

Annual Report for 2004

Article VI.J of the IAEA'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 2004.



IAEA

International Atomic Energy Agency

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Member States of the International Atomic Energy Agency

(designation as of 31 December 2004)

AFGHANISTAN	GUATEMALA	PANAMA
ALBANIA	HAITI	PARAGUAY
ALGERIA	HOLY SEE	PERU
ANGOLA	HONDURAS	PHILIPPINES
ARGENTINA	HUNGARY	POLAND
ARMENIA	ICELAND	PORTUGAL
AUSTRALIA	INDIA	QATAR
AUSTRIA	INDONESIA	REPUBLIC OF MOLDOVA
AZERBAIJAN	IRAN, ISLAMIC REPUBLIC OF	ROMANIA
BANGLADESH	IRAQ	RUSSIAN FEDERATION
BELARUS	IRELAND	SAUDI ARABIA
BELGIUM	ISRAEL	SENEGAL
BENIN	ITALY	SERBIA AND MONTENEGRO
BOLIVIA	JAMAICA	SEYCHELLES
BOSNIA AND HERZEGOVINA	JAPAN	SIERRA LEONE
BOTSWANA	JORDAN	SINGAPORE
BRAZIL	KAZAKHSTAN	SLOVAKIA
BULGARIA	KENYA	SLOVENIA
BURKINA FASO	KOREA, REPUBLIC OF	SOUTH AFRICA
CAMEROON	KUWAIT	SPAIN
CANADA	KYRGYZSTAN	SRI LANKA
CENTRAL AFRICAN REPUBLIC	LATVIA	SUDAN
CHILE	LEBANON	SWEDEN
CHINA	LIBERIA	SWITZERLAND
COLOMBIA	LIBYAN ARAB JAMAHIRIYA	SYRIAN ARAB REPUBLIC
COSTA RICA	LIECHTENSTEIN	TAJIKISTAN
CÔTE D'IVOIRE	LITHUANIA	THAILAND
CROATIA	LUXEMBOURG	THE FORMER YUGOSLAV REPUBLIC OF MACEDONIA
CUBA	MADAGASCAR	TUNISIA
CYPRUS	MALAYSIA	TURKEY
CZECH REPUBLIC	MALI	UGANDA
DEMOCRATIC REPUBLIC OF THE CONGO	MALTA	UKRAINE
DENMARK	MARSHALL ISLANDS	UNITED ARAB EMIRATES
DOMINICAN REPUBLIC	MAURITANIA	UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND
ECUADOR	MAURITIUS	UNITED REPUBLIC OF TANZANIA
EGYPT	MEXICO	UNITED STATES OF AMERICA
EL SALVADOR	MONACO	URUGUAY
ERITREA	MONGOLIA	UZBEKISTAN
ESTONIA	MOROCCO	VENEZUELA
ETHIOPIA	MYANMAR	VIETNAM
FINLAND	NAMIBIA	YEMEN
FRANCE	NETHERLANDS	ZAMBIA
GABON	NEW ZEALAND	ZIMBABWE
GEORGIA	NICARAGUA	
GERMANY	NIGER	
GHANA	NIGERIA	
GREECE	NORWAY	
	PAKISTAN	

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".

The Board of Governors

The Board of Governors oversees the ongoing operations of the Agency. It comprises 35 Member States and generally meets five times a year, or more frequently if required for specific situations. Among its functions, the Board adopts the Agency's programme for the incoming biennium and makes recommendations on the Agency's budget to the General Conference.

In 2004, the Board considered the *Nuclear Technology Review — 2004* and various activities related to nuclear science, technology and applications. This included authorizing the implementation of the Programme of Action for Cancer Therapy (PACT).

In the area of safety and security, it considered the *Nuclear Safety Review for the Year 2003*

and related activities. It approved four Action Plans on various safety related activities and the 2005 edition of the Agency's *Regulations for the Safe Transport of Radioactive Material*, and adopted the Code of Conduct on the Safety of Research Reactors.

As regards verification, the Board considered *The Safeguards Implementation Report for 2003*. It also approved a number of safeguards agreements and additional protocols.

Further to the report of the Chairman of the Working Group on Assessed Programme Costs (APCs) and Technical Cooperation Fund Targets, the Board established the mechanism of 'National Participation Costs' to replace APCs.

Composition of the Board of Governors (2004–2005)

Chairperson: H.E. Ms. Ingrid HALL
Ambassador, Governor from Canada

Vice-Chairman: Mr. Parvez BUTT
*Chairman, Atomic Energy Commission,
Governor from Pakistan*

Vice-Chairman: Mr. Jerzy NIEWODNICZAŃSKI
*President, National Atomic Energy Agency,
Governor from Poland*

Algeria
Argentina
Australia
Belgium
Brazil
Canada
China
Ecuador
France
Germany
Ghana
Hungary
India
Italy
Japan
Korea, Republic of
Mexico
Netherlands

Nigeria
Pakistan
Peru
Poland
Portugal
Russian Federation
Singapore
Slovakia
South Africa
Sri Lanka
Sweden
Tunisia
United Kingdom of
Great Britain and Northern Ireland
United States of America
Venezuela
Vietnam
Yemen

The General Conference

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 programmes and passes resolutions directing the priorities of the Agency's work.

In 2004, the Conference — upon the recommendation of the Board — approved for membership of the Agency the Islamic Republic of Mauritania, the Republic of Chad and the Togolese Republic.

The Agency at a Glance

(as of 31 December 2004)

138 Member States.

65 intergovernmental and non-governmental organizations worldwide having formal agreements with the Agency.

47 years of international service by 2004.

2244 professional and support staff.

\$304 million total regular budget for 2004, supplemented by extrabudgetary contributions received in 2004 amounting to **\$54.5 million**.

\$74.75 million target in 2004 for voluntary contributions to the Agency's Technical Cooperation Fund, supporting projects involving **2618** expert and lecturer assignments, **2296** meeting and workshop participants, **2041** participants in training courses and **1444** fellows and visiting scientists.

2 liaison offices (in New York and Geneva) and **2** safeguards regional offices (in Tokyo and Toronto).

2 international laboratories and research centres.

130 active Coordinated Research Projects involving **1680** approved research contracts and agreements.

237 safeguards agreements in force in **152** States (and with Taiwan, China) involving **2302** safeguards inspections performed in 2004. Safeguards costs in 2004 amounted to **\$103.7 million** in regular budget and **\$16.3 million** in extrabudgetary resources.

17 national safeguards support programmes and **1** multinational support programme (European Union).

8 million monthly hits to the Agency's *iaea.org* web site.

2.54 million records in the International Nuclear Information System, the Agency's largest database.

200 publications and newsletters issued (in print and electronic formats) in 2004.

Notes

- The *Annual Report* reviews the results of the Agency's programme according to the three "pillars" of **technology, safety** and **verification**. The main part of the report, starting on page 13, generally follows the programme structure as it applied in 2004. The introductory chapter, "The Agency and the World in 2004", seeks to provide a thematic analysis, based on the three pillars, of the Agency's activities within the overall context of notable developments during the year. Information on specific issues can be found in the latest editions of the Agency's *Nuclear Safety Review*, *Nuclear Technology Review* and *Technical Cooperation Report*. For the convenience of readers, these documents are available on the CD-ROM attached to the inside back cover of this report.
- Additional information covering various aspects of the Agency's programme is also provided on the attached CD-ROM, and is also available on the Agency's *iaea.org* web site (<http://www.iaea.org/Worldatom/Documents/Anrep/Anrep2004/>).
- 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
ADB	Asian Development Bank
AFRA	African Cooperative Agreement for Research, Development and Training Related to Nuclear Science and Technology
ARCAL	Regional Cooperative Arrangements for the Promotion of Nuclear Science and Technology in Latin America
BWR	Boiling water reactor
CRP	Coordinated Research Project
CTBTO	Comprehensive Nuclear-Test-Ban Treaty Organization
ESTRO	European Society of 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
ICAO	International Civil Aviation Organization
IEA	OECD International Energy Agency
ICTP	International Centre for Theoretical Physics
IPCC	Intergovernmental Panel on Climate Change
IIASA	International Institute for Applied Systems Analysis
ILO	International Labour Organisation
IMO	International Maritime Organization
INDC	International Nuclear Data Committee
INIS	International Nuclear Information System
IOC	Intergovernmental Oceanographic Commission (UNESCO)
ISO	International Organization for Standardization
LWR	Light water reactor
NEA	OECD Nuclear Energy Agency
NPT	Treaty on the Non-Proliferation of Nuclear Weapons
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 Cooperative Agreement for Research, Development and Training Related to Nuclear Science and Technology
SQ	Significant quantity
UNAIDS	Joint United Nations Programme on HIV/AIDS

UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNECLAC	United Nations Economic Commission for Latin America and the Caribbean
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNFPA	United Nations Fund for Population Activities
UNICEF	United Nations Children's Fund
UNIDO	United Nations Industrial Development Organization
UNMOVIC	United Nations Monitoring, Verification and Inspection Commission
UNOPS	United Nations Office for Project Services
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
UPU	Universal Postal Union
WANO	World Association of Nuclear Operators
WCO	World Customs Organization
WEC	World Energy Council
WFP	World Food Programme
WHO	World Health Organization
WMO	World Meteorological Organization
WTO	World Trade Organization
WWER	Water cooled and moderated energy reactor (former USSR)

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The Agency and the World in 2004

Global nuclear developments in 2004, such as the changing outlook for nuclear power, the increasing role of nuclear applications in global sustainable development initiatives, greater international cooperation in matters of safety and security, and the increasing recognition of the need to strengthen the nuclear non-proliferation regime, have created new challenges and opportunities for the Agency. This report highlights the Agency's response to these challenges through activities carried out within the framework of the three pillars of *technology*, *safety* and *verification*.

Technology

Nuclear Power: Status and Trends

The year 2004 marked the 50th anniversary of civilian nuclear power generation — when electricity produced by nuclear power was first delivered to an electrical grid in Obninsk, Russian Federation. Since then, the world has witnessed a steady growth in nuclear power, accompanied by a shift in energy demand growth to the developing countries. Today, developing countries account for 60% of the new reactors under construction, even if 94% of the world's installed nuclear power capacity is in industrialized countries.

With 440 power reactors operating worldwide as of the end of 2004, nuclear energy continues to account for about 16% of world electricity production, keeping pace with the steady growth in the global electricity market. By the end of 2004, 26 nuclear power plants were under construction around the world, the majority (18) being in Asia.

Five new plants were connected to the grid during the year: one in each of China, Japan and the Russian Federation, and two in Ukraine. One laid-up plant was reconnected in Canada, and construction began on India's 500 MW(e) prototype fast breeder reactor and Japan's 866 MW(e) Tomari-3 pressurized water reactor. Five reactors were retired: four 50 MW(e) reactors in the UK and the 1185 MW(e) Ignalina-1 plant in Lithuania.

In Western Europe, excavation work began for the Olkiluoto-3 nuclear power plant in Finland, which will be the first new construction in the region since 1991, and Electricité de France selected the site at

Flamanville for a demonstration European PWR, with construction expected to begin in 2007.

