. In the USA, HTGR concepts and technology are being examined as a possible future design candidate for the 'Generation IV technology roadmap' and 'Nuclear Energy Research Initiative' projects.

The Agency's Technical Working Groups on Advanced Technologies for Light Water Reactors (TWG-LWR) and Heavy Water Reactors (TWG-HWR) focused on technology developments to improve the economic competitiveness of water cooled reactors while meeting stringent safety objectives. In this connection, investigations

aimed at optimizing the technology, safety and the economics of water cooled reactors were carried out jointly with the OECD/NEA, the European Commission, industrial organizations and government agencies. One conclusion was that in order to achieve the largest possible cost reductions for nuclear plants, proven means for reducing costs must be fully utilized, and new approaches should be developed and implemented.

Building on its expertise in water cooled reactor designs, the Agency also sponsors the development of nuclear reactor simulators, which operate on PCs and simulate the responses of medium and large sized water cooled reactor types (e.g. BWRs, PWRs and HWRs) under operating and accident conditions. The Agency's simulator workshops have now become an annual event at the International Centre for Theoretical Physics (ICTP) in Trieste. During 2001, a new 1360 MW(e) BWR simulator was developed and demonstrated at the ICTP workshop. Updated versions of the PCTRAN PWR and the WWER-1000 simulators were also made available.

In the field of metal cooled reactors, one area of concern is thin walled and flexible reactor components that operate at low pressure but could be seriously affected by earthquakes. Responding to this concern, the Agency recently completed a CRP on the verification of analysis methods for predicting seismically isolated nuclear structures, and harmonization and validation of analysis methods for fast reactor thermal-hydraulic codes and relations using experimental data. Another CRP seeks to validate, verify and improve methodologies and computer codes used for the calculation of reactivity coefficients in liquid metal fast reactors.

Lead and lead–bismuth cooled systems offer an alternative to sodium, provided the high corrosion activity and other long term material compatibility problems are solved. In response to Member State requests, the Agency has been conducting information exchange activities in

BOX 1. USING SMALLER PLANTS FOR A WIDER RANGE OF POWER AND NON-POWER APPLICATIONS

Several innovative designs for future nuclear power plants are in the small to medium sized range. These plants can be constructed with factory built structures and components, including complete modular units for rapid installation. They also benefit from economies of *series production*, in contrast to the economies of *scale* sought by larger designs. Small and medium sized reactors (SMRs) may also be easier to finance and may be attractive for countries with small electricity grids or for use in remote locations. Finally, they may be more appropriate for non-electric applications such as district heating, desalination, hydrogen production and oil production from tar sands and heavy crudes. To investigate these various uses, the Agency organized a seminar in Cairo in May on the status and prospects for SMRs, in co-operation with the OECD NEA and the World Nuclear Association (formerly the Uranium Institute). Hosted by the Nuclear Power Plants Authority of Egypt, the seminar looked at innovative SMR concepts with an emphasis on simple and standardized designs, reduced construction times, enhanced safety and reliability and proliferation resistance. Co-generation applications of SMRs such as nuclear seawater desalination and the necessary infrastructure development were also discussed. The major conclusions of the seminar were that with population growth in developing countries greatly increasing the demand for energy and electricity, SMRs were likely to play an important role in these countries. There would also be a continuing global need for different types and sizes of reactors for a range of applications. However, economic competitiveness and public acceptance were seen as the two most critical factors for the growth of nuclear power. There was agreement that the rapid development of commercial SMRs was of great importance as most developing countries would not be willing to wait for two or three decades to increase their electricity capacity. ■

the area of heavy liquid metal coolants for fast reactors. Data on thermophysical and thermal-hydraulic parameters of lead and lead–bismuth eutectic have been collected, reviewed and prepared for documentation, and a comparative assessment was carried out of sodium characteristics.

A new web site *(http://www.iaea.org/inis/aws/fnss)* provides an overview of an Agency project on technology advances in fast reactors and accelerator driven systems for actinide and long lived fission product transmutation. Apart from power production, the rationale for this project stems from public concerns regarding the long term storage of nuclear waste. Fast reactors and accelerator driven systems are being developed in some Member States as a possible response to the challenges of long term waste storage and potential proliferation risks. Through this project, the Agency facilitates information exchange and collaborative R&D, thereby fostering the pooling of resources and expertise. The main objectives of the project are to establish the technical and economic feasibility of new, advanced fast reactor designs, and to provide the basis for hybrid systems technology development activities in Member States.

Starting its second phase of work, the International Nuclear Desalination Advisory Group (INDAG) reviewed recent activities in this area, evaluated the Agency's programme and proposed possible new activities for 2004–2005 to accelerate the deployment of nuclear desalination projects. The first edition of *Newsletter on INDAG*, issued in July, provided information on nuclear desalination activities in several Member States, particularly the demonstration project in Kalpakkam, India.

In October, the National Nuclear Energy Agency of Indonesia and the Korea Atomic Energy Research Institute reached agreement on a joint pre-feasibility study of a nuclear desalination plant in Indonesia under the Agency's interregional technical co-operation programme. A similar agreement was reached between the French Commissariat à l'Energie Atomique and the Tunisian Authority. These important agreements facilitate projects between technology holders and end-users, leading to integrated nuclear desalination systems generating both power and heat.

Other developments in nuclear desalination included:

— Publication of a document on *Safety Aspects of Nuclear Plants Coupled with Seawater Desalination Units* (IAEA-TECDOC-1235);
— Establishment of a web site with information on the technology of nuclear seawater desalination, past and current activities of the Agency, major activities in Member States, sample calculations with the Agency's DEEP software and relevant Agency publications;
— A progress report to the General Conference in September on the Agency's activities in nuclear desalination. Thereafter, in Resolution GC(45)/RES/12, the Conference requested "the Director General to note the high priority given by Member States to the nuclear desalination of seawater and SMR development ... and promote effective international information exchange and co-operation in this area".

A new CRP entitled 'Economic Research on and Assessment of Selected Nuclear Desalination Projects and Case Studies' was launched. Together with an ongoing CRP on the optimization of the coupling of nuclear reactors and desalination systems, this project will facilitate the co-ordination of current and planned national studies on seawater desalination in Member States.

The International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) — a major extrabudgetary initiative co-ordinated by the Agency — is based on a General Conference resolution in September 2000 that invited all interested Member States, both technology suppliers and users, to consider jointly international and national actions required to achieve desired innovations in nuclear reactors and fuel cycles. In Resolution A/RES/56/94, "Report of the International Atomic Energy Agency", the UN General Assembly emphasized "the unique role that the Agency can play in developing user requirements and in addressing safeguards, safety and environmental questions for innovative reactors and their fuel cycles" and stressed

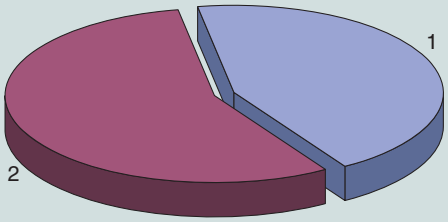
"the need for international collaboration in the development of innovative nuclear technology". During the year INPRO's Steering Committee approved the project's organizational structure, outline of the proposed report, resources, overall schedule, work plan and tasks. A second meeting in December reviewed initial progress reports and approved continued development of the project. Work also began on user requirements in five areas: economics and resources, safety, environmental impacts, proliferation resistance and "cross-cutting issues", which include infrastructural and industrial requirements, and legal and institutional requirements, as well as education, training and R&D. A sixth task was begun to develop assessment methods and criteria for applying these user requirements to specific innovative nuclear designs.

NUCLEAR FUEL CYCLE AND WASTE MANAGEMENT TECHNOLOGY

PROGRAMME OBJECTIVE

To have the latest fuel cycle and waste management strategies adopted in an increasing number of Member States and related state of the art technologies in place in an increasing number of facilities; and to facilitate the planning and implementation of safe, sustainable, cost efficient and environmentally sound nuclear fuel cycle and waste management activities in Member States.

Regular budget expenditure:$5 018 868
Extrabudgetary programme expenditure (not included in chart): $609 508



1. Fuel Cycle and Materials: $2 201 109
2. Waste Management and Technology: $2 817 759

KEY ISSUES AND HIGHLIGHTS

- The latest edition of the IAEA–OECD NEA "Red Book" — *Uranium 2001: Resources, Production and Demand* — was published. A complementary report, *Analysis of Uranium Supply to 2050*, was also published by the Agency.

- Key milestones were achieved in the areas of: mixed oxide (MOX) fuel technology; water chemistry and corrosion control in nuclear power plants; and zirconium alloy degradation by hydrogen.

- With fuel storage periods in some instances becoming longer than originally foreseen, the Agency focused on issues connected with long term dry storage, the implications for fuel fabrication and burnup credit.

- Initiatives to address the issue of geological repositories and the lack of infrastructure and resources to implement available technologies in many developing Member States included: the creation of an 'International Network of Centres of Excellence for Demonstration and Training in Geological Disposal'; and an international conference on the management of radioactive waste from non-power applications.

FUEL CYCLE AND MATERIALS

A new edition of the "Red Book" — *Uranium 2001: Resources, Production and Demand* — was completed and published jointly with the OECD NEA. The Red Book is the foremost world reference on uranium supplies, and includes projections of nuclear energy growth through 2020 and implications for uranium supply and demand. The Agency also published a complementary study, *Analysis of Uranium Supply to 2050*. This study considers both primary supplies (newly produced uranium) and secondary supplies (from reprocessed fuel and surplus nuclear weapons). The report concludes that known resources are adequate to satisfy primary supply requirements through about 2034 in a middle demand case, after which currently speculative, undiscovered resources would need to be developed. Figure 1 shows the projected shortfall in market based production assuming that high enriched uranium (HEU) from nuclear weapons will not be available after 2023 and excess inventories will have been drawn down to strategic levels. Known resources are adequate to satisfy market based requirements to 2034. Cumulative production derived from known resources is adequate to satisfy 80% of total market based production requirements to 2050.

A new report, *Manual of Acid In Situ Leach Uranium Mining Technology* (IAEA-TECDOC-1239), examines in situ leaching (ISL), a relatively new mining approach with both economic and environmental advantages for extracting uranium from suitable sandstone type deposits. ISL has accounted for 13–15% of world output in recent years and is expected to grow further given its low costs and environmental advantages. This document covers uranium geology, geo-hydrology, chemistry, reservoir engineering and process engineering.

In the area of nuclear fuel performance and technology, the Agency began a new CRP on data processing technologies and diagnostics for water chemistry and corrosion control in nuclear power plants (DAWAC). The goal of this project is to develop and implement the most effective systems to collect, evaluate, process and diagnose water chemistry data for a variety of nuclear power plant designs.

Delayed hydride cracking can result in the failure of pressure tubes in CANDU reactors and may contribute to fuel cladding failures in

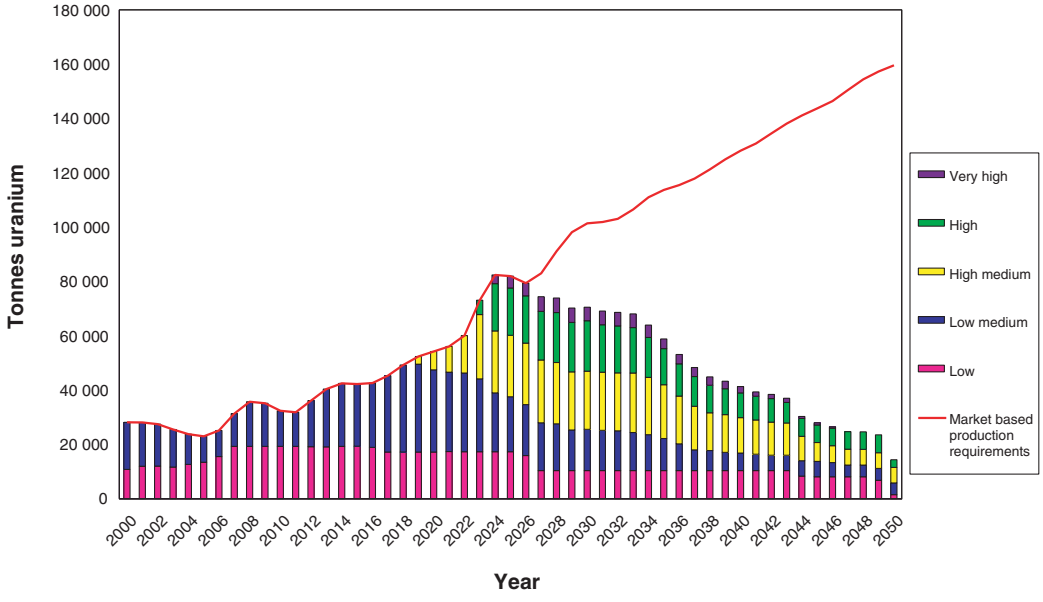


FIG. 1. Projection of market based production from a study of reasonably assured resources by cost category — middle demand case.

LWRs. In a CRP on hydrogen and hydride degradation of zirconium alloys, the Agency completed a round robin exercise to address the difficulties of accurately measuring hydrogen concentrations in zirconium alloys at the low levels often of practical importance. A major outcome of this exercise was an improvement in the techniques used at several participating laboratories.

To address fuel safety issues under sharp transients and accident conditions, the Agency convened a Technical Committee meeting to: review current experimental programmes; analyse the validity and applicability of existing loss of coolant (LOCA) and reactivity initiated accident (RIA) criteria; assess existing databases; and determine needed criteria revisions and new experiments. The participants made recommendations on revising existing LOCA and RIA criteria as they apply to licensing procedures. Licensing criteria dealing with enthalpy deposition for RIAs, for example, may no longer be valid and may require rethinking, both in terms of limit values and whether they actually target the correct failure mechanism.

Spent fuel is accumulating at about 10 500 tonnes of heavy metal (t HM) per year worldwide. Only one third of this is reprocessed — the remaining two thirds must be stored. With storage periods becoming longer, it will be necessary in the near future to extend the licences of existing storage facilities. The long term behaviour of spent fuel and materials during storage is also becoming increasingly important.

In this connection, the Agency completed a CRP on Spent Fuel Performance Assessment and Research (SPAR) dealing with the behaviour of spent fuel and structural materials during long term storage. The principal conclusions were that extending the period of interim storage is a general trend in the countries participating in the CRP regardless of the policy adopted for closing the 'back end' of the nuclear fuel cycle. However, extending the storage period requires knowledge of fuel evolution during very long term storage and the behaviour of the storage system. It is therefore important to maintain the continuity of knowledge for fuel assemblies during the entire fuel cycle and to have a system for registration and documentation using a data storage medium that can be read and used well into the future, i.e. longer than 100 years. In general, the wet storage performance of LWR fuel is excellent. In dry storage, no degradation mechanisms are known and no detrimental experience has been reported. Dry storage has become a mature technology, with almost 20 years of favourable experience for spent power reactor fuel and about 30 years for research reactor fuel. It is important to have dense concrete structures that keep free water to a minimum, making them less vulnerable to freeze–thaw cycles. However, monitoring technologies are particularly important for the long term storage of spent fuel, including monitoring of fuel cladding and component integrity, as well as containment system integrity.

Using extrabudgetary funds, the Agency modified the COBRA-SFS code for use on PCs and held a training workshop to apply the modified code. With this code, countries with WWERs can perform thermal-hydraulic calculations for both cask/container and multivault dry storage systems directly on PCs.

More than 90% of all research reactor fuel is clad in aluminium and stored in water. A CRP that studied the corrosion of such fuel in water was completed. One conclusion was that suboptimal water quality is a major cause of localized corrosion that can eat through the cladding. A number of research reactors already have such leaking fuel. The CRP determined the optimum water chemistry conditions to minimize corrosion. The results have been disseminated to Member States and have already had an appreciable impact on water chemistry control at several facilities.

In the last five years, 674 tonnes of HEU have been declared surplus to defence programmes. A Technical Committee meeting in November analysed the impact of this material on the uranium production market. It was concluded that low enriched uranium blended down from HEU plays an essential role in maintaining the supply of civil uranium resources. In addition, there were still a number of research reactors using HEU.

To date, more than a million tonnes of depleted uranium (DU) have accumulated as a result of

enrichment operations. The Agency addressed this issue jointly with the OECD NEA, producing a report that focused on the management of DU. Among the issues discussed in this report were the length of time that DU could be stored, in what form it would be stored and the implications of its final disposal.

Recent changes in nuclear fuel markets, particularly as a result of market liberalization and expanding nuclear programmes in Asia and Eastern Europe, have created the need for up to date information on national and international fuel cycle activities. In response, the Agency published *Country Nuclear Fuel Cycle Profiles* (Technical Reports Series No. 404), which offers national profiles that can be used by both experts and the public.

WASTE MANAGEMENT AND TECHNOLOGY

Radioactive wastes arising from the operation of nuclear installations require timely and effective management. To this end, accurate assessments of radioactive wastes from all sources are necessary, and safe, cost effective and environmentally sound technologies should be made available for Member States to manage and dispose of their nuclear waste. A related area is decommissioning technology for nuclear power and research reactors. For example, some 200 currently operating research reactors are at least 30 years old and will soon be candidates for decommissioning. Many are in Member States where decommissioning experience may not be readily available.

A CRP that ended in 2001 focused on how decommissioning technology could be improved, adapted or optimized for the specific needs of research reactors. Examples include the development or adoption of simpler decommissioning technologies in place of purchasing costly equipment, such as remote handling equipment. One observation of the CRP was that there is now a trend towards early planning for decommissioning. This was in contrast to the widespread belief in the past that resources required for decommissioning would be readily available whenever needed. This resulted in inadequate planning for decommissioning, including insufficient provision for the required infrastructure (e.g. the absence of decommissioning oriented regulations) or financial resources. Another issue was that despite the maturity of the nuclear decommissioning technology/industry, at least in developed countries, there were still some areas where more work was needed. Thus, technological developments were needed in the treatment and disposal of decommissioning wastes, particularly medium and high activity materials. There is also a clear desire on the part of individual Member States to develop their own decommissioning technologies. This is partly due to the need to understand the effects of decommissioning under site specific conditions in order to satisfy the nuclear regulators, and partly because many processes are proprietary formulations that are expensive to buy on the open market. Achieving the proper balance between developing project and country specific technologies and purchasing technologies in the open market remains a serious challenge for many countries.

To help Member States improve systems, programmes and activities that support nuclear applications and the fuel cycle, including the legacy of past practices and accidents, the Agency established a new *Directory of Radioactively Contaminated Sites* (DRCS). It covers past environmental contamination from the production and processing of nuclear materials, mining, milling, weapons testing, inadequate waste management, and accidents involving nuclear materials. Documentation was also published describing the content, functionality and conceptual layout of the DRCS.

Most Member States have to provide for the safe management of institutional radioactive waste, and many also have to manage naturally occurring radioactive material wastes and disused radioactive sealed sources. 'Management of Radioactive Waste from Non-Power Applications: Sharing the Experience', an Agency conference held in Malta in November, enabled States without nuclear power programmes to share information and learn from experience gained in countries with nuclear power plants. The conference recommended enhanced co-operation to solve technical, organizational and regulatory problems, and emphasized the role of the Agency in co-ordinating these efforts. In

particular, it was recommended the Agency: promote good practices for the management of different types of waste; encourage innovative technology development; organize training and provide methodological support in the management of specific wastes; and set risk levels and standards.

Thousands of tonnes of radioactive graphite and carbon waste are by-products of the decommissioning of an entire generation of graphite moderated nuclear power and research reactors. In addition, its high chemical stability makes irradiated graphite difficult to process for final disposal. An Agency study concluded that the wide variety of graphite forms, contamination levels and physical and chemical characteristics do not permit a universal solution for waste processing and disposal. Management difficulties arise due to the large volume of contaminated graphite and the presence of certain radionuclides (tritium and carbon-14). In addition, high levels of Wigner energy stored in the graphite lattice may lead to problems during processing as well as disposal. On the positive side, the good mechanical properties and relatively high chemical stability of graphite were noted, permitting simplification of the waste conditioning process. In the light of these facts, it was concluded that the processing and disposal of graphite wastes need to be considered on a case by case basis.

Many Member States are engaged in, or planning, the near surface disposal of low and intermediate level waste, creating a need for information and guidance. The Agency has been studying the relevant technologies and issues concerning the development, siting, safety and performance assessment, and implementation of disposal systems. Non-technical concerns, including socioeconomic, institutional, local and national infrastructure, public policy, acceptance and quality management issues have also been addressed. Reports were completed on: *Characterization of Groundwater Flow for Near Surface Disposal Facilities* (IAEA-TECDOC-1199); *Technical Considerations in the Design of Near Surface Disposal Facilities for Radioactive Waste* (IAEA-TECDOC-1256); *Procedures and Techniques for Closure of Near Surface Disposal Facilities for Radioactive Waste* (IAEA-TECDOC-1260); and *Performance of Engineered Barrier Materials in Near Surface Disposal Facilities for Radioactive Waste* (IAEA-TECDOC-1255).

The Agency has a particularly important role to play in fostering co-operation, advancing research and building public confidence in the overall science and technology of disposing high level, long lived radioactive wastes in deep geological repositories. Underground research laboratories (URLs) have a central contribution to make to this effort. For three decades several Member States have conducted extended experimental and demonstration programmes in URLs, providing valuable assessments of potential disposal systems in various geological environments. In order to disseminate this information on a wider basis, the Agency published *Use of Scientific and Technical Results from Underground Research Laboratory Investigations for the Geological Disposal of Radioactive Waste* (IAEA-TECDOC-1243). The opportunity to share expertise, promote international consensus on geological disposal and expand expertise through training and hands-on experience in URLs was offered to the Agency by Belgium, Canada and the USA. These States have been designated as the founding members of the 'International Network of Centres of Excellence for Demonstration and Training in Geological Disposal', which was officially established by the Agency in 2001. The objective of the network is to facilitate the transfer and preservation of knowledge and technologies, supplement national efforts to resolve key technical issues and promote public confidence in waste disposal schemes.

In the area of predisposal management of radioactive waste from nuclear applications, a new training programme in the quality management of radioactive waste was initiated with an emphasis on quality assurance. The plan is to select waste management facilities in different regions that will host training sessions for waste management operators and regulators.

One of the Agency's major tasks is to assist Member States in rendering spent radium sources safe. Such assistance was provided in 2001 to Ethiopia, Indonesia, Lebanon, Philippines, Slovenia, Thailand, Zambia and Zimbabwe. The Agency's newly developed

'International Catalogue of Sealed Radioactive Sources and Devices' is an essential component of this expert advice. The catalogue now includes basic technical data, design features and illustrations for more than 1800 radioactive source models and 300 devices, as well as the address and company history of more than 900 manufacturers and distributors. In addition, two technical documents were published in support of these Agency advisory and assistance projects — *Management for the Prevention of Accidents from Disused Sealed Radioactive Sources* (IAEA-TECDOC-1205) and *Waste Inventory Record Keeping Systems (WIRKS) for the Management and Disposal of Radioactive Waste* (IAEA-TECDOC-1222).

Information collection and dissemination efforts included the release in July of the new 'Net Enabled Waste Management Database' (NEWMDB), which contains waste management information from correspondents nominated by Member States. Data have been collected on national radioactive waste management programmes and organizations, plans and activities, relevant laws and regulations, policies and radio-active waste inventories.

The Contact Expert Group (CEG) for International Co-operation in Radwaste Management with the Russian Federation — for which the Agency acts as the Secretariat — continued to promote and co-ordinate efforts to improve the management of spent nuclear fuel and radioactive waste. In 2001, several new projects were initiated. The first focuses on the Andreeva Bay ex-navy technical base located on the north shore of the Kola Peninsula, which was used for more than 30 years to store radioactive waste and spent nuclear fuel from submarines. About 100 submarine reactor cores have been accumulated and stored in conditions that require improvement. In October, a CEG workshop reviewed Russian technical information and developed project proposals that were formally endorsed by the CEG in November, with negotiations on these projects starting thereafter. Another project deals with the commissioning of two new installations for liquid radioactive waste treatment, one at the Atomflot enterprise in Murmansk (built with the co-operation of Norway and the USA), and the other at the Zvezda plant near Vladivostok (built with Japanese assistance). These installations are designed to eliminate all radioactive releases into the sea during submarine decommissioning. Other projects that have been endorsed by the CEG include rehabilitation of the Murmansk RADON centre and construction of a repository for solid radioactive waste at the Novaya Zemlya Archipelago.

Agency technical co-operation projects are designed to enhance the organizational capabilities of Member States. This is of particular importance for reactor decommissioning, which is a multidisciplinary process requiring an integrated approach that makes optimum use of national and international resources. In this regard, several projects achieved significant milestones during the year. In Slovakia, the Agency provided expertise and training on remotely operated and robotic equipment for decommissioning the A-1 nuclear power plant. Another project focused on developing plans and the necessary infrastructure for decommissioning Ukrainian WWERs. The Agency is also assisting Lithuania in planning for the decommissioning of Unit 1 of the Ignalina nuclear power plant. Through these projects information and know-how on active decommissioning was transferred to States *planning* decommissioning activities. In addition, financial considerations and other impacts of decommissioning were highlighted.

Building capacity in Member States to manage radioactive waste is another important aspect of the Agency's technical co-operation programme. A new project focuses on uranium mining in Portugal, studying numerous small mining and milling sites as well as a former radium processing site. It will also assess and quantify the potential environmental impacts of these sites.

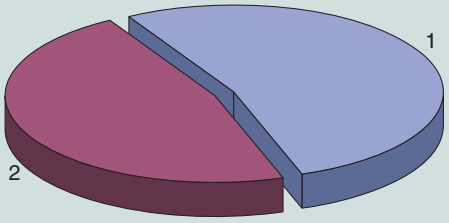
COMPARATIVE ASSESSMENT FOR SUSTAINABLE ENERGY DEVELOPMENT

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: $2 336 980

Extrabudgetary programme expenditure (not included in chart): $103 460



1. Energy Modelling, Databanks and Capacity Building: $1 240 847
2. Energy, Economy, Environment (3E) Analysis: $1 096 133

KEY ISSUES AND HIGHLIGHTS

- New methodological tools to aid in informed decision making were developed and distributed to Member States.
- Analytical reports were completed on the impact of competition on nuclear power, and on the importance of nuclear power for environmental protection and greenhouse gas mitigation.
- Capacity building was promoted through the dissemination of methodologies, provision of training and convening of information seminars for Member States.
- The Agency organized two information seminars at the Commission on Sustainable Development's Ninth Session (CSD-9) (the first to address energy issues) and served as the source of nuclear expertise at UN negotiations on energy, sustainable development and climate change.

ENERGY MODELLING, DATABANKS AND CAPACITY BUILDING

The Agency provides the data, information and analytical tools to support informed decision making by Member States — particularly developing Member States — on sustainable energy development strategies, energy and environmental policies and investment decisions. The Energy and Economic Data Bank (EEDB), for example, is a collection of time-series data for all Member States of the UN system with historical information on energy and electricity production and use, and the status of nuclear power at country, regional and global levels. It also contains medium and long term projections for energy and electricity demand, as well as regional and global projections on nuclear power development. Figure 1 shows the 2001 projections using information from the EEDB. The low projection assumes only the completion of firm plans for new nuclear power plants or the retirement of old ones that have been announced by governments and companies. The high projection reflects additional power plants that are included less firmly in government and company plans, but are judged to be highly plausible by expert meetings convened periodically by the Agency for this purpose.

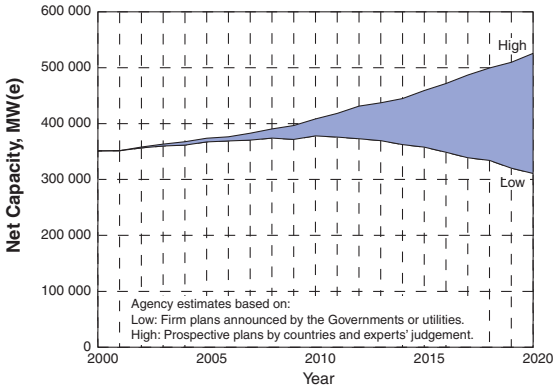


FIG. 1. Outlook for the global development of nuclear power (source: Energy, Electricity and Nuclear Power Estimates for the Period up to 2020, *Reference Data Series No. 1, IAEA, Vienna (2001)).*

In addition to data collection, the Agency provides a package of planning models, developed (or adapted from models in industrialized countries) to match the data availability conditions typical in developing Member States. The models are used to analyse alternative approaches to sustainable energy development (Table I). Although the package is very flexible

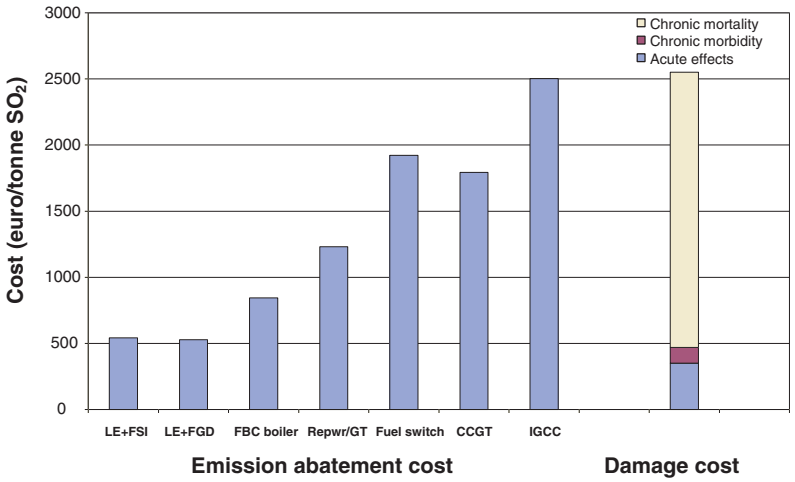
TABLE I. **AGENCY PLANNING MODELS AND THEIR DISTRIBUTION**

Type of package	Description	Releases to Member States
ENPEP	Evaluates energy system development strategies	43
FINPLAN	Assesses the financial viability of energy proposals, including cash flows and financial ratios	17
MAED[a]	Evaluates future energy needs based on development scenarios in a country or region	41
MESSAGE	Formulates and evaluates alternative energy supply strategies for a country or region	10
Simpacts	Estimates environmental impacts and costs using minimum data input	18
WASP	Identifies the optimal long term expansion plan for a power generating system within constraints defined by the user	49

[a] MAED: Model for Analysis of Energy Demand.

and has been used in countries as diverse in size as Armenia and China, it needs regular updating to remain abreast of both technological and institutional changes, including energy market liberalization and stricter environmental controls. An Advisory Group meeting at Argonne National Laboratory, USA, recommended upgrades to the user interfaces of ENPEP (Energy and Power Evaluation Program), FINPLAN (Model for Financial Analysis of Electric Sector Expansion Plans) and MESSAGE (Model of Energy Supply Systems and General Environmental Impacts), extending ENPEP to include infrastructure costs and adding features to FINPLAN to deal with new high priority issues such as electricity imports and exports, and combined heat and power plants. The improvements to ENPEP and FINPLAN were completed in 2001, as was phase I of the MESSAGE improvements. An updated version of the WASP-IV (Wien Automatic System Planning Package) user's manual was also published.

During the year SIMPACTS — Simplified Approach for Estimating Environmental Impacts and External Costs of Electricity Generation — was added to the Agency's planning model package. Developed principally for developing Member States, SIMPACTS allows decision makers to make reasonable estimates of environmental impacts and costs using a minimum amount of input data. The analysis is simple, transparent and user friendly. While not intended as a replacement for a detailed environmental impact assessment, SIMPACTS is capable of producing results that are similar to those obtained through such methods. Currently, there are four modules in SIMPACTS: AIRPACTS for quantifying the impacts and costs of damage due to atmospheric emissions (Fig. 2); NUKPACTS for assessing the collective doses and latent health effects from the routine operation of nuclear facilities and the external costs due to accidents and waste disposal; HYDROPACTS for calculating the damage costs of hydropower dams resulting from resettling people due to flooding and lost land use; and 'DAM', a decision aiding model permitting multi-criteria policy analysis. All four modules were externally peer reviewed in 2001. A CRP was also completed that success-



LE +FSI: life extension + retrofitting of furnace sorbent injection SO_2 control.

LE+FGD: life extension + flue gas desulphurization + low NO_x burners.

FBC boiler: fluidized bed combustion boilers.

Repwr/GT: repowering with gas turbine.

Fuel switch: coal → coal+gas.

CCGT: combined cycle gas turbine.

IGCC: integrated gasification combined cycle.

FIG. 2. Comparison, using AIRPACTS, of the costs of different emission abatement options and health damage costs per tonne of SO_2 for the Ostrołęka power plant in Poland.

fully field tested SIMPACTS for applicability over a wide range of external cost questions. The Agency has begun to use SIMPACTS in its own analytical work. For example, in co-operation with the World Bank, the Agency completed a preliminary assessment in Belarus of the external costs due to environmental damages from the Chernobyl accident. The project focused primarily on assessing the agricultural, forest and water resource sectors, the need for additional monitoring, and especially the effects of agricultural countermeasures on the health and environmental impacts of exposure to caesium-137 from the 1986 Chernobyl accident.

Agenda 21, which was agreed at the 1992 'Earth Summit' in Rio de Janeiro and is the subject of the August 2002 World Summit on Sustainable Development (WSSD) in Johannesburg, calls on "Countries at the national level and international governmental and non-governmental organizations at the international level [to] develop the concept of indicators of sustainable development..." The Indicators for Sustainable Energy Development (ISED) that the Agency has subsequently developed are designed to help national policy makers assess and monitor the contribution of energy to sustainable development in their countries, the impacts of energy on environment, economic and social development, and the inter-relationship between these issues. Other agencies that have formally affiliated themselves with ISED include the OECD International Energy Agency, the UN Department of Economic and Social Affairs and the UN Economic Commission for Europe. In April 2001, the Agency reported on phase I of this project at CSD-9, in New York. Phase I involved a review of the indicator sets and statistics in the energy field, development of a set of 41 indicators and field testing of these indicators. Phase II, starting in 2002, involves streamlining the ISED package and its introduction into the statistical regimes of the Member States of the various sponsoring agencies. Part of this effort will take place under the aegis of a CRP.

Building capacity in Member States and providing technical assistance are two major objectives of the Agency's programme in Comparative Assessment for Sustainable Energy Development. And technical co-operation projects are one of the means for achieving these goals. In a regional project for Asia, 11 Member States received assistance in carrying out studies on the role for nuclear power and other energy options in their countries. Similar projects in Sub-Saharan Africa and in Eastern Europe are helping to build local capabilities for addressing sustainable development issues in national energy policies, thereby contributing to progress on *Agenda 21*.

ENERGY, ECONOMY, ENVIRONMENT (3E) ANALYSIS

To supplement assistance to Member States and to support the studies they may carry out independently, the Agency provides analyses of current topics and concerns, with a strong focus on issues relating to economics and competition, environment and climate change, and sustainable development. As part of this work it seeks to reach out to a broad international audience on the role for nuclear energy in increasingly competitive markets, in mitigating potential climate change and in helping to achieve sustainable development. In this regard, a CRP that ended in 2001 focused on establishing appropriate methodologies and developing suitable analytical tools for Member States analysing the potential contributions of various energy technologies to greenhouse gas (GHG) reductions. Country studies were carried out, each examining a wide range of reduction possibilities at both the national and regional levels. Figure 3, for example, shows the projected extent of avoidance of GHG emissions by nuclear power in the USA for three scenarios with different assumptions about the retirement, life extension and new additions of nuclear power plants. The results of these national studies were also used by some countries directly in official communications to the United Nations Framework Convention on Climate Change (UNFCCC).

The Agency also participated in several key UN activities in 2001 in the fields of sustainable development, environment and climate change. In the 'Third Assessment Report', published in 2001 by the Intergovernmental Panel on Climate Change (IPCC), the Agency contributed to the report of Working Group III, 'Mitigation', which concluded that nuclear power plants have

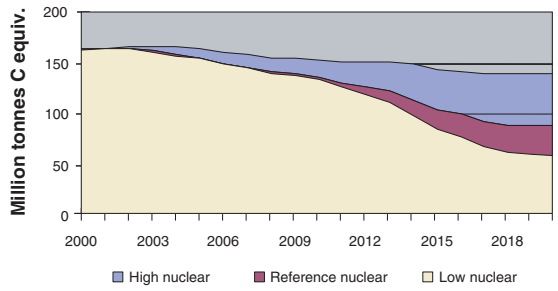


FIG. 3. Projected GHG offsets by nuclear power in the USA.

the highest potential for GHG mitigation in the energy sector, and abatement costs that are among the lowest (see Tables A4–A7 in the Annex).

In addition, as the expert body on nuclear science and technology within the UN family, the Agency has an important role as an information source on nuclear energy for Member States involved in ongoing UN negotiations in the CSD and the Conference of the Parties (COP) to the UNFCCC. CSD-9 was the first session of the CSD to specifically focus on energy. The Agency prepared background information on nuclear energy and organized two information events — one on ISED (described above) and the other on issues central to the debate surrounding nuclear energy's role in sustainable development.

Two outcomes from CSD-9 are significant for nuclear energy. First, the parties agreed to disagree on nuclear energy's role in sustainable development. The final text noted that some countries see nuclear energy as a substantial contributor to sustainable development, while others consider the two to be fundamentally inconsistent. The second significant outcome was unanimous agreement that, "the choice of nuclear energy rests with countries".

The Agency was also present at the 2001 meetings of the UNFCCC COP — COP-6 Part 2, in Bonn in July, and COP-7, in Marrakesh in November. The latter meeting (dubbed the "Marrakesh Accords") was successful in reaching agreement on implementation rules for the Kyoto Protocol. For nuclear energy this was an important step forward since it produces virtually no GHGs and currently avoids 7–8% of global GHG emissions. However, except for a very few instances, there have been no restrictions or taxes on GHG emissions and thus no economic value to their avoidance. The Kyoto Protocol is the world's only currently operative route towards widespread, co-ordinated restrictions on GHG emissions. Thus, the Marrakesh Accords represent a significant step towards attaching a tangible economic value to nuclear power's avoidance of such emissions. However, much of the nuclear industry and the press focused on the Marrakesh Accords' exclusion of nuclear projects from two of the three flexible mechanisms in the Kyoto Protocol, namely joint implementation and the clean development mechanism (the third mechanism is emissions trading). This exclusion reduces cost effectiveness and does not advance the essential UNFCCC objective of stabilizing "greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system".

In order to ensure that nuclear power is given a full and fair hearing in the sustainable energy debate, the Agency conducts studies comparing nuclear power with non-nuclear alternatives. In 2001, the Agency's analyses of the economic future of nuclear power in competitive markets covered an assessment of technology learning needs and experience in the nuclear industry, and the implications for future market growth. This work included an overview of future energy markets, including alternative scenarios for development and niche markets for nuclear power. It also included an assessment of the potential contribution of nuclear energy in a future hydrogen economy.

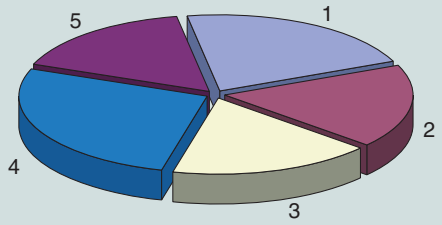
FOOD AND AGRICULTURE

PROGRAMME OBJECTIVE

To enhance capacities at national and international levels for identifying and alleviating constraints to sustainable food security by facilitating the development and adoption of nuclear and related biotechnologies.

Regular budget expenditure: $9 675 594

Extrabudgetary programme expenditure (not included in chart): $2 214 614



1. Soil and Water Management and Crop Nutrition: $2 076 245
2. Plant Breeding and Genetics: $1 705 067
3. Animal Production and Health: $1 701 941
4. Insect and Pest Control: $2 609 023
5. Food and Environmental Protection: $1 583 318

KEY ISSUES AND HIGHLIGHTS

- The 1964 Arrangements between the Directors General of FAO and the Agency for the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture (which plans and implements the food and agriculture programme at the Agency) were revised to enhance their effectiveness. The main features of the new Arrangements include redefinition of the responsibilities of the Joint Division and establishment of a steering committee composed of representatives from the two organizations to oversee the programme's direction and implementation, and review staff and strategic issues.

- Significant achievements were made in applying radiation and isotopic techniques in research, leading to the optimization of water and nutrient use by plants, and ultimately ensuring sustainable crop and livestock productivity and environmental preservation.

- To support human capacity building and technology transfer, standard operating and good laboratory procedures, manuals and guidelines were developed for use by Member State scientists and technicians. Self-reliance at the national and regional levels was also promoted.

SOIL AND WATER MANAGEMENT AND CROP NUTRITION

Soil organic matter, which is a key component of soil fertility, is concentrated in the surface soil and is rapidly lost under tropical conditions through accelerated oxidation due to conventional cultivation practices under hot, moist conditions, as well as through water erosion processes. This rapid loss can be arrested through appropriate soil conservation measures that include retention of crop residues. A CRP completed during the year supported national efforts in 11 Member States to identify management options for crop residues for sustainable agricultural production and environmental preservation in a wide range of soils and cropping systems. Various options for the recycling of crop residues that are sustainable and economically attractive to farmers were examined using isotopic techniques. The value of simple practices using wheat and rice residues to produce compost as an alternative to stubble burning was demonstrated. Such practices can have important implications apart from the desired maintenance of soil organic matter and improving plant growth. For example, millions of tonnes of rice and wheat straw are burnt annually worldwide, causing atmospheric pollution and producing large quantities of carbon dioxide, a greenhouse gas. In addition, various gaseous forms of nitrogen are emitted during burning, representing a loss of fertilizer equivalents and significant pollution of the environment by nitrous oxide.

Soil erosion and associated sediment deposition are natural landscape forming processes that can be accelerated by such human interventions as deforestation, overgrazing, excessive tillage and other non-sustainable farming practices. Recognizing erosion as a serious threat to sustainable agricultural production and hence global food security, the Agency formed two international research networks — through CRPs — involving 25 Member States, to develop standardized methodologies for measuring soil redistribution at the catchment level. The studies resulted in a validated and cost effective technique, based on the fallout radionuclide caesium-137, that provides spatially distributed and time integrated estimates of soil erosion and sedimentation rates in a wide range of environments and scales worldwide. In addition, institutional capacity in the various Member States for conducting applied research on soil erosion has been greatly enhanced. Standardized protocols and methodologies for the use of the caesium-137 technique have paved the way for field testing of strategies to control soil erosion, and to obtain a better understanding of the relationships between rates of soil loss and soil and water quality, soil carbon and nutrient redistribution, and the fate of agrochemicals and related contaminants in the landscape.