In the USA, the Nuclear Regulatory Commission (NRC) approved 11 more licence extensions of 20 years each (for a total licensed life of 60 years for each plant), bringing the total number of approved extensions to 30. To date, about three quarters of the USA's 104 nuclear power plants have received, applied for or stated their intention to apply for licence renewals. The Department of Energy has also approved financial assistance to two industry consortia for nuclear power plant licensing demonstration projects, which could make new nuclear construction in the USA a near term possibility.

While the current outlook for nuclear energy remains mixed, there is clearly a sense of rising expectations. The near term projections released in 2004 by the Agency (see Fig. 1) are markedly different from those of just four years ago. The Agency's low projection — based on the most conservative assumptions — predicts 427 GW of global nuclear capacity in 2020, the equivalent of 127 more 1000 MW nuclear plants than the 2000 projection.

This change in expectations is rooted in specific plans and actions in a number of countries to expand nuclear power. The new expectations regarding nuclear power, particularly over the longer term, have also been strengthened by the entry into force of the Kyoto Protocol. In the past, the virtual absence of restrictions or taxes on greenhouse gas emissions has meant that nuclear power's advantage — of low emissions — has had no tangible economic value. The widespread, coordinated emission restrictions of the Kyoto Protocol will likely change that over the longer term.

Much of the increase in nuclear generating capacity over the past decade has been credited not to new construction, but to the increased availability of existing plants — a change tied directly to improvements in global safety performance. The result is that existing well-run nuclear power plants have become increasingly valuable assets. Although the initial capital cost of a nuclear plant is high, the operating costs are relatively low and stable.

However, not every country shares the view that improved economics and safety performance

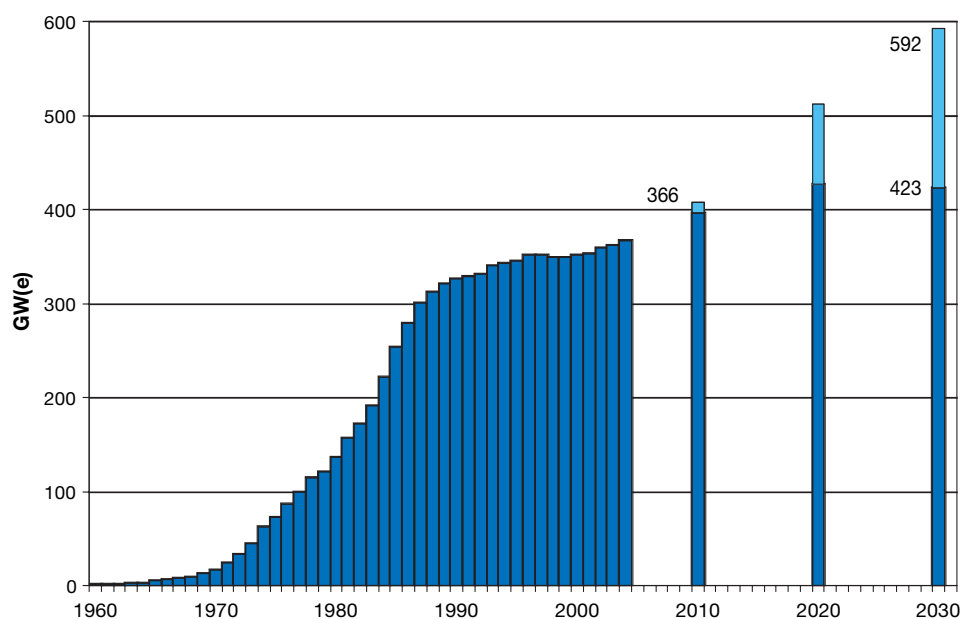


FIG.1. Historical growth in worldwide installed nuclear power capacity, 1960–2004, and the Agency's latest low and high projections through 2030 (low projections: dark blue bars; high projections: light blue bars). (Source: Energy, Electricity and Nuclear Power Estimates for the Period up to 2030, July 2004, Reference Data Series No. 1, IAEA, Vienna (2004)).

warrant a revival of nuclear power. For example, in Western Europe, Belgium, Germany and Sweden currently have nuclear phase-out policies in place; and a number of others, including Austria, Denmark and Ireland, have stated policies against nuclear power.

Agency Energy Assessments and Technology Transfer

The Agency assists interested countries to build their energy planning capabilities with respect to all three aspects of sustainable development — economic, environmental and social. It develops and transfers planning models tailored to their special circumstances, as well as making available the latest data on technologies, resources and economics. In addition, it trains local experts, helps with the analysis of national options for meeting energy demands, and helps to establish continuing local planning expertise. Agency energy planning tools are now used in more than 100 countries around the world.

Demand for the Agency's energy assessment models — which treat all energy supply options equally — and services is growing due to increasingly complex energy systems, market liberalization, privatization and environmental concerns. The number of people attending Agency regional, interregional and national training courses and workshops has risen steadily in recent years

and reached a record high in 2004 of 231 energy professionals from 43 countries.

Uranium Resources

Agency support for nuclear programmes begins at the very front of the fuel cycle with estimates and analysis of uranium resources. The latest edition of the joint OECD/NEA-IAEA 'Red Book' on uranium resources, production and demand, published in 2004, describes a mixed medium term outlook for the uranium market. Of particular importance is uncertainty regarding the continued availability of secondary supply sources — such as civil and military stockpiles, spent fuel reprocessing and the re-enrichment of depleted uranium. While these sources comprised 46% of global uranium needs for civilian power reactors in 2003, their importance is expected to decline as stockpiles are reduced. After 2015, reactor fuel requirements will have to be met by expanded production, development of new sources or the introduction of alternative fuel cycles.

Decommissioning of Nuclear Facilities

Nearer the back end of the fuel cycle, the Agency provides guidance on when to choose decommissioning over licence renewal, and on the decommissioning process itself. Decommissioning decisions are increasingly pressing for many reactors. Seventy-nine (18%) of the reactors operating at the end of 2004 had been in operation for more

than 30 years, while a further 143 reactors had been in operation for more than 25 years. There are two basic decommissioning options — immediate dismantling and long term safe enclosure followed by dismantling. As of the end of 2004, six plants had been completely decommissioned, with the sites released for unconditional use. Seventeen had been partially dismantled and safely enclosed, 33 were being dismantled prior to eventual site release, and 30 were undergoing minimum dismantling prior to long term enclosure.

Decommissioning generates large quantities of waste, a large part of which has low levels of radioactivity. A new category of radioactive waste — very low level waste (VLLW) — has been introduced in some countries. This category is intended for very low radioactivity decommissioning waste that requires less special treatment than traditional low level waste and thus has a much lower disposal cost. A VLLW repository — opened at Morvilliers, in France, in 2003 — reached full operation in 2004.

Continuous Innovation to Improve Efficiency

The future prospects of nuclear power will depend on improving the economic competitiveness, ensuring progress on the management and disposal of spent nuclear fuel, and further improving levels of safety, security and proliferation resistance. Innovation is an essential part of progress on all these fronts. The Agency's International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO), which focuses on promoting innovations in nuclear reactors and fuel cycles to meet future requirements, added six new members in 2004, namely Armenia, Chile, Czech Republic, France, Morocco and South Africa, bringing the total membership to 22 States. During the year, a number of case studies and reports were completed to test the draft methodology published in 2003 for assessing different innovative nuclear energy systems and concepts. Based on these studies, an improved version of the methodology was published.

The other major international effort to promote innovation is the Generation IV International Forum (GIF), which comprises ten States. Following the finalization of its "Technology Roadmap", GIF has continued to work on the development of future nuclear power technologies that address the issues of economics, safety, energy supply security, waste management and non-proliferation.

INPRO and GIF regularly attend each other's policy and steering committee meetings. One area where they have identified synergies and begun

cooperation is in developing an agreed method to assess the relative proliferation resistance of different nuclear energy systems.

Preserving and Maintaining Nuclear Knowledge

The ageing of the nuclear work force is a serious concern for a number of Member States, particularly those where nuclear expansion has slowed or is being reversed by phase-out policies. In these countries new talent must be recruited to replace retirees. New recruits are also needed in countries that are planning to expand the use of nuclear power. Agency activities in the field of nuclear knowledge management have sought to address these concerns, and have been making contributions in terms of sharing experience among Member States, assisting in the establishment of regional programmes and collecting information in specific fields that is otherwise increasingly hard to access. A conference on nuclear knowledge management convened by the Agency in September in Saclay, France, recommended the development of 'knowledge packages' targeted at specific user needs. The Agency also supported the establishment in February 2004 of the Asian Network for Higher Education in Nuclear Technology (ANENT). The goal of ANENT is to promote, manage and preserve nuclear knowledge, and ensure the continued availability of talented and qualified staff in the nuclear field in Asia.

The Agency plans to build on this work by expanding educational networks and training opportunities, providing more comprehensive guidance to Member States about establishing nuclear knowledge management programmes, and expanding the scope and accessibility of information assembled through the Agency's knowledge preservation networks.

Research Reactor Conversion and Fuel Return

For over fifty years research reactors have been a key component in the development of nuclear science and technology. While their contributions to the peaceful applications of nuclear energy are well known, concern has grown in recent years over the proliferation and security risks posed by the high enriched uranium (HEU) fuel used in many of these reactors.

The Agency has supported States wishing to convert research reactors using HEU fuel to low enriched uranium (LEU) (for both fuel and fissile

targets for medical isotope production). Currently, 132 research reactors worldwide are reported in the Agency's database to be operating with HEU, and 99 of these reactors have fuel originally enriched to 90% or more. So far, 33 research reactors have been fully converted and another 6 partially converted.

One of the objectives of the Global Threat Reduction Initiative (GTRI), launched last year by a number of countries, was to speed up conversions of research reactors to LEU fuel. The GTRI also focuses on the equally important task of returning HEU fuel to its country of origin. In December, for example, within the framework of the GTRI, a joint effort between the USA, the Czech Republic, the Russian Federation and the Agency succeeded in safely returning HEU from a research reactor at Rež, near Prague, to the Russian Federation. The Agency also supported similar missions to return significant quantities of HEU from Serbia and Montenegro, Romania, Bulgaria, Libyan Arab Jamahiriya and Uzbekistan to the Russian Federation. By the end of 2004, 95 kilograms of fresh HEU had been repatriated to the Russian Federation. Returns of spent HEU also began; spent HEU of US origin is being returned to the USA routinely, and the first shipment to be returned to the Russian Federation is in an advanced stage.

Nuclear Applications

A major part of the Agency's scientific and technical work involves the transfer of peaceful nuclear technology in such areas as food and agriculture, human health, water resources management, protection of the environment and industrial applications. Many of these applications are proving to be important tools for social and economic development around the world.

Maintaining Human Health

A major focus of Agency work in human health is combating the growing cancer threat in the developing world. Of the estimated 260 million new cancer cases expected in the next 20 years, approximately 175 million will require radiation therapy, and 100 million of those will be in developing countries that have neither the resources nor the expertise to deal with this crisis. Over the last ten years, the Agency has spent more than \$80 million in 90 countries for the purchase, maintenance and repair of equipment and for human resources development. Furthermore, a large number of national and regional projects in radiotherapy are currently active in more than 100 countries.