Human resources development is an important service provided by the Agency to Member States through its CRPs and the technical cooperation programme. The Agency's Laboratories at Seibersdorf provided training in total nitrogen and nitrogen-15 isotope analyses of soil and plant materials and associated quality assurance procedures. Fellowship training was provided to scientists on radiation and isotope methods to monitor flows and the balance of nutrients and water in cropping systems. To support human resources development activities, a new training manual, *Use of Isotope and Radiation Methods in Soil and Water Management and Crop Nutrition*, was published.

PLANT BREEDING AND GENETICS

Global banana production, which totals around 95 million tonnes per year and ranks fourth after cereals, is threatened by many pests and diseases such as Black Sigatoka, *Fusarium* wilt, nematodes and viruses. Among the achievements of a recently concluded CRP on cellular biology and biotechnology, including mutation techniques, for the creation of new useful banana genotypes were the generation and screening in Cuba, Malaysia, Philippines and Sri Lanka of a series of mutants for desirable traits such as early flowering, reduced height, large fruit size and tolerance to *Fusarium*. 'Novaria' — a banana mutant variety derived from mutation induction of 'Grande Naine' with improved traits such as early flowering, short stature, high yield potential and good flavour — was released in Malaysia. Further breakthroughs included: identification of methods for the analysis of karyological stability using a

DNA flow cytometer; early screening of *Fusarium* wilt disease; a selection system against Black Sigatoka disease; and a screening technique for nematode resistance. Significant advances were also made in the application of molecular marker and cytogenetic techniques for the detection of different genomes of *Musa,* and in the genetic stability of micropropagated banana plants. Finally, the CRP helped several young researchers in receiving advanced degrees in Belgium, the Czech Republic and Israel.

A technical co-operation project in Viet Nam led to the development of a new and improved saline tolerant rice mutant, CM6, with an attractive long grain and a higher yield of 3–4.5 tonnes per hectare. The market price for this long grain variety is about one and a half times higher than the price of the currently available salinity tolerant rice mutant variety CM1. In addition, a number of mutant varieties, produced through other technical co-operation projects were officially released (see Table I).

Molecular markers are rapidly being adopted by plant breeders as effective and appropriate tools for accelerating the breeding process. In order to introduce new and promising marker techniques to Member States, a new training programme was developed. The first interregional course in this programme, on mutant germplasm characterization using molecular markers, was held at the Agency's Laboratories at Seibersdorf.

Free access to crop mutants is essential for their widespread use in locations other than their origin of development. Moreover, mutants have become valuable tools in functional genomics and proteomics. An FAO/IAEA Mutant Germplasm Repository was set up at the Agency's Laboratories at Seibersdorf with the aim of collecting and freely distributing mutant germplasm to researchers. An Internet accessible database was also developed to promote the exchange of germplasm from donors to recipients in Member States *(http://www.iaea.org/programmes/nafa/navig/index.html).*

ANIMAL PRODUCTION AND HEALTH

Efficient and robust disease diagnostic tools are essential for any disease control or eradication programme. In 2001, the production and development of animal disease diagnostic kits

TABLE I. **MUTANT VARIETIES OF PLANTS RELEASED BY THE AGENCY IN 2001**

Country	Crop/ornamental plant	Name of mutant variety	Changed character
Mali	Sorghum	Fambe, Tiedjan, Gnome	Increased yield, lodging resistance, improved grain quality, disease (striga) resistance
Egypt	Sesame	Taka 1, Taka 2, Taka 3, Tushki, Shandawill 3	Disease and insect resistance
Malaysia	Orchid (*Dendrobium*)	Sonia Keena Ahmad Sobri	Diamond shaped petals
	Oysterplant (*Tradescantia spathacea*)	Sobrii	Creamy leaf stripes
Thailand	Moss Rose (*Portulaca grandiflora*)	KU1, KU2, KU3	Flower colour
	Canna (*Canna x generalis*)	Pink Peeranuch, Yellow Arunee, Cream Prapanpongse, Orange Siranut	Flower colour

based on nuclear technologies was consolidated in Africa. For the first time animal health authorities in Africa have regional access to kits for the diagnosis of African Swine Fever, Rift Valley Fever, brucellosis and rinderpest. Through state of the art technology utilizing a bacculo-virus expression system that can inexpensively generate highly specific diagnostic reagents, the national veterinary laboratory in Dakar, Senegal, has distributed rinderpest diagnostic kits to some 34 African countries. Similarly, kits for African Swine Fever are now being distributed by the same laboratory. Although requiring further validation, the technology itself is proving appropriate and applicable to the developing country situation. Linked to the use of another biotechnology, the polymerase chain reaction (PCR), African scientists now have a regional capacity to both rapidly diagnose and accurately characterize the major diseases of their livestock. Produced locally, but based on training and technology provided through the Joint FAO/IAEA programme in food and agriculture and Agency technical co-operation activities, this capacity will considerably assist national governments in more effectively combating livestock diseases in the region.

A major constraint to increasing livestock productivity in developing countries is the scarcity and fluctuating quantity and quality of the year round supply of conventional feeds. Trees and shrubs form the most abundant source of protein in nature. However, the amounts of tannins that they contain vary widely, are largely unpredictable and have adverse effects on animals ranging from decreased nutrient utilization to toxicity and death. With a better understanding of tannin properties and proper management, leaves from trees and shrubs could become an invaluable source of protein for strategic supplementation. As the demand for food rises, tanniniferous plants must play an increasingly important part in the diet of animals, in particular for ruminants in smallholder subsistence farming in developing countries. In studies conducted under a CRP, it was found that seven tannin assays are required to predict the nutritional value of tannin containing forages. The use of these assays, including the radiolabelled bovine serum albumin method for predicting the biological effects of feeding tannin containing leaves, together with the new method for hydrolysable tannins developed in this CRP, provide the necessary momentum to the efforts being made by a number of international organizations to develop strategies to effectively utilize the vast resource of protein in the form of trees and browses as livestock feed.

INSECT AND PEST CONTROL

As the interest of the private sector in the application of the sterile insect technique (SIT) increases, there is a need for guarantees that sterile insects will continue to be safely and legally shipped. In response, a 'scenario analysis' technique was used to quantify the potential risks involved in the transboundary shipment of sterile insects for pest control programmes. This analysis was the basis for the development of a draft international standard that was submitted for consideration to the Interim Commission on Phytosanitary Measures (ICPM), the governing body for the International Plant Protection Convention (IPPC). Harmonized guidance on regulating the shipment of sterile insects will facilitate trade, while addressing any concerns about shipment of what could be quarantine pest species.

Fruit flies cause very significant fruit losses, but they are also of major quarantine significance internationally, interfering with the transboundary trade in fresh fruits and vegetables. There are no international guidelines on fruit fly monitoring, with importing countries establishing different and changing monitoring requirements to determine low fly prevalence or fly free status. At the request of Member States, guidelines on fruit fly monitoring were developed. These guidelines are now being used to facilitate the international trade in fruit commodities among Member States.

An International Database on Insect Disinfestation and Sterilization (IDIDAS) was developed to compile information on a species basis for both disinfestation (trade and quarantine) and sterilization (SIT). IDIDAS, which fills a gap in the current knowledge base, adds value to existing information by performing a quality assurance check on existing data and by making the information more accessible.

Considerable progress was made in developing SIT for the date moth, a serious pest in North Africa. Following a ban on the use of insecticides, the Government of Tunisia embarked on a programme to reduce infestation rates in dates using biological control methods including SIT. The introduction of an artificial larval diet and oviposition system through a CRP and a technical co-operation project increased the production level in the rearing unit to one million adult moths per week. In addition, a chilled moth dispersal device was developed and tested. The pheromone lure used to monitor adult male moths was synthesized, and tests on the efficiency and stability of different formulations were carried out in the field.

In response to an outbreak of tsetse transmitted animal trypanosomosis a few years ago, and to reduce the fear of a resurgence of sleeping sickness in tourist areas of the Okavango Delta, the Government of Botswana initiated a series of sequential aerosol spraying operations in the northern part of the delta, to be followed eventually by the use of SIT as a permanent solution. A regional technical co-operation project was set up to support Botswana's integrated, area wide programme for tsetse and trypanosomosis control and eradication. The key component of this support is the establishment of mass reared colonies of *Glossina morsitans centralis* at insectaries of collaborating institutions for the supply of sufficient sterile males for aerial releases.

With the objective of reducing insecticide use in citrus production for export markets, a mass rearing facility for the Mediterranean fruit fly (medfly) capable of producing 12 million sterile males per week was constructed in Sidi Thabet, Tunisia, in the framework of a technical co-operation project. This followed the agreement of the Tunisian Ministry of Agriculture and the fruit industry to participate in the project and undertake field activities. The national Atomic Energy Authority is responsible for sterile fly production. A trapping network has been set up in the Cap Bon Peninsula, the main commercial citrus production area, for the collection of field data.

All medfly SIT field programmes require that the released flies are marked with a fluorescent dye so that they can be distinguished from wild insects following their release. However, the reliability of this procedure can be compromised, leading to misidentification of flies. In addition, the screening of many thousands of individual flies on a daily basis under a fluorescent microscope is extremely labour intensive. A genetic marker called 'Sargent' that produces an extra stripe on the fly was developed as a replacement for the fluorescent dye. Field cage tests in 2001 to assess mating competitiveness produced good results and the marker is now being mass reared.

Several components of medfly SIT implementation may be improved by the ability to introduce genes into the insect by way of transgenic technology. This technology is now available for the medfly and, following collaboration with the United States Department of Agriculture, a series of transgenic medfly lines were generated. These are marked with a fluorescent protein and are being used to monitor key aspects of strain stability and fitness in relation to the use of transgenic technology in SIT.

The extensive use of field cages in the quality assurance of mass produced fruit flies has encouraged its use in tsetse. Field cage tests were carried out to evaluate the effect of various radiation and handling procedures of the mating ability of mass reared tsetse. In addition, mating compatibility assessment of different populations of the same species of tsetse were carried out. The field cage system appears to be eminently suitable as a quality control procedure for tsetse. Standard operating protocols for this quality assurance procedure, as well as for all the other procedures involved in tsetse mass rearing, have been prepared.

FOOD AND ENVIRONMENTAL PROTECTION

The Agency has assisted in the development of international standards and analytical capacity building to ensure the safety and quality of food in international trade. A notable advance in this respect was the progress made in the proposed 'Revised Draft Codex General Standard for Irradiated Foods' at the 24th session of the Codex Alimentarius Commission, held in July. The Commission also accepted a proposed draft 'International Code of Practice for Radiation

Processing'. Adoption of the revised Codex General Standards for Irradiated Foods, with no maximum limit on absorbed dose, by the Commission at its 2003 session will bolster consumer confidence and facilitate international trade. It would also harmonize regulations on irradiation as a food process in Member States. In addition, 'Guidelines for the Single Laboratory Validation of Analytical Methods for Trace Level Concentrations of Organic Chemicals' were endorsed by the Codex Committee for Methods of Analysis and Sampling at its 23rd session in February. The guidelines were then incorporated into the good laboratory practices document by the 33rd session of the Codex Committee on Pesticide Residues in April. It is expected that it will be adopted as a Codex Standard at the 25th session of the Codex Alimentarius Commission in 2003.

On the basis of data generated by CRPs, and recognizing the potential of irradiation for eliminating insect pests of quarantine importance in fresh horticultural commodities in international trade, the third session of the ICPM, the standard setting body of the IPPC, agreed to develop an international standard on irradiation as a phytosanitary treatment. An IPPC Working Group for this purpose was convened in November and a draft international standard was developed for further elaboration by the ICPM. A Guideline on Certification of Food Irradiated other than for Phytosanitary Purposes, drafted earlier by food control officials and plant quarantine officials in Asia and the Pacific, was endorsed for submission to the Codex Alimentarius Commission for its consideration.

Having completed its mandate of developing policy guidelines for the Agency, FAO and WHO, the International Consultative Group on Food Irradiation (ICGFI) decided at its 18th annual meeting in Rome in October to phase out its activities by May 2004. A new organization with the strong involvement of the private sector, especially the food industry, and with emphasis on the implementation of irradiation as a method to enhance food safety, security and trade, is expected to succeed ICGFI.

To strengthen agricultural countermeasures in the event of nuclear accidents, simple and robust methods for analysing the uptake of radionuclides from specific soil types and for determining radionuclide transfer factors in model plants were developed through a CRP. In addition, a new CRP on the introduction of quality assurance/quality control principles in the analysis of pesticide products was initiated. The CRP is expected to facilitate the control of pesticide products by elaborating a multi-analyte procedure that is more cost effective and simpler to implement for Member States.

Mycotoxins are a group of naturally and biologically active substances that are toxic to humans and animals and are not widely regulated in international trade. To help national food control authorities in developing countries to strengthen their analytical capacity for mycotoxin assessment in food and feed, a regional FAO–IAEA–WHO training workshop was held in Cairo in December 2001. The emphasis of the workshop was to develop quality assurance procedures for mycotoxin analysis to enable national food control laboratories to meet safety requirements in the international food trade. The workshop provided the participants with the criteria and tools for meeting ISO 17025 requirements, which is a necessary step in seeking accreditation in mycotoxin analysis so that their results are accepted by regulatory agencies and their trading partners.

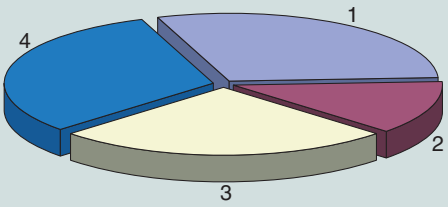
HUMAN HEALTH

PROGRAMME OBJECTIVE

To enhance the capabilities of developing Member States to address important health problems through the development and application of nuclear and related techniques in areas where they confer advantages in comparison with conventional techniques or by themselves constitute the conventional technique.

Regular budget expenditure: $5 510 295

Extrabudgetary programme expenditure (not included in chart): $64 839



1. Nuclear Medicine: $1 636 614
2. Applied Radiation Biology and Radiotherapy: $710 697
3. Dosimetry and Medical Radiation Physics: $1 429 240
4. Nutritional and Health Related Environmental Studies: $1 733 744

KEY ISSUES AND HIGHLIGHTS

- Medical services were developed to detect and manage infectious diseases through in vivo and in vitro nuclear medicine techniques.
- The initial phase of the first thematic CRP in nuclear medicine was completed.
- Analyses and projects were directed at the evaluation of the economics of the radiation therapy of cancer.
- A new instrumentation Code of Practice for dosimetry was developed and published.
- Stable isotope techniques for the prevention of degenerative disease were applied.

NUCLEAR MEDICINE

A priority during the year was the development of diagnostic methods and treatment procedures for coronary artery disease, liver cancer, thyroid cancer, bacterial infection, and infectious and childhood diseases. For example, a toxicology study of rhenium-188 Lipiodol for the treatment of liver cancer was completed after holding workshops in Colombia, Singapore and Viet Nam. The study formed the initial part of the Agency's first 'thematic CRP' in nuclear medicine, launched in 2000, on managing liver cancer using radionuclide methods with a special emphasis on trans-arterial radioconjugate therapy and internal dosimetry. The key feature of a thematic CRP is the pairing of an identical number of research agreement and research contract holders, with each pair supervising a research fellow working towards a doctorate or similar advanced degree in the same area as the CRP. The main benefit is to broaden the base of research in the area under study. Under this new CRP, ten researchers from ten developing countries are pursuing post-graduate training and education.

Tele-imaging and tele-maintenance via the Internet are innovative and cost effective methods of linking and repairing nuclear medicine imaging systems (such as gamma cameras and single photon emission computed tomography (SPECT) imaging) in developing countries. The first trial of the new technology was conducted with the linking of 38 gamma cameras and SPECT systems at various sites in Africa, and in Bolivia, Bulgaria, Hungary, Myanmar, Slovenia and Sri Lanka. Making full use of the expertise in these countries, this promising technology resulted in the repair of 12 gamma cameras and SPECT systems without the need for expert service missions, and a significant reduction in the downtime of these vital medical diagnostic instruments from several months to several days. This scheme has prompted WHO to seek the Agency's expertise for quality control and personnel training efforts, and for the coverage of medical instruments in general.

A critical part of the Agency's human health programme is the *application* of nuclear and related techniques in the treatment of cancer and infectious diseases. A regional technical co-operation project successfully applied an immunoradiometric assay of the hepatitis C antibody in Latin America that resulted in the screening of 18 691 subjects and the detection of 270 positive cases. Another project produced indigenous, high quality antibodies to alpha-feto protein for the detection of liver cancer. This project was carried out in co-operation with Algeria, Argentina, Brazil, Egypt, India, Indonesia, Malaysia and Mongolia. And a project involving a regional screening network for neonatal hypothyroidism in East Asia resulted in the rescue of 360 babies from mental retardation out of a total of 1.3 million babies that were screened. To sustain local expertise in the application of radioimmunoassay to neonatal screening, interactive multimedia teaching software was developed. In Africa, 77 682 tests for the detection of tumour markers were carried out in 17 countries. The number of cancer cases detected/monitored was significant, ranging from 24 to 50% of the patients investigated. The project also contributed to the training of 20 clinical laboratory science graduates in tumour marker assays.

The Agency seeks to maximize the impact of its activities by working with other international organizations working in the same area. One instance involved WHO and the transfer of molecular isotope based tests to Member States. For example, tests for the detection of drug resistant malaria and tuberculosis (TB) were validated. With these tests results can be obtained in two to three days as opposed to conventional methods that take 28 days for malaria and a minimum of five weeks for TB. Practical use was made of this technology in Mali where, during an epidemic, results were quickly provided to the control programme manager showing 75% resistance to the anti-malarial drug chloroquine and none to Fansidar. The latter was used for effective control of the epidemic. In Latin America, similar technology was used to establish less invasive diagnosis of tegumentary leishmaniasis. An antibody based test suitable for screening for Chagas' disease in blood banks using an optimal mixture of recombinant antigens resulted in improved diagnostic accuracy as compared with conventional serology.

APPLIED RADIATION BIOLOGY AND RADIOTHERAPY

Several analyses and projects were directed at the evaluation of the economics of radiation therapy of cancer. It became evident that high dose rate brachytherapy technology has expanded rapidly in Member States, with a concomitant reduction in low dose rate for most applications.

Models to derive the cost of cancer treatment using brachytherapy and cobalt and Linac teletherapy in different countries were developed and implemented. These take into account the utilization of the equipment, the salaries of all personnel, building costs and the duration of a working day to derive a cost per treatment using any of these modalities.

A randomized clinical trial of the treatment of cervical cancer using a new radiation sensitizer versus radiotherapy alone was concluded involving 333 patients from four countries. The study demonstrated a significant improvement in the control rate and survival in patients who received the hypoxic cell sensitizer at the same time as radiotherapy. This is the first positive result reported with this group of sensitizers.

DOSIMETRY AND MEDICAL RADIATION PHYSICS

The Agency is the only organization that provides for developing Member States a link to international standards for measuring radiation and the quality assurance techniques necessary for the calibration of radiation therapy machines and industrial radiation facilities (see Box 1).

With regard to international standards for radiation measurements, the Code of Practice (CoP) for dosimetry based on direct calibration using standards of absorbed dose to water, developed and published by the Agency in 2000 as Technical Reports Series No. 398, was endorsed by WHO, PAHO and ESTRO. In addition, several countries adopted it as the basis for their determination of absorbed dose to water, making it the only internationally accepted CoP. Previously, codes for dosimetry were based on standards of air kerma, which introduced a layer of complication that became unnecessary when Primary Standards Dosimetry Laboratories began disseminating radiation measurement standards of absorbed dose to water determined calorimetrically. Secondary Standards Dosimetry Laboratories in Member States will

BOX 1. HELPING MEMBER STATES TO MAINTAIN QUALITY ASSURANCE IN RADIATION TREATMENT PLANNING SYSTEMS

Medical physicists from the Agency participated in the investigation of two serious incidents involving the overexposure of patients undergoing radiation treatment for cancer. In the first incident, in Panama, the system used to plan radiotherapy treatments gave an incorrect value of the calculated exposure time which was not checked by manual calculation. Of the 28 overexposed patients, 12 subsequently died. In order to assist Member States with the commissioning and quality assurance of their treatment planning systems, a meeting utilizing the services of consultants was convened to establish guidelines for the use of Agency experts conducting on-site review visits for such systems. In the second incident, which occurred in Poland, an electrical power outage appears to have precipitated multiple failures of a linear accelerator involving both its beam output monitor and its safety interlock system. Unfortunately, the resulting large increase in beam output was not detected prior to resuming patient therapy. This resulted in the overexposure of five patients. The Agency's role was to investigate the cause of such incidents in order to inform users of similar equipment of the inherent dangers involved. ■

benefit by having access to a system of dosimetry that is inherently simpler than earlier ones.

In the area of industrial applications, 20% of the 50 cobalt-60 beam audits that were performed for Member States through the International Dose Assurance Service (IDAS) exceeded the acceptance limit of 5%, indicating the importance of this service. At the request of FAO, eight cobalt-60 beam calibrations were checked using IDAS dosimeters for participants of a CRP on the quality assurance of mass produced and released fruit flies. This assistance in dosimetric measurements will help the participants to standardize their irradiation technique.

The IAEA/WHO thermoluminescence dosimetry (TLD) postal dose audit service monitored the calibration of more than 400 radiotherapy beams at hospitals worldwide. The dosimeter return rate exceeded 95%, indicating a significant commitment to the service, but 20% of the results exceeded the 5% acceptance limit. Historically, it has been observed that as laboratories participate in the service, their overall performance improves, pointing to the value of this service for Member States.

NUTRITIONAL AND HEALTH RELATED ENVIRONMENTAL STUDIES

The first thematic CRP on nutrition on isotopic and complementary tools for the study of micronutrient status and interactions in developing country populations exposed to multiple nutritional deficiencies was launched. The aim is to devise approaches for a sustainable focus on micronutrient malnutrition in chronically malnourished populations by evaluating micronutrient interactions, and to support capacity building in the area of food and nutrition in developing countries. Eight doctoral fellows will be able to acquire higher level degrees in food and nutrition as a result of this CRP.

A CRP that ended in 2001 studied the use of stable isotopic techniques in the prevention of degenerative diseases (obesity and 'non-insulin dependent diabetes') in developing countries. Important results of this CRP were the establishment of standard protocols for body composition and physical activity measurements, and the suggestion to use total body fat distribution patterns as predictors of the evolution of insulin resistance syndrome.

The doubly labelled water technique for investigating human body composition was further refined in a CRP that studied measurements of dietary energy intakes in women and men. The results of this CRP, together with those obtained from a regional Latin American technical co-operation project, contributed to the formulation of new recommendations by the Joint WHO–FAO–United Nations University Expert Consultation on Energy in Human Nutrition. These recommendations are, for the first time, based on measured data on energy metabolism in children and adult populations from developing countries.

A technical co-operation project provided guidance to Senegal, for its national nutrition plan campaign, on the use of isotopic methods to quantify the transfer of breast milk from the mother to the baby. The results are being used to optimize planning for food supplements for the baby that is being weaned. In another technical co-operation project, measurement of the effectiveness of multinutrient supplementation was undertaken in several Asian countries. Regional training courses, group training and a workshop for policy makers were key activities in this project. In particular, the results from studies on wheat flour (in Indonesia) helped policy makers and industry to choose the best fortificant(s) for greater effectiveness of national programmes.

In the area of environmental health, a CRP assessed the levels and health effects of airborne particulate matter (APM) in the mining, metal refining and metal working industries using nuclear and related analytical techniques. As a result, strategies and techniques were developed for sampling work place APM and human tissues and/or fluids. In related work, a regional technical co-operation project for Latin America generated reliable compositional data sets for the PM_{10} (particulate matter of 10 micrometre diameter) and $PM_{2.5}$ fractions of APM in Buenos Aires, São Paulo, Santiago de Chile and Mexico

City, all of which suffer from high levels of air pollution. The levels of toxic heavy metals were accurately determined during critical (cold, hot, dry and humid) periods of the year.

The Agency's database on Natural Matrix Reference Materials *(http://www.iaea.org/programmes/nahunet/e4/nmrm/index.htm)* was updated and now contains over 26 000 values (mass fraction or concentration) for 750 different measurements and 2163 reference materials produced by 59 producers from 22 countries. In 2001, the database was extended to include organic constituents, in particular organic macro- and micronutrients.

Attention has recently been focused on the consequences of the military use of depleted uranium (DU) on the environment and local civilian populations. In addition to participation in 2000 in a UNEP sampling mission to evaluate the situation with respect to DU in Kosovo, the Agency's Laboratories at Seibersdorf provided analytical results for total and isotopic uranium analysis (i.e. verification of the origin of the uranium). The Agency organized a scientific seminar and training course in September — in co-operation with UNEP and WHO, and with financial support from Germany, Italy and Switzerland — on 'Depleted Uranium in the Environment'. The seminar and course provided up to date information on the detection, measurement, assessment of risks and potential health effects from the use of DU armour piercing ammunition or by its use in civilian applications (e.g. radiation shielding or as aircraft counterweights). The training course was held jointly at the Agency's Laboratories at Seibersdorf and at the Karlsruhe Training Centre, Germany, and also involved the Institute for Radiation Protection in Neuherberg, which provided assistance on environmental modelling and radioecological aspects of DU, Wismut GmbH, which reported on decontamination issues and site restoration technologies, and the German Army, which supported the field studies.

The Agency was requested by Kuwait to assist in an assessment of the post-Gulf War contamination of the environment by DU and to verify Kuwaiti national results. The Seibersdorf Laboratories analysed 30 samples containing air filters, water, DU (armour piercing) penetrators and soil from various regions of Kuwait. A report summarizing the results is being prepared. Further field sampling is to take place in 2002.

The Agency's Network of Analytical Laboratories Monitoring Environmental Radioactivity (ALMERA) network was established to provide accurate and precise environmental radioactivity measurements in the event of a nuclear incident. Member States nominate laboratories which are required to demonstrate their analytical competence by participation in regular Agency proficiency tests (Table I). The first such test of the ALMERA network was completed in May and a report summarizing the results is in preparation.

Human health and environmental monitoring data are completely dependent on the quality of the primary analytical measurements. As part of its ongoing task to assist laboratories in Member States to evaluate and develop their analytical capabilities for environmental radioactivity monitoring, a phosphogypsum candidate reference material was characterized

TABLE I. **PARTICIPATION IN ALMERA PROFICIENCY TESTS**

Target laboratories	Matrix	No. of sets dispatched	No. of results reported
$\alpha + \beta$ spectroscopy	Soil	56	44
γ spectroscopy	Soil	74	49

for its primordial radionuclide content (uranium, thorium, radium-226 and lead/polonium-210). The Agency's Laboratories at Seibersdorf collected approximately 600 kg of the material, which is now available for preparation as a candidate reference material. Similarly, a total of 13 water samples were prepared as part of a proficiency test on the determination of radium-226/-228 and uranium-234/-235/-238 in natural waters. Samples from five natural water sources were collected in Austria and Poland. The remaining eight sample waters were prepared by spiking de-ionized water with known levels of these primordial radionuclides to simulate a range of low and high salinity waters. In this way, the Agency was able to evaluate the effectiveness of participants' procedures in dealing with a range of water types, from groundwaters to waste waters, within the framework of the proficiency test.

Neutron activation analysis is a versatile tool that can be used for the direct analysis of the trace element content of solid samples. The Agency's Laboratories at Seibersdorf was involved in establishing a neutron activation analysis facility at the KFKI reactor in Budapest to replace the irradiation facility after the Austrian ASTRA reactor was closed in July 1999. In addition, discussions took place concerning modifications to the KFKI reactor to enable it to accept the installation of a fast pneumatic transfer system supplied by the Agency. Such a system permits the analysis of a range of analytes (activation products) that have short half-lives, and permits short irradiation times which can enhance the capabilities of the technique. Based on test irradiations, it was decided that the installation of the Agency's fast pneumatic system should proceed, with funding allocated in 2002.

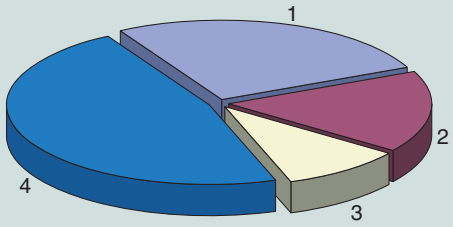
MARINE ENVIRONMENT AND WATER RESOURCES

PROGRAMME OBJECTIVE

To develop and foster the ability of Member States to gain knowledge of the temporal and spatial trends of radioactivity in the oceans and of the controlling processes, and to use isotopic and other technologies to quantify and evaluate marine pollution; and to integrate appropriate isotope and nuclear techniques in the planning and resource management of freshwater resources and gain a better understanding of human induced hydroclimatic impact on the water cycle and its interaction with other environmental systems.

Regular budget expenditure: $5 244 874

Extrabudgetary programme expenditure (not included in chart): $867 814



1. Measurement and Assessment of Radionuclides in the Marine Environment: $1 396 810
2. Transfer of Radionuclides in the Marine Environment: $877 078
3. Monitoring and Study of Marine Pollution: $515 828
4. Development and Management of Water Resources: $2 455 158

KEY ISSUES AND HIGHLIGHTS

- Several new techniques — including continuous in situ radioactivity monitoring — and facilities such as an underground counting laboratory and advanced aquaria for radioecological studies, were developed in the marine environment area. These provide significantly improved methods for the detection and study of both nuclear and non-nuclear marine pollutants in the laboratory and the field.

- In water resources management, the Agency assessed the present status and future directions for isotope applications in water cycle modelling, groundwater sustainability and the impacts of climate change on water resources.

- Efforts were made to link the Agency's R&D and technical co-operation activities to water sector programmes of the UN and bilateral agencies.

- A course was set up with Agency assistance on isotope hydrology in a post-graduate university programme on water resources engineering.

- The Agency was invited to be the UN system's lead organization to mark World Water Day in March 2002, in recognition of the impact of its programme of work in water resources.

MEASUREMENT AND ASSESSMENT OF RADIONUCLIDES IN THE MARINE ENVIRONMENT

In a project on 'Research on Worldwide Marine Radioactivity' (MARS) that ended in 2001, radionuclide data for sea water, sediment and biota were gathered during nine seagoing sampling expeditions organized by the Agency, through IAEA-MEL, and by its Member States. Eight anthropogenic radionuclides were chosen as the most abundant and representative in the marine environment, with the highest potential contribution to radiation doses to humans via seafood. The results indicate that the seas most affected by such radionuclides have been the Irish, Baltic, Black and North Seas. The data were added to the Global Marine Radioactivity Database (GLOMARD) and will be used as an international reference source on the average levels of anthropogenic radionuclides in the marine environment so that any contributions from nuclear reprocessing plants, nuclear power stations, former radioactive waste dumping sites, former nuclear weapons test sites and possible nuclear accidents on land or in the sea can be identified. The MARS project was supported by extrabudgetary funding by the Government of Japan.

A new technique for the investigation of radionuclides in the marine environment was developed at IAEA-MEL. Based on a state of the art underwater stationary gamma ray monitor with satellite data transmission, this technique can be used effectively for both short and long term monitoring of open seas, coastal areas, rivers and lakes. In specific cases, it can replace sporadic sampling campaigns and laborious analytical measurements in the laboratory as it can report real-time data, search for temporal changes and develop time series on radionuclide concentrations. In a joint operation with the Radiological Protection Institute of Ireland, the monitor, after being tested in Monaco Bay, was deployed in the northwestern Irish Sea.

Another innovation was the development, in cooperation with laboratories in Australia, Canada, France, Japan and the USA, of new radiochemical techniques for accelerator mass spectrometry (AMS). The new techniques can be used to analyse long lived radionuclides in the marine environment and have changed the focus of radionuclide analysis from counting radioactive decays to counting the number of atoms in a sample. The advantage of the latter method is its combination of exceptional sensitivity with minimum sample size, opening new frontiers in the study of oceanic processes using radionuclides as tracers.

An underground counting laboratory was constructed at IAEA-MEL for the analysis of radionuclides in marine samples at very low levels, with automated data acquisition and processing. Built using extrabudgetary support from the Governments of Monaco and Japan, the laboratory is situated 30 metres of water equivalent below the surface, where the flux of cosmic ray nucleons is reduced by about ten thousand times. Spectrometers operating in the laboratory in different coincidence–anticoincidence modes permit the analyses of ultra low concentrations of a wide range of short and medium lived radionuclides. This has important financial implications as the time needed for sampling work at sea can be considerably reduced. Valuable information can thus be obtained for assessing environmental radionuclide contamination caused by authorized radioactive discharges, accidental releases or terrorist actions.

The Agency's Analytical Quality Control Services (AQCS) programme continues to assist Member State laboratories in their quality assurance/quality control work (Fig. 1). Highlights in 2001 include: preparation of a seawater

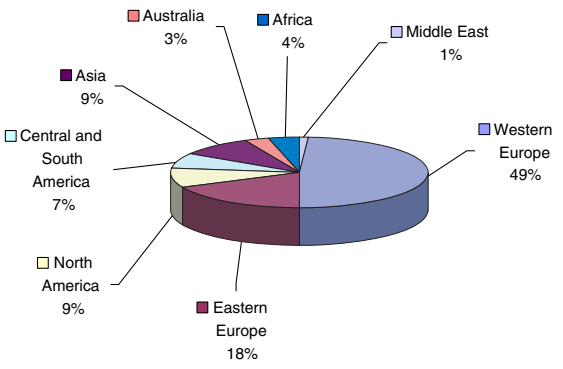


FIG. 1. Geographical distribution of the 184 laboratories participating in AQCS activities for radionuclides in the marine environment.

sample from the Mediterranean Sea (IAEA-418) for a new intercomparison run; preparation of a new intercomparison seabed sediment sample from the Irish Sea (IAEA-385); and completion of a regional intercomparison exercise for the Black Sea countries within the framework of a technical co-operation project and a regional proficiency test for the Baltic Sea countries.

As part of a regional technical co-operation project on the assessment of the contamination of the south Mediterranean Sea by radionuclides, heavy metals and organic compounds, a cruise was organized in coastal waters off Algeria. Seawater, sediment and biota samples were collected and several high resolution profiles of physical and chemical parameters, such as temperature, salinity and dissolved oxygen in the water column, were obtained. Based on the lead-210 chronology and the analysis of heavy metals in the sediment samples, it was concluded that concentrations of heavy metals in sediments in the southwest Mediterranean have been decreasing in recent years.

TRANSFER OF RADIONUCLIDES IN THE MARINE ENVIRONMENT

Nuclear techniques can improve understanding of the processes involved in transferring radionuclides and conventional contaminants through coastal marine environments. The focus in 2001 at IAEA-MEL was on tropical ecosystems: radiotracer experiments were carried out to investigate the bioaccumulation and retention of radionuclides and toxic heavy metals in key marine biota from tropical coastal environments. For economically important marine species like tropical mussels and oysters, the type of food ingested (different species of phytoplankton) was not found to be a predominant controlling factor in radionuclide and toxic metal accumulation, though salinity significantly altered bioaccumulation processes, with considerably higher uptake rates occurring at the lower salinities typically found in estuarine areas.

With the installation of new aquaria maintenance techniques at IAEA-MEL, the medium to long term culturing of tropical species with low mortality rates was successfully achieved. This has facilitated the study, for example, of the radioecology of the very fragile giant clam *Tridacna*, which lives in association with symbiotic microscopic algae (zooxanthellae) incorporated in the clam's tissues. It was found that these edible tropical bivalves readily bioconcentrate radionuclides and toxic metals, and that photosynthetic algae living in their tissues are likely to be responsible for a large part of the bioaccumulation of metallic contaminants in these clams.

The same aquaria maintenance expertise was used in another study that examined the trophic transfer of radionuclides and heavy metals, and their subsequent retention in three species of tropical fish which live in or near estuaries and tolerate a wide range of salinities. Among the contaminants investigated, only the ingested radionuclide caesium-134 was efficiently assimilated and retained, mainly in the edible flesh of these fish. In contrast, the ingested heavy metals cadmium-109 and americium-241 remained totally asso-ciated with the food during gut transit and were not incorporated into the fish tissues. The contaminant assimilation rate and subsequent retention of these radionuclides and metals in the organs of the fish were found to depend more on the element considered than on fish species or age. However, the retention efficiency of the heavy metals cobalt-57, silver-110m and zinc-65 differed significantly among species, suggesting a possible influence of digestive metabolism of the fish on the pollutant turnover rate in their tissues, a factor that should be taken into account when selecting species for fish farming.

Radiotracer experiments demonstrated that some marine organisms are able to retain accumulated pollutants for a very long time, making them very useful long term bioindicators of contamination that occurred several years earlier. One of these species, the common European crab *Pachygrapsus marmoratus,* was observed to have the ability to literally 'trap' a large proportion (more than 50%) of silver-110m ingested with its food. The results of tests performed in collaboration with several Member State laboratories suggest that this sequestration process involves the precipitation of silver as a non-toxic compound, and that such

metabolic trapping of this toxic metal may be a general feature among marine crustaceans.

In coastal zones, estuarine areas receive some of the highest inputs of anthropogenic contamination by trace metals. In areas where aquaculture is taking place, this situation has a potentially large socioeconomic impact, since many cultured bivalves like oysters are known to readily concentrate heavy metals from their environment, particularly the highly toxic contaminants cadmium, copper, zinc and mercury. A collaborative project funded by various French organizations, such as the Ministry of Agriculture and Fisheries and the Ministry of Research, and involving the National Centre of Scientific Research, the Faculty of Sciences of Nantes University and IAEA-MEL, was undertaken to develop radiotracer methodologies for determining the behaviour and fate of cadmium in commercial oysters originating from a cadmium contaminated estuary and those living in a clean area where cadmium contamination levels are low. The findings are of potential significance because they have led to the identification of adaptive cellular mechanisms, which help the organisms to 'adjust' to ambient cadmium contamination, and can also be used in the determination of the regulatory thresholds of cadmium concentrations in oysters.

Radiotracer studies are useful in placing constraints on the degree to which element ratios can be used as proxies to determine palaeoclimates. In this respect, strontium is an element of particular interest because of its involvement in biogeochemical calcification processes in marine organisms. For example, in tropical areas corals have aragonite–carbonate skeletons which contain relatively high amounts of strontium. Because the strontium/calcium ratio is thought to vary with seawater temperature, the ratio in coral skeletons has been proposed as a proxy for reconstructing past temperatures, a hypothesis based on the observation that there is a temperature dependence of strontium partitioning between sea water and coral skeleton. A collaborative project between IAEA-MEL and the Scientific Centre of Monaco used radioactive strontium as a tracer and found that the incorporation of strontium is inversely correlated with the rate of calcification. Thus, in the natural environment the incorporation of strontium in corals should depend on both the calcification rate and sea surface temperature. These findings suggest that specific metabolic interactions between strontium and calcium can alter the ratio, and this fact should be taken into account in palaeoclimate studies which use the ratio to infer past temperature regimes.

Natural radionuclides are important tools in tracing processes that govern carbon dioxide sequestration in the ocean and the role it plays in climate change. A new study using nuclear techniques to measure annual carbon export from surface waters was begun in the Mediterranean Sea near Monaco. Thorium-234, a short lived radionuclide which is produced continuously in sea water at a nearly uniform rate from the decay of uranium-238, becomes rapidly attached to carbon rich particles and is removed from surface waters with the sinking particulates. This preferential removal creates a disequilibrium between both radionuclides that is used, in conjunction with the measured organic carbon/thorium-234 ratio in the sinking particles, to estimate carbon export in the ocean. Measurements of the radionuclide profiles showed a significantly higher removal of dissolved thorium-234 in the upper 200 m in the early summer as compared with the spring. Furthermore, time series observations indicated that organic carbon fluxes derived from radionuclide concentrations were significantly different from the fluxes measured directly with sediment traps on a short time-scale (one to two days), but became very similar when data were integrated over a longer period of time (one to four weeks). Precise information on the downward carbon flux can be used to assess carbon dioxide removal from the upper ocean, a parameter that controls the transport of this greenhouse gas between the atmosphere and the ocean.

MONITORING AND STUDY OF MARINE POLLUTION

Techniques using inductively coupled plasma-mass spectrometry (ICP-MS) provide isotopic data that can complement conventional marine pollution studies. Lead isotopes have been routinely examined by ICP-MS for pollution monitoring programmes to provide source

information. In one application, sediment samples were evaluated for uranium and relatively high lead-206 concentrations to assess nutrient loading from phosphate rich fertilizers, which are generally associated with natural uranium. In another application of the same study, the measured lead isotope ratio was found to be the same as that used in leaded petrol from Morocco. Plutonium isotope data across depth gradients at a variety of locations have provided crucial information for assessing the fate and transport of plutonium in the marine environment. A pollution assessment project in the Caspian Sea examined uranium isotopes, unequivocally showing a different isotopic composition in the Caspian Sea from that found in the Black Sea and the Persian Gulf. More data are being gathered to draw conclusions on the significance of these findings.

Quality assurance programmes assist national laboratories in Member States and regional laboratory networks in obtaining reliable data for a range of non-radioactive marine pollutants (Fig. 2). Such assistance comprises intercomparison exercises, proficiency testing and training courses. Most notably, IAEA-MEL continues to be one of the few producers of marine reference materials. One sample, fish homogenate (IAEA-406), was certified following an intercomparison exercise in 2000 and introduced as a reference material for chlorinated pesticides, polychlorinated biphenyl (PCB) and petroleum hydrocarbons (PHs). Similarly, a sediment reference material (IAEA-405) for heavy metals and methylmercury was produced. In addition, IAEA-MEL prepared a pair of bivalve samples for ROPME (the Regional Organisation for the Protection of the Marine Environment) and two sediment materials for the Caspian Environment Programme.

Contaminant screening provides information on environmental quality that can be used in coastal zone management. A project that screened for trace inorganic and organic contaminants was undertaken in coastal areas in Oman in collaboration with ROPME. Generally the concentrations of organic contaminants in the waters and sediments were insignificant. With respect to biota, organochlorinated compounds, including those of agrochemical origin, were found at quite low levels. The only

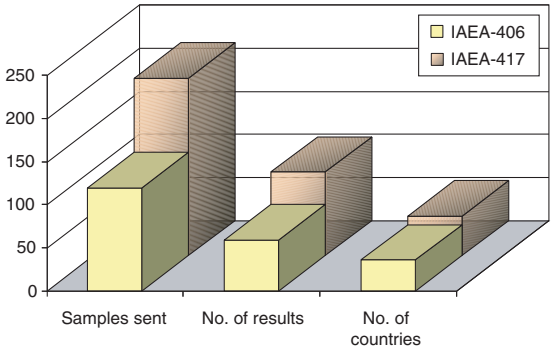


FIG. 2. The number of samples sent and the participants in two intercomparison exercises for organic contaminants: IAEA-406 (fish homogenate) in 2000 and IAEA-417 (sediment) in 2001.

bivalves showing some indication of oil contamination were the pearl oysters from Mirbat in southern Oman. As regards metals, of particular note were the extremely high cadmium concentrations in the livers of spangled emperor fish from southern Oman, the highest such cadmium concentrations yet reported. While anthropogenic contamination cannot be ruled out, the apparent enhancement may be due to food chain transfer of high levels of cadmium brought into the surface waters through the strong upwelling of nutrient rich waters that was occurring during the sampling period.