The Board of Governors endorsed a 'Programme of Action for Cancer Therapy' (PACT) in June, and the 48th regular session of the General Conference passed a resolution in September supporting PACT. This will help the Agency to acquire funds from a wide range of traditional and non-traditional donors to further enhance its delivery of radiotherapy and related diagnostic techniques to Member States. In cooperation with WHO and others, PACT will assist developing countries in assessing needs, and planning, developing and implementing comprehensive cancer control programmes, with particular emphasis on the provision of cancer therapy in combination with other modalities.

Nuclear medicine is also being increasingly used in cancer management, particularly after the introduction of positron emission tomography (PET) in clinical practice. Through a number of technical cooperation projects, the Agency provided Member States with expertise related to the planning and operation of PET centres. The Agency also initiated projects on the use of molecular biology techniques to investigate resistance to anti-malarial drugs and to the genetic profiling of HIV/AIDS patients resistant to therapy and in this regard, the Agency and WHO are working together in support of programmes in Africa.

Training remains one of the keystones in building professional capacity in nuclear medicine in Member States. The Agency developed a 'Distance Assisted Training Programme' during the year for the benefit of those countries where a specific training programme for technologists in nuclear medicine has not yet been established.

To address problems of malnutrition the Agency, in concert with other partners, continued to provide technical support to Member States to develop nutrition strategies for children. Research has been initiated to evaluate innovative strategies to combat malnutrition by the introduction of nutritionally improved crop varieties, and to evaluate the usefulness of biofortified staple foods as sources of micronutrients.

Enhancing Food Production

The sterile insect technique (SIT), which involves the production and release of male insects sterilized by gamma radiation, is an effective and environmentally friendly method of pest control. In 2004, the Agency was implementing over 30 SIT projects, either in the field or as feasibility studies for future applications, targetting the tsetse fly, Old and New World Screwworms and various fruit fly and

United Nations Interagency Coordination on Freshwater Programmes

In 2004, the UN's Chief Executives Board endorsed the creation of an interagency body responsible for coordinating freshwater programmes. This body, called 'UN Water', consists of representatives from more than 25 UN agencies, programmes and funds, and also includes representatives of non-governmental organizations and international programmes active in the field of water. Its aim is to increase the coordination of the UN's programmes on water. One of the major undertakings of UN Water is to produce the *World Water Development Report*, a periodic assessment of the status of global freshwater resources. The next edition is expected in 2006.

moth pests. As a result of area wide SIT campaigns by Member States, fresh vegetable and fruit exports have increased. In the Arava region in the Middle East, fresh vegetable exports have increased in seven years from under \$1 million to over \$30 million per year as a result of a successful medfly suppression programme.

Water for Life

The global management of fresh water continues to be high on the international agenda. In February 2004, the United Nations proclaimed 2005–2015 as the "Decade for Action: Water for Life", recognizing the growing awareness of the critical linkage between water and development.

Given the increased reliance on groundwater to meet growing water resource needs, relevant international organizations, including the Agency, have been working on developing a "World Groundwater Vision" to be presented at the 4th World Water Forum in Mexico 2006. This is intended to serve as a blueprint for the effective management of groundwater, and will include how to utilize appropriately science and technology, such as

isotope hydrology, for effective groundwater management.

Technical Cooperation

Promoting the scientific, technological and regulatory capabilities of developing countries through technology transfer and capacity building is among the main tasks of the Agency's technical co-operation programme, with special emphasis given to technical co-operation among developing countries. In 2004, disbursements increased to \$74.8 million, from \$73.5 million in 2003. The major areas of activities were: human health, safety, food and agriculture, applications of physical and chemical sciences, water resources and environmental protection, nuclear science and capacity building (Fig. 2).

Safety and Security

One of the key elements of the Agency's mandate is to help maintain the safety and security of global nuclear activities. While the overall safety of nuclear

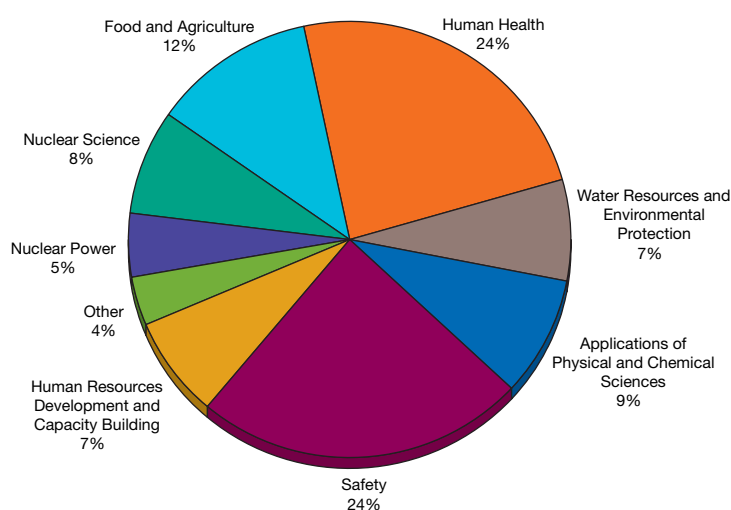


FIG. 2. Technical cooperation programme disbursements in 2004 by area of activity.

installations around the world has improved considerably, there are still a number of challenges to be addressed by States.

Enhancing Global Nuclear Safety

For nuclear power to operate, it must be not only economically viable, but also safe. Consequently, there is an urgent need to maintain an effective and transparent global framework based on strong national safety infrastructures reinforced by widespread subscription to international agreements and norms. The Agency provides support services for most of these international agreements, and assists States in their efforts to enhance nuclear safety. However, many States are not yet party to these agreements, and universal adherence to them continues to be vital in efforts to enhance global nuclear safety.

Safety Standards

A main element of these global agreements and norms is the suite of harmonized and internationally accepted safety standards. Over the past few years, the Agency has continued to update these standards. In 2004, the Board of Governors adopted an Action Plan for the Development and Application of IAEA Safety Standards that is currently being implemented with the aim of universal application.

Safety Services

In providing for the application of these safety agreements and norms, the Agency offers many services. By using the internationally agreed standards as the basis for evaluation, quality and consistency are ensured. Peer review is an important part of most of these services. In 2004, the Agency conducted more than 70 safety review and service missions.

Transport and Radiation Safety

In March, the Board of Governors approved an Action Plan for the Safety of Transport of Radioactive Material, which provides direction for the Agency's transport safety activities over the next five years, and in November the Board approved the 2005 edition of the Regulations for the Safe Transport of Radioactive Material. A Transport Safety Appraisal Service (TranSAS) mission was completed in France and a preparatory mission to Japan was also undertaken for a TranSAS mission to be carried out in 2005.

Some products, such as wood and foodstuffs, may contain radioactivity at levels that are not significant

from a health perspective. In this connection, international consensus was reached with the publication of a Safety Guide on the *Application of the Concepts of Exclusion, Exemption and Clearance*. This publication establishes levels of radioactivity in such materials below which regulatory controls need not be applied.

Ten Years of the Model Projects on Radiation and Waste Safety

For the past ten years, the Agency has been implementing "Model Projects" to improve radiation and waste safety infrastructures in Member States. Five milestones have been established: (1) a regulatory framework; (2) occupational exposure control; (3) medical exposure control; (4) public exposure control; and (5) emergency preparedness and response capabilities. By the end of 2004, more than 90 Member States were participating in these projects. Of these, 48 had attained the first two milestones, while the remaining States have made varying degrees of progress towards attaining them. The Agency continues to work with all Member States to achieve the remaining three milestones.

Civil Liability for Nuclear Damage

The International Expert Group on Nuclear Liability (INLEX), established in 2003, finalized in a series of meetings in 2004 explanatory texts on the nuclear liability instruments adopted under Agency auspices. These texts constitute a comprehensive study of the Agency's nuclear liability regime in order to aid the understanding and authoritative interpretation of that regime. INLEX's work is still ongoing and a number of outreach activities are now on its agenda, in particular the organization of regional workshops on the subject of civil liability for nuclear damage in Asia, the Pacific and the Latin America regions.

Nuclear Security

The security of nuclear and other radioactive material and associated technologies has taken on heightened significance in recent years. However, while nuclear security is and should remain a national responsibility, some countries still lack the programmes and the resources to respond properly to the threat of nuclear and radiological terrorism. For these countries, international cooperation is essential to help them strengthen their national capacities. International cooperation is also essential for the Agency's efforts to assist in building regional

International Agreements Related to Nuclear Safety: A Status Report

- *Convention on Nuclear Safety:* This Convention commits participating States operating land based nuclear power plants to maintain a high level of safety by setting international benchmarks to which States subscribe. The Convention uses a peer review process at a meeting held every three years. At the end of 2004, there were 55 Contracting Parties to the Convention.
- *Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency; Convention on Early Notification of a Nuclear Accident:* These conventions provide the legal framework for international cooperation and coordination in the event of a nuclear or radiological emergency. They establish a notification system for nuclear accidents that have the potential for international transboundary release that could be of radiological safety significance for another State and set out an international framework for cooperation among Parties and with the Agency to facilitate prompt assistance and support in the event of nuclear accidents or radiological emergencies. In June 2004, the Board of Governors approved an International Action Plan for Strengthening the International Preparedness and Response System for Nuclear and Radiological Emergencies. At the end of 2004, there were 90 Contracting Parties to the Assistance Convention and 94 Contracting Parties to the Early Notification Convention.
- *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management:* This convention is the first and only international, legally binding, treaty in the area of spent fuel and radioactive waste management. It commits participating States to achieve and maintain a high level of safety in the management of spent fuel and of radioactive waste for ensuring the proper protection of people and the environment. The Convention uses a peer review process at a meeting held every three years. At the end of 2004, there were 34 Contracting Parties to the Convention.
- *Convention on the Physical Protection of Nuclear Material:* This convention commits Contracting States to ensure during international nuclear transport the protection of nuclear material within their territory or on board their ships or aircraft. A conference of all States Parties to the Convention has been scheduled for July 2005 to consider amendments to the Convention that would extend it to cover, inter alia, the physical protection of nuclear material used for peaceful purposes, in domestic use, storage and transport and the physical protection of nuclear material and the protection of nuclear facilities used for peaceful purposes against sabotage. As of the end of 2004, there were 106 Contracting Parties to the Convention.
- *Code of Conduct on the Safety of Research Reactors:* The objective of this Code is to achieve and maintain a high level of safety in research reactors worldwide. The Board of Governors adopted the Code at its March 2004 session; the General Conference endorsed the Code in September.
- *Code of Conduct on the Safety and Security of Radioactive Sources:* The objective of this Code is to achieve and maintain a high level of safety and security of radioactive sources. In September 2004, the Board of Governors approved guidance supplementary to the Code of Conduct, on the import and export of radioactive sources; it was subsequently endorsed by the General Conference.
- *Safety Standards:* These comprise publications of a regulatory nature covering nuclear, radiation, transport, waste and general safety. By the end of 2004, the Agency had published a total of 99 safety standards, including 13 standards issued in 2004.

and global networks for combating transnational threats. The Agency's nuclear security plan is founded on measures to guard against thefts of nuclear and other radioactive material and to protect related facilities against malicious acts. Its work has three main points of focus: prevention, detection and response.

In preventing any illicit or non-peaceful use of nuclear or other radioactive material, the Agency has been providing a range of international advisory service missions, training workshops and technical guidance documents — on nuclear security, physical protection, 'design basis threat' assessments, and nuclear material accounting — to assist States

in implementing these preventive measures. In 2004, the Agency conducted 14 International Nuclear Security Advisory Service (INSServ) and International Physical Protection Advisory Service (IPPAS) missions.

To help countries to detect, at an early stage, illicit activity related to nuclear material or radioactive sources, the Agency has been assisting States in training customs officials, installing better equipment at border crossings, and ensuring that information on trafficking incidents is shared effectively. The Agency database on illicit trafficking, now with a total of 81 participating countries, has proven helpful in identifying patterns of trafficking activity. Since 1993,

Partnership with Greece to Enhance Nuclear Security

In cooperation with the Greek Atomic Energy Commission and the US Department of Energy, the Agency assisted Greek authorities in maintaining a high level of nuclear security for the 2004 Summer Olympic Games in Athens. Specifically, the Agency evaluated Greece's nuclear security system, assessing the needs, providing advice on how to improve capabilities, testing and validating detection equipment and providing on-site technical support. Greek authorities were provided with training materials and hands-on practical training in the use of detection instruments and detection methodologies and techniques.

over 650 confirmed incidents of trafficking in nuclear or other radioactive material have been recorded; in 2004 alone, 121 such incidents were reported, 11 of which involved nuclear material. This is the highest number of incidents confirmed to the Agency in a single year since 1993. While the majority of trafficking incidents do not involve nuclear material, and while most of the radioactive materials involved are of limited radiological concern, the number of incidents shows that the measures to control and secure nuclear and other radioactive materials need to be improved.

The Agency has been responding to government requests for the recovery of radioactive sources that have been stolen or lost. It has also been working with national governments and international organizations to establish and strengthen programmes to ensure that, in the event that illicit activity occurs — including acts of terrorism involving nuclear material or radioactive sources — the response can be prompt and well coordinated.

The bulk of this nuclear security activity has occurred in the past three years. Since 2001, working in Africa, Asia, Europe and Latin America, the Agency has conducted more than 125 security advisory and evaluation missions, and convened over 100 training courses, workshops and seminars.

Verification

Strengthening the Safeguards System

Safeguards Agreements and Additional Protocols

The implementation of comprehensive safeguards agreements and additional protocols remains crucial for the Agency to be able to provide credible assurances regarding both the non-diversion of declared nuclear material and, importantly, the absence of undeclared nuclear material and activities for a State as a whole. In this connection, the Secretariat continues to promote and facilitate wider adherence to the strengthened safeguards system.

However, the verification activities of the Agency and the non-proliferation regime in general have

been challenged in a number of ways: the rise in international terrorism, the discovery of clandestine nuclear programmes, the emergence of covert nuclear supply networks, and the acquisition by more and more countries of sensitive nuclear know-how and capabilities. The Agency has responded to these challenges, for example, by investigating and analysing the nuclear trade activities of the covert nuclear networks. In June 2004, the Director General also appointed an international expert group to consider possible multilateral approaches to the front and back ends of the nuclear fuel cycle (enrichment, reprocessing, and the storage and final disposition of spent fuel).

In 2004, the number of States where the Agency was implementing strengthened safeguards measures foreseen under an additional protocol increased from 41 in 2003 to 64, including 19 additional States with significant nuclear activities. This substantial increase was due, in part, to the April 2004 entry into force of additional protocols for 15 Member States of the European Union (EU). The number of States parties to the NPT that had yet to conclude comprehensive safeguards agreements decreased from 45 to 40. For these States the Agency cannot provide any level of assurance or draw any conclusions.

Integrated Safeguards

The Agency moved towards a more flexible and operationally effective approach to safeguards implementation based on State-level considerations. In this regard, the Agency now implements “integrated safeguards” in six States, including in a State with an extensive nuclear fuel cycle. “Integrated safeguards” refers to the optimum combination of all safeguards measures available to the Agency under comprehensive safeguards agreements and additional protocols. Two independent evaluations of the Agency's safeguards activities in 2004 commended the overall effectiveness and efficiency of the way that safeguards are being applied and underlined the importance of giving continued

priority to the implementation of integrated safeguards in States with extensive nuclear fuel cycles.

Safeguards Implementation Issues

In 2004, safeguards were applied for 152 States with safeguards agreements in force with the Agency. The Agency concluded that all declared nuclear material in these States, except in the Democratic People's Republic of Korea (DPRK), has remained in peaceful nuclear activities or has been otherwise adequately accounted for. In 21 of these States with both a safeguards agreement and an additional protocol in force, the Agency was also able to complete sufficient work to provide credible assurance regarding the absence of undeclared nuclear material and activities. Four States had been found to have been previously engaged in nuclear activities of varying significance which they had failed to report; corrective actions are being taken by these States, while the Agency's efforts to verify the correctness and completeness of their respective declarations remain ongoing.

The Agency remained unable to perform any verification activities in the DPRK, and therefore could not draw any conclusions about that State's nuclear material or activities.

Islamic Republic of Iran (Iran)

The Agency continued its activities to clarify the remaining outstanding issues regarding Iran's past undeclared nuclear materials and activities. In addition, the Agency performed verification activities related to Iran's voluntary suspension of enrichment related and reprocessing activities. Reports by the Director General were made to the March, June, September and November meetings of the Board of Governors covering, inter alia, the Agency's ongoing verification activities, outstanding issues, particularly the origin of enriched uranium particle contamination found at certain locations in Iran and the extent of Iran's enrichment programme, corrective actions and voluntary transparency measures taken by Iran. The Board adopted four resolutions on the implementation of safeguards in Iran¹.

Libyan Arab Jamahiriya (Libya)

The Director General provided reports on the implementation of safeguards in Libya in February, June and August 2004², covering inter alia Libya's past failures to fulfil the requirements of its NPT safeguards agreement, and that Libya had taken corrective actions, and its decision to sign and implement, pending entry into force, an additional protocol to that agreement. Libya submitted its initial declarations under the protocol and showed good cooperation with the Agency. The Board adopted one resolution on the implementation of safeguards in Libya.

Other Safeguards Implementation Issues

The Republic of Korea (ROK) informed the Agency about experiments involving nuclear material that should have been previously reported, and has cooperated with the Agency in clarifying these past activities. The Director General submitted a report to the Board in November 2004 on the implementation of safeguards in the ROK, which concluded that there was no indication that the undeclared experiments had continued.

The Agency identified several open source documents that indicated the possibility of unreported nuclear material, activities and facilities in Egypt. Egypt acknowledged that it had conducted unreported experiments involving nuclear material and that it had failed to declare small amounts of nuclear material to the Agency. Egypt continues to cooperate with the Agency in clarifying these past activities.

Management

In 2003, after over a decade and a half in which the Agency strove to fulfil its increasing statutory responsibilities within the confines of the zero real growth budgetary constraint, Member States agreed — following extensive analysis and consultations — to an increase in regular budget resources of \$25 million, to be phased in over two biennia. The year 2004 was the first in that process.

A major project for the modernization of the information platform used for the Agency's safeguards work — the IAEA Safeguards Information System (ISIS) was made possible by

¹ See <http://www.iaea.org/NewsCenter/Focus/IaeaIran/index.shtml>.

² See <http://www.iaea.org/NewsCenter/Focus/IaeaLibya/index.shtml>.

the generous commitment of extrabudgetary funds. The project will replace the current safeguards information technology infrastructure and result in: immediate access on-line to all needed safeguards information for inspectors; the capability to analyse all available information to support strengthened and integrated safeguards; and a flexible and adaptable architecture able to accommodate changes to safeguards activities. After the completion of the detailed planning phase in 2002 and a cost-benefit analysis performed in 2003, most of the work carried out in 2004 concentrated on the procurement process and on finalizing staffing of the project management team.

Also dependent on extrabudgetary contributions is the Agency's Nuclear Security Fund, which, since 2001, has received over \$35 million from 26 countries — as well as from the European Union and the Nuclear Threat Initiative (NTI). Moreover, many countries have provided in-kind support.

With completion of a full biennium in which the results based management approach had been applied, a new form of accountability report ('Programme Performance Report') was for the first time produced in early 2004. This contains an assessment of the achievement of outcomes — the effects or changes brought about in Member States as a result of the work of the Agency — on the basis of predetermined performance indicators. The report also details the resources utilized and the lessons learned through an appraisal of

programme implementation in 2002–2003. These lessons, along with those learned from the reviews and in-depth evaluations conducted on certain parts of the Agency's programme, were applied to the formulation of the draft programme and budget for 2006–2007.

Using the results based approach, the Secretariat is able more effectively to view its programme holistically — the 'one house' approach — and has established mechanisms for coordinating 'cross-cutting' subject areas that would formerly have come under the responsibility of a number of different organizational units. This approach — used initially for work related to the environment, quality assurance, knowledge management, research reactors and security — is now being applied to other areas such as reactor decommissioning, public information, and innovative reactors and fuel cycles.

Conclusion

This overview of the 'nuclear world' in 2004 highlights achievements and challenges in all areas of the Agency's work. In this regard, its programmes in nuclear technology, safety, security and verification constitute the unique tools that help build a better world for all people. What is needed is continued global cooperation. For the Agency, this cooperation is the key to harnessing nuclear energy in the service of development and peace.



Technology



Nuclear Power

Objective

To enhance the capability of interested Member States to implement competitive and sustainable nuclear power programmes and to develop innovative nuclear technologies for the future.

Engineering and Management Support for Competitive Nuclear Power

The analysis of operating experience and the continuous improvement of operations, as well as proper plant life management systems and the provision of effective training, contribute in significant measure to the smooth running of nuclear power plants, and the consequent increase in availability and productivity. Recognizing this, the Agency published three technical documents during the year that: provide guidance on managing instrumentation and control (I&C) modernization projects; present an internationally applicable system of coding nuclear power plant outages that provides nuclear utilities with a standardized tool for reporting and learning from outage information; and provide the latest information on ageing, obsolescence and performance monitoring of safety related I&C equipment operated in harsh environments.

Guidance on effective training was contained in three technical documents that focused on nuclear power plant personnel training, transferring nuclear knowledge to the next generation of staff, and the use of control room simulators for training power plant personnel. Also, the second phase of the development of an *Electronic Nuclear Training Catalogue* (ENTRAC) was completed with the inclusion of a search function and greater capability to host training related information.

In the area of nuclear power plant life management, the Agency completed five reports covering such topics as in-service inspection, the master curve approach to reactor pressure vessel (RPV) integrity, surveillance programmes for RPVs, the nickel effect on radiation embrittlement of RPV steels, and radiation damage of WWER RPVs. A computer model for the economic assessment of plant life extension and licence renewal was finalized,

and a new software package was developed on the issue of ageing and concrete containments at nuclear power plants.

To mark the 50th anniversary of when electricity was first produced by nuclear energy — in Obninsk, Russian Federation — the Agency organized an international conference in Obninsk and in Moscow. Entitled ‘Fifty Years of Nuclear Power — The Next Fifty Years’, the conference highlighted the mature stage reached by nuclear power and the vital role it plays in a number of countries. There was also significant support for continued innovation in technology and infrastructure to advance spent fuel recycling, and fast reactor and waste management technologies, all of which were considered to be especially important for the expansion of nuclear energy. The conference noted that greater openness and objectivity were also needed in communications with the public and decision makers.