The Caspian Environment Programme (CEP) is an intergovernmental undertaking of the five Caspian littoral States, namely Azerbaijan, the Islamic Republic of Iran, Kazakhstan, the Russian Federation and Turkmenistan. IAEA-MEL collaborated with CEP on contaminant screening projects in Azerbaijan and the Islamic Republic of Iran in investigating a range of organic and inorganic pollutants in marine sediments from the coastal zone of the Caspian Sea. Petroleum hydrocarbon concentrations in Azerbaijan were quite high by global standards at some locations, notably to the south of Baku Bay. Recent inputs were recognized at a number of sites based on the weathering index. Whereas the polycyclic aromatic hydrocarbon (PAH) and PCB concentrations never exceeded sediment quality guideline values, numerous locations in the coastal zone of Azerbaijan had elevated concentrations of DDT related compounds, demonstrating the importance of organochlo-

rinated compounds derived from agricultural sources. With respect to metals, arsenic, chromium and nickel concentrations were quite high at several locations, but probably reflected high background levels. In contrast, anthropogenic inputs most likely accounted for the elevated copper and mercury concentrations in some hot spots. In the Islamic Republic of Iran, the PHs were weathered rather than fresh inputs and their concentrations in the marine sediments were generally lower than those found in Azerbaijan and were not especially high by global standards. Agrochemicals caused contamination of DDT at several sites and endosulfan sulfate exhibited a hot spot at one location. PAH and PCB levels were not sufficiently high to be of concern. Arsenic, chromium, copper and nickel concentrations were high, but probably of natural origin. Similarly, there was no evidence of cadmium, lead, mercury and silver pollution.

DEVELOPMENT AND MANAGEMENT OF WATER RESOURCES

Submarine groundwater discharge (SGD) is an important component of the continental freshwater balance and may be a significant source of nutrient and pollutant loading in coastal zones (Fig. 3). A new CRP was started on the application of isotope and nuclear techniques for monitoring SGD. As part of this CRP, a pilot study on SGD characterization was conducted off the Sicilian coast in co-operation with the University of Palermo, Italy, UNESCO's International Hydrological Programme (IHP) and the Intergovernmental Oceanographic Commission (IOC).

The IAEA/WMO Global Network for Isotopes in Precipitation (GNIP) is the primary database for isotope applications in hydrological and climate studies. Isotope monitoring of river water, which integrates the spatial and temporal variability of precipitation and hydrology on a catchment scale, greatly enhances the use of GNIP data and provides a robust new tool for evaluating the effects of climate change and land use patterns on water resources, as well as for developing integrated watershed management strategies. A CRP was initiated to formulate design parameters of such a global network for isotopes in rivers (GNIR) and will be implemented in close collaboration with WMO and UNESCO, as well as with international scientific programmes focused on continental scale water balance.

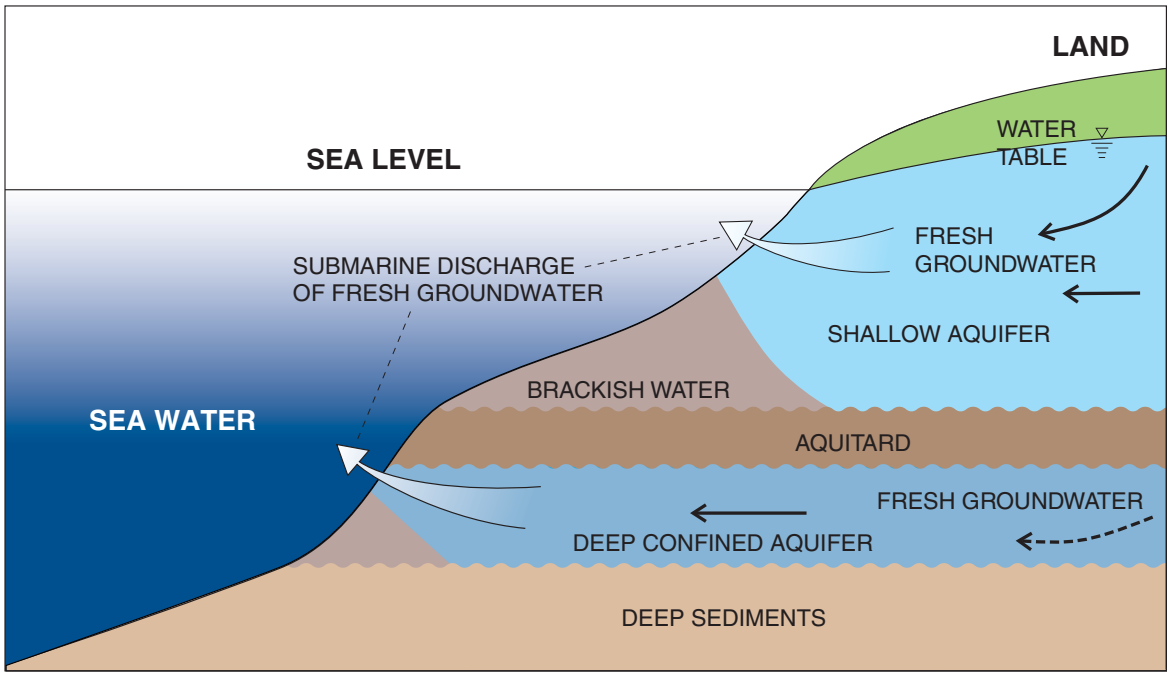


FIG. 3. Schematic representation of the submarine groundwater discharge process.

Nearly half of all fresh water for domestic use and irrigation around the world is derived from aquifers, linking the sustainability of groundwater resources to sustainable human development (Fig. 4). However, water resources in many parts of the world are severely stressed, as witnessed by declining water levels. The role of isotopes as indicators of groundwater sustainability was reviewed at an Advisory Group meeting held in co-operation with UNESCO. The meeting identified the complementary, but critical, role of isotopes in improving methods for groundwater sustainability assessment. Such methods are of great importance, given that current estimates of the world's water resources are generally weak as regards groundwater components, and no information is available as to what proportions of the groundwater bodies are renewable or non-renewable. As a follow-up to this meeting, a joint project with UNESCO was initiated to use extensive isotope data from aquifers worldwide, most which have been collected as part of Agency projects. The aim is to improve the understanding of the global distribution and amounts of non-renewable groundwaters, incorporating this information into a series of maps based on the Geographical Information System.

While it is widely accepted that recent global warming is largely a product of enhanced greenhouse gas (GHG) concentrations in the atmosphere, great uncertainty remains regarding the relationships between specific parameters and climate phenomena, and regarding the impacts of climate change on the Earth's water cycle. The scope of change observed in the last few decades appears to be unprecedented compared with the history of changes in the Earth's climate. Understanding the causes of past climate changes is, therefore, an important part of climate change research and isotopes are one of the most important tools to extend the spatial and temporal analysis of relevant climatic processes. An international conference organized by the Agency in Vienna in April discussed how isotopes could be used in environmental change studies. State of the art isotope techniques and their applications in global climate change research were reviewed and future research directions were discussed. Noting that isotopes are an indispensable tool for climate change research, the conference participants emphasized that the Agency has played a critical role in facilitating isotope based research and information dissemination. Moreover, the Agency's continued support was considered necessary to enhance the role of isotopes in large

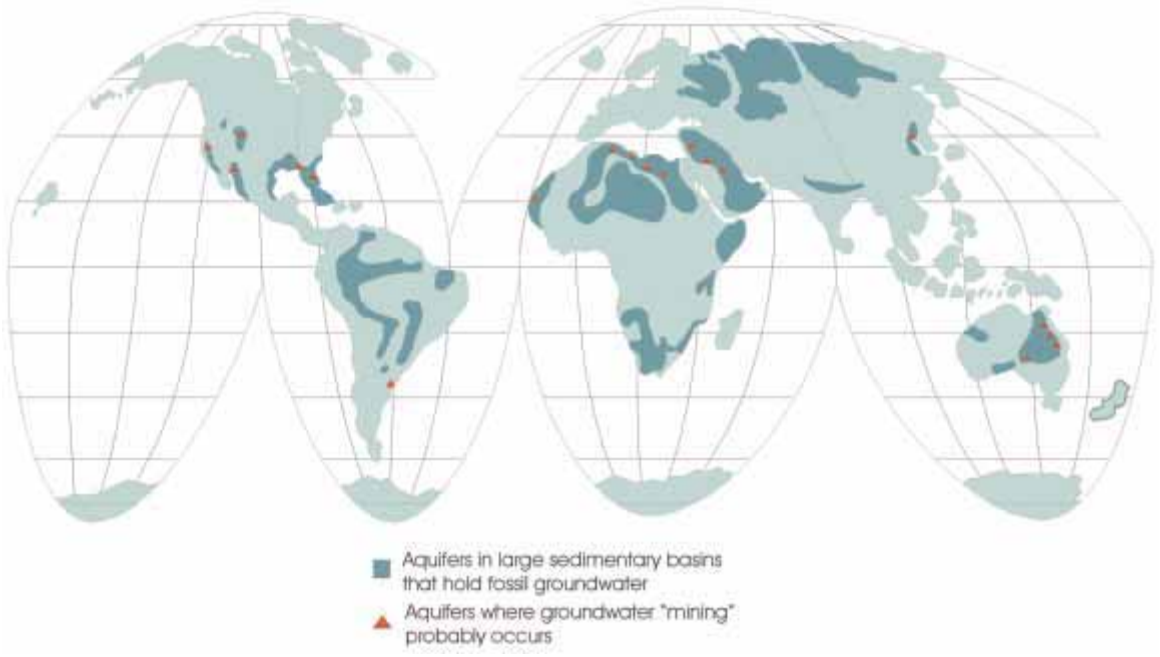


FIG. 4. Global distribution of large aquifers with fossil groundwater.

scale, multi-disciplinary international programmes on climate change research.

One of the accepted mitigation options in the Kyoto Protocol for reducing GHG emissions is the sequestration of carbon dioxide by disposal in geological formations and in the oceans. A review of the potential role of isotope and nuclear techniques for designing and monitoring geological and oceanic carbon dioxide sequestration schemes found that leakage from deep underground storage reservoirs was a major concern for carbon dioxide sequestration operations, and monitoring was required to assess the integrity of the storage reservoir. Isotope techniques can be used to monitor the geological disposal of carbon dioxide in deep aquifers. However, a similar role in oceanic sequestration studies is more difficult, requiring a more precise definition of the problem. A follow-up activity to demonstrate the use of isotopes in geological sequestration studies is being formulated in co-operation with the Alberta Research Council in Canada.

A new regional technical co-operation project was started with the aim of applying isotope techniques in a Global Environment Facility (GEF) project focusing on the environmental protection and sustainable development of the Guarani Aquifer system in Latin America. The Guarani is a large freshwater aquifer underlying Argentina, Brazil, Paraguay and Uruguay, and isotopes are expected to provide critical input for strengthening the conceptual hydrological model of the aquifer. The Guarani project was approved for inclusion in the GEF work programme in December 2001, with the Agency's own technical co-operation project slated to begin in 2002. The World Bank and the Organization of American States are also participating in the Guarani project, together with national institutes.

In another regional techical co-operation project, significant achievements were made in developing and improving the management of groundwater resources in southern and eastern African countries. For instance, the sources of nitrate pollution in groundwater supplying the city of Dodoma, United Republic of Tanzania, were identified by using nitrogen isotopes and the results are being used to develop criteria for land use restrictions and groundwater

BOX 1. USING ISOTOPE TECHNIQUES TO MORE EFFECTIVELY MANAGE DRINKING WATER RESOURCES

One of the main themes of an Agency technical co-operation project on isotope applications for improved drinking water resources management is to improve the reliability of results obtained from numerical models of groundwater flow and solute transport by using isotope data. Among the highlights of this project were the following:

— A better understanding was achieved of groundwater recharge and pollution in the urban aquifer system near Lahore, in Pakistan, where isotope data showed that the deep aquifer was being recharged from the Ravi River. The isotope data were then used to constrain groundwater flow patterns obtained from numerical modelling. The results have provided a basis for local authorities to develop improved groundwater management strategies to reduce pollution of the aquifer, which is the primary source of drinking water.

— In Shijiazhuang City, China, nitrogen-15 analyses have been used to successfully identify the sources of nitrate contamination in groundwater in this densely populated area.

— In the Thung Kula Ronghia region of northeastern Thailand, isotope studies have been used to obtain the origin, age, recharge mechanism and flow dynamics of groundwater.

— Carbon-14 was used to constrain estimates of groundwater flow rates derived from numerical modelling. The combined use of isotope data and numerical modelling helped to improve the understanding of groundwater flow dynamics in the region. ■

protection. And local authorities in South Africa have indicated that changes will be made to the groundwater development strategies for the Taaibosch fault zone on the basis of the isotope results. These positive developments have heightened the interest of national authorities in Namibia and the United Republic of Tanzania in using isotope techniques for water resource assessments. Moreover, major international development projects in the region, such as the "500 Wells" project in Madagascar and the "Watershed Assessment" project in the United Republic of Tanzania, both sponsored by the World Bank, have integrated isotope applications into their programmes.

Agency technical co-operation projects seek to promote the use of nuclear techniques in Member State development efforts. One such project succeeded in increasing the integration of isotope hydrology into water resources management practices in China. A highlight was greater communication and co-operation between the various scientific agencies, where substantial capability in isotope hydrology exists, and the end-user agencies in China through the formation of a national co-ordination committee on isotope hydrology. This committee organized a workshop on the application of isotope techniques in water resources assessment and management in China and published its proceedings in English, with the support of the Agency, as a special issue of the journal *Science in China*. As a result of this increased awareness, the Agency is currently assisting various ministries in applying isotope techniques to groundwater resources assessment and management projects in northwest China. High priority is being given to the relatively large Erdos and Guanzhong groundwater basins, which are important regional development areas being promoted by the central government. As a follow-on effort, the Agency's technical assistance has been requested for integrating isotope techniques in managing river–groundwater interaction in the Black River Basin.

A programme of action for the IAEA–UNESCO Joint International Isotopes in Hydrology Programme (JIIHP) was formulated at an Agency meeting with seven national representatives of IHP. An operational plan was established setting out various activities leading up to the First JIIHP Steering Committee meeting that will be held in June 2002. In addition, the meeting set out a preliminary timetable and identified priority areas for the integration of isotope hydrology activities through the national IHP programmes that will be considered by the Steering Committee.

The urgent need to provide safe, clean drinking water to the world's population is bringing Member States and international organizations together in new partnerships that seek to maximize the benefits of their activities. For example, the Agency participated in the International Conference on Freshwater (ICF) organized by Germany. The objective of this conference was to focus world attention on freshwater issues and develop a common approach for the World Summit on Sustainable Development in Johannesburg in 2002. The Ministerial Declaration at the ICF called for greater efforts to improve the knowledge base for water resources management, and for more co-ordinated UN system activities in the water sector. Both of these items form the basis for much of Agency's programme in water resources development.

Another interagency effort was a workshop organized by the UN Economic Commission for Europe that examined the role of isotopes in the protection of aquifers used for drinking water supply. The objective is to revise and improve groundwater monitoring and protection standards in the European Union. One outcome of this effort was the decision to develop documentation on the use of isotope techniques for the characterization of protection zones for incorporation in the updated version of the European Union's groundwater monitoring guidelines.

The Agency has played a major role in building a cadre of trained isotope hydrologists worldwide (Fig. 5). In the past, the Agency emphasized training as continuing education, not as part of formal education at the university level. As a result, there is a continuing demand for human resources development even in countries where the Agency has built capacity in the past. A lack of sufficient academic training for hydrologists in the use and application of isotope techniques has been identified to be one of the major constraints that limit the integration of isotope

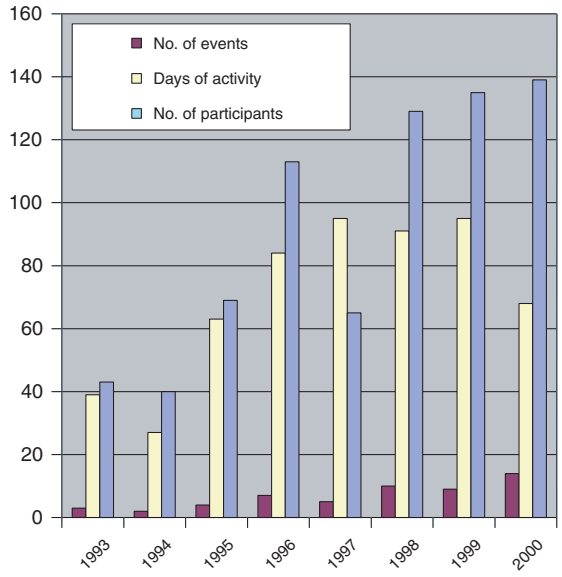


FIG. 5. Training courses and workshops offered by the Agency in isotope hydrology.

hydrology in the water sector of many developing countries. To help overcome these obstacles, the Agency provided assistance to the University of Roorkee, India, in organizing a semester course on isotope hydrology within its post-graduate programme on water resources management. This course is expected to serve as a model for similar courses in other parts of Asia. In addition, two institutes have been identified in Africa where isotope hydrology will be introduced into their post-graduate programmes.

In an Agency interlaboratory comparison to evaluate the quality of tritium analysis of water samples, the performance of less than half of the 86 participating laboratories was found to be sufficient for isotope hydrology applications in terms of accuracy and precision of measurements. Nearly one third of the participating laboratories had systematic errors in their analytical procedures. As a result of their participation in the exercise, 14 laboratories were able to identify and rectify internal analytical problems, as demonstrated by improvements in resubmitted results. Moreover, an overall improvement of 10% was recorded in the sensitivity and performance of participating laboratories compared with the last tritium interlaboratory comparison in 1995.

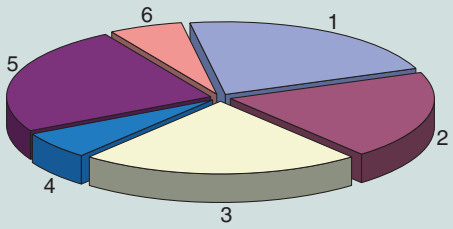
A network of analytical laboratories was established to assist in performing isotope hydrology analyses for technical co-operation projects. The network seeks to increase the participation of Member State laboratories in the Agency's technical co-operation programme while reducing the amount of routine analysis that needs to be performed. At present, the network includes seven laboratories, four from developing Member States. Continuous cross-checking of analytical results by the Agency ensures the quality of the services provided. In addition, the network ensures timely processing of analyses and serves as a means to widen or improve quality assurance schemes in Member State laboratories.

APPLICATIONS OF PHYSICAL AND CHEMICAL SCIENCES

PROGRAMME OBJECTIVE

To enhance the contribution of a wide spectrum of nuclear technologies in meeting the needs of Member States by: providing up to date nuclear and atomic data; supporting programmes based on research reactors and particle accelerators; improving capabilities in the development and use of radioisotope and radiation technology, radioanalytical measurements and nuclear instrumentation; encouraging environmentally friendly technologies based on the use of radiation; and providing a forum for the co-ordination of fusion research worldwide.

Regular budget expenditure: $8 822 587
Extrabudgetary programme expenditure (not included in chart): $20 412



1. Nuclear and Atomic Data for Applications: $1 942 099
2. Nuclear Instrumentation: $1 722 187
3. Theoretical Physics (contribution): $1 983 000
4. Utilization of Research Reactors and Particle Accelerators: $520 573
5. Radioisotopes and Radiation Technology: $2 139 348
6. Nuclear Fusion Research and Plasma Physics Applications: $515 380

KEY ISSUES AND HIGHLIGHTS

- The layout and content of the Agency's nuclear data web site was improved to provide easier access to users for their nuclear data needs. As a consequence, there was a 30% increase in retrievals from the site.
- Research carried out through a CRP resulted in the development of a nuclear data library (WIMS-IAEA) for research reactor calculations.
- An Agency symposium in São Paulo, Brazil, highlighted the role of accelerators for analytical, materials and medical applications.
- Educational kits were provided by the Agency for training in the use and maintenance of nuclear instrumentation employing microcontrollers and microprocessors.
- Techniques were developed through a recently concluded CRP for the labelling of small peptides with rhenium-188 for radiopharmaceutical applications.
- The Agency and WHO, in a joint effort, defined good manufacturing practices (GMP) in radiopharmaceuticals; they will be published as a special section of a WHO manual on GMP for pharmaceuticals.
- The International Thermonuclear Experimental Reactor (ITER) Council declared the successful completion of Engineering Design Activities in July 2001. The next phase is under way, and involves co-ordinated technical activities among ITER parties under Agency auspices.

NUCLEAR AND ATOMIC DATA FOR APPLICATIONS

The results of a CRP that ended in 2001 were published in a technical document, *Charged Particle Cross-Section Database for Medical Radioisotope Production: Diagnostic Radioisotopes and Monitor Reactions* (IAEA-TECDOC-1211). Fully complementing the information available on the Agency's web site *(http://www-nds.iaea.org/medical)*, the document presents recommended cross-sections for 22 beam monitor reactions and 26 production reactions of radioisotopes used in nuclear medicine for diagnostic purposes. These recommended data are sufficiently accurate to meet the demands of the production criteria for high purity diagnostic applications in single photon emission computed tomography and positron emission tomography for biofunctional studies.

The ENDF Verification Support Package (ENDVER) was completed to display the contents of Evaluated Nuclear Data Files (ENDFs) and compare them with experimental data from the Experimental Exchange Format (EXFOR) database. Special features include the capability to display and compare angular distributions, energy spectra and double differential cross-sections. This software package has aided considerably in data verification.

The Atomic and Molecular Data Information System (AMDIS) has been enhanced by the addition of comprehensive data for physical sputtering with both angular and energy dependence. These new data include fusion relevant projectiles impacting on beryllium, carbon, tungsten and related compounds. Furthermore, a comprehensive database for the radiation enhanced sublimation (RES) of carbon and carbon related compounds was developed and added to AMDIS. The results of this work, summarized in the Agency publication *Atomic and Plasma-Material Interaction Data for Fusion*, show the dependency of physical sputtering and RES yields on the temperature of the material, incident projectile energy and incident flux. Version 1.2 of the International Database on Irradiated Nuclear Graphites, developed and maintained through extrabudgetary funding, was also distributed. These databases are of great importance in the design of fusion energy research machines where the interaction of plasmas with the reactor wall is critical to the success of the machine.

Efforts to produce an Internet based search engine for atomic data led to the development of a prototype version that has undergone extensive testing. The initial version of the search engine, released in December 2001, operates on servers at the Agency, the Weizmann Institute of Science (Rehevot, Israel) and at the GAPHYOR Data Center of the Centre National de la Recherche Scientifique (Orsay, France). This project was initiated in response to the difficulties faced by users of atomic and molecular data in easily formulating the correct query for a number of different databases. The search engine permits the user to formulate and pass along one query in the correct form to many databases and to have all search results gathered for display simultaneously, an approach that will allow plasma modellers to access many more data.

The adoption by the Agency of alternative relational database management systems has substantially improved the quality of its computerized data services. These new methods of data storage and distribution also comply with the information technology policy of the Agency. In addition, these systems are expected to have a major impact on the nature, flexibility and cost of all nuclear data services, including the formulation of nuclear reaction databases in multisystem or multimedia environments that will provide a common solution to the handling of different software and hardware platforms and result in more user friendly access.

Access to the Agency's nuclear data server for the Internet (*http://www-nds.iaea.org*) has stabilized over 2000–2001 at a level of 15 000 queries per year (see Table I and Fig. 1). Nevertheless, the total number of data retrievals has increased by 30%, due mainly to customer requirements for data from the general purpose and special applications libraries. The latter are being successfully formulated and introduced through CRPs. Another noteworthy point is that the number of queries from developing countries has continued to grow in 2001. In addition, the layout and design of the web page has been significantly

improved to ease user access to the data. New data libraries have also been added to the site, as well as program packages to verify the evaluated data files and for nuclear model calculations

NUCLEAR INSTRUMENTATION

In supporting the utilization and maintenance of instruments used for nuclear applications in Member States, the Agency develops and disseminates spectrometry software and educational kits for instrument maintenance. Knowledge and competence are imparted through training courses. For example, the Agency's software packages for spectrometry and the related reference spectra are now available on its web site and can be downloaded by users. In this connection, an exercise to compare commercially available software packages for analysing particle induced X ray emission spectra revealed that there is room for improvement in quantifying results from low intensity peaks.

Various distance learning tools for the maintenance of instruments were developed through Agency technical co-operation projects. For example, a CRP was started to develop modules for the troubleshooting of such commonly used instruments as radioimmunoassay and liquid scintillator counters, and electrometers. The aim of the CRP is to develop information

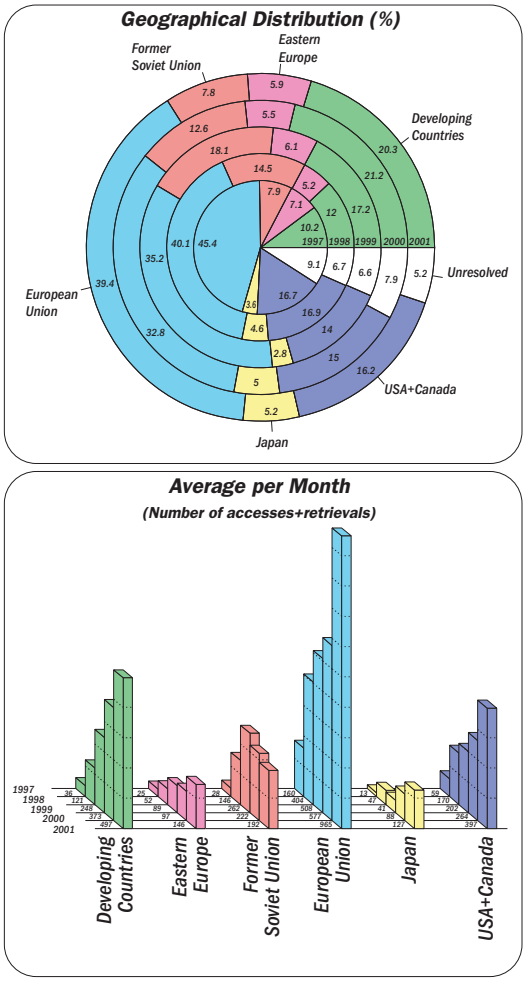


FIG. 1. Number of data accesses and retrievals from the Agency's nuclear data web site and from the mirror server at the Nuclear and Energy Research Institute (IPEN) in Brazil.

TABLE I. **STATISTICAL ANALYSIS OF DATA SERVICES**

	1997	1998	1999	2000	2001
Internet retrievals from the main Agency nuclear databases	23	4276	9581	9642	12 894
Accesses through the Internet to other Agency files and information	4400	7443	7757	11 472	16 153
Telnet based nuclear data retrievals	7350	2700	2180	1387	550
Information on CD-ROMs	—	205	420	648	883
Off-line retrievals	1900	1995	2290	2557	2231

communication technology (ICT) based training modules, including animation and other multimedia techniques, as educational tools to increase the number of trained technical staff in Member States.

Laboratories participating in the second Research Co-ordination Meeting of a CRP on the application of nuclear techniques for the identification of anti-personnel land mines reported advances in the development of portable detection devices. A hand held sensor based on backscattered, thermalized neutrons was identified as a promising tool. The Agency's work in this area was also presented at a European Commission meeting in Brussels.

A new CRP on in situ application of the X ray fluorescence (XRF) technique has the objectives of: developing optimum sampling methodologies; improving performance for field portable XRF spectrometers; and validating quantitative procedures for in situ XRF analysis. The results will benefit applications in environmental monitoring, mineral exploration, cultural heritage preservation and industrial process control.

The Agency's Laboratories at Seibersdorf provided basic technical support for activities related to the use and maintenance of nuclear instrumentation in Member States. Key efforts included the following:

— Assembling and providing educational kits for training on microcontroller and microprocessor based equipment.
— Selecting, testing and implementing ICT based training materials for basic nuclear electronics and for the maintenance and repair of nuclear instruments.
— Establishing a new training station for the repair of printed circuit boards.
— Assessing new radiation detectors for X ray and gamma ray spectrometry.
— Developing instruments for environmental pollution monitoring, dosimetry and agricultural studies.
— Developing a power supply for silicon drift detectors.
— Assisting in the establishment of regional centres for the maintenance and repair of nuclear instruments.
— Providing technical guidelines to Member States on the development and maintenance of instruments for nuclear spectroscopy.
— Assessing the total uncertainty of secondary target/X ray tube based energy dispersive XRF spectrometry, following the ISO standard.

UTILIZATION OF RESEARCH REACTORS AND PARTICLE ACCELERATORS

The main result of a recently concluded CRP to update the Winfrith Improved Multigroup Scheme (WIMS) has been to make available on request an updated, multi-group, neutron cross-section library, WIMS-IAEA, along with calculations for more than 200 benchmark problems. This library will improve the core physics modelling capability at many research reactors.

In addressing the issue of under-utilized research reactors, the Agency has assisted Member States in preparing utilization programmes tailored to the specific capabilities of the reactors. This assistance has taken the form of the publication of three technical documents to guide reactor operators. In addition, a utilization plan for a new research reactor in Nigeria was developed through a technical co-operation project.

Promoting education and training in nuclear technology in Member States is a major aspect of the Agency's technical assistance programme. A report prepared by a Technical Committee presents an overview of educational opportunities in accelerator technology and its applications. In particular, the report focuses on enhancing information exchange and establishing technology transfer mechanisms among different countries, and identifying training opportunities and needs in developing countries. In related work, Agency technical co-operation projects provided assistance in the procurement of an ion beam accelerator for materials development and analysis in the Syrian Arab Republic, and Thailand received helped in the operation and use of accelerators for ion implantation and materials analysis.

At a symposium held in São Paulo, Brazil, on the utilization of accelerators, the different uses of accelerators around the world and the new applications that lie ahead were reviewed. Target areas for Agency supported collaborative R&D programmes in the field of accelerator applications were also defined. Furthermore, the role of accelerators in nano-technology, environmental remediation and the sanitation of mail were considered.

RADIOISOTOPES AND RADIATION TECHNOLOGY

Receptor imaging of the central nervous system (CNS) has been shown to be very valuable in the management of neurological disorders using radiopharmaceuticals labelled with cyclotron produced isotopes, namely, carbon-11, fluorine-18 and iodine-123. However these isotopes are expensive and not readily available. A CNS receptor imaging agent based on technetium-99m will make such techniques widely available at an affordable cost. A CRP that ended in 2001 studied several approaches to synthesize, characterize and evaluate technetium-99m labelled molecules with potential for CNS receptor imaging. Technetium-99m mixed ligand complexes were prepared and in vitro receptor binding methods were developed to determine the receptor affinity and specificity of the compounds, followed by in vivo studies in animals. The CRP succeeded in establishing the radiochemical approaches for the preparation and evaluation of technetium-99m CNS receptor agents, which could pave the way for developing a suitable radiopharmaceutical.

Radioimmunoassays (RIAs) are widely used in clinical chemistry, but also have applications in non-clinical fields, including veterinary medicine, animal reproduction, food processing and the drug industry. A new CRP was started in 2001 to extend the capabilities of national laboratories in developing RIA kits for non-clinical applications. The goal of the CRP is to focus on RIA kit development for aflotoxin B1 — an important contaminant in food, atrazine — an environmental contaminant, and progesterone — for veterinary applications.

Good manufacturing practices, which have long been applied to pharmaceuticals, are also being increasingly used for the manufacture of radiopharmaceuticals. However, there has been a need for international guidelines, particularly for the benefit of developing Member States. The Agency and WHO have jointly prepared such guidelines, which were then approved by the WHO Expert Committee on Specifications for Pharmaceutical Preparations in October 2001. They will be published as a special section of WHO's *GMP Manual for Pharmaceuticals*.

In a recently concluded CRP, several techniques to label small peptides with therapeutic radionuclides were investigated. In particular, the peptide lanreotide was labelled with rhenium-188. This labelling technique can also be extended to several other peptides and biomolecules.

The scientific community became aware of the varying toxicological properties of different chemical forms of trace elements more than thirty years ago, when accidental releases of certain organometallic compounds caused severe health problems in populations eating crops from affected areas. However, the appropriate tools for method validation of speciation analysis, such as natural matrix reference materials, are not easily available. Nuclear analytical techniques are particularly well suited for method development and validation because of their non-destructive nature and their ability to use radioisotopes to determine the fate of compounds and elements. Labelled compounds can be introduced into biological tissues and act as a probe in the same way as natural analogues. A CRP was therefore started in 2001 to validate speciation analysis using nuclear techniques. The objective is to disseminate improved speciation techniques to Member States affected by impaired element concentrations in drinking water, soil or nutrition to monitor the toxic potential to their population.

Another CRP that started in 2001 had as its goal the upgrading of the most popular Agency reference materials to achieve full traceability to the International System of Units for radionuclide concentrations. Five laboratories

and the Agency's Laboratories at Seibersdorf developed traceable measurement techniques for the most important natural radionuclides, fission products and transuranium isotopes in natural matrix materials. Prior to the certification of the radionuclide concentrations, the homogeneity of the different batches of reference materials was verified. The measurement results for evaluation and certification of the materials are expected in 2002.

One of the tasks of the Agency's Laboratories at Seibersdorf was to organize intercomparisons and proficiency tests for CRPs and technical cooperation projects. Two such tests were organized for a project that included samples spiked with anthropogenic, alpha, beta and gamma emitting radionuclides. In addition, a very specialized proficiency test was organized for eight laboratories involving the preparation of 48 different samples representing four matrices (milk, vegetation, soil and water) with varying concentrations and mixtures of both anthropogenic and primordial radionuclides. The Seibersdorf Laboratories provided technical support to Member State counterpart staff in evaluating, interpreting and preparing the individual and summary reports as well as certificates for this proficiency test.

In 2001, orders for products from the Agency's Analytical Quality Control Services (AQCS) were received from approximately 200 customers (Table II).

The training and certification of non-destructive testing (NDT) personnel has significance in any country's industrialization programme. To this end, a revised version of an Agency technical document was prepared (*Training Guidelines in Non-destructive Testing Techniques, 2002 Edition*, IAEA-TECDOC-628/Rev.1). The new version is expected to help end users in Member Sates update their materials and programmes. It will also play an important role in international harmonization efforts in the field of NDT.

A CRP on the use of radiation processing for the sterilization or decontamination of pharmaceuticals and pharmaceutical raw materials was completed. The results of various physico-chemical and pharmacological studies and tests indicated the possibility of radiation treatment of drugs such as cefotaxime, amoxycillin, spyramicine, tetracyclines, cyclophosphamide and sulphonamides. In the case of trifluorothymidine, fluorometholone, deferroxamine and a new peptide, radiation sterilization was found to be better than or equivalent to heat sterilization. The usefulness of radiation processing for the decontamination of various herbal medicines and plant extracts was also shown.

Fumes and other gaseous emissions from industrial activities often contain toxic volatile organic compounds (VOCs). These include by definition all organic compounds that are detrimental to the ozone layer and are considered to contribute to global warming because of their extremely long atmospheric lifetimes. They also include organic compounds that are hazardous materials, causing headaches, dizziness or sore throats, and those that are carcinogenic. Using the services of consultants, the Agency prepared a report that demonstrated that electron beam technology is the most energy efficient treatment technology for all VOCs with the exception of hydrofluorocarbons. Its key advantage over other technologies is in treating low concentrations of VOCs (<1000 ppm), since it does not merely transfer the waste from one medium to another (unlike activated carbon adsorption or scrubbing). It was also shown to have great promise for the remediation of contaminated sites and exhaust gases from various industrial applications.

TABLE II. **NUMBER OF AQCS UNITS SOLD IN 2001**

Analyte group	Number of units sold
Radionuclides	629
Trace elements	257
Methylmercury	17
Organic contaminants	18
Total	**921**

The technical, economic and environmental advantages of the radiation processing of cellulose and wood by-products were assessed in a study. For example, electron beam processing of cellulose pulps provides a technically and commercially viable method that can replace the energy intensive ageing step in conventional viscose processes. Significant reductions in chemical use and toxic emissions benefit the industry in terms of reducing manufacturing costs as well as the pollution associated with the process.

A new CRP entitled 'Integration of Residence Time Distribution (RTD) Tracing with Computational Fluid Dynamics (CFD) Simulation for Industrial Process Visualization and Optimization' began in 2001. The main objective is to develop and validate a method for analysing and diagnosing industrial engineering processes using radiotracer experiment and CFD modelling. Experimental protocols and software codes of a combined experimental and computational method will be elaborated to obtain reliable quantitative results on process performance in industrial vessels and process units to improve and optimize their design and efficiency.

NUCLEAR FUSION RESEARCH AND PLASMA PHYSICS APPLICATIONS

In July 2001, the ITER Council held its final meeting at Agency Headquarters to mark the successful completion of the Engineering Design Activities carried out by the ITER Joint Central Team and the ITER Parties' National Teams between 1992 and 2001. In preparation for the construction of ITER, the current ITER Parties (Canada, the European Union, Japan and the Russian Federation) have agreed to conduct, under Agency auspices, Co-ordinated Technical Activities (CTA) until the end of 2002. One goal is to adapt the final ITER design to site specific conditions. Thereafter, the Joint Implementation (Construction, Operation and Decommissioning) of the ITER Project is expected to start.

A CRP was started to investigate dense magnetized plasma applications for harnessing nuclear fusion, both as a power source and as an intense radiation source. Dense magnetized plasmas can be generated by various types of devices, including pinches, focuses, plasma accelerators, open switches, sparks and hollow

TABLE III. **AGENCY TECHNICAL COMMITTEE MEETINGS ON NUCLEAR FUSION**

Title	Location
Control, data acquisition and remote participation for fusion research	Padova, Italy
Research using small fusion devices	São Paulo, Brazil
Spherical tori	São Jose dos Campos, Brazil
Divertor concepts	Aix-en-Provence, France
H-mode physics and transport barriers	Tokai, Japan
High average power drivers for inertial fusion energy	Kyoto, Japan
Energetic particles in magnetic confinement systems	Gothenburg, Sweden

cathode discharges. Magnetized plasmas may provide a more efficient route to achieving fusion ignition.

The Agency continued to be a catalyst in fusion research and information exchange, with a range of Technical Committee meetings conducted under its auspices (Table III). At the meeting on H mode physics and transport barriers, it was reported that after new divertors were installed, the Wendelstein 7-AS Stellarator in Garching, Germany, achieved the highest densities ever in a magnetic confinement experiment (up to $n_e \sim 4 \times 10^{20}$ m^{-3}).

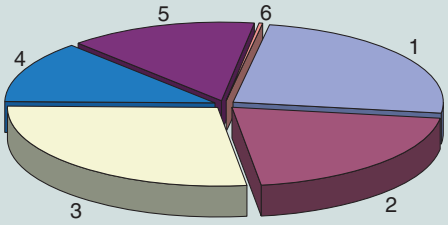
The Agency's Programme in 2001: Safety

NUCLEAR SAFETY

PROGRAMME OBJECTIVE

To achieve and maintain a high level of safety of nuclear installations under design, construction or operating worldwide by: establishing standards of safety for the protection of health including standards for research reactors, nuclear power plants and other non-reactor nuclear installations; and providing for the application of these standards through support for the Agency's technical co-operation programme, the rendering of services, the promotion of education and training, the fostering of information exchange and the co-ordination of research and development.

Regular budget expenditure:$5 428 683
Extrabudgetary programme expenditure (not included in chart): $2 235 562



1. Safety Assessment Developments: $1 329 374
2. Nuclear Plant Engineering Safety: $1 106 655
3. Operational Safety: $1 500 866
4. Research Reactor Safety: $696 723
5. Regulatory Activities Related to Nuclear Safety: $773 998
6. Safety of Other Installations: $21 067

KEY ISSUES AND HIGHLIGHTS

- Three Safety Guides were published, with six more approved and in the process of being published.
- There was continuing, and in many cases increasing, demand for Agency safety review services. The results of these safety 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.
- An international action plan was developed to improve the safety of research reactors.
- Following up on earlier meetings in 1991 and 1998, an international conference on topical issues in nuclear safety was held in September (Box 1).

SAFETY ASSESSMENT DEVELOPMENTS

The Secretariat began development of safety standards addressing the safety of non-reactor nuclear fuel cycle facilities. Safety Requirements for fuel cycle and isotope production facilities and two Safety Guides covering mixed oxide and uranium fuel production facilities were drafted. Publications covering other types of facility are planned for the coming years. The standards for fuel cycle facilities build upon the established standards for nuclear power plants, with the addition of international consensus requirements and guidance on specific issues relevant to the different types of facility.

In light of the increasing use of probabilistic safety assessment (PSA) by operators and regulators to support safety related decisions, the Agency's activities in this area focused on promoting improvements in the quality and consistency of PSAs as a prerequisite for their use in decision making. Regulatory review guides on level 1, 2 and 3 PSAs were developed

BOX 1. BUILDING AN INTERNATIONAL CONSENSUS ON KEY ISSUES IN NUCLEAR SAFETY

In 1991, the Agency organized an international conference on the safety of nuclear power, with a particular focus on developing a strategy for the future. As a follow-up, another conference was held in 1998 to discuss various topical issues in nuclear, radiation and radioactive waste safety. Substantial progress has since been made by Member States in enhancing the safety of their nuclear power plants. However, there are still areas of concern, for example research reactor safety and the safety of other facilities in the nuclear fuel cycle.

In response, the Agency convened a conference in September 2001 to study the following "topical issues":

- Risk informed decision making,
- Influence of external factors on safety,
- Safety of fuel cycle facilities,
- Safety of research reactors,
- Safety performance indicators.

There was broad agreement at the conference that, where the capability exists, risk informed decision making can be a significant enhancement to nuclear safety and safety focus. With regard to external factors, it was noted that in cases where the achievement of strong business performance was recognized to be a natural result of strong safety performance, market liberalization could enhance safety. For fuel cycle facilities, the conference felt that development of the appropriate safety standards was a prerequisite to the provision of safety services to Member States. Turning to research reactor safety, there was agreement that the organizations responsible for these reactors should develop strategic plans on their future utilization to help in making decisions on whether or not to terminate operations or decommission reactors in extended shutdown. The Agency was requested to place greater emphasis on helping countries to build their national infrastructure for education and training programmes. There was recognition that while research reactors are currently under-utilized, they could become valuable resources for training and practical experience, especially if they were used to support regional centres for education and training. Finally, a three tier approach was considered for the development of a possible framework for safety performance indicators, focusing first on the needs of the nuclear facility, then on the regulatory bodies and later on the public. There was consensus that the Agency should continue its work to ensure that definitions of safety indicators allow their effective use for nuclear power plants, research reactors and other nuclear fuel cycle facilities. ■

in co-operation with the OECD NEA, advice and training were provided on achieving quality and consistency of PSAs, and PSA intercomparison exercises were conducted for WWER-1000 and PHWR reactors. Substantial progress was also made on a technical document on methods, requirements and applications of PSA for risk informed decision making, which will be published in 2002.

To support Member States in their development and use of PSA, the Agency conducted workshops and training activities, including risk monitors (a plant specific real-time analysis tool) and a level 2 PSA. Six International Probabilistic Safety Assessment Review Team (IPSART) missions were conducted to review PSAs and to provide guidance on the use of the results. Although the results of these reviews are dependent on the individual studies, in general the weak areas relate to the estimation of initiating event frequencies, identification and modelling of human errors and common cause failures, and the completeness of information and the screening process for fire analysis. Common weaknesses were also identified in technical quality assurance processes for PSAs and in the preparation of supporting documentation.

The new Review of Accident Management Programmes (RAMP) service aims to assist Member States in the development and implementation of effective plant specific accident management programmes consistent with the Agency's safety standards. A pilot mission visited the Krško nuclear power plant in Slovenia in November 2001. The objective was to review the comprehensiveness, consistency and quality of the accident management programme for the plant, including material and human resources, interrelation with other plant activities and emergency arrangements, and the qualifications and training of plant personnel. The mission found that the programme had been successfully developed and largely implemented in accordance with Agency guidance and good international practice. The mission team identified a number of positive features, and also made recommendations on areas in which improvements could be made. The lessons learned during the pilot mission will be used in further improving the review methodology and guidelines for this service.

An extrabudgetary programme on the safety of nuclear installations continued to provide assistance to China, Indonesia, Malaysia, Philippines, Thailand and Viet Nam, with contributions from France, Germany, Japan, the Republic of Korea, Spain and the USA. The objective is to strengthen safety infrastructure and the safety of nuclear power plants and research reactors in the region, and in particular to develop human resources and enhance the technical capabilities of regulatory authorities and supporting organizations. In China expert missions visited the newly constructed Tianwan Nuclear Power Plant (a WWER-1000 design), reviewing the design with regard to severe accident mitigation, the reactor protection system and the control room, and validation and verification of the safety software. The reviews, intended to serve as training for the Chinese organizations, involved experts from Russian and German companies that are designing the instrumentation and control and other systems for the nuclear power plant. Safety Analysis Reports for research reactors in Malaysia, Thailand and Viet Nam were reviewed with the aim of improving their scope and technical quality. And a pre-International Regulatory Review Team mission visited Thailand to review the practices of the regulatory body and make recommendations to strengthen and enhance its effectiveness.

NUCLEAR PLANT ENGINEERING SAFETY

A Safety Guide, *Safety Assessment and Verification for Nuclear Power Plants*, was published in 2001, the second in a series of Guides supporting the new Safety Requirements for design published in 2000. Another Safety Guide, *Instrumentation and Control Systems Important to Safety in Nuclear Power Plants*, is in the process of being published; nine other Safety Guides on design safety are being prepared.

Design safety review services have gained momentum recently in relation to both new designs and existing nuclear power plants. A number of projects are under way within which such reviews have been conducted. Under a technical co-operation project, the Preliminary Safety Analysis Report (PSAR) for the Bushehr

Nuclear Power Plant in the Islamic Republic of Iran is being reviewed. The design of this plant is unique: the civil engineering structures from a partially built PWR are being used to house a WWER-1000 reactor. The structures have also been repaired after suffering war damage. In addition to this support to the operator, another technical co-operation project is supporting the regulator: six meetings were held with the regulatory body in 2001 — in Tehran, Moscow and Vienna — providing advice on atomic law, reviewing various parts of the PSAR and the environmental impact assessment report, and reviewing the regulatory body's training programme. In addition, an Iranian delegate participated as an observer in an Operational Safety Review Team (OSART) mission, and a workshop on accident analysis was conducted.

A design safety review of the LWR project for the Democratic People's Republic of Korea was conducted by the Agency in June 2001 at the request of the Korean Peninsula Energy Development Organization (KEDO). The review covered all aspects of the siting and design of the plant, and was aimed at verifying the compliance of the design with the Agency's safety standards and international practices. Comments and recommendations for improving the safety of the plant and its documentation were also made. Two teams in parallel reviewed the PSAR and the assessment of the site, including the radiological environmental impact and the external hazards. The design is based on the proven technology and performance of the reference design (Ulchin 3 and 4 in the Republic of Korea), and includes the most recent design improvements made for Ulchin 5 and 6. The Kumho site was found to have no characteristics that would make it unacceptable from a nuclear or radiological safety point of view. However, some recommendations were made in a number of areas, including further investigation of the seismic situation.

The final design safety review mission of 2001 was to the Temelin nuclear power plant in the Czech Republic, in November 2001, to review the resolution of safety issues identified when the Agency conducted a similar review in 1996. The expert mission addressed both the Agency issues and those raised in recent years by other parties. Because of the recent OSART mission to Temelin, the review did not include the issues related to operational safety. The experts concluded that most of the design safety issues identified as being relevant to reactors of the generic Temelin design had been addressed and resolved, and that work is nearing completion on the few remaining issues. The judgement of these experts was that these issues would not preclude the safe operation of Temelin.

A technical document (IAEA-TECDOC-1235) published in 2001 addresses the safety and licensing aspects of nuclear plants coupled with seawater desalination plants and the basis for the safety assessment of such plants. It also proposes a general approach for the preparation of safety requirements for reactors with special safety features or of a smaller size as compared with nuclear power plants. This approach is aimed at generating the safety design requirements for any kind of nuclear reactor starting from those for nuclear power plants.

Seismic safety review services continue to address both the application of the seismic re-evaluation of existing nuclear power plants and more general siting projects, including facilities other than power plants. A mission to the Armenia Nuclear Power Plant in May gave advice on the second phase of a seismic reevaluation programme for the plant, including the possible role of PSA in the programme.

A series of reports on the assessment and management of ageing of major nuclear power plant components important to safety was completed when a technical document (IAEA-TECDOC-1197) covering CANDU reactor assemblies was published. The series documents current practices for the assessment of safety margins (fitness for service) and the inspection, monitoring and mitigation of ageing degradation of selected components of CANDU reactors, BWRs, PWRs (including Soviet designed WWERs). These practices are intended to ensure the safe operation of nuclear power plants and also provide a common technical basis for dialogue between plant operators and regulators when dealing with age related licensing issues.

Intergranular stress corrosion cracking in stainless steel pipes is a safety issue for BWRs. An extrabudgetary programme on the mitigation of

such cracking in the austenitic stainless steel piping of RBMK reactors assists countries operating such reactors in establishing effective mitigation programmes through technology transfer, training and guidance. The programme is entering its final phase. The main achievements in 2001 included: adaptation of sizing procedures for ultrasonic testing to RBMKs; training of RBMK operators on advanced ultrasonic testing; development of an ultrasonic testing qualification procedure for a pilot study; development of a risk based inspection system for the Ignalina nuclear power plant in Lithuania; transfer of technology and training on repair techniques; and formulation of guidance on improving water chemistry monitoring and control.

OPERATIONAL SAFETY

Two Safety Guides were published in 2001 supporting the Safety Requirements for the operation of nuclear power plants, published in 2000. The new Guides discuss modifications to nuclear power plants and the operating organization. Three other Safety Guides in the operational safety area will be published in 2002, and four others are being prepared.

The Agency's operational safety review services are being improved to better meet current and future challenges identified by the Member States using these services. More requests have been received from utilities and regulatory organizations to provide methodologies for the self-assessment of management processes and safety culture, and there has been greater demand for assistance in areas identified by assessments as needing improvement.

The general impression gathered from OSART missions is that managers are committed to improving the operational safety and reliability of their plants. The missions identified several examples of good practices, and also made recommendations and suggestions to improve operational safety. The results of each mission are made available to the nuclear industry and their regulatory authorities through a database called OSMIR. Follow-up missions in recent years confirm that operational safety services such as OSART are helping Member States achieve and maintain a high level of safety performance. On average, the rate of resolution of and compliance with the Agency's recommendations has improved over the last five years from 80% to over 90%.

Recently, the Agency, in consultation with Member States, developed the Peer Review of Operational Safety Performance Experience Review processes, known as PROSPER. Guidelines for the PROSPER service were finalized during the year. Another service, the Safety Culture Enhancement Programme (SCEP), supports Member States in their efforts to develop a sound safety culture in their organizations. The SCEP services can be tailored to the needs of a particular organization, where they may want support only in certain steps of the process. The ongoing SCEP support to Electronuclear, in Brazil, has served as a basis for the continued development of these services. Based on the experience gained, guidance is being developed on how to implement such a programme. Full scope SCEP support has also been initiated for the Laguna Verde Nuclear Power Plant in Mexico, and for the fuel cycle facilities in Industrias Nucleares do Brazil.

RESEARCH REACTOR SAFETY

In response to a resolution from the 2000 General Conference, the Secretariat's proposal for an international research reactor safety enhancement plan aimed at strengthening the safety, monitoring of safety and regulatory supervision of research reactors worldwide was endorsed by the Board of Governors. This plan calls on the Agency to:

— Conduct a survey of research reactor safety in Member States;
— Prepare a code of conduct on the safety of research reactors with a view to establishing the desirable attributes for management of safety;
— Explore possible means to strengthen the system for monitoring the safety of research reactors, taking account of the experience of organizations working in other fields.

The number of requests to conduct Integrated Safety Assessment of Research Reactors

(INSARR) missions is increasing. During 2001, a mission to Greece reviewed operational safety aspects of the GRR-1 ("Demokritos") research reactor and concluded that: the reactor is generally in good condition and is being operated safely; and the operating organization has the human and financial resources to keep the facility running well. A number of good practices were identified, and recommendations were made to address several weaknesses and opportunities for improvement. A mission to Australia in May–June 2001 reviewed the PSAR for the Replacement Research Reactor to be built at Lucas Heights (to replace the existing HIFAR research reactor at the same site). This was a follow-up to a 1998 review by the Agency of the environmental impact statement for the reactor. It was noted that all of the recommendations made then had been addressed in the PSAR. Recommendations for further improvement were made, but the review generally concluded that the PSAR reflected the design accurately and effectively, had been prepared using Agency safety standards, reflected current good international practices and provided an adequate basis for licensing purposes.

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 closely monitor research reactors subject to such agreements. Accordingly, seven safety review missions visited research reactors during the year.

The Incident Reporting System for Research Reactors (IRSRR) has 31 participating countries, representing a large majority of the research reactors in the world. In November, the second meeting of IRSRR national co-ordinators was held in Lisbon. A pilot version of incident reporting software for the system was demonstrated, and the participants presented reports of incidents for inclusion in the database. A workshop on human performance was also part of the meeting.

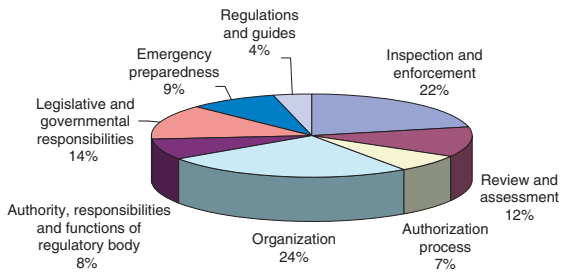


FIG. 1. Distribution of recommendations from seven full scope IRRT missions.

REGULATORY ACTIVITIES RELATED TO NUCLEAR SAFETY

The Agency's International Regulatory Review Team (IRRT) service studies the effectiveness of regulatory bodies and exchanges information and experience. 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 also raised. A review of the recommendations and suggestions from seven full scope IRRT mission reports identified areas where more effort to improve regulatory effectiveness was recommended (Fig. 1).

The Incident Reporting System (IRS), operated jointly with the OECD NEA, exchanges information on unusual events at nuclear power plants, and seeks to increase the awareness of actual and potential safety problems. As Fig. 2 shows, participating countries submitted 76 reports in 2001. This number is, for the second consecutive year, at the lower end of the expected range. A questionnaire to IRS co-ordinators will try to identify possible problems in reporting, following which the Secretariat will prepare recommendation for the participating countries.

Two IRS topical studies — on incidents caused by loss of corporate knowledge and memory, and on events indicating non-compliance with operational limits and conditions (OLCs) — were completed. The first study provided findings in particular subject areas. More generally, the procedure for analysing events helped to generate ideas for improvement in the areas of: identifying and using event information to avoid loss of knowledge; using event information to ensure better learning from other events; and reducing recurring events, especially by enabling

comparison between different events. The second study found that the majority of events were related to human factors deficiencies and procedural inadequacies rather than to deficiencies in the OLCs themselves. Other findings highlighted the importance of functional testing after maintenance to ensure that equipment is restored to an operable status, of explicitly highlighting OLC values in procedures and providing visual indications of OLCs on monitoring instrumentation, and of operators taking adherence to OLCs seriously. It was recognized, however, that competitive pressures may encourage operators to perform closer to limits, which may result in an increased number of events of this type in the future.

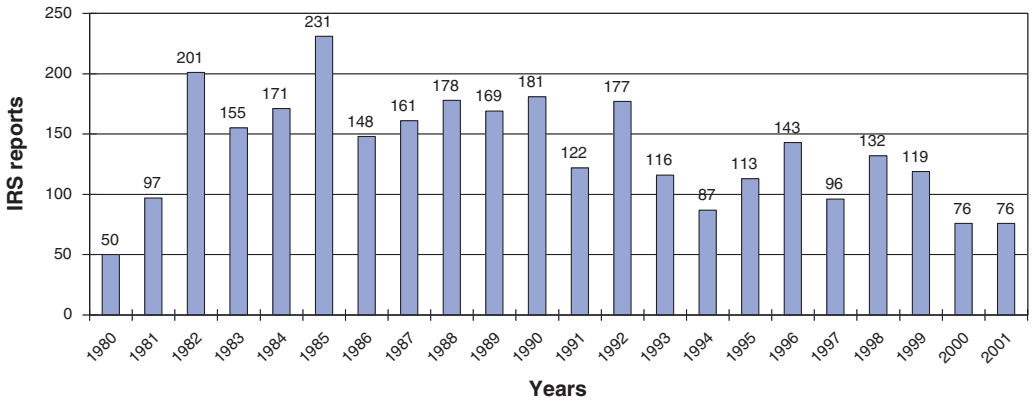


FIG. 2. Number of events reported to the IRS, 1980–2001.

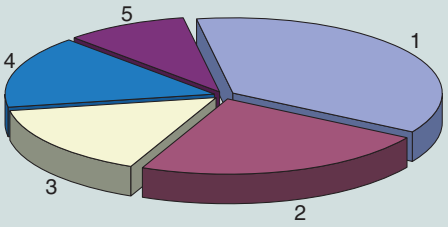
RADIATION SAFETY

PROGRAMME OBJECTIVE

To establish, in consultation and — where appropriate — in collaboration with the competent organs of the United Nations and with the specialized agencies concerned, standards of safety for the protection of health, including standards relating to radiological protection, radiation source safety, radioactive materials security and the safe transport of radioactive materials; to provide for the application of those standards through, inter alia, support for the Agency's technical co-operation programme, the rendering of services, the promotion of education and training, the fostering of information exchange and the co-ordination of research and development — all in the field of radiation safety; to service the Early Notification and Assistance Conventions; and to ensure an appropriate level of radiation safety in the Agency's own operations.

Regular budget expenditure: $3 675 857

Extrabudgetary programme expenditure (not included in chart): $299 508



1. Radiation Protection: $1 340 455
2. Safety of Radiation Sources and Security of Radioactive Material: $843 507
3. Safe Transport of Radioactive Material: $574 442
4. Radiation Emergencies: $566 649
5. Operational Services for Radiation Monitoring and Protection: $350 804

KEY ISSUES AND HIGHLIGHTS

- The action plan on the safety of radiation sources and the security of radioactive materials was updated to take account of recommendations from an Agency conference of national regulators held in Buenos Aires in December 2000.
- An Agency conference on the radiological protection of patients, held in Málaga, Spain, recommended that a group of experts be convened to develop an international action plan in this area.
- Proposals for changes to the Agency's Transport Regulations were agreed, with an updated edition of the Regulations planned for issue in 2003.
- The framework for responding to nuclear and radiological emergencies was reviewed by representatives of competent authorities from Member States.
- The achievements of the Agency's technical co-operation Model Project on upgrading radiation protection infrastructure were reviewed. As a result of this review, the project was split into two, with one part concentrating on the most basic infrastructure elements and the other on the more advanced milestones.
- A new Occupational Radiation Protection Appraisal Service was launched and the first review was conducted.

RADIATION PROTECTION

A technical document published in 2001, *Assessment by Peer Review of the Effectiveness of a Regulatory Programme for Radiation Safety* (IAEA-TECDOC-1217), sets out a methodology by which the status of a regulatory programme for radiation safety can be assessed so that areas where improvements are necessary or useful can be identified. The methodology was initially developed in 1997–1999, and was subsequently refined on the basis of experience gained during Agency peer review missions in 1999 and 2000. In 2001, Radiation Safety Regulatory Infrastructure (RSRI) peer review missions visited Niger, Philippines, Thailand and Venezuela.

The technical co-operation Model Project on upgrading radiation protection infrastructure was initiated in 1995 with the aim of assisting Member States in establishing the infrastructure elements regarded as prerequisites for implementing the requirements of the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources (BSS). In November, the Secretariat reported to the Board of Governors on the implementation of the Model Project between 1995 and 2001. The levels of attainment among the 52 participating States of milestone 1, the basic legal and regulatory infrastructure for the control of radiation sources, and milestone 2, a system for controlling occupational radiation exposure, were much lower than originally expected. Although various difficulties had been foreseen, the time needed to overcome them was in some cases underestimated. The Secretariat has informed the participating Member States that new technical co-operation projects involving the use of radiation sources would be proposed to the Board of Governors as fully funded projects only after States have attained these two milestones. In this regard, new technical co-operation projects were started in 2001 to assist Member States in reaching these milestones. One project each in Europe, Latin America, Africa, West Asia, and East Asia and the Pacific addresses milestones 1 and 2, while the others relate to milestones 3–5 (systems for controlling medical exposure and public exposure, and for emergency preparedness and response). In addition, 29 other Member States have requested assistance through these new projects.

Medical practice involving the use of ionizing radiation accounts for about 95% of human exposure from human made sources of radiation. Furthermore, accidents during medical treatment with radiation continue to occur occasionally, with severe and sometimes fatal consequences. A conference on the radiological protection of patients in diagnostic and interventional radiology, nuclear medicine and radiotherapy, held in Málaga, Spain, in March, confirmed that there was scope for reducing the radiological risks involved in both diagnostic and therapeutic uses of radiation without reducing the medical benefits. The conference's overall conclusion was that the "relevant international organizations should convene a group of experts, including experts from professional societies and regulatory bodies, to formulate an action plan based on the findings of the conference for future work relating to the radiological protection of patients." The Board of Governors and General Conference endorsed this conclusion; the action plan will be developed in 2002.

Under the terms of the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, Member States can request the Agency to provide support and assistance, and conduct follow-up investigations in the event of a radiological accident. In response, the Agency published a report entitled *Investigation of an Accidental Exposure of Radiotherapy Patients in Panama*. Compiled by a team of experts, the report contains the assessment of a radiological accident that led to the serious overexposure of 28 radiotherapy patients in Panama. From August 2000 to February 2001, as the result of a calculational error in the data entry of a treatment plan, patients were treated with doses up to 100% higher than those prescribed. The report evaluates the doses incurred, provides a medical evaluation of the affected patients' prognosis and treatment, and presents a number of findings, conclusions and lessons to be learned. The Agency also issued advisory material for Member States describing the causes of the accident.

SAFETY OF RADIATION SOURCES AND SECURITY OF RADIOACTIVE MATERIAL

At the request of the Board of Governors, the Agency's 'Action Plan for the Safety and Security of Radiation Sources' was revised, taking into consideration the findings of an Agency conference on 'National Regulatory Authorities with Competence in the Safety of Radiation Sources and the Security of Radioactive Materials', which was held in Buenos Aires in December 2000. As well as adjusting or emphasizing ongoing activities, a number of additional tasks were added. Several of these are aimed at improving the exchange of information and experience on various topics covered by the action plan between the Agency, regulatory bodies, source manufacturers and suppliers, and users of sources. Other new tasks emphasize the promotion of self-assessment of protection arrangements/infrastructure by States and mutual assistance between States, review of the use of the Agency's system for categorizing sources, more guidance and assistance to Member States on locating orphan sources and responding to emergencies, and rationalization of the Agency's databases on radiation sources and events. "As a highest priority", the revised action plan calls on the Agency to "explore the possibility of developing and implementing a universal system of labelling such that any member of the public is immediately aware of the dangers associated with hazardous radiation sources". It should be emphasized that the plan continues to focus on measures to prevent and respond to the unintended absence or loss of control over radiation sources. Although some of these measures might also contribute to preventing or responding to malicious acts involving radiation sources, the proper consideration of this latter issue calls for different expertise and measures, and should be treated separately.

In April, the Secretariat organized the First Africa Workshop on the Establishment of a Legal Framework Governing Radiation Protection, the Safety of Radiation Sources and the Safe Management of Radioactive Waste in Addis Ababa. The workshop adopted a "Common Position", in which the participants called upon the Agency to "create a forum for African countries to consider the Code of Conduct on the Safety and Security of Radioactive Sources and give it a legally binding effect so that the safe and peaceful use of nuclear technology is not compromised". The main elements of the Common Position were taken into account in drawing up the revised action plan for the safety and security of radiation sources referred to in the previous paragraph.

SAFE TRANSPORT OF RADIOACTIVE MATERIAL

In accordance with the review cycle for the Agency's Transport Regulations, a panel meeting in November 2001 recommended the publication of a revised version of the Regulations in 2003 as the '1996 Edition (As Amended 2003)'. The amendments in this new version will then be incorporated into the mode specific regulations of other international organizations with effect from 2005.

TranSAS (Transport Safety Appraisal Service) was established by the Agency in 1999 to provide, at the request of a Member State, an appraisal of that State's national implementation of the Agency's Transport Regulations. The first TranSAS mission was to Slovenia and was completed in 1999. Requests for further TranSAS missions were received from Brazil in 2000 and from Panama, Turkey and the United Kingdom in 2001. Pre-TranSAS missions to Brazil, Turkey and the United Kingdom had been completed by the end of 2001, and full TranSAS missions to all three countries are planned for 2002 (the mission to Panama is expected to be carried out in 2003).

The final report of a CRP on the severity, probability and risk of accidents during the maritime transport of radioactive material was published in 2001. The report, prepared by the participants from the five Member States, provides estimates of the frequencies of ship collisions and ship fires. Models of ship collisions led to the conclusion that even if crush forces were applied to a flask due to deep penetration of the hold, the forces would be relieved by the collapse of ship structures rather than that of the flask (Fig. 1). With regard to fires, shipboard tests and analytical modelling indicated that a fire

was not likely to spread to a hold containing radioactive material. If a fire did reach the hold, it was unlikely to burn at a sufficiently high temperature or for long enough to cause the release of radioactive material from a Type B flask. Finally, illustrative analyses indicated that neither the loss of a flask into the ocean nor the release of radioactive material to the atmosphere as the result of a severe ship collision that initiated a severe fire would be likely to subject exposed individuals to radiation doses that were significant by comparison with normal background doses.

RADIATION EMERGENCIES

In response to requests for assistance under the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, missions were sent to Panama and Poland in relation to accidents involving radiotherapy patients. In each case the Agency advised on the medical treatment of the victims, assisted in assessing the causes and consequences of the accidents and ensured that the equipment involved in the accidents was in a safe and secure condition.

Safety Requirements on preparedness and response to a nuclear or radiological emergency were endorsed by the Commission on Safety Standards and, if approved by the Board of Governors, will be published in 2002. The Requirements are sponsored by the Agency, FAO, ILO, OECD NEA, UN OCHA, PAHO and WHO.

In May 2001, the Agency participated in an international nuclear emergency exercise, JINEX 1. Involving 55 States and jointly sponsored and co-ordinated by the Agency, the European Commission, OECD NEA, WHO and WMO, the exercise was based on a hypothetical accident at the Gravelines nuclear power plant in northern France. The main objectives of the exercise were to: test existing national and international procedures and arrangements for responding to a nuclear emergency; co-ordinate the release of information; and assess the effectiveness of advisory and decision making mechanisms.

The Secretariat held a 'First Meeting of Representatives of the National Competent Authorities', identified under the Convention on Early Notification of a Nuclear Accident and the Assistance Convention, to evaluate the effectiveness of arrangements given in the latest edition of the *Emergency Notification and Assistance Technical Operations Manual* (ENATOM), and to identify problems that should be resolved before

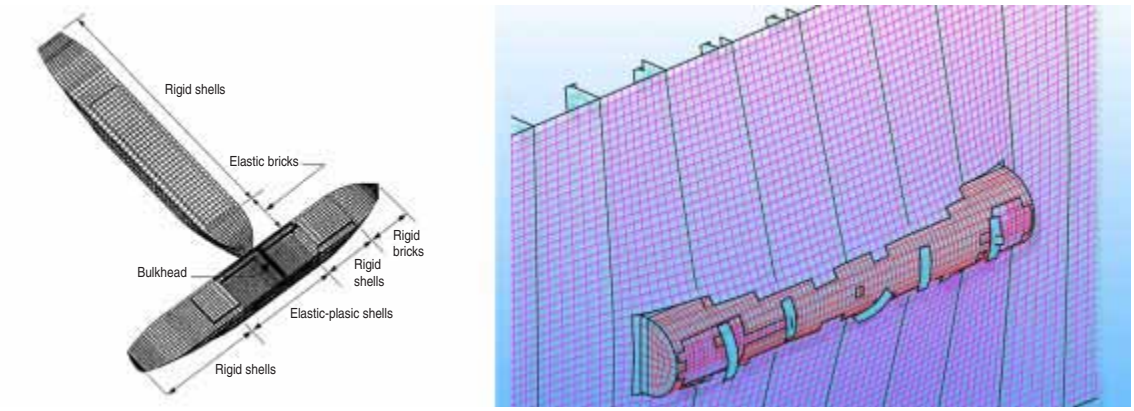


FIG. 1. Modelling of ship collisions (left) has indicated that the magnitude of crush forces that radioactive material packages transported by sea are likely to be subjected during even the most severe ship-to-ship collisions is limited by the strength of the side structure of the transporting vessel. The graphic on the right shows the undamaged container emerging from the side of a ship.

the next edition is issued in December 2002. The meeting suggested a number of operational changes to the system described in ENATOM, provided detailed comments on the ENATOM documentation and recommended a number of actions to be considered by the Secretariat in developing its future plans for strengthening and harmonizing international emergency preparedness and response arrangements for nuclear and radiological emergencies.

OPERATIONAL SERVICES FOR RADIATION MONITORING AND PROTECTION

A new Occupational Radiation Protection Appraisal Service (ORPAS) was developed to 'audit', against the Agency's relevant radiation safety standards, the regulatory and practical implementation of occupational radiation protection arrangements in the requesting Member State. The key objectives of the appraisal are to: provide the host country with an objective assessment of the provisions for occupational radiation protection; identify the strengths in the host country that are unique and worth bringing to the attention of others; promote the use of self-assessment by the host country; identify areas where performance should be improved to meet international standards; and make recommendations on actions to be taken to achieve such improvements. The first appraisal was carried out in Slovenia in July.

Quality management has become an important issue not only in Member State laboratories, but also in those operated by the Agency. In this connection, quality management documentation was prepared for the Agency's radiation monitoring and protection services. The material is consistent with the relevant ISO standards and Agency safety standards, and comprises the policy, scope, objectives, technical procedures, work instructions and checklists applicable to the Agency's operational activities in this area. It also provides guidance on the mechanisms and procedures for reviewing and assessing the effectiveness of protection and safety measures of the services rendered.

The organization of regional ALARA (as low as reasonably achievable) networks was initiated with the purpose of providing forums for information exchange on current practical experience in occupational exposure control. ALARA networks will assist Member States participating in the Model Project on upgrading radiation protection infrastructure in meeting the requirements of milestone 2 on occupational radiation control.

Exposure to natural radiation sources is estimated to account for more than 80% of the annual collective dose worldwide from occupational exposure (uranium mining excluded). An expert committee prepared a report on the assessment of occupational protection conditions in work places with high levels of exposure to natural radiation to provide further guidance to the Agency on priority areas for its work. The experts recommended that the highest priority be placed on developing safety reports for a number of specific industrial sectors where natural radioactive materials may cause a problem, and on developing detailed guidance on the identification of work places with potentially high radon levels and the necessary remedial actions.

An international intercomparison of measurements of the activity of gamma emitting radionuclides in human urine samples found no major inconsistencies in the activity values measured, but some inconsistencies were observed in the uncertainty calculations. Overall, the results showed that occupational monitoring assessment in the case of an intake of gamma emitters and measurement of urine samples is highly satisfactory.

In an ARCAL project on the promotion of nuclear science and technology in Latin America and the Caribbean, two intercomparisons were carried out. One related to measurements of ambient dose equivalent with radiation protection survey equipment. The results of this intercomparison showed that the majority of the equipment performed within a 10% deviation, but it also revealed the inadequacy of legal requirements for equipment calibration and a lack of calibration facilities in the region. The other project focused on measurement of the activity of radionuclides in food and environmental samples. Nine laboratories reported results and performed well in the determination of gamma activity, although some inconsisten-

cies were found in the uncertainty calculations of the activity values.

External experts conducted a peer review of the Agency's radiation monitoring and protection services. The goal was to help improve the relevance, effectiveness, efficiency and impact of existing projects and formulate better projects for the future. The experts recognized the importance of the Country Radiation and Waste Safety Profiles, acknowledging them as a useful tool for prioritizing and optimizing the use of limited Agency resources. However, they identified some concerns related to the ownership and maintenance of the profiles that are being addressed.

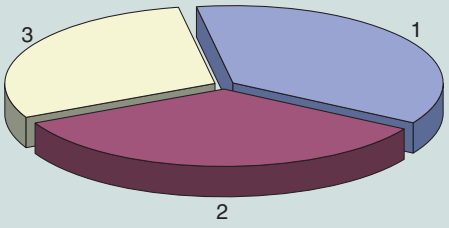
RADIOACTIVE WASTE SAFETY

PROGRAMME OBJECTIVE

To establish safety standards covering the management of solid radioactive wastes, the control of discharges of radioactive materials into the environment, and the restoration of environments with radioactive residues from past events and activities; to provide for the application of those standards through support for the Agency's technical co-operation programme; to service the London Convention 1972 and the Joint Convention; and to support the Global Programme of Action for Protection of the Marine Environment from Land-based Activities.

Regular budget expenditure: $1 705 990

Extrabudgetary programme expenditure (not included in chart): $292 248



1. Safety of Disposable Radioactive Waste: $622 264
2. Safety of Radioactive Discharges: $581 201
3. Safety of Radioactive Residues: $502 525

KEY ISSUES AND HIGHLIGHTS

- Safety standards were published on the decommissioning of nuclear fuel cycle facilities, and progress was made in the establishment of new consensus standards on geological disposal.
- Recommendations from the Agency's international conference on the safety of radioactive waste management, held in 2000 in Córdoba, Spain, were incorporated into the Agency's work plan for the future.
- Together with the OECD NEA, the Agency organized a peer review of the performance assessment being developed for a proposed waste disposal site at Yucca Mountain, in Nevada, USA.

SAFETY OF DISPOSABLE RADIOACTIVE WASTE

A specialists meeting in June on the geological disposal of radioactive waste addressed a number of topics on which consensus still needs to be developed so that Agency safety standards on the subject can be finalized. These included: a common framework for radioactive waste disposal; demonstrating compliance with safety criteria; safety indicators (in addition to dose and risk); reference critical groups and biospheres; assessment of human intrusion; reversibility and retrievability; and monitoring and institutional control. The meeting helped to clarify and document the areas of agreement that could be reflected in safety standards, and the outstanding issues.

At the request of the General Conference in 2000, the Agency prepared a report assessing the implications of the conclusions and recommendations from a 2000 conference on the safety of radioactive waste management on the Agency's programme of work. The report was finalized by taking account of comments during the March 2001 session of the Board of Governors and consultations with Member States, and was endorsed by the General Conference in September. The report highlights seven actions: develop a common framework for the disposal of different types of radioactive waste; assess the safety implications of the extended storage of radioactive waste; promptly develop safety standards for geological disposal; develop an internationally accepted and harmonized approach for controlling the removal of materials and sites from the regulatory system; develop a programme to ensure adequate application of the Agency's waste safety standards; explore ways to ensure that information, knowledge and skills concerning radioactive waste management are made available to future generations; and develop a programme of work aimed at addressing the broader social dimensions of radioactive waste management.

Following its peer review of the biosphere component of the United States Department of Energy's (DOE's) performance assessment of the planned high level waste repository at Yucca Mountain, Nevada, the Agency was requested by the DOE to conduct, in co-operation with the OECD NEA, a peer review of the Yucca Mountain Total System Performance Assessment supporting the site recommendation process (TSPA-SR). The primary objective was to review and critically analyse the performance assessment methodology and rationale used by the DOE in order to: identify consistencies and inconsistencies with international recommendations, standards and practices; provide a statement regarding the adequacy of the overall performance assessment approach for supporting the site recommendation decision; and provide recommendations for technical and other improvements. The international review team assembled by the Agency and the OECD NEA stated that "Overall … the implemented performance assessment approach provides an adequate basis for supporting a statement on likely compliance within the regulatory period of 10 000 years and, accordingly, for the site recommendation decision". However, based on "a growing international consensus", the team also stressed that "understanding of the repository system and how it provides for safety should be emphasized more in future iterations, both during and beyond the regulatory period". In this regard, the team made recommendations on technical issues that the DOE should consider for future assessments.

An expert team visited Lithuania in May at the request of the local regulatory body to review safety analysis reports (SARs) relating to radioactive waste management facilities at the Ignalina nuclear power plant. The team reviewed the assumptions, analyses and conclusions underlying the safety case presented in the two SARs, concluding that the documents were excellent examples of a preliminary SAR. However, a number of improvements were felt to be necessary before they could be considered final SARs. The team also indicated the kinds of iterative discussions that would have to take place between the regulator and the operator to finalize the documents.

SAFETY OF RADIOACTIVE DISCHARGES

A new publication, *Generic Models for Use in Assessing the Impact of Discharges of Radioactive Substances to the Environment* (Safety

Reports Series No. 19), describes an approach for assessing doses to members of the public as part of an environmental impact analysis of predictive radioactive discharges. This is achieved by using screening models that describe environmental processes in mathematical terms, producing a quantitative result. The report supports a Safety Guide on this subject and supersedes an earlier safety series publication.

In its role as the competent international organization on matters related to radioactive materials in the context of the London Convention 1972, the Agency published a report summarizing the accidents that have occurred at sea involving radioactive materials (IAEA-TECDOC-1242). The report was accepted at the 22nd Consultative Meeting of the Contracting Parties to the Convention. The Agency is also developing guidance for Contracting Parties on how to determine when materials being considered for disposal at sea are exempt from the Convention on radiological grounds.

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 organized by the Agency in November provided an opportunity for both information exchange on appropriate regulatory and research developments, and also discussion of many of the issues being addressed as part of the development of guidance. The meeting concluded that a system for the protection of the environment (or biotic components of it) from the effects of ionizing radiation should take into account the current state of knowledge, but should not be restricted by it. Additional research priorities were identified, including development of a better understanding of the mechanisms by which radiation exposure relates to protection endpoints and relevant dose–response relationships, and an appropriate definition of quantities and units.

SAFETY OF RADIOACTIVE RESIDUES

In Resolution GC(44)/RES/15 in 2000, the Secretariat was requested "to develop … during the next two years … radiological criteria for long-lived radionuclides in commodities, particularly foodstuffs and wood". Development of these criteria — intervention exemption levels — has, because of the complexity of the existing system of exemption, clearance and generic action levels, proved to be technically difficult and controversial. All of these levels can be regarded as defining the lower boundary of the scope of certain aspects of regulatory control. However, because of the differences between these aspects, and between different approaches to deriving the relevant levels, there are several sets of values. A Technical Committee meeting in July expressed concern that this could lead to confusion and contradiction in the implementation and enforcement of regulations. Work continued during the year, in consultation with the Radiation Safety Standards Committee and the Waste Safety Standards Committee, with the aim of developing a coherent system of radionuclide specific levels for defining the scope of regulatory standards which would, at the same time, respond to the resolution.

Under another technical co-operation project, a mission visited Gabon in June to evaluate the remediation programme for the closure of a uranium mining site. This was a follow-up to a preliminary radiological assessment of the environmental impact at the site in 1999 that highlighted some problems, in particular for the water downstream of the site. The mission team found that about 80% of the remediation work had been completed, with the remaining work to be finished by the end of 2002. The radiological condition of the air and of the water downstream of the site had improved considerably since 1999. The team concluded that the remediation programme was acceptable, but certain improvements were necessary to ensure the protection of the public and of the environment in the medium and long term.

A former uranium mining and milling facility in Tajikistan, where the majority of the tailings have not been stabilized or remediated and represent a potential source of radiation exposure for the local population and for neighbouring countries, was visited by a technical co-operation mission. In this case, the situation had not improved since a previous visit in 1999. The team provided field instruction on proper

monitoring techniques and procedures for identifying areas affected by tailings, and recommended the development of a remediation plan as a priority.

In September, at the request of the Kuwaiti Government and in co-operation with UNEP and WHO, the Agency organized a fact-finding mission to Kuwait. The team of experts visited most of the sites identified by the Kuwaiti authorities as having been affected or potentially affected by depleted uranium (DU) residues, agreed on the methodology for the assessment which will be part of the study, and formulated a plan for the sampling campaign scheduled for early 2002. The Agency also continued to co-operate with UNEP's investigations into the consequences of the use of DU in Kosovo.

A Safety Guide on the decommissioning of nuclear fuel cycle facilities was published. It applies to facilities such as: surface processing facilities for the mining and milling of uranium and thorium; uranium conversion and enrichment facilities; fuel fabrication facilities; spent fuel storage facilities away from the reactor; reprocessing facilities; and storage, treatment and conditioning facilities for radioactive waste. This is the last in a set of three Safety Guides on decommissioning, supporting the Safety Requirements publication *Predisposal Management of Radioactive Waste, Including Decommissioning*, issued in 2000. (Safety Guides on the decommissioning of nuclear power plants and research reactors and of medical, industrial and research facilities were published in 1999.)

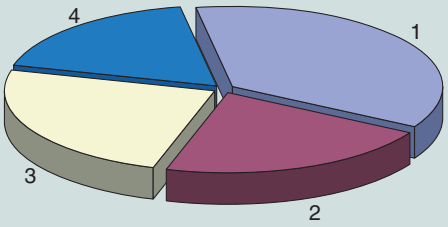
As part of a technical co-operation project to assist Kazakhstan in decommissioning the BN-350 fast reactor, the Agency organized a Technical Committee meeting at the Dounreay site of the United Kingdom Atomic Energy Authority (UKAEA) in June. An important objective of the meeting was to pass on the experience of UKAEA personnel in decommissioning the Dounreay Fast Reactor and Prototype Fast Reactor to the Kazakh participants. A major focus of the presentations made by the UKAEA was the handling and disposal of sodium and its residues, an issue of specific concern for the decommissioning of sodium cooled fast reactors. The Agency is also providing assistance to Lithuania in decommissioning Ignalina, and to Ukraine for Chernobyl units 1–3.

CO-ORDINATION OF SAFETY ACTIVITIES

PROGRAMME OBJECTIVE

To ensure technical consistency in the Agency's safety related functions (revision and development of safety standards, servicing safety conventions, safety information exchange and support to safety activities in the technical co-operation programme), as well as coherence with corresponding safety activities carried out by Member States and other international organizations.

Regular budget expenditure: $2 421 905
Extrabudgetary programme expenditure (not included in chart): $142 178



1. Safety Policies and Standards: $876 104
2. Safety Conventions: $516 461
3. Safety Information Exchange: $590 322
4. Support to the Technical Co-operation Programme: $439 018

KEY ISSUES AND HIGHLIGHTS

- Five safety standards were published, with 16 others approved and in the process of being published.
- Through the technical co-operation programme, the Agency implemented numerous projects in the areas of nuclear, radiation and waste safety.
- Assistance was provided in the form of training courses, workshops, fellowships and scientific visits and training for safety professionals in Member States.
- A long term strategy was developed for the Agency's education and training programmes aimed at promoting self-sustaining training capabilities in Member States.

SAFETY POLICIES AND STANDARDS

To facilitate use of the Agency's safety standards in Member States, the full texts of recently published standards were posted on the Agency's web site for the first time in 2001 (located at *http://www.iaea.org/ns/CoordiNet/safetypubs/inclSStandardsPublished.htm*). Five revised or new Safety Guides were published (see Box 1), and 16 other Safety Guides have been approved and are in the process of being published. The Safety Requirements publication *Preparedness and Response for a Nuclear or Radiological Emergency* (co-sponsored by FAO, ILO, OECD/NEA, UN OCHA, PAHO and WHO) was endorsed by the Commission on Safety Standards (CSS) and submitted to the Board of Governors for approval. A summary of the current status of all the safety standards is available at the web site *http://www.iaea.org/ns/committees/css/STATUS.PDF*. Detailed information on the activities of the various Safety Standards Committees and the CSS is also available at this site.

The Agency's current safety standards on quality assurance for nuclear installations (a Code and 14 Safety Guides) were issued together on CD-ROM. The electronic version enables the user to search for and access any topic directly through the contents list and by keyword searches.

For several years the Agency has organized Peer Discussions on Regulatory Practices, a forum in which senior regulators can exchange information and experiences on current issues. The topic for the 2001 round of discussions was 'Quality Management of the Nuclear Regulatory Body'. The Agency published a report by the regulators, summarizing the discussions and giving 21 examples of good practices.