Nuclear Power Technology Development and Applications

The Agency’s International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) continued to grow, with Armenia, Chile, Czech Republic, France, Morocco and South Africa becoming members. Total membership now stands at 22. INPRO completed six national case studies and eight individual studies to test the draft methodology published in 2003 for assessing different innovative nuclear energy systems and concepts. Using the results of the studies, a revised and improved version of the methodology was completed and approved. (The INPRO schedule, or time-line, is shown in Fig. 1.)

Terms of reference were established for the next stage of INPRO, covering 2005 and 2006, to facilitate the assessment of innovative nuclear systems by Member States using the updated INPRO methodology. The project will also develop supporting models and codes, draft a user’s manual; identify possibilities for collaborative R&D, strengthen collaboration with the Generation IV International Forum — another international effort to promote innovation — analyse deployment scenarios for innovative nuclear systems, and review possible multilateral nuclear fuel cycles.

Work began on a joint assessment by China, France, India, the Republic of Korea and the Russian

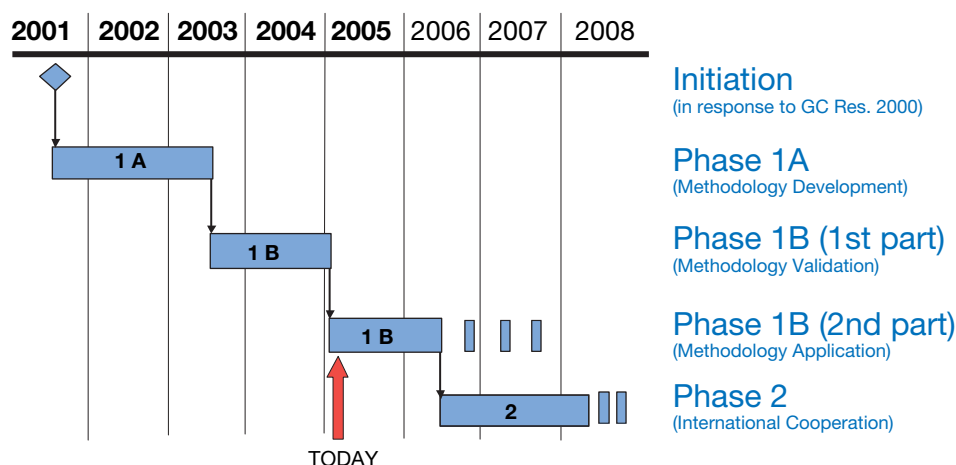


FIG. 1. Overall schedule for INPRO.

Federation to assess closed nuclear fuel cycle concepts using fast reactors through the use of the INPRO methodology.

The Agency's Technical Working Groups bring together experts from developing and industrialized Member States to pool R&D resources from national organizations towards agreed common goals. In 2004, two technical documents were published, on the status of advanced LWRs, and on the intercomparison and validation of computer codes for the thermal-hydraulic safety analysis of HWRs.

Research began in a new CRP on natural circulation phenomena and the reliability of passive safety systems that utilize natural circulation. The goal of the CRP is to improve the reliability, economics and safety of water cooled reactors through the use of passive safety systems based on natural circulation.

The final report for a CRP on the establishment of a thermophysical properties database for materials of LWRs and HWRs was completed. The result is both a technical document reporting new measurements and assessments of thermophysical properties and an associated Internet database established by Hanyang University, in the Republic of Korea. Improved data reduce the need for considerable design margins solely to compensate for limitations of calculational methodology and data uncertainties, and can thus contribute to improving the economics of new nuclear power plant designs.

The Agency hosted a workshop at the Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste on nuclear power plant simulators for education. One of the major objectives of this workshop, held regularly at ICTP, is to disseminate the Agency's PC based simulators of the performance of various reactor types. The Agency's software in

this area is widely used for education and includes simulators for a BWR, a conventional PWR, a passive PWR, a WWER-1000 and a CANDU.

With respect to fast reactors and accelerator driven systems (ADSs), the Agency completed a status and review report dealing with national programmes on fast reactors and hybrid systems for energy production and transmutation. Figure 2 shows the 65 MW(th) China Experimental Fast Reactor, currently under construction. In this connection, technical meetings were convened on the utilization of MONJU (the prototype Japanese fast breeder reactor) for international cooperation in fast reactor R&D, and on the application of cross-section libraries for ADSs and transmutation.

In the field of high temperature gas cooled reactors (HTGR), two Agency CRPs promoted R&D on: (a) core physics and thermal-hydraulic code benchmarks; and (b) coated fuel particle technology. In 2004, the former completed and analysed results for a second set of code benchmarks, and the latter focused on issues of HTGR fuel



FIG. 2. The China Experimental Fast Reactor under construction.

design and fabrication, fuel characterization and testing, benchmarking of fuel performance and fission product release models as well as spent fuel management. Agency activities related to the exchange of information on HTGRs included participation in the biennial international conference on high temperature reactors (HTR-2004), together with the European HTR-TN network and Tsinghua University of China. And interest in the Agency's HTGR activities continued to grow — the hit rate for the Agency's HTGR web site <http://www.iaea.org/OurWork/ST/NE/NENP/NPTDS/Projects/HTGR/index.html>

increased from 50 000 per month to 90 000 in 2004.

The application of nuclear power technology to seawater desalination has been the subject of past resolutions of the General Conference. In 2004, the Agency conducted technical cooperation projects on integrated nuclear power and desalination system design and the simulation of a nuclear desalination plant. In addition, national counterparts in Indonesia and the Republic of Korea completed a report on the economic feasibility of nuclear desalination in Madura Island, Indonesia. ■

Nuclear Fuel Cycle and Materials Technologies

Objective

To strengthen the capabilities of interested Member States for policy making and strategic planning, technology development and implementation of safe, reliable, economically efficient, proliferation resistant and environmentally sound nuclear fuel cycle programmes.

Uranium Production Cycle and Environment

The latest update of the biennial 'Red Book', *Uranium 2003: Resources, Production and Demand*, was published jointly by the Agency and the OECD/NEA in 2004. Reviewing data from 44 countries, the Red Book's main conclusion is that the uranium market is very uncertain in the medium term. This is due to the limited information on what might be available in the future from secondary supplies, which include civilian and military stockpiles, uranium reprocessing and re-enrichment of depleted uranium. At the beginning of 2003, these sources provided 46% of the world's uranium needs for civilian power reactors, but they are expected to decline in importance as stockpiles diminish. After 2015, reactor requirements will have to be met increasingly by the expansion of existing production capacity, the development of additional production centres or the introduction of alternative fuel cycles. Moreover, such disparate factors as market uncertainty, improved global prospects for nuclear energy, and the lingering effects of low mining investments in the past have combined to fuel the recent rise in spot market prices, which have increased more than 100% since the end of 2002 (Fig. 1).

Other work on the uranium production cycle and the environment was reported in four publications issued in 2004:

- *Recent Developments in Uranium Resources, Production and Demand with Emphasis on In Situ Leaching* (IAEA-TECDOC-1396);
- *Treatment of Liquid Effluents from Uranium Mines and Mills* (IAEA-TECDOC-1419);
- *Recent Developments in Uranium Resources, Production and Demand and the Environment* (IAEA-TECDOC-1425);

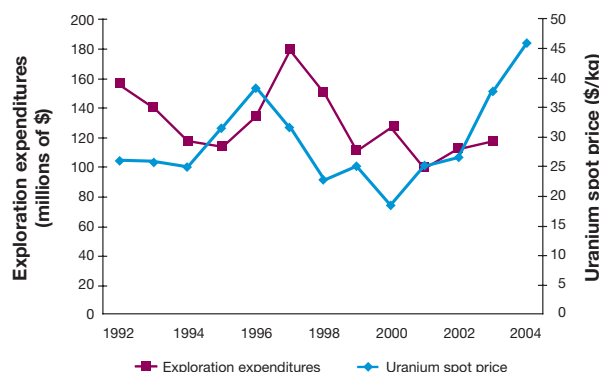


FIG. 1. Uranium market price and exploration expenditures, 1992–2004.

- *Guidebook on Environmental Impact Assessment for In Situ Leach (ISL) Mining Operations* (IAEA-TECDOC-1428).

Within the framework of the Agency's technical cooperation programme, expert teams visited Romania to review the status of a project on restructuring the uranium mining industry. Another team visited Argentina for a project on prospecting for uranium and other elements using gamma ray spectrometry surveys.

Nuclear Fuel Performance and Technology

To assist Member States in enhancing the performance and reliability of zirconium alloy clad fuel, the Agency initiated a CRP on delayed hydride cracking (DHC) in zircaloy fuel cladding material. Participating laboratories will receive guidance in deriving reproducible measurements of DHC, after which they will share experimental results to obtain a better understanding of the phenomenon.

One of the recommendations of an earlier CRP on Fuel Modelling at Extended Burnup (FUMEX) was that information meetings should be held on outstanding issues in fuel modelling. As part of this agreement, a meeting was held by the Agency and the OECD/NEA in Cadarache, France, on the issue of pellet-clad interaction. Other work dealing with fuel modelling included the provision of data to the IAEA–OECD International Fuel Performance Experimental Database (IFPE), which contains

experimental data to allow modellers to test and validate their codes. The IFPE is the data source for the second FUMEX CRP, which is investigating fuel modelling at high burnup and is currently in progress.

A database on post-irradiation examination (PIE) facilities and techniques was made available on the Agency's web site (<http://www-nfcis.iaea.org>) in February 2004. It includes information on techniques from 33 hot labs from 19 countries. The database complements, and is run cooperatively with, the database on hot cell design developed by the European working group on hot laboratories and remote handling as part of the 6th European Conference framework programme.

Spent Fuel Management

During the Scientific Forum held in conjunction with the 48th regular session of the General Conference in September, a meeting on waste and spent fuel management issues concluded that safe and robust interim storage technologies are available to provide flexibility in addressing longer term options and issues (Fig. 2). Also, reprocessing of irradiated power reactor fuel was noted to be a mature technology, demonstrating compatibility with all applicable requirements while reducing the resulting waste volumes. With regard to geological disposal, the participants reviewed the progress to date. The majority of technological issues have been satisfactorily addressed, but non-technical issues, including public acceptance and political endorsement, still remain unresolved. On multinational repositories, the session noted that having operating national repositories first would facilitate progress on multinational geological repositories. Further information on the Scientific Forum is available at <http://www.iaea.org/About/Policy/GC/GC48/ScientificForum/index.html>.

A new CRP on spent fuel performance assessment and research (SPAR-II) was approved. This project builds on results from preceding CRPs by developing a knowledge base on the long term storage of power reactor spent fuel through the evaluation of operating experience and research by participating Member States.