The Agency provides the Secretariat for the International Nuclear Safety Advisory Group (INSAG), which advises the Director General on nuclear, radiation and radioactive waste safety from a global perspective. In 2001, INSAG approved a *Note on Maintaining Knowledge, Training and Infrastructure for Research and Development in Nuclear Safety*, which was distributed in interim form at the Agency's General Conference in September, and a report on *Key Practical Issues in Strengthening Safety Culture*. Both documents will be published by the Agency in 2002.

SAFETY CONVENTIONS

The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management entered into force on 18 June 2001. A preparatory meeting was held in December 2001 at which the Contracting Parties adopted the rules of procedure and

BOX 1. **SAFETY STANDARDS PUBLISHED IN 2001**

Safety Guides	Safety Standards Series No.
• Building competence in radiation protection and the safe use of radiation sources (co-sponsored by ILO, PAHO and WHO)	RS-G-1.4
• Decommissioning of nuclear fuel cycle facilities	WS-G-2.4
• Modifications to nuclear power plants	NS-G-2.3
• Safety assessment and verification for nuclear power plants	NS-G-1.2
• The operating organization for nuclear power plants	NS-G-2.4

financial rules, as well as guidelines regarding the review process and the form and structure of national reports.

An organizational meeting was held in September for the second Review Meeting of Contracting Parties to the Convention on Nuclear Safety, which will take place in April 2002. The meeting decided on the composition of the six country groups in which national reports will be discussed during the Review Meeting, and selected the officers for the meeting and the country groups.

SAFETY INFORMATION EXCHANGE

The International Nuclear Event Scale (INES) is used by 60 countries to facilitate rapid communication to the media and the public on the safety significance of events at all nuclear installations associated with the civil nuclear industry, including events involving the use of radiation sources and the transport of radioactive material (Fig. 1). In 2001, a new edition of the *INES User's Manual* was published incorporating experience gained from applying the 1992

BOX 2. **SAFETY STANDARDS APPROVED AND IN THE PROCESS OF BEING PUBLISHED**

Safety Guides	Safety Standards Series No.
• Advisory material for the Regulations for the Safe Transport of Radioactive Material	TS-G-1.1
• Core management and fuel handling in nuclear power plants	NS-G-2.5
• Dispersion of radioactive material in air and water and consideration of the population distribution in site evaluation for nuclear power plants	NS-G-3.2
• Documentation for use in regulating nuclear facilities	GS-G-1.4
• External human induced events in site evaluation for nuclear power plants	NS-G-3.1
• Instrumentation and control systems important to safety in nuclear power plants	NS-G-1.3
• Maintenance, surveillance and in-service inspection in nuclear power plants	NS-G-2.6
• Management of radioactive waste from the mining and milling of ores	WS-G-1.2
• Organization and staffing of the regulatory body for nuclear facilities	GS-G-1.1
• Planning and preparing for emergency response to transport accidents involving radioactive material	TS-G-1.2
• Predisposal management of high level radioactive waste	WS-G-2.6
• Predisposal management of low and intermediate level radioactive waste	WS-G-2.5
• Radiation protection and radioactive waste management in the operation of nuclear power plants	NS-G-2.7
• Radiological protection for medical exposure to ionizing radiation (co-sponsored by PAHO and WHO)	RS-G-1.5
• Regulatory inspection of nuclear facilities and enforcement by the regulatory body	GS-G-1.3
• Review and assessment of nuclear facilities by the regulatory body	GS-G-1.2

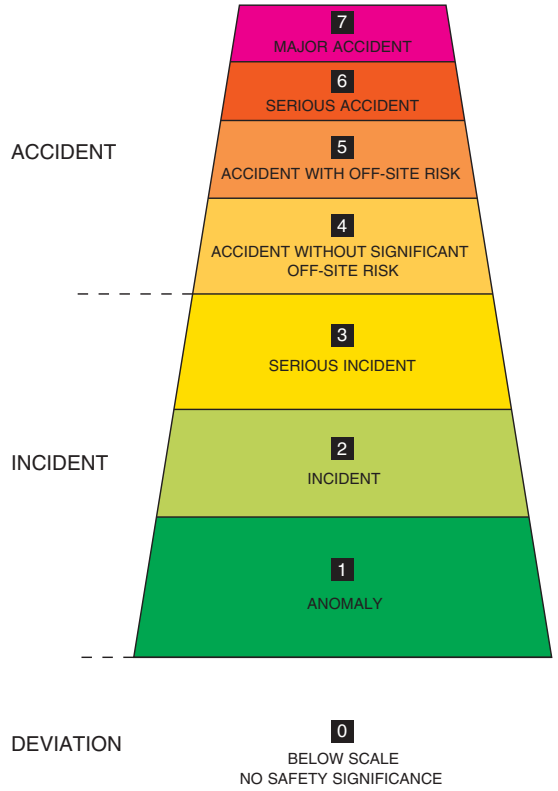


FIG. 1. The International Nuclear Event Scale.

version of the scale and clarification of various issues raised during that period. A total of 28 events were reported in 2001, of which 6 were rated at level 0, 8 at level 1 and 14 at level 2.

In co-operation with the OECD NEA and the World Association of Nuclear Operators (WANO), the Agency developed a Nuclear Events Web-based System (NEWS) to help disseminate information on events to participants in Member States more quickly and easily. The system underwent a one year trial beginning early in 2001 and is expected to go into full operation early in 2002. The success of the system will ultimately depend upon the readiness of participants to disseminate information on events quickly.

SUPPORT TO THE TECHNICAL CO-OPERATION PROGRAMME

During 2001, approximately 150 technical co-operation projects were supported, corresponding to an adjusted budget of about $18 million, in the areas of nuclear, radiation, transport and waste safety. In addition, about 110 training courses, workshops and seminars were held, most organized through the technical co-operation programme, but some also a part of the extrabudgetary programmes on the Safety of Nuclear Installations in the South East Asia, Pacific and Far East Countries, and on Mitigation of Intergranular Stress Corrosion Cracking in RBMK Reactors. The bulk of the training activities in radiation and waste safety were organized within the framework of the technical co-operation Model Project on upgrading radiation protection infrastructure.

Regional technical co-operation projects, including training courses, can be made more effective by consolidating objectives common to a number of Member States. In this regard, training courses in nuclear safety were held in France (for the Europe region) and in the USA (under the Extrabudgetary Programme on the Safety of Nuclear Installations in the South East Asia, Pacific and Far East Countries). Post-graduate educational courses in radiation protection and the safety of radiation sources were held in South Africa (for the Africa region) and in Malaysia (for the East Asia region), and a post-graduate diploma course on radiation protection (in Arabic) was held in the Syrian Arab Republic. The regular post-graduate educational course in radiation protection and nuclear safety (in Spanish) was held in Argentina.

Two Advisory Group meetings were held on education and training in nuclear safety and in radiation and waste safety. The recommendations of the Advisory Groups were used to develop a strategy for the Agency's activities in support of education and training. There is a gap between the knowledge needed in Member States and the ability of the Agency to provide training. Therefore, as a complement to its educational and training courses, the Agency is concentrating on helping Member States to establish sustainable national education and training programmes that are consistent with international safety standards. An essential element of this effort is the development of model training curriculums that can be used in training the trainers who will ultimately

implement the national programmes. Other measures to be adopted include: greater use of distance learning to complement more traditional training; development of modular training material, which allows flexibility in the choice of material; increasing the use of and access to computer based material; and a systematic approach to the establishment of regional and national training centres and to the development of a network of such centres. A new feature of the Agency's training activities is the provision of advisory services to Member States wishing to evaluate their national training needs, and to organize and assist with the required training, or peer reviews of existing national programmes.

A pilot project was launched in 2001 to test the Agency's model programme for the training of regulatory staff for nuclear facilities in selected Member States (currently Pakistan, the Russian Federation and Slovakia, with the likely future addition of Brazil). The programme uses a systematic competency framework to determine the training needed and to identify gaps in existing national programmes.

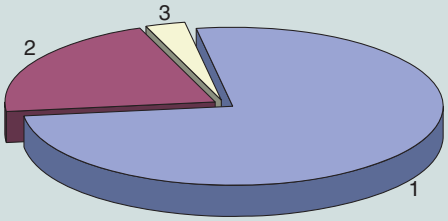
The Agency's Programme in 2001: Verification

SAFEGUARDS

PROGRAMME OBJECTIVE

To provide the international community, through the application of the Agency's safeguards system, with independent assurance that States are complying with their safeguards commitments.

Regular budget expenditure: $69 970 800
Extrabudgetary programme expenditure (not included in chart): $15 172 034



1. Operations: $53 117 908
2. Development and Support: $14 764 957
3. Management: $2 087 935

THE SAFEGUARDS STATEMENT FOR 2001

In fulfilling the safeguards obligations of the Agency in 2001, 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 nor of misuse of facilities, equipment or non-nuclear material placed under safeguards. On this basis, the Secretariat concluded that, in 2001, the nuclear material and other items placed under safeguards remained in peaceful nuclear activities or were otherwise adequately accounted for.

Notwithstanding the conclusion above, 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 all nuclear material subject to safeguards has been declared. The DPRK remains in non-compliance with its safeguards agreement, which is in force and binding. In 2001, the Agency maintained a continuous inspector presence in Nyongbyon to monitor the freeze of the DPRK's graphite moderated reactors and related facilities.

From 1991 to 1998, 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 that State pursuant to United Nations Security Council Resolution 687 and related resolutions. Since December 1998, the Agency has not been in a position to implement its Security Council mandated activities in Iraq. Pursuant to its safeguards agreement with Iraq, for the year 2001 the Agency conducted a physical inventory verification of the nuclear material placed under safeguards in Iraq and verified the presence of the nuclear material in question.

In 2001, with regard to nine States, the Secretariat — having evaluated all the information obtained through activities pursuant to these States' comprehensive safeguards agreements and additional protocols, and all other information available to the Agency — found no indication of undeclared nuclear material or activities in those States. On this basis, and taking into account the conclusion referred to in the first paragraph of this statement, 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 other 16 States with comprehensive safeguards agreements and additional protocols in force, the Agency's evaluations for drawing such a conclusion are in progress.

KEY ISSUES AND HIGHLIGHTS

- A comprehensive safeguards agreement pursuant to the Treaty on the Non-Proliferation of Nuclear weapons (NPT) entered into force for the Lao People's Democratic Republic. An exchange of letters between the Agency and Colombia entered into force which provides that Colombia's safeguards agreement concluded pursuant to the Treaty of Tlatelolco satisfies the requirements of Colombia under the NPT. Comprehensive safeguards agreements pursuant to the NPT with Andorra and Oman were signed and one for Niger was approved by the Board of Governors.

- Since the approval in 1997 of the Model Additional Protocol, activities related to the negotiation and implementation of additional protocols have significantly increased. In 2001, protocols additional to safeguards agreements came into force for Bangladesh, Ecuador, Latvia, Panama, Peru and Turkey. In addition, Andorra, Costa Rica, Guatemala, Mongolia and Nigeria signed protocols additional to their safeguards agreements. Of the European Union (EU) non-nuclear-weapon States (NNWSs), Austria and Portugal notified the Agency that the additional protocol had been ratified by their respective governments, bringing the total number of EU NNWSs having ratified additional protocols to eight (Austria, Finland, Germany, Greece, Netherlands, Portugal, Spain and Sweden). The United Kingdom indicated that it had completed all internal preparations for entry into force of the protocol between it, the Agency and Euratom.

- By the end of 2001, additional protocols for 61 States had been approved by the Board of Governors and subsequently signed. Twenty-four such protocols were in force with Australia, Azerbaijan, Bangladesh, Bulgaria, Canada, Croatia, Ecuador, the Holy See, Hungary, Indonesia, Japan, Jordan, Latvia, Lithuania, Monaco, New Zealand, Norway, Panama, Peru, Poland, Romania, Slovenia, Turkey and Uzbekistan (see Fig. 1). Furthermore, an additional protocol with Ghana was being implemented provisionally pending entry into force. Measures foreseen under the Model Additional Protocol were implemented in Taiwan, China.

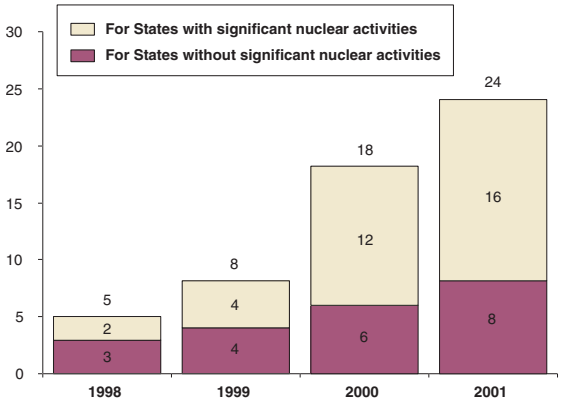


FIG. 1. Number of States with additional protocols in force. (In addition, in Ghana an additional protocol is being applied provisionally since June 1998. Measures foreseen under the Model Additional Protocol were also applied in Taiwan, China.) In the context of this report, "significant nuclear activities" means a State that has any amount of nuclear material in a facility or location outside facilities or nuclear material in excess of the limits in paragraph 37 of INFCIRC/153.

- The development of a conceptual framework for integrated safeguards was completed as a priority item. This framework comprises the set of safeguards concepts, approaches, guidelines and criteria that govern the design, implementation and evaluation of integrated safeguards. When applied, it will ensure that there is consistent, non-discriminatory implementation of integrated safeguards in States with similar types of facility and fuel cycle.

  — Model integrated safeguards approaches were developed for three more generic facility types: for LWRs with mixed oxide (MOX) fuel, for on-load refuelled reactors; and for fabrication plants for depleted, natural and low enriched uranium (LEU) fuel. In addition, the Agency refined the integrated safeguards approaches for LWRs without MOX fuel, for research reactors and for spent fuel storage facilities that had been developed in

2000. Guidelines for the design of an integrated safeguards approach for a State were developed and are being used to prepare State level integrated safeguards approaches for specific States.

— A significant accomplishment is the first implementation of integrated safeguards in a State, namely Australia, beginning in 2001.

- Introduced as a key safeguards strengthening measure in the mid-1990s, the evaluation of information on a State's nuclear programme for safeguards purposes is now an integral part of the process of deriving conclusions about the non-diversion of declared nuclear material and, where appropriate, about the absence of undeclared nuclear material and activities in that State.

  — The information available to the Agency for analysing a State's nuclear activities has increased steadily owing to: the growing number of States providing declarations pursuant to additional protocols; increased access to nuclear sites, including complementary access; information collection through the use of additional open sources and software; exploitation of new technologies such as commercial satellite imagery; and information voluntarily provided by Member States.

  — The Agency allocated substantial resources to meet the new requirements emerging from increased information collection, analysis and evaluation activities, such as the review of declarations[1] pursuant to additional protocols and the preparation and review of State evaluation reports. Forty-one State evaluation reports[2] were prepared by the Agency for the purpose of drawing safeguards conclusions for 2001 compared with 32 for 2000 and 17 for 1999 (see Box 1 and Fig. 2). In addition, there was complementary access (see Fig. 3) to confirm the absence of undeclared nuclear material and activities in 13 States. During 2001, seven States submitted their initial declarations, pursuant to Articles 2 and 3 of their additional protocols, to the Agency for review.

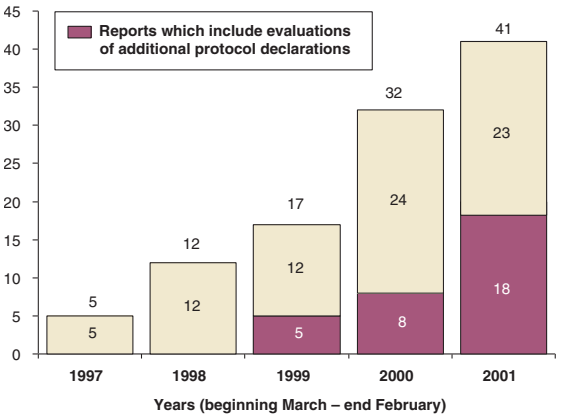


FIG. 2. State evaluation reports (completed and reviewed).

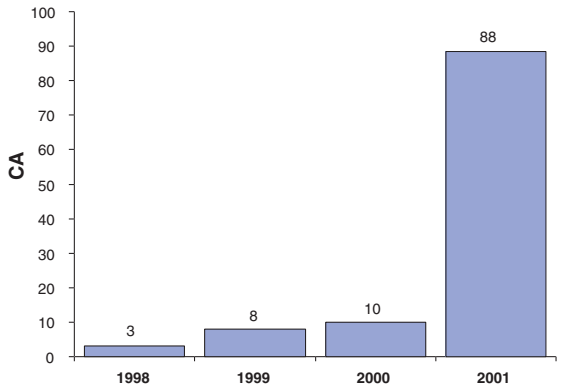


FIG. 3. Complementary access (CA), 1998–2001.

[1] The Model Protocol Additional to Safeguards Agreements (INFCIRC/540 (Corr.)), approved by the Board of Governors in May 1997, provides for a State to *declare* information about all its activities related to the use of nuclear material to the Agency. Furthermore, it provides for expanded physical access *(complementary access)* for Agency inspectors to confirm the State's declarations

[2] In addition, one evaluation report was prepared for Taiwan, China.

- The first phase of the development of software to assist in the review and evaluation of additional protocol declarations was completed. Regarding the use of satellite imagery, commercial sources of high resolution imagery were diversified to enhance quality and independence of the information available to the Agency. Geo-referenced datasets that enable information to be stored and referenced based on global location were expanded.

- The ninth symposium on 'International Safeguards: Verification and Nuclear Material Security' was held in Vienna in October–November 2001, drawing considerable interest from the general public and the media. The topics covered the full spectrum of current nuclear security interests, such as non-proliferation and nuclear material security. Taking note of the September 11 attacks in the USA, a special session on combating nuclear terrorism was added. Experts from outside the Agency were invited to describe the potential threats arising from the possibility of nuclear terrorism.

- The Agency spent $70.8 million in regular budget funds (equivalent to $82.9 million at an exchange rate of 12.70 Austrian Schillings to the US dollar) on activities related to nuclear verification and the security of material, divided between $70 million for the implementation of safeguards and $0.8 million for the security of material programme. It should be noted that 18.3% of all expenditures ($15.1 million for safeguards implementation and $0.76 million for the security of material) came from extrabudgetary resources. In particular, extrabudgetary funds were used for the procurement of safeguards equipment required for strengthening safeguards and to support Member States, particularly in the areas of physical protection and trafficking. In order to cover staff costs, a significant amount of money originally budgeted for equipment was reallocated, leading to an increased dependence on Member States for extrabudgetary assistance.

OPERATIONS

Safeguards implementation. At the end of 2001, safeguards activities were being applied at 908 facilities in 70 States (and in Taiwan,

BOX 1. **EVALUATING INFORMATION ON A STATE'S NUCLEAR PROGRAMME — A KEY SAFEGUARDS STRENGTHENING MEASURE**

All information available to the Agency on a State's nuclear programme is subject to continuous review. State evaluations take place in three stages:

1. Through baseline evaluation of a State's nuclear programme, a profile is developed against which to compare and assess new information for safeguards purposes.

2. Further evaluation following the implementation of an additional protocol in a State includes consideration of the information contained in the initial declarations of a State pursuant to an additional protocol and the results of other activities conducted, as needed, under the additional protocol. This evaluation is essential for drawing a conclusion of the absence of undeclared nuclear material and activities in a State.

3. Continuing evaluation of the State's nuclear programme, including consideration of updated information regarding a State, as well as updated declarations and activities conducted pursuant to an additional protocol. This ongoing evaluation is critical for maintaining the Agency's ability to regularly reaffirm its conclusions. ■

China). In addition to the activities mentioned above, noteworthy activities included the following:

— A Short Notice Random Inspection scheme was fully implemented at four LEU fuel fabrication facilities in Japan. In this context, short notice inspections were performed for the first time at Japanese LWRs to facilitate the fulfilment of safeguards criteria for LEU fuel fabrication plants.
— The absence of nuclear material in the core of an on-load reactor in Japan was verified prior to the start of decommissioning.
— The Agency successfully maintained continuity of knowledge on 28 fresh MOX fuel assemblies that had been manufactured in Belgium in 2000, re-packed into containers suitable for transportation by sea and subsequently stored in a French facility throughout 2000 and shipped to Japan in January 2001.

Rokkasho Reprocessing Plant (RRP). The safeguards approach for the new large reprocessing plant that is being built by Japan Nuclear Fuel Ltd (JNFL) was further refined. The plant is expected to start operation in 2005. Specifications for the design, procurement, installation, testing and acceptance of safeguards equipment and software systems were produced. The construction of an On-site Analytical Laboratory (OSL) progressed with the installation of glove boxes and hot cells. Agency support for the OSL included carrying out tasks on analytical instrumentation/methods such as hybrid K-edge densitometry, spectrophotometry, alpha/gamma spectrometry and density measurement. In addition, a robotized sample preparation system that had been developed with the assistance of a Member State Support Programme (MSSP) was successfully transferred to Japan. In 2001, more than 100 person-days in the field were required for examination and verification of design information, including tank calibration. When the plant is in full operation, it is expected to require at least 900 person-days of verification in the field per year, which represents an increase of about 10% of the total safeguards inspection activities in the field.

Spent fuel verification. Agency activities related to the verification of spent fuel and the transfer of spent fuel to dry storage are continuously increasing. Significant transfers of spent fuel to dry storage facilities were undertaken in Germany (involving material that was returned from intermediate storage in the United Kingdom), Czech Republic, Belgium, Hungary, Argentina, Canada, India and Switzerland.

Preparations for safeguarding spent fuel transfers from the three shut down reactor units at Chernobyl to on-site storage began in 2001. So far, the design of integrated non-destructive assay (NDA), a containment/surveillance (C/S) monitoring system for the conditioning and storage of spent fuel and user requirements for a monitoring system for the transport of the safeguarded material within the facility have been completed. These preparations required close co-operation between the US MSSP, Ukraine, Framatome and the Agency.

Phase I of a canning campaign in Kazakhstan involving the verification of irradiated fuel to be canned for long term storage was completed. The canned fuel is to be maintained under dual C/S measures. Satellite communication equipment installed in January was used for a remote monitoring (RM) test which continued throughout the year to assess the technical and economical feasibility of RM for safeguards at the Kazakh facility. Video and radiation data were received successfully at Agency Headquarters.

New equipment for the verification of spent fuel was developed, including:

— An improved Spent Fuel Attribute Tester system to facilitate the verification of WWER-1000 spent fuel assemblies with low burnup and long cooling time. The system was successfully tested in co-operation with the Finnish Support Programme, Ukrainian facilities and the Ukrainian Government.
— A new type of Fork Detector system for the verification of spent fuel from WWER-1000 reactors. This system was successfully tested at a facility in Ukraine and subsequently put into use during the transfer

campaign of spent fuel assemblies from a reactor at this facility to dry storage.

Co-operation with regional and State authorities. The Agency made progress in negotiating Subsidiary Arrangements in connection with safeguards agreements. A new General Part entered into force for Armenia. Revised General Parts entered into force for the Czech Republic, Estonia, the Islamic Republic of Iran, Hungary, Slovakia, Ukraine and the Federal Republic of Yugoslavia. Ten Facility Attachments entered into force for facilities in Argentina, Armenia, Brazil, the Czech Republic, Japan and Slovenia.

A Memorandum of Understanding between the Agency and the Republic of Korea for enhanced co-operation in safeguards implementation at LWRs was signed in October. Arrangements include: training of State System of Accounting and Control (SSAC) personnel; electronic transfer of encrypted operational/accounting data to Agency Headquarters; use of remote data transmission equipment; joint use of safeguards equipment; and joint inspection procedures. Successful field trials were conducted involving three nuclear sites (one reactor per site); as a result the scheme was implemented as of January 2002.

Substantial contributions were made through MSSPs to Agency safeguards. The following States and organizations have formal support programmes: Argentina, Australia, Belgium, Canada, the European Union, Finland, France, Germany, Hungary, Japan, Netherlands, the Republic of Korea, the Russian Federation, Sweden, the United Kingdom and the USA. There were 246 MSSP tasks under way addressing needs identified by the Agency through its new R&D programme, which also facilitated rationalization of the different tasks.

Entry into force of the additional protocol for the 13 EU NNWSs will only take place following ratification by all 15 EU States. At the end of 2001, ratification by six EU States (Belgium, Denmark, France, Ireland, Italy and Luxemburg) was still lacking. In preparation for the approaching additional protocol implementation, an Agency–Euratom working group was established to draft procedures for information flow, interface arrangements for complementary access and assistance and advice to EU Member States in compiling their initial declarations. The Agency continued field trials of elements of the additional protocol in Finland and Netherlands initiated in 2000. These trials are intended to test the individual reporting responsibilities of Euratom and Member States.

Activities in nuclear weapon States. Inspections continued to be carried out at plutonium and high enriched uranium (HEU) storage facilities following the decision by the USA in 1993 to submit to Agency safeguards nuclear material specified as no longer required for military purposes (Table I).

The shipment area of a MOX fuel fabrication facility in France was designated for the verification of shipment of MOX fuel assemblies to Japan. The designation of this part of the facility for safeguards will permit more effective allocation of Agency resources for verification activities in Japan.

The possibility of reducing Agency resources allocated to safeguarding two plutonium storage facilities in the United Kingdom was discussed with State authorities. As a result, an optimized safeguards approach has been drawn up, which includes the application of dual C/S measures at the storage facilities together with off-site data review.

In China, limited frequency unannounced access started in the cascade hall of an enrichment plant.

Co-operation with ABACC was intensified, particularly in the form of the common use of safeguards equipment installed and owned by ABACC and the Agency, and in conducting joint inspection activities at facilities in Argentina and Brazil.

Trilateral Initiative. Some progress was made towards the resolution of the legal, technical and financial issues associated with the verification of weapons origin and other fissile material specified by the Russian Federation and the USA as released from defence programmes. The verification methodologies for classified forms of fissile material, including nuclear weapon

components, were agreed at the conceptual level, and development work related to specific systems to be employed in both States was initiated. The work under way is shifting from the development and testing of concepts to the construction of specific systems intended for use in specified facilities.

DEVELOPMENT AND SUPPORT

The first phase of developing software to assist in the review and evaluation of Member State additional protocol declarations was completed. With this software, documents, image review results and other types of data can be transferred electronically and integrated with additional protocol declarations.

Material balance evaluation is an important component of safeguards implementation. In order to describe the statistical methodology and ensure consistency in the evaluations, a new guide documenting the material balance evaluation process within the Agency was issued. Furthermore, the Agency started development of software for the quality control of Member State nuclear material accounting reports to the Agency. The software can be used by Member States to improve the quality of their accounting reports.

The collection and evaluation of both open source information and information declared by States was electronically supported for State evaluations and the review of safeguards implementation. The open source system was expanded to over 3.7 million documents. New software was introduced to improve the organization of this large quantity of information and to facilitate its analysis.

The Agency's Satellite Imagery Analysis Laboratory produced 34 reports documenting analyses of satellite images. The EU Support Programme has developed Geographical Information

TABLE I. **VERIFICATION ACTIVITIES IN 2001**

	1999	2000	2001
Person-days of inspection	10 190	10 264	10 314
Number of new or revised Subsidiary Arrangements negotiated			
— General Parts	2	2	9
— Facility Attachments	118	26	10
Nuclear material accountancy measures			
Number of nuclear material samples analysed	650	621	831
Number of nuclear material analytical results reported	1356	1401	1747
Number of environmental swipe samples taken	149	224	263
Nuclear material under safeguards (in tonnes)			
Plutonium contained in irradiated fuel (including recycled plutonium in fuel elements in reactor cores)	617	654	690
Separated plutonium outside the reactor core	67	72.2	77.5
High enriched uranium	21.2	21.8	20.9
Low enriched uranium	49 408	48 974	50 079
Source material	91 647	91 686	94 940

System (GIS) software for associating satellite imagery with other information relevant to declared nuclear sites. Under the German MSSP, a system has been developed which can be applied to the GIS to detect significant changes over time at declared sites. Altogether, eight MSSPs are involved in the Agency's activities in satellite imagery analysis.

In 2001, software to support inspection activities in the field was developed and configured for 23 facilities. Functions include the on-site support of the examination of accounting records and updating of inventories, verification of the physical inventory, and comparison of records with State reports. In addition, software for data gathering and evaluation to be used in tank calibration activities was developed, part of which is now in use at reprocessing facilities in Japan.

In order to increase the security of information within the Agency's safeguards network, the firewall configuration has been enhanced. In addition, current electronic security measures were evaluated and improvements were initiated. Further security measures are in the test phase (e.g. biometric authentication). The Agency's secure communications structures for processing nuclear material accounting reports have been expanded to allow the receipt of data from several States via e-mail.

With regard to quality assurance, the Agency's safeguards software development process was certified as being compliant with Level II of the Capability Maturity Model for software engineering developed by the Software Engineering Institute of Carnegie Mellon University in the USA. The assessment was performed by accredited external auditors.

Development and installation of equipment. The implementation of remote monitoring continued at a reduced rate due to the need to improve its cost effectiveness and reliability. In 2001, solutions were found to reduce the radiation susceptibility of the digital camera module and, as a result, the replacement of obsolete film and video surveillance systems resumed. During the year, 62 digital cameras, connected to 32 systems, were installed, either replacing ageing and obsolete film and videotape surveillance units, or as new installations. By the end of the year, 350 digital cameras were in operation, connected to 206 surveillance systems. Thirty of these systems were operating in an RM mode in Belarus, Japan, the Republic of Korea, South Africa, Sweden, Switzerland and Ukraine, and in Taiwan, China.

Among the new equipment developed was a portable digital surveillance system. In addition, a new multi-camera digital surveillance system was tested and is expected to be authorized for inspection use in early 2002. New electronic seals to replace the current VACOSS electronic seals were developed by the German and French MSSPs and by a commercial company from the USA. They will be tested in 2002.

More VXI Integrated Fuel Monitor (VIFM) based monitoring systems were installed. These play a key role in the spent fuel monitoring of on-load refuelled reactors. Presently, 23 VIFM systems are installed in seven facilities worldwide. In addition, problems regarding reliability and usability were resolved.

In support of strengthened safeguards and the implementation of additional protocols, the Fieldspec (HM-5) handheld monitor was authorized for use. This portable, lightweight, sodium iodide based instrument can determine the presence of radioactive materials. It is useful for both inspection verification activities and complementary access. It also has direct application in searches for indications of the illicit trafficking of nuclear material.

The Agency further standardized equipment, thereby reducing the number of equipment types being utilized in the field. Also, an improved preventive maintenance programme for safeguards equipment was initiated. Significant preparatory work included analysing maintenance records in order to establish the service history of each instrument, which serves as the basis for devising preventive maintenance plans for each equipment type.

Safeguards analytical laboratories and capabilities. In the Safeguards Analytical Laboratory (SAL) at Seibersdorf and the Network of Analytical Laboratories (NWAL), 842 samples of nuclear materials and

heavy water were analysed and 1769 results for the material accountancy verification of facility operators' declarations were provided. In addition, 151 samples were measured for other purposes such as for the Agency's Iraq Action Team under UN Security Council Resolution 687 and for validation of the in situ verification method of uranium mining. In support of Agency activities in relation to the illicit trafficking of nuclear material, SAL provided results of nine samples from an illicit trafficking incident and participated — in collaboration with the Austrian Research Centers — in an interlaboratory round robin comparison exercise organized by the International Trafficking Working Group involving the characterization of HEU oxide powder.

A major achievement is SAL's ability to analyse neptunium and curium in spent fuel and highly radioactive liquid waste samples. Neptunium analysis will be used for flowsheet verification of facilities, with the potential to separate neptunium to confirm that the facilities are being operated as declared. Curium analysis is for the support of in situ NDA measurements.

The Clean Laboratory of SAL received 263 environmental samples, including 20 samples of air filters, soil, swipes and vegetation from a field trial of air particulate sampling. The staff of the Clean Laboratory also collaborated with experts from the Khlopin Radium Institute in St. Petersburg, Russian Federation, and the Los Alamos National Laboratory, in the USA, on the development of new sample preparation procedures. Techniques were developed for the indexing and relocation of micrometer sized particles with scanning electron microscopy and secondary ion mass spectrometry (SIMS), permitting both the elemental and isotopic analysis of selected particles. SAL also participated in a round robin exercise on particle analysis with the Institute for Transuranium Elements, in Karlsruhe, Germany, preparing a number of test samples to be measured by seven SIMS laboratories in the NWAL.

A revised and updated version of International Target Values (ITVs) for uncertainty components in measurements of nuclear materials was published. The ITVs reflect the current state of measurement capabilities achievable for all major destructive and NDA measurement techniques used in safeguards verification activities. They are intended for use by facility operators and safeguards organizations as a reference of the quality of measurements achievable in nuclear material accountancy.

Training. The safeguards training curriculum was enhanced with updated training courses. The 45th and 46th introductory courses on Agency safeguards were organized for 29 new safeguards inspectors. A new training course for Agency and Euratom inspectors on New Partnership Arrangements concerning safeguards for specific facility types took place in Vienna. Workshops and training on special aspects of safeguards, such as nuclear material accounting, additional protocol related issues and new safeguards concepts were held with the financial assistance of Member States

With the assistance of the Swedish MSSP, a satellite imagery awareness course designed for inspectors and other Agency users of imagery was developed and conducted in Vienna.

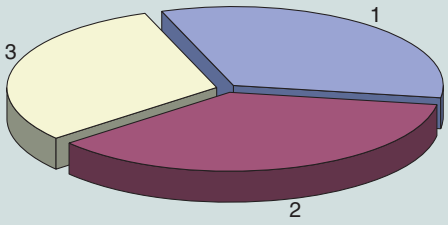
In preparation for the application of quality management techniques to all safeguards activities, a workshop on a quality management system was developed and four workshops were held.

SECURITY OF MATERIAL

PROGRAMME OBJECTIVE

To improve Member States' ability to protect nuclear and other radioactive material, through exchange of information, provision of standards and guides, training, expert assistance and equipment, from subnational, terrorist or other illegal activities that could impose a proliferation threat, or could endanger health and safety; and to detect and respond to such incidents

Regular budget expenditure: $869 058
Extrabudgetary programme expenditure (not included in chart): $757 861



1. Protecting and Controlling Nuclear Material: $316 233
2. Illegal Activities Involving Nuclear and other Radioactive Material: $288 006
3. Protection of other Radioactive Material: $264 819

KEY ISSUES AND HIGHLIGHTS

- The tragic terrorist attacks that occurred in the USA on 11 September 2001 have resulted in considerable attention being focused on assuring the effectiveness of security measures for the protection of nuclear facilities, nuclear materials and other radioactive materials. Of utmost concern is the level of protection against terrorist activity and subnational threats.

- The Agency organized an international conference entitled 'Security of Material: Measures to Prevent, Intercept and Respond to Illicit Uses of Nuclear Material and Radioactive Sources', which was held in Stockholm in May.

- Responding to a resolution from the General Conference, the Secretariat presented a report, 'Measures to Improve the Security of Nuclear Materials and other Radioactive Materials', which included a plan of activities for the Agency's work in this area. This was endorsed by the Board of Governors, and the General Conference took note of the plan in September.

- The expert meeting to discuss whether there is a need to revise the Convention on the Physical Protection of Nuclear Material (CPPNM), convened by the Director General, completed its work, concluding that there "was a clear need to strengthen the international physical protection regime". Upon the recommendation of the meeting, an open-ended group of legal and technical experts began to prepare a draft amendment to the CPPNM.

- The Board of Governors also endorsed the 'Physical Protection Objectives and the Fundamental Principles' as a Security Fundamentals document. This endorsement was welcomed by the General Conference.

Note: The headings in this chapter reflect a rearrangement of activities during 2001 in the Agency's programme on the security of nuclear and radioactive material.

- Responding to a resolution from the General Conference in September, which requested the Director General to review thoroughly the activities and programmes of the Secretariat with a view to strengthening work relevant to preventing acts of terrorism involving nuclear materials and other radioactive sources, the Director General presented a report to the Board of Governors in November. Entitled 'Protection Against Nuclear Terrorism', it outlined the Secretariat's response to the resolution adopted at the General Conference; activities in the field of the security of material were a major component of the report.

- In response to requests from Member States, the Secretariat continued to organize advisory missions, training courses and workshops to improve the effectiveness of measures for the security of nuclear and radioactive material. Following the events of September, the demand for these services increased greatly.

PROTECTING AND CONTROLLING NUCLEAR MATERIAL

Continuing its support to Member States in evaluating their national systems of physical protection, the Agency conducted International Physical Protection Advisory Service (IPPAS) missions to Indonesia and Ukraine. Good practices and recommendations for improving physical protection were provided to the government authorities in these countries. Preparatory meetings were held with two Member States to conduct missions to follow-up previous IPPAS missions. A fact-finding, broadened IPPAS mission, covering the security of nuclear and other radioactive material and evaluating the need for security arrangements at a nuclear research centre, visited Tunisia.

In response to an increased need to incorporate a 'design basis threat' (DBT) as part of a State system of physical protection, the Agency conducted three workshops, in Kazakhstan, Romania and Slovakia, to assist the competent authorities in those States with the development and maintenance of a national DBT. Another workshop to foster regional co-operation in common physical protection issues was held in Lithuania. A regional training course on the physical protection of nuclear material and facilities was held in Brno, Czech Republic. Finally, a new hands-on physical protection training course on the practical aspects of physical protection equipment installation and maintenance was held in Obninsk, Russian Federation.

Efforts to assist Member States in establishing and implementing norms and guides for nuclear material accountancy and control continued to make an important contribution to the effective physical protection of nuclear material. During 2001, close co-operation with several States and regional organizations continued and courses were held in Argentina and the USA. Assistance with the application of norms and guides was also facilitated through self-assistance programmes using self-assessment questionnaires.

A conference entitled 'Security of Material: Measures to Prevent, Intercept and Respond to Illicit Uses of Nuclear Material and Radioactive Sources' was held in Stockholm in May. Organized by the Agency in co-operation with the World Customs Organization, Interpol and the European Police Office (Europol), it was hosted by the Swedish Government. The conference focused on measures to reduce the possibilities of illegal activities such as theft, sabotage and illicit trafficking of nuclear materials, and on associated proliferation and radiation risks. A summary document which covered observations, summary statements and steps for the future was subsequently issued by the Secretariat as a note.

ILLEGAL ACTIVITIES INVOLVING NUCLEAR AND OTHER RADIOACTIVE MATERIAL

In the case of a failure in the system of physical protection of nuclear material, Member States should be able to detect and identify nuclear material as well as radioactive sources illegally crossing international borders. In order to enhance Member State capabilities for detecting

shipments of radioactive material at borders and at internal checkpoints, the Agency sponsored courses on a national level for front line officers in Kazakhstan and Azerbaijan. Additionally, the Agency sponsored a first ever meeting of heads of customs authorities of the Newly Independent States (NIS) in the Russian Federation. It was decided at the meeting that representatives from each NIS customs authority would participate in two train the trainers courses at the Russian Customs Academy in St. Petersburg. By August, some 60 participants had graduated from the course.

The Illicit Trafficking Database (ITDB), which relies on Member States reporting information on incidents and seizures, continued to be expanded. Periodic reports were issued on highlights and trends in illicit trafficking incidents. Information from the ITDB is also utilized to assist the Agency in its efforts to better inform the public about the threats to nuclear material security. An improved CD-ROM version of the ITDB was released that offers both a report on the highlights plus data on trends in illicit trafficking incidents for use by Member States. In response to suggestions from the Member State Points of Contact, the database software was modified to allow for the tracking of additional attributes of incidents reported, for example better descriptions of the circumstances of seizures, including the technical properties of material and criminal attributes.

In related work, analysis of information in the ITDB provided a foundation for the internal planning and prioritization of strengthened measures against nuclear terrorism. This is because the ITDB, while containing information only on known cases, provides a useful starting point for understanding the types and quantities of nuclear materials and radioactive sources seized in trafficking, the types of facilities that have been targets for theft, the kinds of persons who have engaged in trafficking, and what is known about terrorist interest in nuclear or radiological materials. As a result, the Agency continues its efforts to collect post-incident information and reporting, from laboratory analysis and forensics to the eventual outcomes of criminal cases in order to increase the usefulness and effectiveness of the ITDB.

VERIFICATION IN IRAQ PURSUANT TO UNSC RESOLUTIONS

PROGRAMME OBJECTIVE

To provide credible assurance to the United Nations Security Council (UNSC) that Iraq is complying with the provisions of UNSC Resolution 687 (1991) and other relevant resolutions, through the implementation of a system of verification able to detect, in a timely manner, prohibited equipment, materials and activities.

In 2001, extrabudgetary programme expenditures amounted to $2 503 745.

KEY ISSUES AND HIGHLIGHTS

- Since the end of 1998, in spite of the adoption of Resolution 1284 (1999) which confirms its mandate in Iraq, the Agency has not been in a position to implement its UNSC mandated activities in Iraq. It could not, therefore, provide any assurance that Iraq was in compliance with its obligations under these resolutions.

OPERATIONS

During 2001, the Agency was unable to implement its inspection programme as mandated by the relevant UNSC resolutions. However, its Action Team has maintained its readiness to resume monitoring activities in Iraq.

Regular contact has been maintained by the Action Team with the United Nations Monitoring, Verification and Inspection Commission (UNMOVIC) since the latter's establishment in order to co-ordinate efforts as required under UNSC Resolution 1284 (1999). These contacts have included exchanges on such topics as the definition of the logistical support to be provided by UNMOVIC to the Agency, the co-ordination of resources for the resumption of inspection activities, database and communication requirements to facilitate operations and the implementation of export–import monitoring.

With the support of several Member States, the Action Team co-ordinated field trials of air particulate sampling in order to evaluate the capabilities of such environmental monitoring for the detection of clandestine activities under various operational conditions. Technical conclusions are expected during 2002.

ANALYSIS

Activities were focused on the improvement of computer based inspection and analytical tools as well as on the detailed analysis of information accumulated from previous field activities and on recent information such as that provided by commercially available satellite imagery. These analytical activities have confirmed the validity of the Agency's technically coherent picture of Iraq's past clandestine nuclear programme and nuclear related capabilities as of December 1998.

The Action Team revised the list of items and technologies to which the export–import mechanism, approved by UNSC Resolution 1051 (1996), apply.

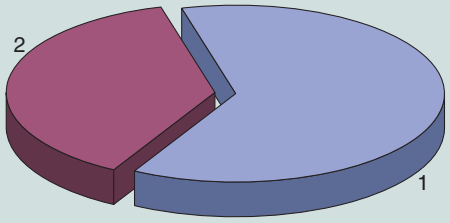
The Agency's Programme in 2001: Management

MANAGEMENT OF TECHNICAL CO-OPERATION FOR DEVELOPMENT

PROGRAMME OBJECTIVE

To strengthen the effectiveness of a technical co-operation programme that will contribute to tangible social and economic benefits to Member States.

Regular budget expenditure: $11 528 187
Extrabudgetary programme expenditure (not included in chart): $346 822



1. Technical Co-operation Programme: $7 183 563
2. Planning, Co-ordination and Evaluation: $4 344 624

KEY ISSUES AND HIGHLIGHTS

- The Secretariat delivered a record $71 million worth of training, expert services, equipment and other assistance to Member States under its technical co-operation programme in 2001 — 7.6% more than in 2000 — despite forced cancellations and postponements of activities in most regions following the events of 11 September in the USA. This achievement was due in part to the extra human resources made possible by the decision of the Board of Governors to allow the Agency to use, as an exceptional measure in 2001, up to $1 million of technical co-operation funds for extra staff in the Department of Technical Co-operation. In June, the Board recommended increasing the regular budget allocation for the management of technical co-operation activities, thereby allowing the additional staff to be kept on board.

- The Agency began 'upstream' work for the 2003–2004 technical co-operation programme. This was characterized by an emphasis on projects that are supported by a national programme and enjoy government commitment. This approach resulted in noticeably better project requests for the new programme.

- Technology transfer was the focus of the Scientific Forum at the 2001 regular session of the General Conference. The forum looked at several technical co-operation projects as case studies and discussed what made these particular projects successful.

- More strategic partnerships were created by the signing of agreements with bilateral donors and a Letter of Intent with the World Bank.

- With the addition of four new States to the Agency, the number of Member States/territories benefiting from technical co-operation activities is now 106.

TECHNICAL CO-OPERATION PROGRAMME

Achieving a coherent, results based programme of technical co-operation requires more than good project design. It also requires working with partner governments and institutions in new ways in order to maximize impact in the long term. Four management trends stood out in 2001:

— First, the Agency increased its support for the efforts of institutions involved in nuclear technology to achieve greater self-sufficiency.
— Second, it bolstered technical co-operation among developing countries by increasing the use of information and communication technology in the technical co-operation programme.
— Third, recognizing the importance of partnering with other UN organizations and bilateral and multilateral organizations to make a greater impact with limited resources, the Agency made special efforts to identify and work with partners.
— Fourth, it collaborated with large national and regional campaigns to strengthen the roots of government commitment.

An increasingly important theme in technology transfer is the need to develop the self-sufficiency of institutions involved with nuclear technology. Part of this theme is that technical co-operation between developing countries is a precursor to *economic* co-operation among developing countries.

For example, in South Africa nuclear institutions went through a readjustment process to become more self-reliant. This successful change has enabled the country to lead the transformation under an AFRA project in the region by providing specialized teams to help implement the necessary changes in the other five participating countries, including income generation, mobilization of funds and quality control. This process created a new synergy on the continent, which has in turn encouraged other countries (such as Tunisia) to embark on readjustment programmes. Training in modern management, marketing and customer relationships was built into the programme for all relevant categories of personnel. In addition to managers, atomic energy commissioners were brought together in Pretoria to debate strategies for the rationalization and integration of scientific programmes into national development objectives.

Another success in achieving greater self-reliance was recorded in Asia. As a result of Agency support for technology transfer and the Government's commitment, the commercial revenue of the Atomic Energy Authority (AEA) of Sri Lanka has grown nearly 100% over the past ten years and now represents approximately 35% of the operating budget, including salaries for the AEA staff. The lack of a central laboratory for nuclear research in Sri Lanka was identified as the main constraint to developing nuclear technology and providing services to end users. Demonstrating its commitment, the Government approved $1.3 million to support the AEA in its efforts to establish a new laboratory complex. Recognizing the national priority, the Agency assisted the AEA to develop the infrastructure for the safe application of nuclear technologies. The new laboratory complex is now complete and is offering its services.

Information and communication technology can help strengthen technical co-operation between developing countries. The Nuclear Medicine Department at the Yangon General Hospital in Myanmar has three gamma cameras, but the hospital could neither perform regular maintenance nor improve the equipment. An expert from Sri Lanka, who received Agency training in instrumentation and maintenance, was recruited to assist the hospital in repairing and upgrading one of the gamma cameras using a computer card developed in Slovenia. The expert also trained technicians at the hospital to communicate via the Internet with other technicians in the world, particularly their counterparts in Slovenia, to improve the images from the camera and receive guidance on regular maintenance and repair of the device. This example demonstrates the effectiveness of promoting co-operation between countries; it is a strategic approach to enhance the effectiveness and sustainability of the technology and regional co-operation.

In related work, following the example of an RCA web site hosted in Malaysia, the Agency

supported the development of web sites for ARCAL and AFRA. The ARCAL site is in Spanish and has already proven to be a very useful and cost effective communication and information exchange medium.

Working with other UN organizations, as well as multilateral organizations and counterpart institutions, gives the Agency's technical co-operation programme — and the funds supporting it — a greater impact on the problems to be solved using nuclear technology. Thus, co-ordination between the Agency and the EU is a priority to avoid duplication of efforts or gaps in coverage. European Union experts were invited to participate in regional activities, and joint missions were undertaken. In 2001, EU authorities responsible for assistance programmes in Europe made it a point to recognize the value of the Agency's planning process. One instance was in Bulgaria, where the Agency and the Kozloduy Nuclear Power Plant worked in co-ordination with the European Bank for Reconstruction and Development and its Kozloduy International Decommissioning Fund to establish a project management information and control system to support the decommissioning of Units 1 and 2. Another example was in Lithuania, where a detailed work plan for Agency assistance was developed in early 2001 and the activities co-ordinated with other donors and the EU. Achievements related to the Agency's assistance included changes in the Government's infrastructure by creating a new organization for radioactive waste management and increasing the staff at the Lithuanian nuclear safety regulatory authority.

In Latin America, Costa Rican authorities are seeking Agency assistance in conjunction with their own national campaign to build a cancer institute. The Agency was requested to train institute personnel to develop a national oncology programme. To show its commitment to the project, the counterpart institute is preparing to make a major extrabudgetary contribution to the Agency. Assistance has already begun through expert missions to define technical specifications for equipment, which will be purchased by the counterpart.

Capitalizing on government commitment by collaborating with national and regional campaigns is a key means of increasing the impact of programmes. For example, African leaders participating in the 37th OAU Summit adopted the Pan African Tsetse and Trypanosomosis Eradication Campaign (PATTEC) Action Plan. This campaign focuses on area wide approaches to tsetse eradication. PATTEC provides an opportunity and a mechanism for the mandated organizations of the UN system, working with the OAU, to design and implement intervention measures to help combat tsetse infestation (see Box 1 on the next page). The campaign was officially launched in Ouagadougou, Burkina Faso, in September 2001. The campaign garnered support from Member States, who endorsed it in major forums, including the UN Economic and Social Council, FAO, WHO and the Agency's General Conference. Technical support also came from the Programme Against African Trypanosomosis. Part of the enthusiasm for the campaign stemmed from recent evidence from Zanzibar, United Republic of Tanzania, where, following the eradication of tsetse, milk production has tripled, local beef production has doubled and the number of farmers who fertilize crops with manure has multiplied fivefold. With Agency assistance and an extrabudgetary contribution from the OPEC Fund, a new environment conducive to livestock development has been created.

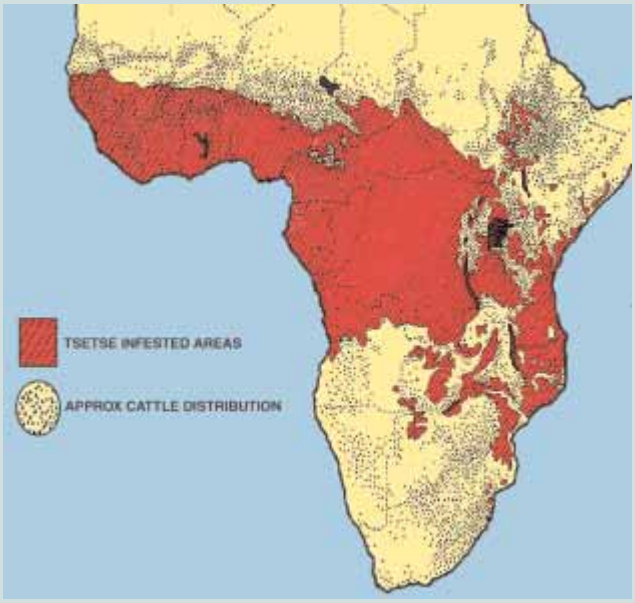
Government commitment can also be demonstrated by cost sharing. As an example, a major cyclotron facility for the production of radionuclides for medical applications was completed in the Syrian Arab Republic for which the Government committed more than $1.5 million.

PLANNING, CO-ORDINATION AND EVALUATION

Upstream work was carried out for the preparation of the 2003–2004 technical co-operation programme. In addition to discussions with individual countries and regional groups to determine their priority needs, an important part of this work was the preparation of Thematic Plans. These are one of the three major instruments of the Technical Co-operation Strategy and are valid not only for a single biennium, but for the longer term. They derive from an assessment of

BOX 1. **TSETSE FLY: A BARRIER TO SOCIOECONOMIC DEVELOPMENT IN AFRICA**

The two figures below combine to make the compelling argument that tsetse flies and trypanosomosis are barriers to Africa's socioeconomic development. Tsetse flies infest about 10 million km^2 of fertile land spread across 37 countries. Most of the countries infested with tsetse flies are heavily indebted poor countries (HIPCs), as shown in the upper figure. Cattle, which are important for agricultural production, cannot be raised in tsetse infested areas. The distribution of cattle in Africa and the areas infested with tsetse flies are shown in the lower figure. FAO has estimated that Africa loses about $4.5 billion annually from tsetse transmitted diseases. In addition, WHO has estimated that more than 550 000 people are infected with sleeping sickness. An estimated 30 000 become infected every year, and over 60 million people living in these countries are at risk of becoming infected with the disease. ■



the potential benefits of nuclear techniques and the record of past activities and are part of the Agency's efforts to expand its comparative advantage. Two Thematic Plans were completed in 2001, one on coastal zone management and the other on area wide tsetse control using the sterile insect technique (SIT). While the plan on the application of SIT is based on many years of Agency experience in this field, the one on coastal zone management, which has been developed in co-operation with IAEA–MEL in Monaco, supports new Agency initiatives in an area of growing importance for the world's population.

The trend of increasing financial resources for the technical co-operation programme continued during the year. Total new resources amounted to $71.1 million, up by $3.1 million from 2000. Extrabudgetary resources reached $7.1 million, the highest amount in more than ten years, including government cost sharing of $2.6 million, an encouraging trend that shows government commitment to the Agency's technical co-operation activities. The principle of "rate of attainment" was introduced; this measures the ratio of total voluntary payments to the Technical Co-operation Fund (TCF) against the TCF target for a programme year. Member States achieved the rate of attainment of 80% set for the year. Seventy-eight countries made pledges to the TCF for 2001, the highest number ever; to date, however, only 65 have paid all or part of their pledge. Special efforts will be necessary on the part of all Member States to pay their full target shares in 2002 in order to reach the rate of attainment of 85% set by the General Conference for that year.

The Agency made progress in enhancing TC-PRIDE (Technical Co-operation Project Information Dissemination Environment), the on-line project information system that provides detailed real-time data on the budgets and implementation of the technical co-operation programme. New types of reports were added that increased its usefulness as a management tool for Agency staff. There was also a significant growth in the number of registered users in Member States, from 76 countries in January 2001 to 100 at the end of the year.

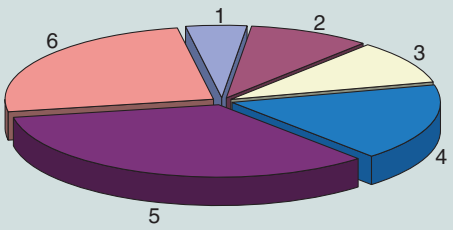
As requested by Member States, the Agency continues to improve the processes and systems in its technical co-operation programme. For example, a new course management system was introduced to improve efficiency when setting up a training course. An internal evaluation report reviewed specific projects, technology transfer mechanisms and new trends in the technical co-operation programme to give a 'basket' of indicators for programme success. One innovation was the introduction of participatory evaluation. Brazil commenced an evaluation of its country programme internally, supported by the Agency. As can be seen from the exercises already undertaken, stakeholders are more inclined to apply the lessons learned through evaluation if they have been personally involved in the process used to derive those lessons.

POLICY-MAKING, MANAGEMENT AND SUPPORT SERVICES

PROGRAMME OBJECTIVE

To achieve optimum levels of efficiency, effectiveness and transparency in management and establish more effective and efficient support services.

Regular budget expenditure: $56 625 752
Extrabudgetary programme expenditure (not included in chart): $612 497



1. Executive Management: $2 705 839
2. Services for Policy-making Organs: $5 257 947
3. Legal Activities, External Relations and Public Information: $ 5 573 120
4. Administration: $9 796 459
5. General Services: $19 084 596
6. Information Management and Support Services: $14 207 791

LEGAL ACTIVITIES

The Agency continued to foster the development of comprehensive basic nuclear energy laws governing radiation protection, nuclear and radiation safety, nuclear liability, safeguards and physical protection. In particular, 13 countries received assistance by means of written comments or advice on specific national legislation submitted to the Agency for review. The Agency also provided individual training on issues dealing with nuclear legislation at the request of nine Member States.

Further to the decisions of the Board of Governors at its December 1999 and November 2001 meetings related to the implementation of the technical co-operation Model Project on upgrading radiation protection infrastructures, priority continued to be given to the provision of legislative assistance to Member States 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. Advice was also provided on:

— The establishment of a legal framework governing radiation protection, the safety of radiation sources and the safe management of radioactive waste (for English speaking African countries and for Latin American countries).
— The effective implementation of national nuclear energy legislation for countries of Eastern Europe.
— Drafting of nuclear legislation for individual Member States.

A new *Handbook on Nuclear Energy Legislation* was developed by the Agency to assist legislators, government officials, technical experts, lawyers and users in general of nuclear technology in understanding the basic requirements and procedures of nuclear energy law. The handbook explains the overall character of nuclear energy law and the process by which it is developed and applied. It also offers a summary overview of specific areas involving the use of nuclear materials and techniques such as elements of nuclear energy legislation, radiation protection, nuclear and radiation safety, nuclear liability and coverage, non-proliferation and physical protection. It will be published in 2002.

The issue of the amendment of the Convention on the Physical Protection of Nuclear Material (CPPNM) continued to be addressed by an open-ended Expert Meeting. In May, the Expert Meeting concluded in its report that there was "a clear need to strengthen the international physical protection regime" and that a spectrum of measures should be employed — including the drafting of a well defined amendment to strengthen the CPPNM, to be reviewed by the States Parties with a view to determining if it should be submitted to an amendment conference in accordance with Article 20 of the CPPNM. In its final report, the Expert Meeting stated that the well defined amendment should address the following subjects: extension of the scope to cover, in addition to nuclear material in international nuclear transport, nuclear material in domestic use, storage and transport, as well as protection of nuclear material and facilities from sabotage; the importance of national responsibility for physical protection; the importance of protection of confidential information; the Physical Protection Objectives and Fundamental Principles; and Definitions. The meeting recommended that other issues should not be included in an amendment of the CPPNM, namely, a requirement to submit reports to the international community on the implementation of physical protection; a peer review mechanism; a mandatory application of INFCIRC/225, e.g. through direct reference and also through "due consideration"; mandatory international oversight of physical protection measures; and, nuclear material and nuclear facilities for military use."

The Director General — in response to the recommendations of the Expert Meeting — convened an open-ended group of legal and technical experts to draft an amendment. This meeting, which took place in December and involved 43 States and the European Commission, achieved a complete and detailed review of the scope of the potential amendments to the CPPNM. The group will continue its work at a second meeting in 2002.

PUBLIC INFORMATION

Interest in nuclear matters at the global level remained high throughout the year, and was particularly strong after the 11 September attacks in the USA, when issues such as the physical protection of nuclear material, illicit trafficking and the possible use by subnational groups of unconventional weapons came to the fore. The Agency launched a press campaign on 'Combating Nuclear Terrorism', which resulted in extensive media coverage for the Agency.

At the same time, the Agency placed increased emphasis on greater visibility and transparency and on outreach activities towards its various constituencies using a variety of methods. These efforts benefited from extrabudgetary support from Member States, notably Japan and the USA. For example, public service announcements of varying lengths on the Agency's work were launched on CNN in the second half of the year. The work of the Agency was also publicized through information seminars held in Indonesia, Slovenia, the Republic of Korea and South Africa.

The Agency's *WorldAtom* web site was further enhanced and expanded, resulting in a significant increase in the number of visits to the site. A notable event in April was multimedia coverage of the 15th anniversary of the Chernobyl accident. As the lead body in the UN system, the Agency also laid the public information groundwork for the 'World Water Day' celebrations in March 2002 at the Agency's Headquarters in the Vienna International Centre (VIC). This included the creation of a dedicated web site launched in December *(http://waterday2002.iaea.org/English/index.html)*.

FINANCIAL MANAGEMENT

For 2001, the General Conference appropriated an amount of $230 million for the Agency's Regular Budget on the basis of an exchange rate of 12.70 Austrian Schillings to one dollar, of which $225.1 million was related to Agency programmes. The latter amount was adjusted to $193.1 million to account for the average UN exchange rate (15.3642 Austrian Schillings to one dollar) actually experienced during the year.

The regular budget for 2001, at an exchange rate of 15.3642 Austrian Schillings to one dollar, amounted to $197.2 million, of which $189.1 million was to be financed from contributions by

Member States on the basis of the 2001 scale of assessment, $4.1 million from income from reimbursable work for others and $4 million from other miscellaneous income.

The actual expenditures for the Agency's Regular Budget in 2001 amounted to $196.8 million, of which $192.9 million was related to the Agency's programmes. The unused budget from the Agency's programmes amounted to $0.1 million, while the total unused budget was $0.4 million when reimbursable work for others was taken into account.

The target for voluntary contributions to the Technical Co-operation Fund for 2001 was established at $73 million, out of which Member States pledged $58 million.

A total of $51.7 million in extrabudgetary resources were actually available for Agency programmes. This total consisted of $17.7 million unused balance carried forward from 2000 and $34 million additional extrabudgetary funds made available in 2001. The 2001 expenditure amounted to $26.8 million, of which 55% was spent from US funds, mostly to support Agency programmes for safeguards activities. About 14% of the 2001 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 10%, from funds provided by European Union countries, basically financed support programmes for Agency safeguards activities. The remaining 21% of 2001 expenditures was covered by funds from other donors, and predominantly financed verification activities in Iraq and work in food and agriculture.

PERSONNEL MANAGEMENT

In focusing on staff–management relations, the Agency's management and the Staff Council agreed to carry out a survey to seek staff feedback in determining the current working climate and assessing the degree of job satisfaction and morale. Following the presentation of the results to staff and discussion of the survey at the Senior Management Conference in January 2001, the Director General requested that a working group be set up to devise an action plan to address issues raised in the survey. This action plan, to be implemented in 2002, covers improvements in the areas of communication, career development, leadership and management effectiveness, performance management and corporate identity.

The Agency has undertaken numerous efforts to streamline recruitment procedures and increase the representation of staff from four target groups: developing countries, underrepresented and unrepresented Member States, and women. Greater use is also being made of the Internet for the distribution of vacancy notices. The Director General has also created an international advisory group — comprised of members drawn from professional nuclear associations — to advise him and recommend ways in which gender concerns could be addressed in the Agency's programme and the representation of women in the Secretariat can be increased.

A major challenge facing the Agency is a projection that 42% of positions in the scientific and technical fields that are subject to geographical distribution will fall vacant over the next seven years. This need for specialized personnel must be seen in the light of the diminishing human resource pool in the nuclear field. While increasing its recruitment efforts, the Secretariat also intends to encourage Member States to include the Agency in their action plans to ensure the availability of a qualified work force in the nuclear sector.

At the end of 2001, there were 2205 staff members in the Secretariat — 950 in the Professional and higher categories and 1255 in the General Service category. These figures represent 1638 regular, 324 temporary assistance and 154 extrabudgetary staff, as well as 64 cost free experts and 25 consultants. Ninety-five nationalities were represented among the 689 staff members in posts subject to geographical distribution.

INFORMATION MANAGEMENT

Following a recommendation from the Information Technology Task Force, the Agency's central

computer services were moved to the Department of Management to form the Division of Information Technology. Subsequently, the telecommunications function was also relocated to this newly established division to promote integration and improve planning in the adoption of emerging technologies. An inter-departmental IT Committee was also set up to strengthen co-ordination so that appropriate IT solutions can be implemented efficiently and effectively throughout the Agency. The Committee will determine priorities and establish IT standards, including those dealing with security. In this connection, the migration of personal computers throughout the Secretariat to standard desktop software continued. Increased security will be one of the main features of this migration.

The tendering, technical evaluation and ordering process for all IT infrastructure equipment purchased from the Equipment Replacement Fund 2000 was completed. The S/390 and Unix servers were upgraded and a major first step was taken in the upgrading of the network, which will be completed in phases over the next several years.

A new version of *GovAtom*, the Agency's restricted access web site containing documents of the policy making organs, was developed. The enhanced version, based on feedback from Member States and their permanent missions in Vienna, features a more user friendly format with an improved document search capability. It also permits the acquisition of documents in languages other than English.

LIBRARY SERVICES

During the year the Agency devoted considerable effort to reorganizing the VIC Library in view of the termination of common library services in 2002. This included: reviewing, evaluating and selecting information resources which will be required for the Agency; reducing and reorganizing human and financial resources for the provision of library services; and providing assistance to the United Nations Office at Vienna and CTBTO to ensure smooth continuation of library services.

Electronic information resources on the VIC Library web site *VICLNET* were updated, with access to 216 subscribed electronic journals, 227 free Internet journals, 24 databases and 8 commercial electronic information services. In addition, 32 529 records in the Library's on-line public access catalogue were updated.

Library services to the Member States included: remote access to *VICLNet* and document delivery services for the staff of permanent missions located in Vienna. For institutions in Member States, the Library fulfilled 139 requests for audiovisual and other information materials from the Library's collections. Regular training for Library users was conducted to promote electronic information services and develop skills in their use. A total of 61 training courses were conducted for these purposes.

CONFERENCE AND PUBLISHING SERVICES

A report on simplified categories of Agency meetings aimed at rationalizing and reducing their number was approved. In related work, a computer design of an Agency wide meeting system was completed, with planning initiated for an electronic room reservation system. The use of the Agency's video-conferencing facilities increased from 36 meetings in 1999 and 61 in 2000 to 117 in 2001.

Efforts to increase the electronic dissemination of the Agency's publications led to new agreements being concluded with commercial distributors for the on-line sale and marketing of selected titles. In addition, the full texts of the latest publications in the Safety Standards Series were made available free of cost on the Agency's *WorldAtom* web site *(http://www.iaea.org/worldatom/Books/)*. Publishing activities included the issue of 182 books, reports, journal issues, CD-ROMs, newsletters and leaflets.

The visibility of Agency publications was enhanced through the production of updated catalogues and the display of books at international book fairs and professional meetings such as the Annual American Radiation Safety Conference, the 4th Annual European Nuclear

Fuel Management Seminar, the Annual Meeting of the Society of Nuclear Medicine, the Annual Meeting of the International Federation of Library Associations and Institutions, the Frankfurt International Book Fair, Waste Management 2001 and the IRPA Regional Congress on Radiation Research.

With the aim of providing the most efficient and cost effective services to Member States, the Agency decided to outsource the production of the *Nuclear Fusion* journal to the Institute of Physics Publishing (IOPP) in the United Kingdom, starting with the January 2002 issue. While editorial policy and control will remain the Agency's responsibility (including operation of the journal's editorial office), IOPP will handle copyediting, layout, printing and distribution.

In the area of translations, work continued on the introduction of computer assisted translation software — designed to improve consistency and efficiency — and on the development of a centralized terminology database. There was a 2% increase in the number of pages translated as compared with 2000.

The trend of handling more colour productions, but fewer publications continued in 2001. The number of page impressions, as compared with 2000, was down by 2.3%. The main reason for this reduction is the increased emphasis on electronic dissemination of Agency publications.

INTERNATIONAL NUCLEAR INFORMATION SYSTEM

The International Nuclear Information System (INIS) collects and distributes scientific information in all areas of nuclear science and technology published in Member States, including bibliographic data and the full texts of documents — such as reports and dissertations — which are not readily available through commercial channels (non-conventional literature (NCL)). The current number of participating members is 122, including 103 countries and 19 international organizations.

A total of 69 391 records were added to the database, an increase of 3677 records from 2000. There are now 2 283 882 records in the INIS Database. This included 6170 bibliographic records prepared as voluntary contribution by INIS members (including electronic journals and 657 records of British Library NCL) and 8111 records prepared by the INIS Secretariat (3929 Agency and UN documents, along with 4182 electronic records and NCL documents from the British Library).

The Agency signed an agreement with Elsevier Science BV for the acquisition of electronic bibliographic records. These will be upgraded to INIS standards and added to the collection of articles from core scientific journals. INIS members from Ireland, Netherlands, the United Kingdom and the USA funded this project.

As of the end of 2001, there were 128 paid and free subscriptions to the INIS Database on the Internet, for a total of 70 068 users, a significant increase from last year. The INIS Database on CD-ROM had 438 paid and free subscriptions.

The Agency continued its co-operative arrangement with the OECD NEA Data Bank. In 2001, 366 computer programs (out of 3 594) 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 who are not members of the OECD.

Non-conventional literature on CD-ROM is distributed by the Agency to users in Member States. INIS received more NCL documents in 2001 than in the previous year: 6757 documents were added to the NCL collection for a total of 290 042 pages, compared with 5083 documents (351 819 pages) in 2000. Of these, 3446 were imaged by the INIS Clearinghouse for a total of 153 384 pages scanned. This represents 29 CD-ROMs, for a total of 189 CD-ROMs since imaging began (over 2 300 000 pages).

The percentage of NCL submitted (in relation to the total NCL bibliographic input) has decreased, a trend observed over the last few years. NCL has become more difficult to acquire because of changes in distribution brought about by the Internet. However, this has been compensated for by an increase in the number of hyperlinks provided for on-line access.

A total of 1624 NCL CD-ROMs were distributed (paid or free) in 2001. All of these CD-ROMS are duplicated in-house. In addition, the INIS Clearinghouse distributed 1542 documents in electronic form to Agency staff and users in Member States.

As part of INIS web services, a Fast Reactor Database *(http://www-frdb.iaea.org/index.html)* and an Accelerator Driven Systems Database *(http://www-adsdb.iaea.org/index.cfm)* were launched. Both databases are part of an Agency web site on technology advances in fast reactors and accelerator driven systems for actinide and long lived fission product trans-mutation, that was launched in June 2001 *(http://www.iaea.org/inis/aws/fnss/)*. Other projects include a directory of nuclear information on the Internet *(http://www.iaea.org/inis/ws/index.html),* and the Gas Cooled Reactor Knowledge Base *(http://www.iaea.org/inis/aws/htgr/)*.

The Agency makes promotional materials available to INIS Members for use in their countries. In this regard, the INIS Secretariat strengthened its marketing programme to increase the use of INIS services, in the process receiving a strong commitment from INIS Liaison Officers.

Annex

TABLE A1. **ALLOCATION AND UTILIZATION OF REGULAR BUDGET RESOURCES IN 2001**

Programme	2001 budget GC(44)/6 (at AS 12.70)	2001 adjusted budget (at AS 15.3642)	2001 total expenditure		Unused (over-expended) budget
			Amount	% of adjusted budget (3) / (2)	(2) – (3)
	(1)	(2)	(3)	(4)	(5)
Nuclear Power	4 636 000	4 031 000	4 124 557	102.32%	(93 557)
Nuclear Fuel Cycle and Waste Management Technology	5 835 000	5 086 000	5 018 868	98.68%	67 132
Comparative Assessment for Sustainable Energy Development	2 727 000	2 366 000	2 336 980	98.77%	29 020
Subtotal	**13 198 000**	**11 483 000**	**11 480 405**	**99.98%**	**2 595**
Food and Agriculture	11 004 000	9 736 000	9 675 594	99.38%	60 406
Human Health	6 218 000	5 516 000	5 510 295	99.90%	5 705
Marine Environment and Water Resources	6 020 000	5 205 000	5 244 874	100.77%	(39 874)
Applications of Physical and Chemical Sciences	9 834 000	8 826 000	8 822 587	99.96%	3 413
Subtotal	**33 076 000**	**29 283 000**	**29 253 350**	**99.90%**	**29 650**
Nuclear Safety	6 224 000	5 339 000	5 428 683	101.68%	(89 683)
Radiation Safety	3 805 000	3 287 000	3 675 857	111.83%	(388 857)
Radioactive Waste Safety	2 267 000	1 951 000	1 705 990	87.44%	245 010
Co-ordination of Safety Activities	3 054 000	2 655 529 [a]	2 421 905	91.20%	233 624
Subtotal	**15 350 000**	**13 232 529**	**13 232 435**	**100.00%**	**94**
Safeguards	81 890 000	69 937 000	69 970 800	100.05%	(33 800)
Security of Material	1 093 000	938 000	869 058	92.65%	68 942
Subtotal	**82 983 000**	**70 875 000**	**70 839 858**	**99.95%**	**35 142**
Management of Technical Co-operation for Development	13 641 000	11 557 471 [a]	11 528 187	99.75%	29 284
Subtotal	**13 641 000**	**11 557 471**	**11 528 187**	**99.75%**	**29 284**
Policy-making, Management and Support Services:					
Executive Management	3 064 000	2 612 000	2 705 839	103.59%	(93 839)
Services for Policy-making Organs	6 237 000	5 342 000	5 257 947	98.43%	84 053
Legal Activities, External Relations and Public Information	7 095 000	6 113 000	5 573 120	91.17%	539 880
Administration	12 234 000	10 414 000	9 796 459	94.07%	617 541
General Services	23 080 000	19 281 000	19 084 596	98.98%	196 404
Information Management and Support Services	15 135 000	12 867 000	14 207 791	110.42%	(1 340 791)
Subtotal	**66 845 000**	**56 629 000**	**56 625 752**	**99.99%**	**3 248**
TOTAL – Agency's Programmes	**225 093 000**	**193 060 000**	**192 959 987**	**99.95%**	**100 013**
Reimbursable work for others	4 891 000	4 174 000	3 844 129	92.10%	329 871
TOTAL	**229 984 000**	**197 234 000**	**196 804 116**	**99.78%**	**429 884**

[a] Based on Board of Governor's Resolution GOV/1999/15, an amount of $34 529 was transferred from the subprogramme "Planning, Co-ordination and Evaluation" to the subprogramme "Safety Conventions" (in the Co-ordination of Safety Activities programme) to cover the cost of emergency assistance provided to Greece, Panama and Poland.

TABLE A2. **EXTRABUDGETARY FUNDS IN 2001 — RESOURCES AND EXPENDITURES**

Programme	Extrabudgetary budget figures GC(44)/6 (1)	Resources available in 2001 [a] (2)	Expenditure during 2001 (3)	Unused balance as at 31 Dec 2001 (2)–(3) (4)
Nuclear Power	686 000	1 209 440	589 175	620 265
Nuclear Fuel Cycle and Waste Management Technology	605 000	1 412 638	609 508	803 130
Comparative Assessment for Sustainable Energy Development	0	134 551	103 460	31 091
Subtotal	**1 291 000**	**2 756 629**	**1 302 143**	**1 454 486**
Food and Agriculture	2 199 992	3 329 472	2 214 614	1 114 858
Food and Agriculture	1 031 008 [b]	0	0	0
Human Health	0	257 096	64 839	192 257
Marine Environment and Water Resources	956 000	1 475 835	867 814	608 021
Applications of Physical and Chemical Sciences	13 000	43 304	20 412	22 892
Subtotal	**4 200 000**	**5 105 707**	**3 167 679**	**1 938 028**
Nuclear Safety	2 078 000	5 708 581	2 235 562	3 473 019
Radiation Safety	100 000	735 483	299 508	435 975
Radioactive Waste Safety	250 000	406 053	292 248	113 805
Co-ordination of Safety Activities	126 000	296 890	142 178	154 712
Subtotal	**2 554 000**	**7 147 007**	**2 969 496**	**4 177 511**
Safeguards	6 875 000	30 389 005	15 172 034	15 216 971
Security of Material	1 046 000	1 780 404	757 861	1 022 543
Verification in Iraq pursuant to UNSC Resolutions	10 650 000	2 519 033	2 503 745	15 288
Subtotal	**18 571 000**	**34 688 442**	**18 433 640**	**16 254 802**
Management of Technical Co-operation for Development	310 000	479 255	346 822	132 433
Subtotal	**310 000**	**479 255**	**346 822**	**132 433**
Policy-making, Management and Support Services:				
Services for Policy-making Organs	0	4 853	4 853	0
Legal Activities, External Relations and Public Information	805 000	1 453 982	583 755	870 227
Administration	0	9 767	8 837	930
Information Management and Support Services	0	15 552	15 052	500
Subtotal	**805 000**	**1 484 154**	**612 497**	**871 657**
Agency's Programmes	**27 731 000**	**51 661 194**	**26 832 277**	**24 828 917**

[a] The column "Resources Available in 2001" includes cash contributions received as well as the unused balances as at 1 January 2001 and cash due from FAO, UNEP and UNOPS for approved activities.

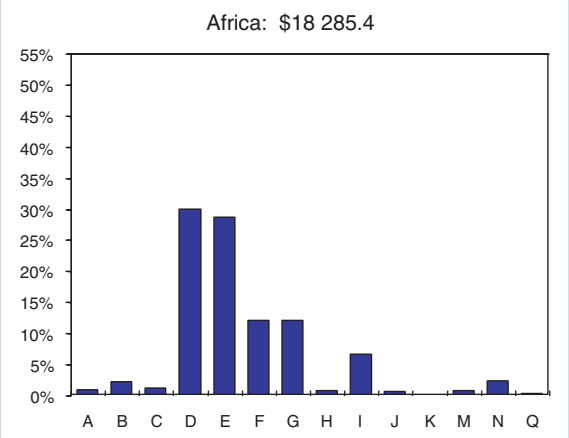
[b] The FAO budget includes $1 031 008 estimated costs for FAO professional staff working in the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture. The salaries of these staff members are paid by FAO and, therefore, are not included in columns 2 and 3.

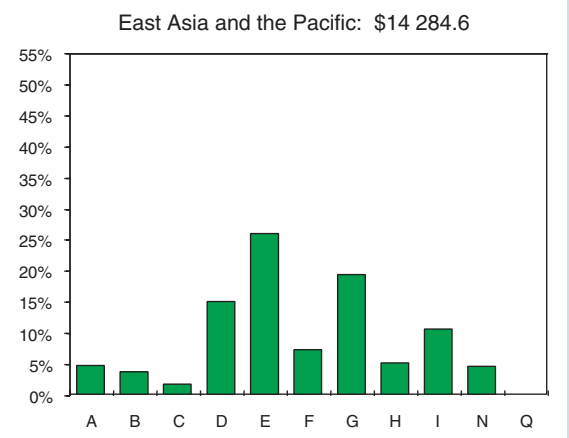
TABLE A3. **TECHNICAL CO-OPERATION DISBURSEMENTS BY AGENCY PROGRAMME AND REGION IN 2001**

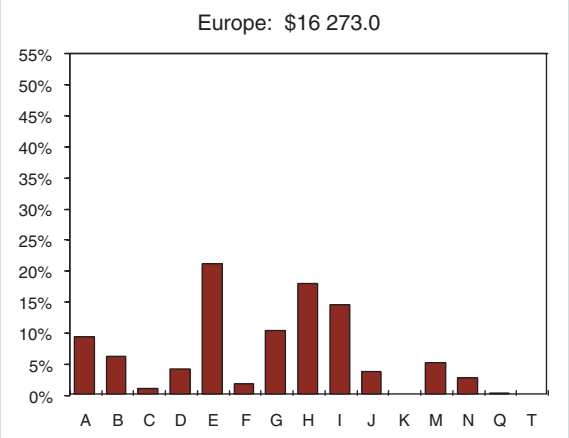
I. Summary of all regions (in thousands of dollars)

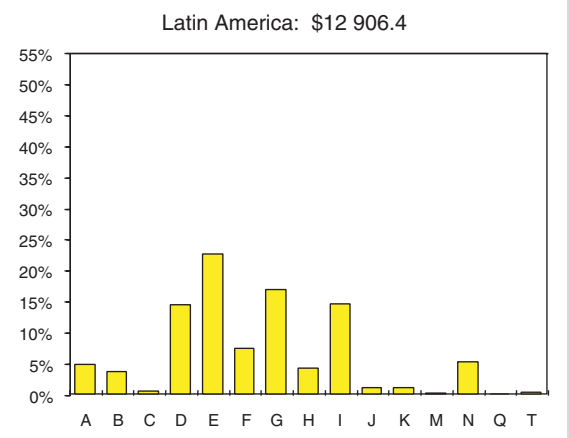
Programme	Africa	East Asia and the Pacific	Europe	Latin America	West Asia	Global/inter-regional	Total
A Nuclear Power	195.1	693.5	1538.0	655.2	611.0	164.2	3857.0
B Nuclear Fuel Cycle and Waste Management Technology	413.9	552.4	1032.4	496.3	242.3	516.3	3253.7
C Comparative Assessment for Sustainable Energy Development	247.5	275.6	179.6	87.1	36.0	2.9	828.7
D Food and Agriculture	5496.4	2177.0	692.1	1881.3	1164.8	745.9	12 157.6
E Human Health	5261.3	3716.0	3446.7	2939.6	1115.8	427.1	16 906.5
F Marine Environment and Water Resources	2229.2	1060.9	302.2	974.5	196.5	33.2	4796.4
G Applications of Physical and Chemical Sciences	2224.9	2786.0	1693.5	2197.1	1529.4	141.5	10 572.3
H Nuclear Safety	156.2	765.2	2927.1	575.7	299.5	95.9	4819.6
I Radiation Safety	1236.3	1542.4	2366.6	1909.1	1246.0	59.3	8359.7
J Radioactive Waste Safety	142.3	10.0	629.0	161.3	108.7	65.3	1116.6
K Co-ordination of Safety Activities	22.6	1.7	16.4	164.8	179.4	0.0	384.9
M Security of Material	144.9	0.0	873.7	51.0	0.0	0.0	1069.5
N Management of Technical Co-operation for Development	435.3	674.8	472.4	711.2	107.6	2596.6	4997.9
Q Legal Activities, External Relations and Public Information	71.6	22.8	80.3	32.1	0.0	87.5	294.3
T Information Management and Support Services	8.0	6.0	23.1	70.3	4.1	0.0	111.5
TOTAL	**18 285.4**	**14 284.6**	**16 273.0**	**12 906.4**	**6841.1**	**4935.7**	**73 526.2**

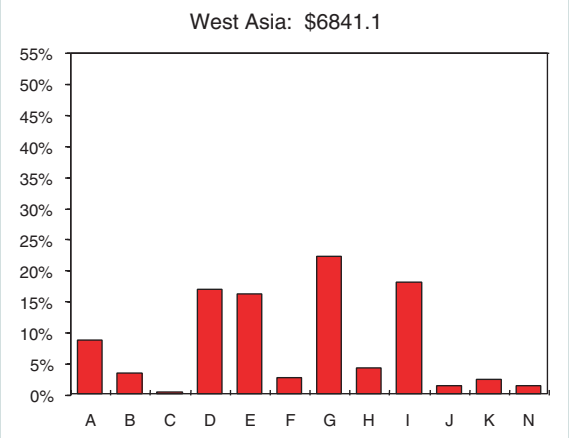
II. Distribution by region

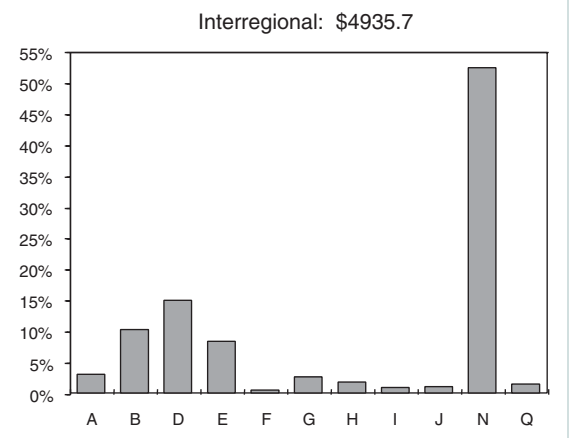












Note: Letters denote Agency programmes; they are explained in part I on the previous page.

TABLE A4. **ESTIMATED COSTS OF ALTERNATIVE MITIGATION TECHNOLOGIES IN THE POWER GENERATION SECTOR COMPARED WITH BASELINE COAL FIRED STATIONS AND POTENTIAL REDUCTIONS IN CARBON EMISSIONS TO 2010 AND 2020 FOR ANNEX I COUNTRIES**
(source: Third Assessment Report of the IPCC, 2001)

Technology	pf+FGD, NO_x, etc.	IGCC and super-critical	CCGT	pf+FGD +CO_2 capture	CCGT + CO_2 capture	Nuclear	PV and thermal solar	Hydro	Wind turbines	BIGCC
Energy source	Coal	Coal	Gas	Coal	Gas	Uranium	Solar radiation	Water	Wind	Biofuel
Generating costs (cents/kW·h)	4.90	3.6–6.0	4.9–6.9	7.9	6.4–8.4	3.9–8.0	8.7–40.0	4.2–7.8	3.0–8	2.8–7.6
Emissions (g C/kW·h)	229	190–198	103–122	40	17	0	0	0	0	0
Cost of carbon reduction ($/t C)	Baseline	-10–40	0–156	159	71–165	-38–135	175–1400	-31–127	-82–135	-92–117
Reduction potential to 2010, (Mt C/a)	Baseline	13	18	2–10	—	30	2	6	51	9
Reduction potential to 2020, (Mt C/a)	Baseline	55	103	5–50	—	191	20	37	128	77

Abbreviations: BIGCC: biomass integrated gasification combined cycle; CCGT: combined cycle gas turbine; FGD: flue gas desulphurization; IGCC: integrated gasification combined cycle; pf: pulverized fuel; PV: photovoltaic.