At a technical meeting on the storage of spent power reactor fuel, held in Ljubljana, Slovenia, in October, participants focused on system deployment, operating experience and cooperative initiatives. There was agreement among the experts that significant progress had been made in Bulgaria,

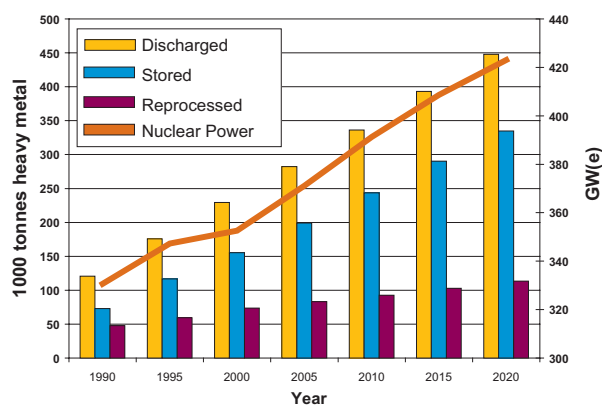


FIG. 2. Cumulative spent fuel discharged, stored and reprocessed between 1990 and 2020.

Croatia, Czech Republic, Hungary, Lithuania, Romania, Slovakia, Slovenia and Ukraine over the last few years in arrangements for interim spent fuel storage.

Nuclear Fuel Cycle Issues and Information Systems

In addition to its work on the front and back ends of the fuel cycle, the Agency carries out activities on selected topics of special interest to Member States. For example, in 2004 the Agency completed a technical document, *Thorium Fuel Cycle – Potential Benefits and Challenges*, that summarizes the issues and challenges at both the front and back ends of the thorium fuel cycle, highlighting fuel fabrication, implementation scenarios, data needs, reprocessing and waste management.

A technical meeting was held in June on the current status and future prospects of gas cooled reactor fuels to address key aspects of coated particle fuel development. The meeting reviewed progress in Member States, examined current development needs, studied the capabilities and limitations of coated particle fuel models, and reviewed applicable safety criteria, high temperature fuel performance, transuranic incineration and particularly promising new directions for research.

The proliferation potential of high enriched uranium (HEU) is such that its management, control and disposition have assumed great importance in nuclear non-proliferation efforts worldwide. In this context, a technical document was drafted that addresses both HEU management and the economic and technical impacts of LEU derived from HEU.

To support programmes within the Agency and as a general service to Member States, the Agency

maintains a number of databases to provide information on all dimensions of the nuclear fuel cycle, and on nuclear fuel cycle activities around the world. Currently, three databases and one simulation system are available on-line at <http://www-nfcis.iaea.org>: the Nuclear Fuel Cycle Information System; World Distribution of Uranium Deposits; Post-Irradiation Examination Facilities; and the Nuclear Fuel Cycle Simulation System (VISTA).

In 2004, the Agency began a new CRP on partitioning and transmutation (P&T) in response

to broad interest among Member States. These technologies use pyrochemical or advanced aqueous processes to reduce the radiotoxicity of spent fuel and to utilize fissile materials efficiently. Since progress in developing and implementing successful P&T systems will be facilitated by easily accessible information on the properties of the minor actinides, work began on developing a Minor Actinide Database for the thermochemical and thermophysical properties of these actinides.



Capacity Building and Nuclear Knowledge Maintenance for Sustainable Energy Development

Objective

To enhance the capacity of Member States to perform their own analyses regarding electricity and energy system development, energy investment planning and energy–environment policy formulation; to maintain and enhance the information and knowledge resources concerning the peaceful uses of nuclear energy; and to keep the nuclear option open for Member States who wish to retain it.

Capacity Building

The Agency assists interested countries to build their energy planning capabilities with respect to all three aspects of sustainable development — economic, environmental and social. Specifically, it develops and transfers planning models tailored to their special circumstances, as well as making available the latest data on technologies, resources and economics (Table 1). As of 2004, Agency energy planning tools were being used in more than 100 countries around the world.

Demand for the Agency's energy assessment models — which treat all energy supply options equally — and services is growing due to

increasingly complex energy systems, market liberalization, privatization and environmental concerns. Country studies were completed in 2004 for Bulgaria, China, Haiti, India, Indonesia, Republic of Korea, Lithuania, Mongolia, Nigeria, Pakistan, Philippines, Sri Lanka and Vietnam. Technical cooperation projects are the main mechanism for such studies. In 2004, eight such projects — four national and four regional, involving 36 Member States — were either concluded or were in progress. Two new regional projects will be launched in Asia (with 13 countries) and Europe (three countries), as well as five national projects in Azerbaijan, Colombia, Ghana, Guatemala and Nicaragua.

The number of people attending Agency regional, interregional and national training courses and workshops has risen steadily in recent years and reached a record high in 2004 of 231 energy professionals from 43 countries.

Training and national applications of the Agency's modelling tools are supplemented by CRPs that serve both to improve the understanding of important aspects of energy planning and further disseminate the models to interested Member States. For example, in a CRP on 'Cost Effectiveness of Nuclear Power Compared with CO₂ Capture and

Table 1. Agency Planning Models and their Distribution in 2004

Model	Description	Releases to Member States
MAED	Evaluates future energy needs based on development scenarios in a country or region	55
WASP	Identifies the optimal long term expansion plan for a power generating system within constraints defined by the user	80
MESSAGE and ENPEP	Formulate and evaluate alternative energy supply strategies for a country or region	62
FINPLAN	Assess the financial viability of plans and projects	13
SIMPACTS	Estimates environmental impacts and costs using minimum data input	23

ENPEP: Energy and Power Evaluation Package; **FINPLAN:** Model for Financial Analysis of Electric Sector Expansion Plans; **MAED:** Model for Analysis of Energy Demand; **SIMPACTS:** Simplified Approach for Estimating Environmental Impacts and External Costs of Electricity Generation; **MESSAGE:** Model of Energy Supply Systems and General Environmental Impacts; **WASP:** Wien Automatic System Planning Package.

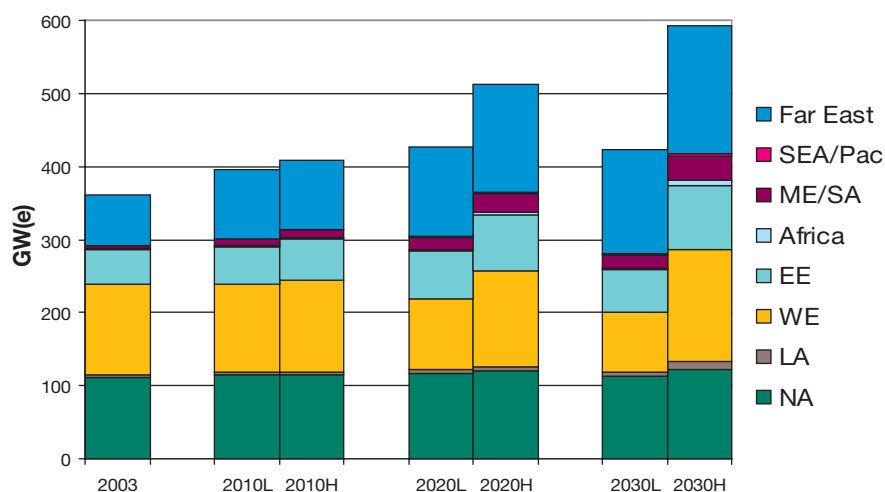


FIG. 1. The Agency's latest low and high projections through 2030 for worldwide installed nuclear power capacity (source: Energy, Electricity and Nuclear Power Estimates for the Period up to 2030, July 2004, Reference Data Series No. 1, IAEA, Vienna (2004)). (L: Low; H: high; NA: North America; LA: Latin America; WE: Western Europe; EE: Eastern Europe; ME/SA: Middle East and South Asia; SEA/Pac: South East Asia and the Pacific.)

Sequestration from Fossil Fuel Power Plants' five publications were completed, and one of the teams participating in the CRP received an international award in 2004 for its work in the design of a CO₂ pipeline.

In addition, the Agency is constantly improving its models and databanks for energy planning and analysis. In 2004, the Agency developed PMAT (Plant Modification Assessment Tool) to rank prospective plant modifications both in terms of their performance impact and their risk impact.

The Agency publishes two projections for nuclear energy use every year — a low projection, which assumes that no new nuclear power plants will be built beyond those already under construction or currently planned, and a high projection that incorporates nuclear projects proposed beyond those already firmly in the pipeline. Figure 1 shows the Agency's two medium term nuclear energy projections, as updated in 2004. The low projection is shown by the left bar in each pair, while the high projection is represented by the right bar in each pair. The figure shows different trends for different regions. For North America, for example, both projections are relatively flat. Western Europe shows a notable decrease in the low projection and a notable increase in the high projection. The Far East shows expansion in both projections. Both projections are higher than comparable projections made in 2003, reflecting a sense of rising expectations for nuclear power. For the low projection, 2004 was the fourth year in a row in which the projection was adjusted upwards. For example, in 2000 the low

projection projected 300 GW(e) for 2020. The 2004 low projection in Fig. 1 now projects 427 GW(e).

Energy Economics Environment (3E) Analysis

In addition to capacity building, the Agency assists Member States in analysing and designing energy strategies consistent with national sustainable development objectives. In 2004, the Agency completed an initial study on *Energy Supply Options for Lithuania* (IAEA-TECDOC-1408) to assess alternative energy strategies in light of the scheduled closure of the Ignalina nuclear power plant. A subsequent study was initiated on energy security and independence in the Baltic region with the participation of Estonia, Latvia and Lithuania. The Agency also launched a study to assess the contribution of nuclear technology to economic development in the Republic of Korea. Finally, an *Energy and Nuclear Power Planning Study for Armenia* (IAEA-TECDOC-1404) was completed. It identifies least cost energy strategies and their dependence on economic growth and nuclear development policy.

The Agency is active in several initiatives within the UN system to promote sustainable development and follow up the Johannesburg Plan of Implementation and the UN's Millennium Development Goals. A major activity in 2004 was the Agency's continuing coordination of a multi-year effort to produce a major interagency publication, *Energy Indicators for Sustainable Development: Guidelines and Methodologies*. Partners in the report's

development were UNDESA, OECD/IEA, Eurostat and the European Environment Agency. The report — which was finalized in 2004 and published in early 2005 — is intended both to support stand-alone national assessments of sustainable energy development and also, in combination with scenarios and models, to chart national sustainable energy strategies. Another initiative to promote sustainable development was the establishment, in cooperation with FAO, of a prototype financial decision support system for selecting countermeasures in regions contaminated by radioactive material.

Work in the area of sustainable development also included the involvement of the Secretariat staff as coordinating and lead authors of several reports prepared by the IPCC, the UN Water Assessment and the Millennium Ecosystem Assessment. The Agency provided input to global policy processes such as the Conference of the Parties to the UNFCCC. With the entry into force of the Kyoto Protocol on 16 February 2005, many Member States are re-evaluating nuclear power as an important option for meeting their Kyoto obligations, and in terms of prospective, possibly tighter restrictions beyond the UNFCCC's first 'commitment period' of 2008–2012.

The Agency also took an active role in the creation of 'UN Energy' in April 2004, working with sister UN organizations involved in providing energy related assistance to Member States. The creation of UN Energy followed a specific request by the UN's High Level Committee on Programmes, after their review of the UN system's capacity to carry out its part of the Johannesburg Plan of Implementation. UN Energy is designed to better connect energy activities throughout the UN system, to continuously improve efficiency and mutual support.

Nuclear Knowledge Management

Scenarios of expanding global energy demands project growing requirements for nuclear energy, nuclear expertise and nuclear knowledge. At the same time, some sections of the nuclear community are already experiencing work force ageing and attrition. Agency activities in the field of nuclear knowledge management address both of these concerns.