TABLE A5. **ESTIMATED COSTS OF ALTERNATIVE MITIGATION TECHNOLOGIES IN THE POWER GENERATION SECTOR COMPARED WITH BASELINE COAL FIRED STATIONS AND POTENTIAL REDUCTIONS IN CARBON EMISSIONS TO 2010 AND 2020 FOR NON-ANNEX I COUNTRIES**
(source: Third Assessment Report of the IPCC, 2001)

Technology	pf+FGD, NO_x, etc.	IGCC and super-critical	CCGT	pf+FGD +CO_2 capture	CCGT + CO_2 capture	Nuclear	PV and thermal solar	Hydro	Wind turbines	BIGCC
Energy source	Coal	Coal	Gas	Coal	Gas	Uranium	Solar radiation	Water	Wind	Biofuel
Generating costs (cents/kW·h)	4.45	3.6–6.0	4.45–6.9	7.45	5.95–8.4	3.9–8.0	8.7–40.0	4.2–7.8	3.0–8	2.8–7.6
Emissions (g C/kW·h)	260	190–198	103–122	40	17	0	0	0	0	0
Cost of carbon reduction ($/t C)	Baseline	-10–200	0–17	136	62–163	-20–77	164–1370	-10–129	-56–137	-63–121
Reduction potential to 2010 (Mt C/a)	Baseline	36	20	0	—	36	0.5	20	12	5
Reduction potential to 2020 (Mt C/a)	Baseline	58	137	5–50	—	220	8	55	45	13

TABLE A6. **ESTIMATED COSTS OF ALTERNATIVE MITIGATION TECHNOLOGIES IN THE POWER GENERATION SECTOR COMPARED WITH GAS FIRED CCGT POWER STATIONS AND POTENTIAL REDUCTIONS IN CARBON EMISSIONS TO 2010 AND 2020 FOR ANNEX I COUNTRIES** *(source: Third Assessment Report of the IPCC, 2001)*

Technology	CCGT	pf+FGD + CO_2 capture	CCGT + CO_2 capture	Nuclear	PV and thermal solar	Hydro	Wind turbines	BIGCC
Energy source	Gas	Coal	Gas	Uranium	Solar radiation	Water	Wind	Biofuel
Generating costs (cents/kW·h)	3.45	7.6–10.6	4.95	3.9–8.0	8.7–40.0	4.2–7.8	3.0–8	2.8–7.6
Emissions (g C/kW·h)	108	40	17	0	0	0	0	0
Cost of carbon reduction ($/t C)	Baseline	610–1050	165	46–421	500–3800	66–400	-43–92	-60–224
Reduction potential to 2010 (Mt C/a)	Baseline	—	2–10	62	0.8	3	23	4
Reduction potential to 2020 (Mt C/a)	Baseline	—	5–50	181	9	18	61	36

TABLE A7. **ESTIMATED COSTS OF ALTERNATIVE MITIGATION TECHNOLOGIES IN THE POWER GENERATION SECTOR COMPARED WITH GAS FIRED CCGT POWER STATIONS AND POTENTIAL REDUCTIONS IN CARBON EMISSIONS TO 2010 AND 2020 FOR NON-ANNEX I COUNTRIES** *(source: Third Assessment Report of the IPCC, 2001)*

Technology	CCGT	pf+FGD + CO_2 capture	CCGT + CO_2 capture	Nuclear	PV and thermal solar	Hydro	Wind turbines	BIGCC
Energy source	Gas	Coal	Gas	Uranium	Solar radiation	Water	Wind	Biofuel
Generating costs (cents/kW·h)	3.45	6.9–8.7	4.95	3.9–8.0	8.7–40.0	4.2–7.8	3.0–8	2.8–7.6
Emissions (g C/kW·h)	108	40	17	0	0	0	0	0
Cost of carbon reduction ($/t C)	Baseline	507–772	165	46–421	500–3800	66–400	-43–92	-60–224
Reduction potential to 2010 (Mt C/a)	Baseline	—	0	10	0.2	9	5	1
Reduction potential to 2020 (Mt C/a)	Baseline	—	5–50	70	4	26	21	6

TABLE A8. **INTERNATIONAL PROBABILISTIC SAFETY ASSESSMENT REVIEW TEAM (IPSART) MISSIONS IN 2001**

Review type	Nuclear power plant	Country
Level 1 follow-up and level 2 PSA	Ignalina	Lithuania
Level 1 PSA	KANUPP	Pakistan
Level 1 pre-IPSART	Cernavoda	Romania
External events and level 2/3 PSA	Novovoronezh, unit 5	Russian Federation
Level 1 PSA and hazards	Mochovce	Slovakia
Level 1 PSA	Zaporozhe	Ukraine

TABLE A9. **REVIEW OF ACCIDENT MANAGEMENT PROGRAMMES (RAMP) IN 2001**

Type	Location	Country
Pilot RAMP	Krško	Slovenia

TABLE A10. **OPERATIONAL SAFETY REVIEW TEAM (OSART) MISSIONS IN 2001**

Type	Nuclear power plant type	Country
Preparatory meeting	Angra 2 PWR	Brazil
OSART follow-up	Kozloduy WWER	Bulgaria
Preparatory meeting	Pickering PHWR	Canada
Pre-OSART	Lingao PWR	China
Full OSART	Dukovany WWER	Czech Republic
Full OSART	Temelin WWER	Czech Republic
Full OSART	Paks WWER	Hungary

TABLE A11. **PEER REVIEW OF OPERATIONAL SAFETY PERFORMANCE EXPERIENCE (PROSPER) MISSIONS IN 2001**

Type	Plant/location	Country
Introductory mission	Metsamor	Armenia
Assistance mission	Karachi	Pakistan
Preparatory meeting	Cernavoda	Romania
Workshop	Bilibino	Russian Federation
Seminar	VNIIAES	Russian Federation

TABLE A12. **SAFETY CULTURE ENHANCEMENT PROGRAMME (SCEP) ACTIVITIES IN 2001**

Type	Location/nuclear power plant	Country
SCEP workshop	INB, Rio de Janeiro and Resende	Brazil
Workshop for managers on the management of safety and safety culture	Eletronuclear, Rio de Janeiro and Angra dos Reis	Brazil
Self-assessment training workshop	INB, Rio de Janeiro and Angra dos Reis	Brazil
Regional workshop on safety culture for non-power nuclear installations	Santiago de Chile	Chile
Regional workshop on management of safety and safety culture	Daya Bay	China
Safety culture seminar	INSTN, Saclay	France
Self-assessment training workshop	Laguna Verde	Mexico
Workshop	Volgodonsk	Russian Federation
Safety culture seminar	Slovak Technical University, Bratislava	Slovakia
Regional workshop on management of safety and safety culture	Piestany	Slovakia
Presentation on management of safety and safety culture	SGS, Stockholm	Sweden
Seminar on management of safety and safety culture	Stockholm	Sweden

TABLE A13. **ENGINEERING SAFETY REVIEW SERVICE (ESRS) MISSIONS IN 2001**

Service	Site/plant	Country
Ageing safety review	Medzamor	Armenia
Seismic safety review follow-up	Medzamor	Armenia
Site safety review (preliminary)	Rooppur	Bangladesh
Periodic safety review	Qinshan	China
Design safety review	Tianwan	China
Review of Agency safety issues	Temelin	Czech Rep.
PSAR review assistance	Bushehr	Islamic. Rep. of Iran
Design safety review	Korean Next Generation Reactor	Republic of Korea
Documentation review on severe accident safety features	Tianwan	China
PSAR review, chapters 9 and 10	Bushehr	Islamic Rep. of Iran
Periodic safety review	Krško	Slovenia
Seismic safety review	Istanbul	Turkey

TABLE A14. **INTEGRATED SAFETY OF RESEARCH REACTORS (INSARR) MISSIONS IN 2001**

Type	Research reactor	Country
Pre-INSARR	3MW TRIGA	Bangladesh
Pre-INSARR	La Reina RR	Chile
Pre-INSARR	SPR, NHR, HTR-10	China
Pre-INSARR	GRR-1	Greece
INSARR	GRR-1	Greece
Pre-INSARR	TRR-1	Islamic Rep. of Iran
Pre-INSARR	14 MW TRIGA II	Romania
Pre-INSARR	MNSR RR	Syrian Arab Republic

TABLE A15. **SAFETY REVIEW MISSIONS IN 2001 TO RESEARCH REACTORS UNDER PROJECT AND SUPPLY AGREEMENTS**

Type	Country
Australian Replacement Research Reactor—Review of the Preliminary Safety Analysis Report	Australia
Activities to prepare facilities for INSARR	China
Assistance for the safety review of a newly designed research reactor: MIPR	China
ETRR-2 fact finding mission	Egypt
Follow-up of a safety project for the research reactors	Libyan Arab Jamahiriya
Assistance on the commissioning programme and completion of SAR for the reactor under construction	Morocco
Fact finding mission	Uzbekistan

TABLE A16. **INTERNATIONAL REGULATORY REVIEW TEAM (IRRT) MISSIONS IN 2001**

Type	Country
Full scope	Czech Republic
Full scope	Lithuania
Full scope	Mexico
Pre-IRRT	Thailand
Full scope follow-up	Ukraine

TABLE A17. **NUMBER OF STATES HAVING SIGNIFICANT NUCLEAR ACTIVITIES AT THE END OF 1999, 2000 AND 2001**

	Number of States		
	1999	2000	2001
States with safeguards applied under NPT or NPT/Tlatelolco agreements	60	60	61
States with safeguards applied under Tlatelolco agreements	1	1	0
States with safeguards applied pursuant to other comprehensive safeguards agreements	0	0	0
States with safeguards applied under INFCIRC/66/Rev.2-type agreements[a]	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[b]	71	71	71

[a] 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.

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

TABLE A18. **APPROXIMATE QUANTITIES OF MATERIAL SUBJECT TO AGENCY SAFEGUARDS AT THE END OF 2001**

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 (including recycled plutonium in fuel elements in reactor cores)	577.5	30	82.9	86 303
Separated plutonium outside reactor cores	13.6	0.1	63.8	9673
HEU (equal to or greater than 20% ^{235}U)	10.8	0.1	10	580
LEU (less than 20% ^{235}U)	42 993	2922	4164	13 288
Source material[d] (natural or depleted uranium and thorium)	81 252	1728	11 960	7294
Non-nuclear material[e]				
Heavy water	0	479	0	24
Total significant quantities	92 623	4518	20 021	117 162

[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 88.6 t (11 081 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 A19. **NUMBER OF FACILITIES UNDER SAFEGUARDS OR CONTAINING SAFEGUARDED MATERIAL ON 31 DECEMBER 2001**

Facility type	Number of facilities (number of installations)			
	Comprehensive safeguards agreements[a]	INFCIRC/66[b]	Nuclear weapon States	Total
Power reactors	186 (223)	11 (14)	1 (1)	198 (238)
Research reactors and critical assemblies	141 (152)	7 (7)	1 (1)	149 (160)
Conversion plants	13 (13)	1 (1)	— (—)	14 (14)
Fuel fabrication plants	38 (39)	3 (3)	— (—)	41 (41)
Reprocessing plants	5 (5)	1 (1)	— (—)	6 (6)
Enrichment plants	8 (8)	— (—)	2 (4)	10 (12)
Separate storage facilities	67 (68)	3 (3)	7 (8)	77 (79)
Other facilities	82 (92)	1 (1)	1 (1)	84 (94)
Subtotals	**540 (600)**	**27 (30)**	**12 (15)**	**579 (645)**
Other locations	325 (423)	3 (30)	— (—)	328 (453)
Non-nuclear installations	— (—)	1 (1)	— (—)	1 (1)
Totals	865 (1023)	31 (61)	12 (15)	908 (1099)

[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 A20. **ADDITIONAL SAFEGUARDS SUPPORT PROVIDED BY STATES AND ORGANIZATIONS**

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

TABLE A21. **STATUS WITH REGARD TO THE CONCLUSION OF SAFEGUARDS AGREEMENTS AND ADDITIONAL PROTOCOLS**[a, b] *(as of 31 December 2001)*

State[c]	SQP[d]	Status of safeguards agreement(s)	INFCIRC	Additional Protocol status
Afghanistan	X	In force: 20 February 1978	257	
Albania		*In force: 25 March 1988* [1]	359	
Algeria		In force: 7 January 1997	531	
Andorra		*Signed: 9 January 2001*		Signed: 9 January 2001
Angola				
Antigua and Barbuda	X	In force: 9 September 1996 [2]	528	
Argentina		In force: 4 March 1994 [3]	435	
Armenia		In force: 5 May 1994	455	Signed: 29 September 1997
Australia		In force: 10 July 1974	217	In force: 12 December 1997
Austria		Accession: 31 July 1996 [4]	193	Signed: 22 September 1998 [5]
Azerbaijan	X	In force: 29 April 1999	580	In force: 29 November 2000
Bahamas	X	In force: 12 September 1997 [2]	544	
Bahrain				
Bangladesh		In force: 11 June 1982	301	In force: 30 March 2001
Barbados	X	In force: 14 August 1996 [2]	527	
Belarus		In force: 2 August 1995	495	
Belgium		In force: 21 February 1977	193	Signed: 22 September 1998
Belize	X	In force: 21 January 1997 [2]	532	
Benin				
Bhutan	X	In force: 24 October 1989	371	
Bolivia	X	In force: 6 February 1995 [2]	465	
Bosnia and Herzegovina		In force: 28 December 1973 [6]	204	
Botswana				
Brazil		In force: 4 March 1994 [7]	435	
Brunei Darussalam	X	In force: 4 November 1987	365	
Bulgaria		In force: 29 February 1972	178	In force: 10 October 2000
Burkina Faso				
Burundi				
Cambodia	X	In force: 17 December 1999	586	
Cameroon		*Signed: 21 May 1992*		
Canada		In force: 21 February 1972	164	In force: 8 September 2000

[a] This annex does not aim at listing all safeguards agreements that the Agency has concluded. Not included are agreements whose application has been suspended in the light of the application of safeguards pursuant to a comprehensive safeguards agreement.

[b] The Agency also applies safeguards in Taiwan, China under two agreements, INFCIRC/133 and INFCIRC/158, which came into force on 13 October 1969 and 6 December 1971, respectively.

[c] States in bold type are those which are not party to the NPT and whose safeguards agreements are of INFCIRC/66-type. States in italics are those which are party to the NPT but have not concluded a safeguards agreement pursuant to that Treaty; the safeguards agreements referred to are comprehensive safeguards agreements concluded pursuant to the NPT, unless otherwise indicated. Safeguards agreements marked with an asterisk denote voluntary offer safeguards agreements.

[d] Operational small quantity protocol (SQP): States with a legal obligation to conclude a comprehensive safeguards agreement which have nuclear material in quantities not exceeding the limits of paragraph 37 of INFCIRC/153 and no nuclear material in any facility, have the option to conclude an SQP, thus holding in abeyance the implementation of most of the detailed provisions set out in Part II of a comprehensive safeguards agreement as long as these conditions continue to apply. Six States meet the conditions for an SQP but do not have one i.e. Albania, Bosnia and Herzegovina, Côte d'Ivoire, Liechtenstein, Sri Lanka and Tunisia.

TABLE A21. **(cont.)**

State[c]	SQP[d]	Status of safeguards agreement(s)	INFCIRC	Additional Protocol status
Cape Verde				
Central African Republic				
Chad				
Chile		In force: 5 April 1995 [8]	476	
China		In force: 18 September 1989	369(*)	Signed: 31 December 1998
Colombia		In force: 22 December 1982 [8]	306	
Comoros				
Congo				
Costa Rica	X	In force: 22 November 1979 [2]	278	Signed: 12 December 2001
Côte d'Ivoire		In force: 8 September 1983	309	
Croatia	X	In force: 19 January 1995	463	In force: 6 July 2000
Cuba		In force: 5 May 1980	281	Signed: 15 October 1999
		In force: 7 October 1983	311	
Cyprus	X	In force: 26 January 1973	189	Signed: 29 July 1999
Czech Republic		In force: 11 September 1997 [9]	541	Signed: 28 September 1999
Democratic People's Republic of Korea		In force: 10 April 1992	403	
Democratic Republic of the Congo		In force: 9 November 1972	183	
Denmark		In force: 21 February 1977 [10]	193	Signed: 22 September 1998
Djibouti				
Dominica	X	In force: 3 May 1996 [11]	513	
Dominican Republic	X	In force: 11 October 1973 [2]	201	
Ecuador	X	In force: 10 March 1975 [2]	231	In force: 24 October 2001
Egypt		In force: 30 June 1982	302	
El Salvador	X	In force: 22 April 1975 [2]	232	
Equatorial Guinea		*Approved: 13 June 1986*		
Eritrea				
Estonia		In force: 24 November 1997	547	Signed: 13 April 2000
Ethiopia	X	In force: 2 December 1977	261	
Fiji	X	In force: 22 March 1973	192	
Finland		Accession: 1 October 1995 [12]	193	Signed: 22 September 1998 [5]
France		In force: 12 September 1981	290 (*)	Signed: 22 September 1998
		Signed: 26 September 2000 [13]		
Gabon		*Signed: 3 December 1979*		
Gambia	X	In force: 8 August 1978	277	
Georgia		*Signed: 29 September 1997*		Signed: 29 September 1997
Germany		In force: 21 February 1977 [14]	193	Signed: 22 September 1998 [5]
Ghana		In force: 17 February 1975	226	Signed: 12 June 1998 [15]
Greece		Accession: 17 December 1981 [16]	193	Signed: 22 September 1998 [5]
Grenada	X	In force: 23 July 1996 [2]	525	
Guatemala	X	In force: 1 February 1982 [2]	299	Signed: 14 December 2001
Guinea				
Guinea-Bissau				
Guyana	X	In force: 23 May 1997 [2]	543	
Haiti		*Signed: 6 January 1975* [2]		
Holy See	X	In force: 1 August 1972	187	In force: 24 September 1998
Honduras	X	In force: 18 April 1975 [2]	235	
Hungary		In force: 30 March 1972	174	In force: 4 April 2000

TABLE A21. **(cont.)**

State[c]	SQP[d]	Status of safeguards agreement(s)	INFCIRC	Additional Protocol status
Iceland	X	In force: 16 October 1974	215	
India		In force: 30 September 1971	211	
		In force: 17 November 1977	260	
		In force: 27 September 1988	360	
		In force: 11 October 1989	374	
		In force: 1 March 1994	433	
Indonesia		In force: 14 July 1980	283	In force: 29 September 1999
Iran, Islamic Republic of		In force: 15 May 1974	214	
Iraq		In force: 29 February 1972	172	
Ireland		In force: 21 February 1977	193	Signed: 22 September 1998
Israel		In force: 4 April 1975	249/Add.1	
Italy		In force: 21 February 1977	193	Signed: 22 September 1998
Jamaica		In force: 6 November 1978 [2]	265	
Japan		In force: 2 December 1977	255	In force: 16 December 1999
Jordan	X	In force: 21 February 1978	258	In force: 28 July 1998
Kazakhstan		In force: 11 August 1995	504	
Kenya				
Kiribati	X	In force: 19 December 1990	390	
Korea, Republic of		In force: 14 November 1975	236	Signed: 21 June 1999
Kuwait		*Signed: 10 May 1999*		
Kyrgyzstan		*Signed: 18 March 1998*		
Lao People's Democratic Republic	X	In force: 5 April 2001	599	
Latvia		In force: 21 December 1993	434	In force: 12 July 2001
Lebanon	X	In force: 5 March 1973	191	
Lesotho	X	In force: 12 June 1973	199	
Liberia				
Libyan Arab Jamahiriya		In force: 8 July 1980	282	
Liechtenstein		In force: 4 October 1979	275	
Lithuania		In force: 15 October 1992	413	In force: 5 July 2000
Luxembourg		In force: 21 February 1977	193	Signed: 22 September 1998
Madagascar	X	In force: 14 June 1973	200	
Malawi	X	In force: 3 August 1992	409	
Malaysia		In force: 29 February 1972	182	
Maldives	X	In force: 2 October 1977	253	
Mali				
Malta	X	In force: 13 November 1990	387	
Marshall Islands				
Mauritania				
Mauritius	X	In force: 31 January 1973	190	
Mexico		In force: 14 September 1973 [17]	197	
Micronesia, Federated States of				
Monaco	X	In force: 13 June 1996	524	In force: 30 September 1999
Mongolia	X	In force: 5 September 1972	188	Signed: 5 December 2001
Morocco	X	In force: 18 February 1975	228	
Mozambique				
Myanmar	X	In force: 20 April 1995	477	
Namibia	X	In force: 15 April 1998	551	Signed: 22 March 2000

TABLE A21. **(cont.)**

State[c]	SQP[d]	Status of safeguards agreement(s)	INFCIRC	Additional Protocol status
Nauru	X	In force: 13 April 1984	317	
Nepal	X	In force: 22 June 1972	186	
Netherlands		In force: 5 June 1975 [13]	229	
		In force: 21 February 1977	193	Signed: 22 September 1998 [5]
New Zealand	X	In force: 29 February 1972	185	In force: 24 September 1998
Nicaragua	X	In force: 29 December 1976 [2]	246	
Niger		*Approved: 20 March 2001*		
Nigeria	X	In force: 29 February 1988	358	Signed: 20 September 2001
Norway		In force: 1 March 1972	177	In force: 16 May 2000
Oman		*Signed:28 June 2001*		
Pakistan		In force: 5 March 1962	34	
		In force: 17 June 1968	116	
		In force: 17 October 1969	135	
		In force: 18 March 1976	239	
		In force: 2 March 1977	248	
		In force: 10 September 1991	393	
		In force: 24 February 1993	418	
Palau, Republic of				
Panama	X	*In force: 23 March 1984* [18]	316	In force: 11 December 2001
Papua New Guinea	X	In force: 13 October 1983	312	
Paraguay	X	In force: 20 March 1979 [2]	279	
Peru		In force: 1 August 1979 [2]	273	In force: 23 July 2001
Philippines		In force: 16 October 1974	216	Signed: 30 September 1997
Poland		In force: 11 October 1972	179	In force: 5 May 2000
Portugal		Accession: 1 July 1986 [19]	193	Signed: 22 September 1998 [5]
Qatar				
Moldova, Republic of		*Signed: 14 June 1996*		
Romania		In force: 27 October 1972	180	In force: 7 July 2000
Russian Federation		In force: 10 June 1985	327*	Signed: 22 March 2000
Rwanda				
St. Kitts and Nevis	X	In force: 7 May 1996 [11]	514	
St. Lucia	X	In force: 2 February 1990 [11]	379	
St. Vincent and the Grenadines	X	In force: 8 January 1992 [11]	400	
Samoa	X	In force: 22 January 1979	268	
San Marino	X	In force: 21 September 1998	575	
São Tome and Principe				
Saudi Arabia				
Senegal	X	In force: 14 January 1980	276	
Seychelles				
Sierra Leone		*Signed: 10 November 1977*		
Singapore	X	In force: 18 October 1977	259	
Slovakia		In force: 3 March 1972 [20]	173	Signed: 27 September 1999
Slovenia		In force: 1 August 1997	538	In force: 22 August 2000
Solomon Islands	X	In force: 17 June 1993	420	
Somalia				
South Africa		In force: 16 September 1991	394	
Spain		Accession: 5 April 1989	193	Signed: 22 September 1998 [5]

TABLE A21. **(cont.)**

State[c]	SQP[d]	Status of safeguards agreement(s)	INFCIRC	Additional Protocol status
Sri Lanka		In force: 6 August 1984	320	
Sudan	X	In force: 7 January 1977	245	
Suriname	X	In force: 2 February 1979 [2]	269	
Swaziland	X	In force: 28 July 1975	227	
Sweden		Accession: 1 June 1995 [21]	193	Signed: 22 September 1998 [5]
Switzerland		In force: 6 September 1978	264	Signed: 16 June 2000
Syrian Arab Republic		In force: 18 May 1992	407	
Tajikistan				
Thailand		In force: 16 May 1974	241	
The Former Yugoslav Rep. of Macedonia		*Signed: 10 October 2000*		
Togo		*Signed: 29 November 1990*		
Tonga	X	In force: 18 November 1993	426	
Trinidad and Tobago	X	In force: 4 November 1992 [2]	414	
Tunisia		In force: 13 March 1990	381	
Turkey		In force: 1 September 1981	295	In force: 17 July 2001
Turkmenistan				
Tuvalu	X	In force: 15 March 1991	391	
Uganda				
Ukraine		In force: 22 January 1998	550	Signed: 15 August 2000
United Arab Emirates				
United Kingdom		In force: 14 December 1972	175 [22]	
		In force: 14 August 1978	263 [(*)]	Signed: 22 September 1998 [5]
		Approved: September 1992 [13]		
United Republic of Tanzania		*Signed: 26 August 1992*		
United States of America		In force: 9 December 1980	288 [(*)]	Signed: 12 June 1998
		In force: 6 April 1989 [13]	366	
Uruguay		In force: 17 September 1976 [2]	157	Signed: 29 September 1997
Uzbekistan		In force: 8 October 1994	508	In force: 21 December 1998
Vanuatu				
Venezuela		In force: 11 March 1982 [2]	300	
Viet Nam		In force: 23 February 1990	376	
Yemen, Republic of		*Signed: 21 September 2000*		
Yugoslavia, Federal Republic of		In force: 28 December 1973 [23]	204	
Zambia	X	In force: 22 September 1994	456	
Zimbabwe	X	In force: 26 June 1995	483	

[1] Sui generis comprehensive safeguards agreement.

[2] Safeguards agreement refers to both the Treaty of Tlatelolco and the NPT.

[3] Date refers to the safeguards agreement concluded between Argentina, Brazil, ABACC and the Agency. On 18 March 1997, upon approval by the Board of Governors, an exchange of letters entered into force between Argentina and the Agency confirming that the safeguards agreement satisfied the requirements of Article 13 of the Treaty of Tlatelolco and Article III of the NPT to conclude a safeguards agreement with the Agency.

[4] 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.

[5] The Agency has received notification from the State that it has fulfilled its own internal requirements for entry into force of the additional protocol concluded with Euratom and the Agency. The additional protocol will enter into force on the date when the Agency receives written notification from all the States and Euratom that their respective requirements for entry into force have been met.

[6] 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.

[7] Date refers to the safeguards agreement concluded between Argentina, Brazil, ABACC and the Agency. On 10 June 1997, upon approval by the Board of Governors, an exchange of letters entered into force between Brazil and the Agency confirming that the safeguards agreement satisfied the requirements of Article 13 of the Treaty of Tlatelolco. On 20 September 1999, upon approval by the Board of Governors, an exchange of letters entered into force confirming that the safeguards agreement also satisfied the requirements of Article III of the NPT.

[8] Date refers to a safeguards agreement pursuant to Article 13 of the Treaty of Tlatelolco. Upon approval by the Board of Governors an exchange of letters entered into force (for Chile on 9 September 1996; for Colombia on 13 June 2001) confirming that the safeguards agreement satisfied the requirement of Article III of the NPT.

[9] 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.

[10] 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 o f 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 for Greenland.

[11] An exchange of letters has entered into force between this state and the Agency confirming that the NPT safeguards agreement satisfies the obligations of the state under Article 13 of the Treaty of Tlatelolco.

[12] 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.

[13] The safeguards agreement referred to is pursuant to Additional Protocol I to the Treaty of Tlatelolco.

[14] 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.

[15] Pending entry into force, the additional protocol is applied provisionally in this State.

[16] 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.

[17] The safeguards agreement referred to was concluded pursuant to both the Treaty of Tlatelolco and the NPT. The application of safeguards under an earlier safeguards agreement pursuant to the Treaty of Tlatelolco, which entered into force on 6 September 1968 (INFCIRC/118), was suspended as of 14 September 1973.

[18] Date refers to a safeguards agreement concluded pursuant to Article 13 of the Treaty of Tlatelolco. A safeguards agreement pursuant to the NPT and the Tlatelolco Treaty was signed on 22 December 1988 but has not yet entered into force.

[19] 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.

[20] The NPT safeguards agreement concluded with the Czechoslovak Socialist Republic (INFCIRC/173), which entered into force on 3 March 1972, continues 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.

[21] 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.

[22] Date refers to the INFCIRC/66-type safeguards agreement, concluded between the United Kingdom and the Agency, which remains in force.

[23] 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 A22. **PARTICIPATION BY STATES IN MULTILATERAL TREATIES FOR WHICH THE DIRECTOR GENERAL IS DEPOSITARY, CONCLUSION OF REVISED SUPPLEMENTARY AGREEMENTS AND ACCEPTANCE OF AMENDMENTS TO ARTICLES VI AND XIV.A OF THE AGENCY'S STATUTE**
(status as of 31 December 2001)

P&I	Agreement on the Privileges and Immunities of the IAEA.
VC	Vienna Convention on Civil Liability for Nuclear Damage.
VC/OP	Optional Protocol Concerning the Compulsory Settlement of Disputes.
CPPNM	Convention on the Physical Protection of Nuclear Material.
NOT	Convention on Early Notification of a Nuclear Accident.
ASSIST	Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency.
JP	Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention.
NS	Convention on Nuclear Safety.
RADW	Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.
PVC	Protocol to Amend the Vienna Convention on Civil Liability for Nuclear Damage *(not yet entered into force).*
SUPP	Convention on Supplementary Compensation for Nuclear Damage *(not yet entered into force).*
RSA	Revised Supplementary Agreements Concerning the Provision of Technical Assistance by the IAEA (RSA).
VI	Acceptance of Amendment to Article VI of the IAEA Statute.
XIV.A	Acceptance of Amendment to Article XIV.A of the IAEA Statute.

	P&I	VC	VC/OP	CPPNM	NOT	ASSIST	JP	NS	RADW	PVC	SUPP	RSA	VI	XIV.A
* **Afghanistan**					Sr	Sr						S		
* **Albania**												S		
* **Algeria**					Sr	Sr		S				S	X	X
Andorra														
* **Angola**														
Antigua and Barbuda				P										
* **Argentina**	P	P		P	Pr	Pr	S	P	P	CS	CS	S		
* **Armenia**		P		P	P	P		P						
* **Australia**	P			P	Pr	Pr		P	S		S			
* **Austria**				Pr	P	Pr		P	P					
* **Azerbaijan**														
Bahamas														
Bahrain														
* **Bangladesh**					P	P		P				S		
Barbados														
* **Belarus**	Pr	P		Pr	Pr	Pr		P	S	S		S	X	X
* **Belgium**	Pr			Pr	P	P	S	P	S					
Belize														
* **Benin**														
Bhutan														
* **Bolivia**	P	P										S		
* **Bosnia and Herzegovina**		P		P	P	P								
Botswana				P										
* **Brazil**	P	P		P	P	P		P	S			S		
Brunei														
* **Bulgaria**	Pw	P		Pw	Pw	Pw	P	P	P			S		
* **Burkina Faso**												S		
Burundi														
* **Cambodia**														
* **Cameroon**	P	P			S	S	P					S		

***:** Agency Member State; **S:** Signatory; **P:** Party; **CS:** Contracting State; **r:** existing reservation/declaration; **w:** withdrawal of previous reservation/declaration.

TABLE A22. **(cont.)**

	P&I	VC	VC/OP	CPPNM	NOT	ASSIST	JP	NS	RADW	PVC	SUPP	RSA	VI	XIV.A
* **Canada**	Pr			P	Pr	Sr		P	P				X	X
Cape Verde														
* **Central African Republic**														
Chad														
* **Chile**	Pr	Pr		P	S	S	P	P				S		
* **China**	Pr			Pr	Pr	Pr		P				S		
* **Colombia**	P	S	S									S		
Comoros														
Congo														
* **Costa Rica**					P	P						S		
* **Croatia**	P	P		P	P	P	P	P	P			S	X	X
* **Côte d'Ivoire**					S	S						S		
* **Cuba**	Pr	P		Pr	Pr	Pr		S				S		
* **Cyprus**	P			Pr	P	P		P				S		
* **Czech Rep.**	Pw	P		P	P	P	P	P	P	S	S	S		
Dem. People's Rep. of Korea					Sr	Sr								
* **Dem Rep. of the Congo**					S	S						S		
* **Denmark**	Pr			P	P	S	P	Pr	Pr					
Djibouti														
Dominica														
* **Dominican Republic**				S								S		
* **Ecuador**	P			P								S		
* **Egypt**	P	P			Pr	Pr	P	S				S		
* **El Salvador**												S		
Equatorial Guinea														
Eritrea														
* **Estonia**	P	P		P	P	P	P		S			S		
* **Ethiopia**												S		
Fiji														
* **Finland**	P			Pr	P	Pr	P	P	P					X
* **France**				Pr	Pr	Pr	S	P	P				X	X
* **Gabon**														
Gambia														
* **Georgia**												S		
* **Germany**	Pr			Pr	Pr	Pr	P	P	P				X	X
* **Ghana**	P							S				S		
* **Greece**	P			Pr	Pr	Pr	P	P	P			S	X	X
Grenada														
* **Guatemala**				Pr	P	P						S		
Guinea														
Guinea-Bissau														
Guyana														
* **Haiti**				S								S		
* **Holy See**	P				S	S							X	X
Honduras														
* **Hungary**	Pr	P		Pw	Pw	Pw	P	P	P	S		S		
* **Iceland**					P	S		S				S		
* **India**	P				Pr	Pr		Sr						
* **Indonesia**	Pr			Pr	Pr	Pr		S	S	S	S	S		
* **Iran, Islamic Rep. of**	P				Pr	Pr						S		

*: Agency Member State; **S:** Signatory; **P:** Party; **CS:** Contracting State; **r:** existing reservation/declaration; **w:** withdrawal of previous reservation/declaration.

TABLE A22. **(cont.)**

	P&I	VC	VC/OP	CPPNM	NOT	ASSIST	JP	NS	RADW	PVC	SUPP	RSA	VI	XIV.A
* **Iraq**					Pr	Pr						S		
* **Ireland**	P			Pr	P	Pr		P	P			S	X	X
* **Israel**		Sr		Sr	Pr	Pr		S				S		
* **Italy**	Pr			Pr	Pr	Pr	P	P	S	S	S			
* **Jamaica**	P											S		
* **Japan**	P			P	P	Pr		P					X	
* **Jordan**	Pr				P	P		S				S		
* **Kazakhstan**	P							S	S			S		
* **Kenya**												S		
* **Korea, Rep. of**	Pr			Pr	P	Pr		P	S			S	X	X
* **Kuwait**	P													
Kyrgyzstan														
Lao People's Dem. Rep.														
* **Latvia**	P	P			P	P	P	P	P	CS		S		
* **Lebanon**		P		P	P	P		P	S	S	S	S		
Lesotho														
* **Liberia**														
* **Libyan Arab Jamahiriya**				P		P						S		
* **Liechtenstein**				P	P	P							X	X
* **Lithuania**	P	P		P	P	P	P	P	S	S	S	S	X	X
* **Luxembourg**	Pr			Pr	P	P		P	P				X	X
* **Madagascar**												S		
Malawi														
* **Malaysia**					Pr	Pr						S		
Maldives														
* **Mali**					S	S		P				S		
* **Malta**												S	X	X
* **Marshall Islands**														
Mauritania														
* **Mauritius**	P				Pr	Pr						S		
* **Mexico**	Pr	P		P	P	P		P				S		
Micronesia														
* **Monaco**				P	Pr	Pr		S					X	X
* **Mongolia**	Pw			Pw	Pw	Pw						S		
* **Morocco**	Pr	S		S	P	P	S	S	P	CS	CS	S	X	
Mozambique														
* **Myanmar**					Pr							S	X	X
* **Namibia**												S		
Nepal														
* **Netherlands**	P			Pr	Pr	Pr	P	P	P					
* **New Zealand**	P				P	Pr								
* **Nicaragua**	P				Pr	Pr		S				S		
* **Niger**	P	P		S	S	S						S		
* **Nigeria**					P	P		S				S		
* **Norway**	P			Pr	P	Pr	P	P	P					
Oman														
* **Pakistan**	Pr			Pr	Pr	Pr		P				S	X	X
Palau														
* **Panama**				P	P	P						S		
Papua New Guinea														

***:** Agency Member State; **S:** Signatory; **P:** Party; **CS:** Contracting State; **r:** existing reservation/declaration; **w:** withdrawal of previous reservation/declaration.

TABLE A22. **(cont.)**

	P&I	VC	VC/OP	CPPNM	NOT	ASSIST	JP	NS	RADW	PVC	SUPP	RSA	VI	XIV.A
* **Paraguay**				P	S	S						S		
* **Peru**		P		P	Pr	Pr		P	S	S	S	S		
* **Philippines**	P	P	P	P	P	P	S	S	S	S	S	S		
* **Poland**	Pw	P		Pw	Pw	Pw	P	P	P	S		S	X	X
* **Portugal**				Pr	P	S	S	P				S		
* **Qatar**												S		
* **Rep. of Moldova**		P		P	P	P		P				S		
* **Romania**	Pr	P		Pr	Pr	Pr	P	P	P	CS	CS	S	X	X
* **Russian Federation**	Pr	S		Pr	Pr	Pr		P	S					
Rwanda														
St. Kitts and Nevis														
St. Lucia														
St. Vincent and the Grenadines		P			P	P	P							
Samoa														
San Marino														
São Tome and Principe														
* **Saudia Arabia**					Pr	Pr						S		
* **Senegal**					S	S						S		
Seychelles														
* **Sierra Leone**					S	S						S		
* **Singapore**	Pr				P	P		P				S		
* **Slovakia**	Pw	P		P	Pr	Pr	P	P	P			S		
* **Slovenia**	P	P		P	P	P	P	P	P				X	X
Solomon Islands														
Somalia														
* **South Africa**				Sr	Pr	Pr		P						
* **Spain**	P	S		Pr	Pr	Pr	S	P	P			S		
* **Sri Lanka**					Pr	Pr		P				S		
* **Sudan**				P	S	S		S				S		
Suriname														
Swaziland														
* **Sweden**	P			Pr	P	Pr	P	P	P				X	X
* **Switzerland**	Pr			Pr	P	P	S	P	P				X	X
* **Syrian Arab Republic**	P				S	S		S				S		
* **Tajikistan**				P										
* **Thailand**	Pr				Pr	Pr						S		
* **The Former Yugoslav Rep. of Macedonia**		P		P	P	P						S		
Togo														
Trinidad and Tobago		P		P										
* **Tunisia**	P			P	P	P		S				S		
* **Turkey**	Pr			Pr	Pr	Pr	S	P				S		
Turkmenistan														
* **Uganda**												S		
* **Ukraine**	Pr	P		P	Pr	Pr	P	Pr	P	S	S	S		
United Arab Emirates					Pr	Pr						S		
* **United Kingdom**	Pw	S	S	Pr	Pr	Pr	S	P	P				X	X
* **United Rep. of Tanzania**												S		
* **United States of America**				P	Pr	Pr		P	S		S			
* **Uruguay**		P	P		P	P		S				S		

***:** Agency Member State; **S:** Signatory; **P:** Party; **CS:** Contracting State; **r:** existing reservation/declaration; **w:** withdrawal of previous reservation/declaration.

TABLE A22. **(cont.)**

	P&I	VC	VC/OP	CPPNM	NOT	ASSIST	JP	NS	RADW	PVC	SUPP	RSA	VI	XIV.A
* **Uzbekistan**				P								S		
Vanuatu														
* **Venezuela**												S		
* **Viet Nam**	P				Pr	Pr						S		
* **Yemen**														
* **Yugoslavia, Fed. Rep. of**	P	P	S	P	P	P						S		
* **Zambia**												S		
* **Zimbabwe**					S	S						S		

***:** Agency Member State; **S:** Signatory; **P:** Party; **CS:** Contracting State; **r:** existing reservation/declaration; **w:** withdrawal of previous reservation/declaration.

TABLE A23. CONVENTIONS NEGOTIATED AND ADOPTED UNDER THE AUSPICES OF THE AGENCY AND FOR WHICH THE DIRECTOR GENERAL OF THE AGENCY IS DEPOSITARY (STATUS AND RELEVANT DEVELOPMENTS)

Agreement on the Privileges and Immunities of the IAEA (reproduced in INFCIRC/9/Rev. 2). In 2001, one State accepted the Agreement. By the end of the year, there were 68 Parties.

Vienna Convention on Civil Liability for Nuclear Damage (reproduced in INFCIRC/500). Entered into force on 12 November 1977. In 2001, 1 State adhered to the Convention. By the end of the year there were 33 Parties.

Optional Protocol Concerning the Compulsory Settlement of Disputes (reproduced in INFCIRC/500/Add.3). Entered into force on 13 May 1999. In 2001, the status remained unchanged 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 2001, one State adhered to the Convention. By the end of the year there were 69 Parties.

Convention on Early Notification of a Nuclear Accident (reproduced in INFCIRC/335). Entered into force on 27 October 1986. In 2001, one State adhered to the Convention. By the end of the year there were 87 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 2001, one State adhered to the Convention. By the end of the year there were 83 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 2001, three States adhered to the Protocol. By the end of the year there were 24 Parties.

Convention on Nuclear Safety (reproduced in INFCIRC/449). Entered into force on 24 October 1996. In 2001, the status remained unchanged with 53 Parties.

Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (reproduced in INFCIRC/546). Entered into force on 18 June 2001. In 2001, four States adhered to the Convention and one State signed it. By the end of the year there were 27 Parties.

Protocol to Amend the Vienna Convention on Civil Liability for Nuclear Damage (reproduced in INFCIRC/566). Opened for signature on 29 September 1997. In 2001, one State adhered to the Protocol and one State signed it. By the end of the year there were 4 Contracting States and 15 Signatories.

Convention on Supplementary Compensation for Nuclear Damage (reproduced in INFCIRC/567). Opened for signature on 29 September 1997. In 2001, the status remained unchanged with 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. In 2001, two States adhered to the Agreement. By the end of the year, there were 22 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. In 2001, its status remained unchanged with 17 Parties.

Revised Supplementary Agreements Concerning the Provision of Technical Assistance by the IAEA (RSA). In 2001, three States concluded Agreements. By the end of the year 95 States had 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 2001, four States adhered to the Agreement and three States signed it. By the end of the year there were 5 Contracting States and 17 Signatories.

TABLE A24. **CO-ORDINATED RESEARCH PROJECTS — NEW OR COMPLETED IN 2001**

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

New

Economic research on, and assessment of, selected nuclear desalination projects and case studies
Evaluation of radiation damage to WWER reactor pressure vessels: Using the IAEA database on reactor pressure vessel materials
Verification of WWER steam generator tube integrity

Completed

Intercomparison of techniques for pressure tube inspection and diagnostics
Optimization of the coupling of nuclear reactors and desalination systems
Potential of thorium based fuel cycles to constrain plutonium and to reduce long term waste toxicities
Use of a thorium based fuel cycle in accelerator driven systems (ADSs) to incinerate plutonium and to reduce long term waste toxicities

Nuclear Fuel Cycle and Waste Management Technology

New

Corrosion of research reactor aluminium-clad spent fuel in water (Phase II)
Data processing technologies and diagnostics for water chemistry and corrosion control in nuclear power plants (DAWAC)
Nuclear fuel cycle aspects of the disposition of depleted uranium

Completed

Chemical durability and performance assessment of spent fuel and high level waste forms under simulated repository conditions (extended to 2005)
Combined methods of liquid radioactive waste treatment
Decommissioning techniques for research reactors
Modelling of transport of radioactive substances in primary circuit of water cooled reactors
Treatment of liquid effluent from uranium mines and mills during and after operation

Comparative Assessment for Sustainable Energy Development

New

Cost effectiveness of nuclear power compared to carbon dioxide capture and sequestration from fossil fuel power plants
Historical evolution of Indicators of Sustainable Energy Development (ISED) and the use of this information for designing guidelines for future energy strategies in conformity with the objectives of sustainable development
Impact of infrastructural requirements on the competitiveness of nuclear power

Completed

Case studies to assess and compare different energy sources in sustainable energy and electricity supply strategies
Estimating the external costs associated with electricity generation options in developing countries using simplified methodologies

Food and Agriculture

New

Development of strategies for the effective monitoring of veterinary drug residues in livestock and livestock products in developing countries
Enabling technologies for the expansion of the sterile insect technique for the Old and New Screwworm
Integrated approach for improving small scale market oriented dairy systems
Integrated soil, water and nutrient management for sustainable rice–wheat cropping systems in Asia
Use of irradiation to ensure hygienic quality of fresh, pre-cut fruits and vegetables and other minimally processed foods of plant origin

TABLE A24. **(cont.)**

Completed

Assessment of soil erosion through the use of caesium-137 and related techniques as a basis for soil conservation, sustainable production and environmental protection
Automation in tsetse fly mass rearing for use in sterile insect technique programmes
Cellular biology and biotechnology including mutation techniques for creation of new useful banana genotypes
Use of isotope techniques in studies on the management of organic matter and nutrient turnover for increased, sustainable agricultural production and environmental preservation
Use of nuclear and colorimetric techniques for measuring microbial protein supply from local feed resources in ruminant animals

Human Health

New

Application of isotopic and nuclear techniques in the study of nutrition pollution interactions and their impact on the nutritional status of human subjects in developing country populations
Comparative assessment of teletherapy modalities
Development of techniques at Secondary Standard Dosimetry Laboratories for the dissemination of absorbed dose to water standards
Development of thermoluminescence dosimetry based quality audits for radiotherapy dosimetry in non-reference conditions
Harmonization of protocols and procedures in the management of neonatal hydronephrosis
Isotopic and complementary tools for the study of micronutrient status and interactions in developing country populations exposed to multiple nutritional deficiencies
Radiopharmaceutical imaging to predict and evaluate the response of breast cancer to neo-adjuvant chemotherapy
Use of nuclear and related analytical techniques in studying human exposure to toxic elements consumed through foodstuffs contaminated by industrial activities

Completed

Clinical application of radiosensitizers in cancer radiotherapy
Development and validation of an Internet based clinical and technical study communication system for nuclear medicine
Development of a quality assurance programme for radiation therapy dosimetry in developing countries
Development of an improved serological kit for Chagas diagnosis using radionuclide methods
Electron paramagnetic resonance biodosimetry
Human immunodeficiency virus (HIV) markers in patients treated with radiotherapy for cervical cancer

Applications of Physical and Chemical Sciences

New

Atomic and molecular data for fusion plasma diagnostics
Data for molecular processes in edge plasmas
Dense magnetized plasmas
Development of distance learning modules on troubleshooting of nuclear instruments
In situ application of the X ray fluorescence technique

Completed

WIMSD library update project

Nuclear Safety

Completed

Investigation of methodologies for incident analysis
Round robin exercise on WWER-440 reactor pressure vessel weld metal irradiation embrittlement and annealing

TABLE A24. **(cont.)**

Radiation Safety
Completed
Development of radiological basis for the transport safety requirements for low specific activity materials and surface contaminated objects

TABLE A25. **TRAINING COURSES, SEMINARS AND WORKSHOPS IN 2001**

Nuclear Power

Courses

Korea International Cooperation Agency/IAEA training course on nuclear power planning and project management for middle level managers — Republic of Korea
Regional course on mechanical equipment — Republic of Korea
Regional course on modernization of nuclear power plant instrumentation and control systems — Germany
Regional course on optimization of nuclear power plant maintenance programmes — Germany

Seminar

Status and prospects for small and medium sized reactors — Egypt

Workshops

Regional workshop on ageing management programme for mechanical equipment and instrumentation and control equipment — Headquarters
Regional workshop on application of the leak-before-break concept — Slovenia
Regional workshop on condition monitoring methods and techniques for assessing lifetime — Ukraine
Regional workshop on configuration management throughout plant service life — Slovenia
Regional workshop on data acquisition system and ageing management — Romania
Regional workshop on the economics of nuclear power plant performance — Hungary
Regional workshop on experience in the management of delayed nuclear power projects — Slovakia
Regional workshop on human–machine interface design for the main control room — Brazil
Regional workshop on management competencies required for the competitive environment — China
Regional workshop on managing human resources during organizational transition — Romania
Regional workshop on nuclear power plant maintenance and in-service inspection — China
Regional workshop on qualification of in-service inspection systems with special regard to the technical justification — Czech Republic
Regional workshop on strategies and policies in implementation of nuclear power plant life management programmes — Slovenia
Regional workshop on structural integrity assessment — Germany
Regional workshop on modern instrumentation and control technology for advanced process control systems — Islamic Republic of Iran
Workshop on advanced nuclear power plant simulation — Abdus Salam International Centre for Theoretical Physics, Trieste
Workshop on desalination economic evaluation — Abdus Salam International Centre for Theoretical Physics, Trieste
Workshop on hybrid nuclear systems for energy production, utilization of actinides and transmutation of long lived radioactive waste — Abdus Salam International Centre for Theoretical Physics, Trieste
Workshop on technologies for desalination — Abdus Salam International Centre for Theoretical Physics, Trieste

Nuclear Fuel Cycle and Waste Management Technology

Courses

Course on implementation of burnup credit in spent fuel management systems — USA
Course on nuclear fuel cycle — Morocco
Decommissioning of research reactors and other small nuclear facilities — Republic of Korea
Demonstration of predisposal waste management and procedures — Russian Federation
Regional course on management of disused sealed radioactive sources — South Africa

Workshop

Computational workshop and course on implementing burnup credit — USA

Comparative Assessment for Sustainable Energy Development

Courses

National group training on energy planning for electricity generation using the Agency's WASP model — Armenia; Haiti

TABLE A25. **(cont.)**

National group training on the Energy and Power Evaluation Program (ENPEP) — Sudan
National group training on the IAEA's model FINPLAN for financial analysis of nuclear power projects — Bulgaria
National group training on the use of Model for Analysis of Energy Demand (MAED) — Syrian Arab Republic
Regional course on the Energy and Power Evaluation Program (ENPEP) as an IAEA tool for greenhouse gas (GHG) abatement cost studies —Ukraine
Regional course on the use of the Agency's methodologies and tools in greenhouse gas abatement studies — Republic of Korea

Seminars
Regional seminar to exchange experiences in conducting national studies on greenhouse gas abatement — Viet Nam

Workshops
Interregional workshop on enhanced energy system analysis and planning, incorporating social, economic and environmental aspects in decision making — USA

Food and Agriculture

Courses
Interregional course on the use of the sterile insect and related techniques for the area wide management of insect pests — USA
National group training in agriculture and related fields — Nigeria
National group training studying the fate of nitrate in soil and water under intensive vegetable production systems — Mauritius
Regional (AFRA) course on improved mutation, in vitro culture and drought screening techniques for the improvement of African crops — South Africa
Regional course on the application of neutron probe and nitrogen-15 under fertigation — Turkey
Regional Latin America course on fruit fly area wide management — Mexico

Workshops
FAO/IAEA regional training workshop on mutagenesis, molecular pathology and markers in date palm improvement — Tunisia
FAO/IAEA training workshop on in vitro plant multiplication, selection, mutagenesis and molecular marker studies in plant improvement — Malaysia
FAO/IAEA training workshop on induced mutations and biotechnology in ornamental plant improvement — Indonesia
FAO/IAEA workshop on introduction of quality assurance/quality control principles in the analysis of pesticide products — Hungary
FAO/IAEA (RCA) workshop on process control of irradiation as a sanitary and phytosanitary treatment for food — China
FAO/IAEA/WHO regional workshop for Africa and the Near East on development of quality assurance for mycotoxin analysis of food and feed — Egypt
ICGFI regional workshop for Latin America on certification of irradiation as a sanitary and phytosanitary treatment for food — Brazil
National training workshop on disease surveillance, reporting and emergency preparedness systems — Pakistan
RCA training workshop on in vitro techniques for feed evaluation — Indonesia
Regional training workshop update on technologies for the surveillance of rinderpest freedom — Senegal
Regional West Asia workshop on using GIS for SIT data management — Austria
Regional workshop to train trainers on methodologies and use of information communication technology (ICT) based training materials in animal reproduction and health — United Republic of Tanzania
South African Development Community/IAEA technical co-operation workshop on diagnostic kit production and related quality assurance issues in South African developing countries — Zimbabwe
Second FAO/IAEA interregional consultants meeting/workshop on developing standardized training material to assist FAO/IAEA Member States to establish quality systems for veterinary diagnostic laboratories — South Africa

TABLE A25. **(cont.)**

Workshop on integrated crop, soil, water and nutrient management in rice based cropping systems with emphasis on biofertilizer technologies — Bangladesh

Human Health

Courses

Course on basic clinical radiobiology (IAEA/ESTRO) — Spain
Course on clinical research in radiation oncology (IAEA/ESTRO) — Turkey
Course on dose and monitor unit calculations for high energy photon beams, basic principles and application to modern techniques (IAEA/ESTRO) — Portugal
Course on evidence based radiation oncology: principles and methods (IAEA/ESTRO) — Egypt
Course on imaging for target volume determination in radiotherapy (IAEA/ESTRO) — Poland
Course on intensity modulated radiation therapy (IAEA/ESTRO) — Netherlands
Course on modern brachytherapy techniques (IAEA/ESTRO) — France; Slovakia
Course on physics for clinical radiotherapy (IAEA/ESTRO) — Belgium
Course on radiation oncology in the new millennium (RCA/ISRO) — India
Course on radiotherapy treatment planning: Principles and practices (IAEA/ESTRO) — Ireland
Course on the physical aspects of quality assurance in radiotherapy — Argentina
National course on basic radioimmunoassay — Sudan
National course on radioimmunoassay: Theory, methodology and quality control — Viet Nam
Regional course on basic nuclear cardiology — Egypt
Regional (AFRA) course on brachytherapy — Tunisia
Regional course on formulation of immunoradiometric assay for prostatic specific antigen using antibodies from open sources — Syrian Arab Republic
Regional course on molecular biology techniques in diagnosis of viral hepatitis — Uruguay
Regional course on nuclear cardiology — Estonia
Regional course on nuclear cardiology technicians — Algeria
Regional course on nuclear oncology — Italy
Regional course on paediatric nuclear medicine for nuclear medicine physicians — Cyprus
Regional course on radiation oncology: What have we learnt from evidenced based medicine? (RCA/ISRO) — India
Regional (RCA) course on radiobiological and physical aspects of brachytherapy in uterine cervix cancer — Japan
Regional course on radionuclide and molecular techniques in the detection of drug resistant malaria — Uganda
Regional course on scintimammography, sentinel lymph node detection and intra-operative surgical probe technology — Pakistan
Seminar on iron and zinc fortification of wheat flour — Indonesia
Regional course on the operation of tissue banking: First phase — Argentina
Regional (RCA) course on treatment planning in clinical radiation oncology — Australia

Seminars

National screening programme for neonatal hypothyroidism: Regional seminar for policy makers and professionals on congenital hypothyroidism — Philippines

Workshops

International workshop on k_0 users — Belgium
International workshop on multi-micronutrient deficiency control in the life cycle — Peru
National workshop on neonatal screening for congenital hypothyroidism in Viet Nam — Viet Nam
National workshop on nuclear medicine — Colombia
National workshop on a service network with tele-imaging and tele-maintenance — Bolivia
Regional (AFRA) workshop on evidence based diagnostic radioimmunology — Mauritius
Regional management workshop on strategies to enhance utilization of local radiopharmaceuticals — Republic of Korea
Regional training workshop on atmospheric chemistry and transport — Republic of Korea
Regional training workshop on nuclear cardiology techniques — South Africa
Regional training workshop on paediatric nuclear medicine — Tunisia

TABLE A25. **(cont.)**

Regional training workshop on quality control of single photon emission computed tomography (SPECT) systems — Morocco
Regional training workshop on radionuclide treatment of liver cancer — Australia
Regional training workshop on review of the distance assistance training programme for nuclear medicine technologists — South Africa
Regional workshop on application of SPECT techniques in cardiology and oncology for nuclear medicine technologists — Viet Nam
Regional workshop on application of the manual of procedures in nuclear nephro-urology and its clinical applications — Mexico
Regional workshop on management of thyroid cancer — Philippines
Regional workshop on myocardial perfusion scintigraphy using SPECT for nuclear medicine physicians — Indonesia
Regional workshop on neutron monitoring and dosimetry — Republic of Korea
Regional workshop on quality assurance programme for molecular based diagnosis of infectious diseases — Thailand
Regional (AFRA) workshop on radiation oncology departmental management decision making — South Africa
Regional workshop on traceability of measurements for protection level dosimetry — Latvia
Regional workshop on treatment planning — Germany
Workshop on capacity building in Africa in the area of food and nutrition — South Africa

Marine Environment and Water Resources

Courses
Advanced regional course on isotope data interpretation — USA
Basic regional course on the use of methodologies of isotope hydrology — Tunisia
MEDPOL course on the analyses of chlorinated pesticides and PCBs in marine samples — Monaco
MEDPOL course on the analyses of trace metals in marine samples — Monaco
Regional course on groundwater: Evaluation, techniques and management — Colombia
Regional course on isotope hydrology — Namibia

Workshop
Regional workshop for project assessment of isotope applications for improved drinking water resources management — Republic of Korea

Applications of Physical and Chemical Sciences

Courses
Accelerator training school 2001 — Indonesia
Regional course on fabrication of non-destructive testing test pieces — South Africa
Regional course on surface methods: Level II — Jordan; Tunisia
Regional course on ultrasonic testing proficiency of welds — Australia

Workshops
Regional workshop on neutron beam research — Republic of Korea
Workshop on nuclear data for science and technology: Accelerator driven waste incineration — Italy

Nuclear Safety

Courses
Course on advanced ultrasonic testing — Russian Federation; Lithuania
Course on safety design requirements of nuclear power plants — China
Group training on the introduction of existing regulatory and utility design safety requirements — China
Regional basic professional course on nuclear safety — France
Regional basic professional course on nuclear safety (East Asia and Pacific) — USA
Regional course for junior operators and regulators on safety and utilization of research reactors — Austria; Slovakia
Regional course on advanced probabilistic safety assessment (PSA) modelling techniques — United Kingdom
Regional course on regulatory control of nuclear power plants — Germany

TABLE A25. **(cont.)**

Regional course on the safety assessment of nuclear power plants — United Kingdom

Seminars
INES seminar — Czech Republic; Slovakia
International seminar on horizontal steam generators — Finland
Seminar on automated ultrasonic testing — Spain
Seminar on qualification of welding techniques — USA
Seminar on self-assessment of operational safety performance — Russian Federation

Workshops
First regional workshop on safety analysis and computer code utilization — Republic of Korea
Management workshop on competencies for competitive environment — China
National workshop on configuration management — China
National workshop on external events in site and design of nuclear power plants — Lithuania
National workshop on fundamental event analysis techniques — Republic of Korea
National workshop on operational experience and event analysis techniques — Republic of Korea
National workshop on self-assessment of operational safety — Pakistan
Regional training workshop on safety analysis methodology and computer code utilization — Republic of Korea
Regional workshop on accident management — Ukraine
Regional workshop on ageing of research reactors — Brazil
Regional workshop on comparison of thermal hydraulic analyses performed to support WWER-1000 PSAs — Russian Federation
Regional workshop on core calculations — Argentina
Regional workshop on development of safety analyses reports — Slovenia
Regional workshop on emergency preparedness of research reactors — Romania
Regional workshop on extended shutdown and decommissioning of research reactors — Latvia
Regional workshop on fundamental techniques for event analyses — Lithuania
Regional workshop on modernization of protection systems — Mexico; Peru
Regional workshop on periodic safety review — Bulgaria
Regional workshop on RBMK safety issues — Lithuania
Regional workshop on regulatory review of licensee safety performance — USA
Regional workshop on risk informed regulations — Hungary
Regional workshop on safety culture — China
Regional workshop on safety culture enhancement programme support — Slovakia
Regional workshop on safety culture for research reactors — Chile
Regional workshop on strategies for safe operation — Republic of Korea
Regional workshop on the IAEA nuclear safety standards (safety requirements) — Japan
Regional workshop on tools for enhancement of regulatory effectiveness — Slovenia
Regional workshop on WWER-1000 design basis documentation management system — Czech Republic
Strengthening safety assessment capabilities of nuclear power plants — Ukraine
Workshop for middle and senior managers on harmonization of PSA — Spain
Workshop on ageing of research reactors — China
Workshop on assessing and assuring plant modification safety — Slovenia
Workshop on BWR water chemistry — Germany
Workshop on challenges to the operator–regulator interface — Germany
Workshop on check criteria before acceptance for three categories of fast reactor design basis accidents — China
Workshop on engineering safety assessment of existing nuclear power plants — Russian Federation
Workshop on periodic safety review — Bulgaria
Workshop on probabilistic safety assessment for pressurized heavy water reactors — Canada
Workshop on PSA: A tool to support operational decision making — India
Workshop on regulatory aspects for research reactors — Viet Nam
Workshop on regulatory body review and assessment of safety analysis reports — Czech Republic
Workshop on regulatory requirement for licensing research reactors — Malaysia
Workshop on requirements for level 2 PSA — China

TABLE A25. **(cont.)**

Workshop on requisites for establishment of regulatory body, licensing, inspection and enforcement — Viet Nam
Workshop on safe operating envelope for nuclear power plants with pressurized heavy water reactors — Canada
Workshop on strengthening management of plant operational safety — Ukraine
Workshop on Tianwan nuclear power plant reactor protection system and validation and verification of the safety software — Germany
Workshop on training staff of a regulatory body based on competency — Brazil

Radiation Safety

Courses
National course on assistance with preparation of national training courses on radiation protection — Bolivia
National course on assistance with preparation of national training courses on radiation protection for officers in radiotherapy and nuclear medicine — Bolivia
National course on emergency preparedness and response to radiological emergencies — Costa Rica
National course on emergency response and preparedness — Guatemala
National course on health surveillance and medical management of overexposed workers — Romania
National course on organization and implementation of a national regulatory programme for the control of radiation sources — Bosnia and Herzegovina
National course on radiation protection for officers in radiotherapy and nuclear medicine — Bolivia
National course on radiation protection for radiation protection officers — Guatemala
National course on radiation protection in diagnostic and interventional radiology — Latvia
National course on radiation protection in diagnostic radiology — Albania
National course on radiation protection in diagnostic radiology — Republic of Moldova
National course on radiation protection in hospitals — Saudi Arabia
National course on radiation protection in industrial radiography — The Former Yugoslav Republic of Macedonia
National course on radiation protection in nuclear medicine — Lithuania
National course on radiation protection in radiotherapy — Estonia
National course on regulatory control of radiation sources — Malta
Post-graduate educational course in radiation protection and nuclear safety — Argentina
Post-graduate educational course in radiation protection and safety of radiation — Malaysia
Regional course on assessment of occupational exposure due to external radiation sources — Turkey
Regional course on design, implementation and management of individual monitoring programmes — Japan
Regional course on organization and implementation of a national regulatory programme for the control of radiation sources — Islamic Republic of Iran; Slovenia
Regional post-graduate diploma course in radiation protection — Syrian Arab Republic
Regional post-graduate educational course in radiation protection and safety of radiation sources — South Africa
Regional train the trainers course for developing a syllabus/training material for optimization of radiation protection — Republic of Korea
Regional train the trainers course on medical education for nuclear accident preparedness — Slovenia

Seminars
National forum on the Basic Safety Standards — Colombia
National seminar on legislative assistance (experts from URT) — Austria
National seminar on regulatory framework for nuclear and radiation safety — Nigeria

Workshops
IAEA–GCC workshop on radiation protection and waste safety infrastructure — Bahrain
National train the trainers workshop on diagnosis and biological dose assessment of radiation injuries — China
National workshop in nuclear medicine — Saudi Arabia
National workshop on planning medical response to radiological accidents — Egypt
National workshop on radiation protection in diagnostic, radiology, radiotherapy and nuclear medicine — Jordan
Regional training workshop on radiation protection in diagnostic and interventional radiology — France
Regional workshop on management of occupational radiation exposure during outages, Karachi nuclear power plant — Pakistan

TABLE A25. **(cont.)**

Regional workshop on optimization of radiation protection in nuclear power plants for regulatory staff — Spain
Regional workshop on the safety of radiation sources and security of radioactive materials — Morocco; Thailand
Workshop on radiation protection for occupationally exposed workers of the IAEA Marine Environment Laboratory — Monaco

Radioactive Waste Safety

Courses
Regional course on decontamination and decommissioning of research reactors and other small nuclear facilities — Republic of Korea
Regional course on exposures to the public and their control — Belarus
Regional course on sources, assessment, monitoring and control of public exposures — Lithuania

Seminars
Executive seminar on information/guidance on decommissioning — Lithuania

Workshops
National training workshop on rapid measurements of caesium-137 and strontium-90 in food — Ukraine
Regional workshop on safety assessment methodologies for "RADON" radioactive waste disposal facilities — Russian Federation

Safeguards

Courses
Course on implementation of state systems of accounting for and control of nuclear material — USA
Regional course on state systems of accounting for and control of nuclear material — Argentina; Australia

Seminars
Regional seminar on the protocol additional to nuclear safeguards agreements — Peru
Seminar on legislative assistance to representatives from Bulgaria and the Slovak Republic — Headquarters

Workshops
National workshop on additional protocol and safeguards implementation — Romania
Workshop on IAEA safeguards — Japan
Workshop on IAEA safeguards activities — Russian Federation
Workshop on nuclear material accounting and reporting — Ukraine
Workshop on the additional protocol for the Czech Republic and the Slovak Republic — Headquarters

Security of Material

Courses
Fifth Brno regional course on physical protection system design methodology (IAEA–USDOE) — Czech Republic
Regional course on practical operation of physical protection systems — Russian Federation
Regional train the trainers course on combating illicit trafficking of nuclear and/or radioactive materials (IAEA–Russian Customs Academy) — Russian Federation

Seminars
Subregional workshop–seminar on physical protection — Lithuania

Workshops
National design basis threat (DBT) workshop — Kazakhstan; Romania; Slovakia
National workshop on combating illicit trafficking of nuclear and/or radioactive materials — Azerbaijan; Kazakhstan
Regional workshop on physical protection and combating the illegal movement of nuclear material and other radioactive sources — Argentina

TABLE A25. **(cont.)**

Policy-making, Management and Support Services
National public information seminar on application of nuclear science and technology for human welfare — Indonesia
Regional public information seminar on peaceful uses of nuclear energy in central and eastern Europe — Slovenia
Regional public information seminar on serving human needs: Nuclear energy and technology for Africa — South Africa
Regional workshop on case studies in nuclear public information — Republic of Korea

TABLE A26. **PUBLICATIONS ISSUED IN 2001**

Nuclear Power

A systematic approach to human performance improvement in nuclear power plants: Training solutions — IAEA-TECDOC-1204

Assuring the competence of nuclear power plant contractor personnel — IAEA-TECDOC-1232

Country nuclear power profiles: 2001 edition (print and CD-ROM)

Critical experiments and reactor physics calculations for low enriched HTGRs — IAEA-TECDOC-1249

Current status and future development of modular high temperature gas cooled reactor technology — IAEA-TECDOC-1198

Design and evaluation of heat utilization systems for the high temperature engineering test reactor — IAEA-TECDOC-1236

Effective management of nuclear power plant instrumentation and control modernization projects including development of a database (proceedings of a specialists meeting) (CD-ROM)

Gas turbine power conversion systems for modular HTGRs — IAEA-TECDOC-1238

Heat transport and afterheat removal for gas cooled reactors under accident conditions — IAEA-TECDOC-1163

Information integration in control rooms and technical offices in nuclear power plants — IAEA-TECDOC-1252

Introduction of nuclear desalination — Technical Reports Series No. 400

Managing change in nuclear utilities — IAEA-TECDOC-1226

Modernization of instrumentation and control in nuclear power plants (proceedings of a regional training course) (CD-ROM)

Nuclear power engineering section newsletter, Vo. 3, No. 1

Nuclear power programme planning: An integrated approach — IAEA-TECDOC-1259

Nuclear power reactors in the world — Reference Data Series No. 2

Operating experience with nuclear power stations in Member States in 1999

Operating experience with nuclear power stations in Member States in 2000

Performance of operating and advanced light water reactor designs — IAEA-TECDOC-1245

Quality assurance for safety in nuclear power plants and other nuclear installations — Safety Series No. 50-C/SG-Q (CD-ROM)

Reactor simulator development workshop material — Training Course Series No. 12

Reference manual on the IAEA JRQ correlation monitor steel for irradiation damage studies — IAEA-TECDOC-1230

Risk management: A tool for improving nuclear power plant performance — IAEA-TECDOC-1209

Safety related design and economic aspects of HTGRs — IAEA-TECDOC-1210

Staffing requirements for future small and medium reactors (SMRs) based on operating experience and projections — IAEA-TECDOC-1193

Thermohydraulic relationships for advanced water cooled reactors — IAEA-TECDOC-1203

Nuclear Fuel Cycle and Waste Management Technology

Analysis of uranium supply to 2050 — special publication

Assessment of uranium deposit types and resources: A worldwide perspective — IAEA-TECDOC-1258

Characterization of groundwater flow for near surface disposal facilities — IAEA-TECDOC-1199

Country nuclear fuel cycle profiles — Technical Reports Series No. 404

Design criteria for a worldwide directory of radioactive contaminated sites (DRCS) — IAEA-TECDOC-1251

Handling and processing of radioactive waste from nuclear applications — Technical Reports Series No. 402

Impact of new environmental and safety regulations on uranium exploration, mining, milling and management of its waste — IAEA-TECDOC-1244

Implementation of burnup credit in spent fuel management systems — IAEA-TECDOC-1241

TABLE A26. **(cont.)**

Management for the prevention of accidents from disused sealed radioactive sources — IAEA-TECDOC-1205

Manual of acid in situ leach uranium mining technology — IAEA-TECDOC-1239

Methods for the minimization of radioactive waste from decontamination and decommissioning of nuclear facilities — Technical Reports Series No. 401

Monitoring of geological repositories for high level radioactive waste — IAEA-TECDOC-1208

Multi-purpose container technologies for spent fuel management — IAEA-TECDOC-1192

Nuclear fuel behaviour modelling at high burnup and its experimental support — IAEA-TECDOC-1233

Nuclear graphite waste management (proceedings of a Technical Committee meeting held in Manchester, United Kingdom, 18–20 October 1999) — IAEA-NGWM/CD (CD-ROM)

Organization and management for decommissioning of large nuclear facilities — Technical Reports Series No. 399

Performance of engineered barrier materials in near surface disposal facilities for radioactive waste: Results of a Co-ordinated Research Project — IAEA-TECDOC-1255

Procedures and techniques for closure of near surface disposal facilities for radioactive waste — IAEA-TECDOC-1260

Radioactive waste management status and trends — IAEA/WMDB/ST/1 (CD-ROM)

Seismic design considerations of nuclear fuel cycle facilities — IAEA-TECDOC-1250

Technical considerations in the design of near surface disposal facilities for radioactive waste — IAEA-TECDOC-1256

Technologies for the management of radioactive waste from nuclear power plants and back end nuclear fuel cycle activities (proceedings of a symposium held in Taejon, Republic of Korea, 30 August–3 September 1999) — C&S Papers Series No. 6 (IAEA-CSP-6/CD)

Use of scientific and technical results from underground research laboratory investigations for the geological disposal of radioactive waste — IAEA-TECDOC-1243

Waste Inventory Record Keeping Systems (WIRKS) for the management and disposal of radioactive waste — IAEA-TECDOC-1222

Waste management research abstracts, Nos 25, 26 (CD-ROM)

Comparative Assessment for Sustainable Energy Development

Energy, electricity and nuclear power estimates for the period up to 2020: July 2001 — Reference Data Series No. 1

Wien Automatic System Planning (WASP) package: A computer code for power generating system expansion planning version, WASP-IV — Computer Manual Series No. 16

Food and Agriculture

Animal production and health newsletter, Nos 33, 34

Consumer acceptance and market development of irradiated food in Asia and the Pacific — IAEA-TECDOC-1219

Economic evaluation of three alternative methods for control of the Mediterranean Fruit Fly (Diptera: Tephritidae) in Israel, Jordan Lebanon, Syrian Arab Republic and Territories under the Jurisdiction of the Palestinian Authority — IAEA-TECDOC-1265

Food and environmental protection newsletter, Vo. 3, Nos 1, 2

Impact of long term pesticide usage on soil properties using radiotracer techniques — IAEA-TECDOC-1248

Induced mutations in connection with biotechnology for crop improvement in Latin America — IAEA-TECDOC-1216

Insect and pest control newsletter, Nos 56, 57

In vitro techniques for selection of radiation induced mutations adapted to adverse environmental conditions — IAEA-TECDOC-1227

TABLE A26. **(cont.)**

Irradiation to control *Vibrio* infection from consumption of raw seafood and fresh produce — IAEA-TECDOC-1213

Mutation breeding newsletter, No. 45

Mutation breeding review, No. 13

Performance indicators for rinderpest surveillance — IAEA-TECDOC-1261

Plant breeding and genetics newsletter, Nos 6, 7

Radioactively labelled DNA probes for crop improvement — IAEA-TECDOC-1253

Radioimmunoassay and related techniques to improve artificial insemination programmes for cattle reared under tropical and subtropical conditions — IAEA-TECDOC-1220

Sesame improvement by induced mutations — IAEA-TECDOC-1195

Soils newsletter, Vols 23, 24

Standardized methods to verify absorbed dose in irradiated food for insect control — IAEA-TECDOC-1201

Use of isotope and radiation methods in soil and water management and crop nutrition — Training Course Series No. 14

Human Health

Absorbed dose determination in external beam radiotherapy: An international Code of Practice for dosimetry based on standards of absorbed dose to water — Technical Reports Series No. 398

Current status of neutron capture therapy — IAEA-TECDOC-1223

Implementation of microsource high dose rate (mHDR) brachytherapy for developing countries — IAEA-TECDOC-1257

SSDL newsletter, Nos 44, 45

The role of radiotherapy in the management of cancer patients infected by human immunodeficiency virus (HIV) — IAEA-TECDOC-1224

Therapeutic applications of radiopharmaceuticals — IAEA-TECDOC-1228

Marine Environment and Water Resources

Isotope based assessment of groundwater renewal in water scarce regions — IAEA-TECDOC-1246

Isotope techniques in water resource investigations in arid and semi-arid regions — IAEA-TECDOC- 1207

New approaches for stable isotope ratio measurements — IAEA-TECDOC-1247

Use of isotope techniques in lake dynamics investigations — IAEA-TECDOC-1206

Water and environment news, Nos 13, 14

Applications of Physical and Chemical Sciences

Atomic and plasma-material interaction data for fusion, Vols 7, 9

Bulletin on atomic and molecular data for fusion, Nos 60, 61

Charged particle cross-section database for medical radioisotope production: Diagnostic radioisotopes and monitor reactions — IAEA-TECDOC-1211

CINDA 2000

Compilation and evaluation of fission yield nuclear data — IAEA-TECDOC-1168

Co-ordination of the international network of nuclear structure and decay data evaluators — INDC(NDS)-422

Development of a database for prompt gamma-ray neutron activation analysis — INDC(NDS)-424

Final report of the ITER EDA — ITER EDA Documentation Series No. 21

Fusion energy 2000 — C&S Papers Series No. 8

Guidebook for the fabrication of non-destructive testing (NDT) test specimens — Training Course Series No. 13

International bulletin on atomic and molecular data for fusion, Issue Nos 59, 60

TABLE A26. **(cont.)**

ITER Council proceedings 2000 — ITER EDA Documentation Series No. 20

ITER CTA newsletter, No. 1

ITER EDA newsletter, Vol. 9, Nos 11, 12; Vol. 10, Nos 2–7

ITER-FEAT outline design report — ITER EDA Documentation Series No. 18

Long term needs for nuclear data development: Texts of papers presented at the Advisory Group meeting — INDC(NDS)-428

Nuclear data newsletter, Nos 31, 32

Nuclear research centres in the 21st century — special publication

Nuclear structure and decay data (NSDD) network — INDC(NDS)-421

Quality aspects of research reactor operations for instrumental neutron activation analysis — IAEA-TECDOC-1218

Radiotracer technology as applied to industry — IAEA-TECDOC-1262

Report on the IAEA consultants' meeting on the co-ordination of nuclear reaction data centres (technical aspects) — INDC(NDS)-427

Second (final) IAEA Research Co-ordination meeting on charge exchange cross-section data for fusion plasma studies — INDC(NDS)-426

Second (final) IAEA Research Co-ordination meeting on plasma–material interaction data for mixed plasma facing materials in fusion reactors — INDC(NDS)-429

Strategic planning for research reactors — IAEA-TECDOC-1212

Summary of the ITER final design report — ITER EDA Documentation Series No. 22

Summary report of the Advisory Group meeting on long term needs for nuclear data development — INDC(NDS)-423

Summary report of the consultants' meeting on improvement of the standard cross-sections for light elements — INDC(NDS)-425

Tc-99m labelled peptides for imaging of peripheral receptors — IAEA-TECDOC-1214

Technical basis for the ITER-FEAT outline design — ITER EDA Documentation Series No. 19

The applications of research reactors — IAEA-TECDOC-1234

Use of irradiation for chemical and microbial decontamination of water, wastewater and sludge — IAEA-TECDOC-1225

Use of research reactors for neutron activation analysis — IAEA-TECDOC-1215

X ray fluorescence in the IAEA and its Member States, Newsletter, No. 2

Nuclear Safety

Application of non-destructive testing and in-service inspection to research reactors — IAEA-TECDOC-1263

Applications of probabilistic safety assessment (PSA) for nuclear power plants — IAEA-TECDOC-1200

Assessment and management of ageing of major nuclear power plant components important to safety — IAEA-TECDOC-1197

Mitigation of hydrogen hazards in water colled power reactors — IAEA-TECDOC-1196

Modifications to nuclear power plants — Safety Standards Series No. NS-G-2.3

Quality management of the nuclear regulatory body — PDRP-6

Regulatory review of probabilistic safety assessment (PSA) level 2 — IAEA-TECDOC-1229

Safety aspects of nuclear plants coupled with seawater desalination units — IAEA-TECDOC-1235

Safety assessment and verification for nuclear power plants — Safety Standards Series No. NS-G-1.2

Safety of and regulations for nuclear fuel cycle facilities — IAEA-TECDOC-1221

Seismic evaluation of exisitng nuclear power facilities — IAEA-TECDOC-1202

TABLE A26. **(cont.)**

The International Nuclear Event Scale (INES) user's manual, 2001 edition

The operating organization of nuclear power plants — Safety Standards Series No. NS-G-2.4

Training the staff of the regulatory body for nuclear facilities: A competency framework — IAEA-TECDOC-1254

Radiation Safety

An international peer review of the biosphere modelling programme of the US Department of Energy's Yucca Mountain Site Characterization Project — special publication

Arrangements for transition from the 1985 edition (as amended 1990) to the 1996 edition of the IAEA Transport Regulations — IAEA-TECDOC-1194

Arrangements for transition from the 1985 edition (as amended 1990) to the 1996 edition of the IAEA Transport Regulations — IAEA-TECDOC-1194 (Rev. 1)

Assessment by peer review of the effectiveness of a regulatory programme for radiation safety — IAEA-TECDOC-1217

Building competence in radiation protection and the safe use of radiation sources — Safety Standards Series No. RS-G-1.4

Cytogenetic analysis for radiation dose assessment, a manual — Technical Reports Series No. 405

Directory of national competent authorities' approval certificates for package design, special form material and shipment of radioactive material, 2001 edition — IAEA-TECDOC-1237

Emergency communications with the IAEA Emergency Response Centre — special publication

Generic models for use in assessing the impact of discharges of radioactive substances to the environment — Safety Reports Series No. 19

IAEA Emergency Response Network ERNET — special publication

Inventory of accidents and losses at sea involving radioactive material — IAEA-TECDOC-1242

Investigation of an accidental exposure of radiotherapy patients in Panama: Report of a team of experts, 26 May–1 June 2001 — special publication

Joint radiation emergency management plan of the international organizations JPLAN — special publication

National competent authorities responsible for approvals and authorizations in respect of the transport of radioactive material: List No. 32 (2001 edition)

National regulatory authorities with competence in the safety of radiation sources and the security of radioactive materials (proceedings of an international conference held in Buenos Aires, 11–15 December 2000) — C&S Papers Series No. 9

ORPGUIDE: Occupational radiation protection, IAEA Safety Standards Series — special publication (CD-ROM)

Present and future environmental impact of the Chernobyl accident — IAEA-TECDOC-1240

Radiological protection of patients in diagnostic and interventional radiology, nuclear medicine and radiotherapy (including CD-ROM) — Proceedings Series

Radiological protection of patients in diagnostic and interventional radiology, nuclear medicine and radiotherapy: Contributed papers (including CD-ROM) — C&S Papers Series No. 7

Restoration of environments with radioactive residues — Proceedings Series

Severity, probability and risk of accidents during maritime transport of radioactive material — IAEA-TECDOC-1231

The criticality accident in Sarov — special publication

Training in radiation protection and the safe use of radiation sources — Safety Reports Series No. 20

Radioactive Waste Safety

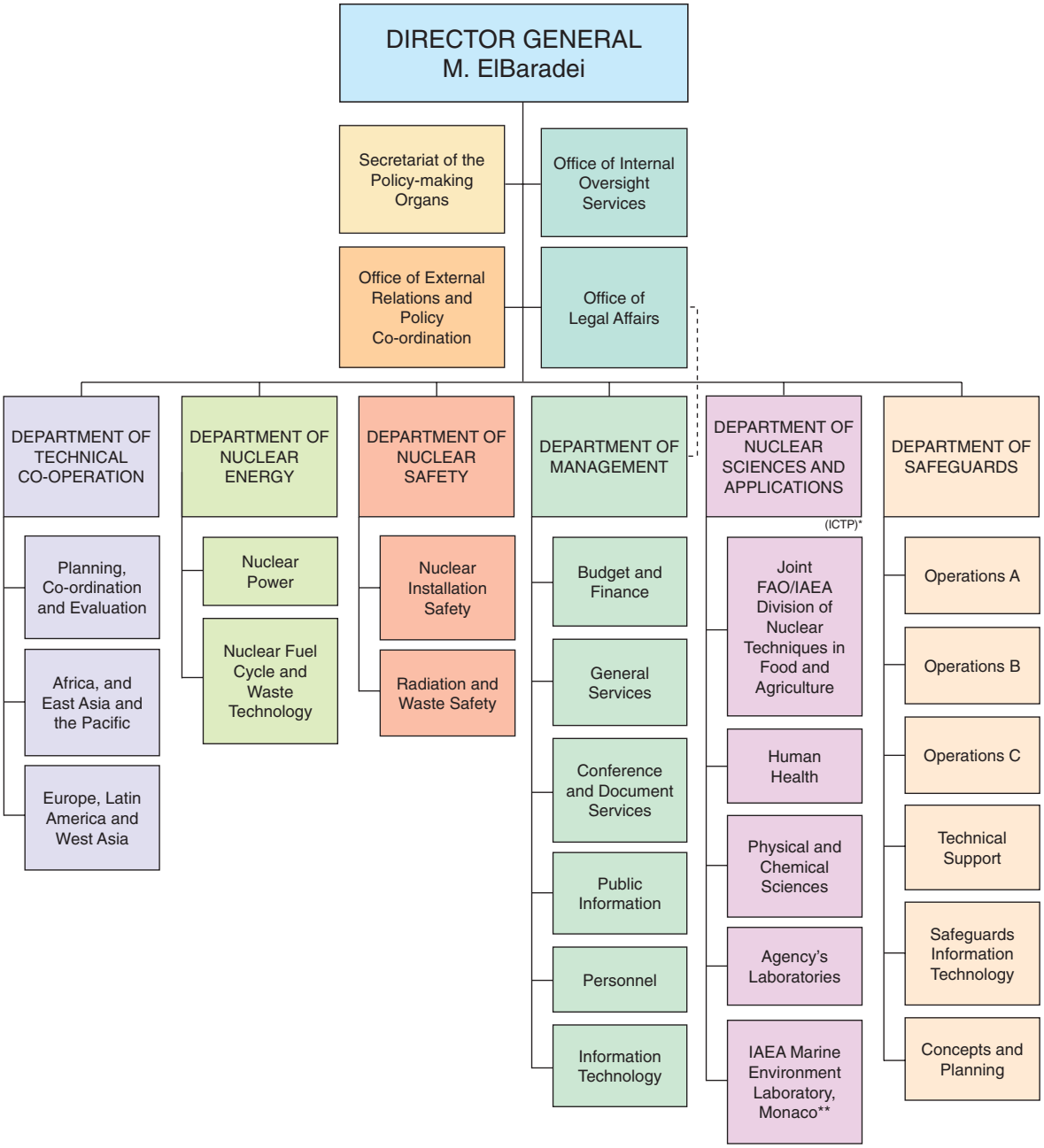
Decommissioning of nuclear fuel cycle facilities — Safety Standards Series No. WS-G-2.4

TABLE A26. **(cont.)**

Co-ordination of Safety Activities
Maintaining knowledge, training and infrastructure for research and development in nuclear safety — INSAG Note No. 4
Nuclear safety review for the year 2000
Safeguards
International safeguards: Verification and nuclear material security — Proceedings Series
Policy-making, Management and Support Services
INIS: Authority list for journal titles — INIS Reference Series No. 11
Manual for online retrieval from the INIS database on the internet — INIS Reference Series No. 24
Nuclear Fusion, Vol. 41, Nos 1–12

ORGANIZATIONAL CHART

(as of 31 December 2001)



* 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.

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