In this context, an international conference on 'Nuclear Knowledge Management: Strategies, Information Management and Human Resource Development' was held in September in Saclay, France. The conference supported development by the Agency of 'knowledge packages' targeted at

specific user needs and encapsulating key knowledge about nuclear technologies and power plants.

Educational networking is a key strategy for capacity building and for the better use of available educational resources. The Asian Network for Higher Education in Nuclear Technology (ANENT) was established in 2004. ANENT was set up to promote, manage and preserve nuclear knowledge and to ensure the continued availability of talented and qualified staff in the nuclear field in the Asian region and to enhance the quality of human resources for the sustainability of nuclear technology.

The Agency was a founding supporter of the World Nuclear University (WNU), together with the OECD, WANO and the World Nuclear Association. In June 2004, the Agency convened a technical meeting on planning support activities for WNU and to prepare an action plan for 2004–2005. It was agreed that the first activity would be a WNU Summer Institute in 2005. A meeting of the WNU hosted by the Agency in December 2004 finalized the syllabus of the Summer Institute and discussed the technical and financial support needed to ensure wide participation by all interested States, particularly developing countries.

Data and information from the German KNK-II experimental fast reactor continued to be retrieved and archived within the Agency's Fast Reactor Data Retrieval and Knowledge Preservation Initiative. In 2004, documents from various KNK archives were quality checked, digitized and preserved. Moreover, all documents have been integrated into the Agency's INIS network, and a CD-ROM was produced that documents progress on the KNK-II knowledge preservation project.

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 text of documents not readily available through commercial channels, such as reports and dissertations. The INIS Database contains more than 2.5 million records and is the largest of its kind in the world. The addition of Botswana in 2004 brought the membership to 130 — 111 States and 19 international organizations.

In 2004, INIS added a record 106 929 bibliographic entries. The increase was due to the introduction of a computer assisted indexing system and the direct

acquisition of electronic records from publishers. A total of 10 675 items of non-conventional literature (NCL) were also added to the INIS NCL Collection. There were 399 subscriptions to the INIS Database on the Internet in 2004, an increase of 20% over 2003. The total number of authorized users reached 974 475, representing an increase of 66% over 2003, and an additional 74 universities were provided with access, an increase of 42% over 2003.

New innovations introduced during the year include a pilot version of a new Internet interface that provides direct linking to all NCL full text documents, and a computer assisted indexing system

that began operation in June. This system accelerated the indexing of electronic records acquired from publishers without compromising quality.

Assistance in the use of INIS in Member States around the world continued through two technical cooperation projects that provided the services of experts, staff training, equipment and support materials. The Agency also continued its cooperative arrangement with the OECD/NEA Data Bank through which the Agency both distributes programmes to non-OECD countries (1060 in 2004) and facilitates non-OECD contributions to the Data Bank. ■

Nuclear Science

Objective

To increase Member State capabilities in the development and application of nuclear science as a tool for their economic development.

Atomic and Nuclear Data

The Agency continues to play an important role in coordinating the generation, validation and compilation of atomic and nuclear data, while also facilitating easy, reliable access to a vast range of these well defined data for various applications. The Agency developed a new system in a collaborative effort with the US National Nuclear Data Center in Brookhaven, New York, which is better suited for the establishment of local data centres including in regions where Internet connections may be slow. A local 'model' data centre of this kind became operational in November 2004 at the Bhabha Atomic Research Centre in Mumbai, India.

Collaboration with the Los Alamos National Laboratory (LANL) has produced an interface for running several computer codes for the calculation of atomic structure, electron impact excitation and ionization processes. The interface has been installed on a server at LANL and is now available to the public, resulting in the ability to access on-line atomic and molecular (A+M) data rapidly for a number of processes important in fusion energy research. A similar interface has also been developed for heavy particle collisions. Extensive new data sets have been added to the A+M electronic database, including data for charge exchange and for molecular processes.

As shown in Table 1, Member State use of the Agency's nuclear data services through the Internet, on CD-ROM and paper continued to increase in

2004. Figure 1 provides a detailed breakdown of Internet access to Agency nuclear data files. Agency training activities also proved popular, particularly the regular biennial workshop on 'Nuclear Data for Nuclear Reactors — Physics, Design and Safety' at the International Centre for Theoretical Physics in Trieste, Italy.

Research Reactors

To date, some 672 research reactors have been built, and of these 274 reactors in 56 countries continue to operate. In 2004, the Agency continued to provide support to the Reduced Enrichment for Research and Test Reactors (RERTR) programme, which has the mission of developing substitute fuel of higher density LEU. Specifically, fresh fuel was shipped to the Russian Federation from the Czech Republic, Libyan Arab Jamahiriya and Uzbekistan.

A draft technical document on the state of the art in the development and qualification of high density uranium-molybdenum fuels is under review prior to publication. This document will be included as an annex to the Agency's Core Conversion Guidebook. Qualification of uranium-molybdenum fuels is of crucial importance in the conversion of HEU fuels to LEU fuels. The Agency continues to be active in this area, and will participate as an observer in an international working group (under the RERTR programme) attempting to find remedies for fuel failures detected during high temperature irradiation.

Agency contributions to the assessment of stored spent fuel and its repatriation have taken various forms, such as a fact-finding mission to Belarus; convening of a training course in Indonesia; preparation of guidelines in Russian and English for fuels of Russian origin; and development of

Table 1. Requests for Agency Nuclear Data Services, 2001–2004

User requests	2001	2002	2003	2004
Internet retrievals from the main Agency nuclear databases	12894	20773	29875	22196
Access through the Internet to other Agency files and information	16153	18135	23146	33558
Information on CD-ROMs	883	1108	852	1489
Off-line retrievals	2528	2543	2420	2765

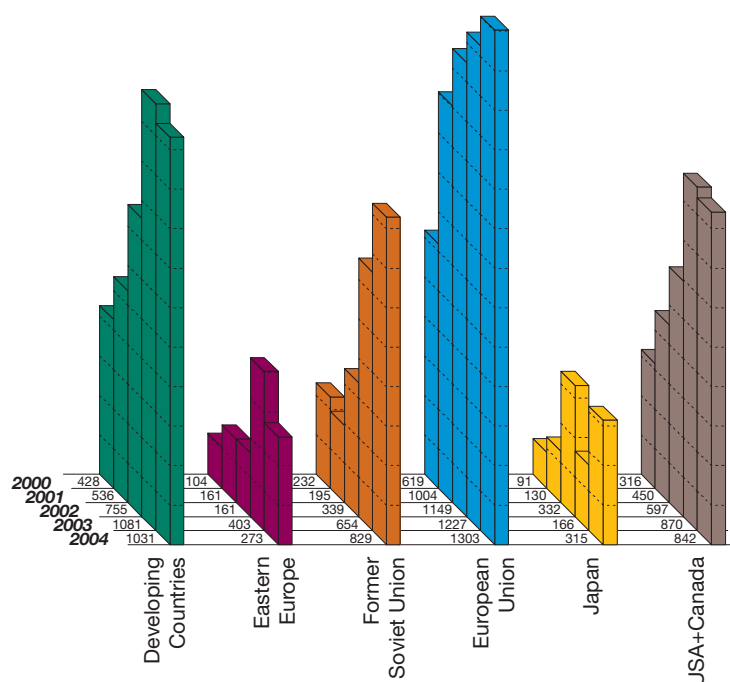


FIG. 1. Number of Internet accesses and retrievals of Agency nuclear data files, by region (average per month).

national and regional projects through the technical cooperation programme. In addition, the Agency assisted in the procurement of lower enriched fuel for the Maria research reactor in Poland and is assisting in the procurement of LEU for the TRIGA reactor in Romania.

A meeting on the RERTR was organized by the Agency, in cooperation with Argonne National Laboratory which manages the RERTR programme. The meeting recommended that the development and qualification of high density LEU fuels be pursued. On a related subject, another meeting was held during the RERTR conference to review the status of development of LEU targets for fission molybdenum-99 production. This is an important raw material radioisotope for nuclear medicine applications involving the technetium-99m radiotracer. This led to the formulation of a new CRP to foster further development of LEU targets for molybdenum-99 production.

The role of research reactors is gradually changing from the support of fundamental research and training to helping facilities formulate strategic plans for the development and use of new applications and techniques. A series of meetings were held during the year to review progress and assist in planning for the next phase of activities, and also to formulate a methodology to assess the utilization of research reactors, review the problems faced and suggest possible ways to resolve them.

Utilization of Accelerators

The first Research Coordination Meeting for a new CRP on the ion beam modification of insulators was held in Vienna. This subject is attracting significant interest around the world as a means of modifying surface properties and in the fabrication of new advanced materials. It also has applications in advanced electronic devices for high speed and power application and in radiation detection.

Large accelerator driven neutron sources (ADNSs) are based on high energy particle accelerators operating at energies over 1 GeV. These sources have advantages over conventional neutron sources because they use the highly efficient spallation process, which overcomes many limitations associated with steady state reactor neutron sources. In this connection, the Agency held a meeting to identify different possibilities that could promote the construction of small and medium scale ADNSs suitable for placement in developing countries. A report was drafted which outlined the advantages of these types of sources as a complement to existing conventional sources and large (>1 GeV) neutron spallation sources.

The development of an international data format standard for the exchange of ion beam spectral information was initiated as part of an intercomparison and validation exercise for accelerator based, nuclear analytical software. As part

of this exercise, an expert task force was established to generate challenging simulation exercises on the interaction of ion beams with matter, and critically evaluate and compare the outputs with the best available experimental data and between different nuclear models and computational strategies. The objective is to understand the advantages and deficiencies in the underlying science, and to develop new knowledge to drive improvements.

A CRP on the development of new techniques and applications of accelerator mass spectrometry (AMS) was initiated. This CRP will gather data and focus on those knowledge areas that underpin the development of new and improved AMS technologies, especially for the non-radiocarbon radionuclides. A broad spectrum of activities has been initiated that will strengthen the capacity of Member States to build and sustain their nuclear knowledge and expertise.

The Agency published a technical document on the results of a CRP to promote the potential of accelerator based nuclear techniques for the analysis of light elements in thin films. The CRP succeeded in:

- Developing a coordinated research effort between accelerator laboratories and materials science research groups to support and promote the development of quality assurance methods;
- Evaluating databases of the parameters needed for quantitative analysis;
- Developing and applying techniques for selected problems concerning the surface modification of materials and the production of thin films.

Nuclear Instrumentation

Training activities on the maintenance of nuclear instrumentation included:

- Introduction of ICT based training modules, which have replaced several introductory lectures;
- Distribution of more than 150 training modules;
- Creation of a new web site for the international groups working on X ray fluorescence (<http://www.iaea.org/OurWork/ST/NA/NAAL/pci/ins/xrf/pciXRFcurr.php>).

Nuclear Fusion Research

Programmes to harness the potential of controlled nuclear fusion power are being pursued in about 50 countries, as shown in the newly updated version



FIG. 2. Inside view of the Japanese stellarator LHD vacuum chamber — a toroidal nuclear fusion confinement concept — showing the covered helical winding of the coil system. The fusion plasma is confined by the coils inside the vacuum chamber.

of the world survey on controlled nuclear fusion (Fig. 2). The progress in magnetic confinement research is reflected in the design features of the 500 MW International Thermonuclear Experimental Reactor (ITER). One major breakthrough of the ITER meetings was the agreement on the financial plan for construction, operation and decommissioning. The negotiations on choosing a site for ITER continue.

A Technical Meeting, which was combined with the final Research Coordination Meeting on the 'Physics and Technology of Inertial Fusion Energy Targets, Chambers and Drivers', outlined the potential of laser or particle driven fusion approaches. This is in line with the Agency's mandate to foster the exchange of scientific and technical information on the peaceful uses of atomic energy. The biennial fusion energy conferences, which first began in 1961, are another example of the Agency's efforts to enlarge the contribution of nuclear technology for human welfare. The conference in 2004, held in Vilamoura, Portugal, highlighted the progress in magnetic confinement research made during the past two years, especially in the divertor tokamaks, which were used to carry out ITER baseline scenario experiments. Long pulse scenario with high performance has been demonstrated.

A new CRP on 'Joint Research using Small Tokamaks' was initiated in 2004 with the objective of making better use of existing infrastructure, and to support small tokamak projects that can be more easily integrated into national and international fusion activities. ■

Food and Agriculture

Objective

To enhance capabilities within Member States for alleviating constraints to sustainable food security by the application of nuclear techniques.

Sustainable Intensification of Crop Production Systems

Significant challenges in many parts of the world are the achievement of better soil, nutrient and water management practices to improve low crop yields and to reduce natural resource degradation, the selection and breeding of crops that give higher yields and nutritional value, and the control of insect pests that threaten livelihoods, food security and economic development. Agency support, involving the use of nuclear techniques, enabled Member States to address these challenges, both by conducting research that helped to identify and evaluate options for more productive and sustainable systems, and through technical cooperation projects for pilot testing and for extending these options to farming communities.

A CRP, aimed at increasing crop production by managing nutrients and water in rain fed, arid and semi-arid areas, assisted ten countries in the use of isotopes and neutron moisture probes for a reduction by up to 50% of recommended rates of fertilizer nitrogen without affecting crop yields. The efficiency of water use by crops was also increased by the same amount by changing management practices according to the pattern of rainfall during the growing season, resulting in better overall crop productivity and profitability and improved conservation of scarce water resources. A similar approach in a regional technical cooperation project involving nine European countries demonstrated the substantial agronomic and environmental benefits from using 'fertigation' (an irrigation technique that provides fertilizer nutrients to plants at the time of irrigation) compared with conventional methods of providing irrigation and fertilizers. Higher crop yields resulted, with an increase in the efficiency of water and fertilizer use and with minimal nitrate leaching to groundwater. Continuing this theme, 11 countries under an RCA technical cooperation project developed and tested new management

practices that restored soil fertility in rice based cropping systems.

Two important roles for the Agency in promoting economic development is increasing the availability and facilitating greater exchange between Member States of crop breeding lines possessing a variety of improved mutation induced traits. For example, genetic variability was induced in sorghum by gamma irradiation, and ten mutant lines showing promise for drought tolerance were identified as a result of cooperation between India and Indonesia. Subsequent field evaluation proved that the mutant lines could tolerate longer drought stress and produce higher grain and biomass yields for food and feeding livestock. New mutant wheat varieties with root systems that provide higher tolerance to water stress in drought-prone western China were developed through a CRP, which also led to chickpea mutant lines in South Africa that produced 30% more than the parent variety under drought conditions, and to the establishment of the first international consortium on plant root research (<http://www.crop-roots.org>).

Another important area of work for the Agency was reducing the constraints of disease and soil salinity in food production. A breeding programme using gamma irradiation of sesame seeds, a major oil seed crop, for mutation induction was initiated at the Department of Plant Research of the Egyptian Atomic Energy Authority. Three mutant varieties were developed with high yielding potential and disease and insect resistance. These varieties already occupy 13% of the total area under sesame cultivation in Egypt three years after they were released. Additionally, several mutants with resistance to the toxin causing Black Sigatoka disease in banana were reproduced at the Agency's Laboratories at Seibersdorf and are being field tested. Rice mutants with enhanced tolerance to saline soils were also field tested and integrated into national crop improvement programmes in Myanmar and Vietnam.

A Mutant Germplasm Repository has been set up to distribute germplasm to breeders in Member States. Mutations were developed in a CRP for wheat, rice, pea, barley, maize, pearl millet, soybeans and flax. They are undergoing extensive phenotypic characterization to form part of this repository. The Agency's regional technical cooperation projects in Asia and Africa were also used to exchange

mutant germplasm among Member States in order to improve food and oil crops, including neglected species.

The interest of commercial companies in the mass production of sterile insects is growing as the sterile insect technique (SIT) is more widely adopted for controlling insect pests of crops. Fresh vegetable exports have increased to over \$30 million per year in the Arava region between Israel and Jordan as a result of a successful Mediterranean Fruit Fly (medfly) suppression programme, and a private company has initiated the construction of a sterile fly mass rearing facility in Israel. Also, the success of a medfly suppression programme in South Africa in the grape exporting Hex River valley has triggered the start of similar programmes in several neighbouring valleys. As a consequence, the Government has now privatized the mass production of sterile medflies.

The Agency is also transferring SIT technology to Spain through a Memorandum of Understanding with the Territory and Housing Department of the Valencian Community for the transfer of medfly genetic sexing strains and related technologies. As a result of a successful pilot trial conducted in two areas, the Government of Valencia has started construction of a mass rearing and sterilization facility with an initial production capacity of 300–400 million sterile flies per week. This will be sufficient to cover major citrus production areas of the province.

Recognizing the importance of harmonizing international trapping procedures for fruit flies, the Agency published *Trapping Guidelines for Area-wide Fruit Fly Programmes*. Providing strategic guidance and direction to national and regional plant protection organizations, as well as the fruit industry, on implementing fruit fly surveys, the publication will support FAO and Agency Member States in obtaining international recognition of their fruit fly control and quarantine activities. In addition, the Agency developed an interactive 'Tephritid Worker Database' to provide information on fruit flies.

Sustainable Intensification of Livestock Production Systems

The Agency's efforts in the sustainable intensification of livestock production systems are directed at identifying and disseminating nuclear technologies and related guidelines and standards that lead to improvements in productivity and income generation from the domestic and international trade in livestock and livestock

products. Thus, two regional technical cooperation projects and a CRP on artificial insemination (AI) significantly improved the reproductive efficiency of cattle reared in smallholder farming systems in more than 20 Member States. Increases of 10–25% in milk production and of about 10% in meat production were achieved. The projects brought together technical and managerial staff of 25 laboratories in Africa and Asia, with local farmers, veterinarians and technicians, using diagnostic support in the form of radioimmunoassay technology.

Agency assistance, through a CRP and an RCA project, to improve animal nutrition led to the development of a new iodine-125 labelled protein and carbon-14 labelled polyethylene glycol based methods to measure the biological activity of tannins, predict the nutritional value of tannin-containing feeds and help to identify alternative local sources of animal feeds. Feeding blocks containing plant and herbal compounds increased the income of dairy farmers by 5% to 180% per cow per day, with an average increase of 38% in Bangladesh, India, Indonesia, Malaysia, Philippines, Thailand and Vietnam while income from beef cattle and small ruminants increased by up to 30% per animal (Fig. 1). Of the 47 feeds evaluated by 12 Member States, 39 showed potential as an alternative animal feed resource. China, Thailand and Vietnam introduced these novel feeding practices to more than 2450 farmers.

The development and implementation of guidelines, quality assurance procedures and reference standards for the diagnosis and surveillance of animal diseases contributed to the ability of Member States to deal with a number of major transboundary infections. Five Member States in Africa, Europe and Asia used these new surveillance guidelines in the last stages of their eradication campaigns and in the development of dossiers for recognizing freedom from rinderpest by the World Organisation for Animal Health, thereby improving their trade status. In the Global Rinderpest Eradication Programme, a number of countries in Africa were recognized as being free of infection or the disease.

Reagents for detecting antibodies against the non-structural proteins of foot and mouth disease virus, which allow countries to discriminate between vaccinated and field infected cases, were developed and validated through a CRP. Sustainable reagent kit production was established in the Islamic Republic of Iran and Thailand by the provision of reagents, guidelines and procedures.

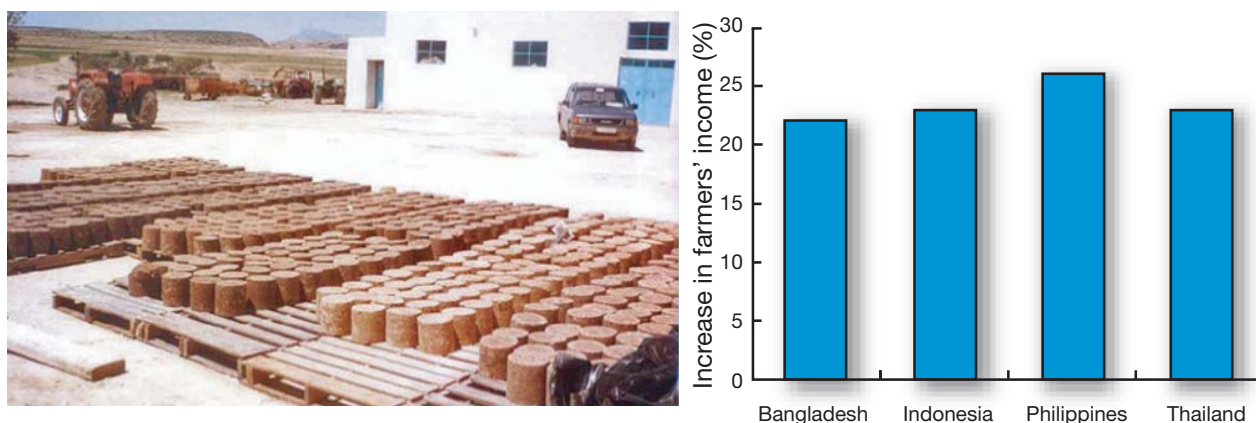


FIG. 1. Feeding blocks containing plant and herbal compounds to improve animal nutrition.

Quality assured procedures and implementation guidelines for enhancing the proficiency of veterinary diagnostic laboratories were developed and introduced into 30 countries through an inter-regional technical cooperation project. Ten of these countries are now approaching accreditation status under ISO 17025. This process was assisted by Austria, which granted a licence to import biological materials for the establishment of a serum reference bank at the FAO/IAEA Agriculture Laboratory at Seibersdorf.

An FAO-IAEA feasibility project for control of the Old World Screwworm (OWS) was started using funds from the Arab Organization for Agricultural Development. This project, which also includes a possible SIT component, is intended to provide training for countries affected by OWS, and carry out studies on OWS population genetics. Planning has also commenced for the establishment of the first small module of an OWS rearing facility to assess the technical feasibility of the SIT component.

Improving Food Quality and Safety

The development and application of guidelines and principles for the use of good agricultural practices throughout food chains is critical for

ensuring the safety of food supplies and for promoting the sustainability of the agricultural sector in developing countries. Agency activities focus on the use of nuclear and related analytical methods for ensuring compliance with maximum residue limits for pesticides and veterinary drugs, and integrated approaches to the application of agricultural countermeasures following a nuclear or radiological emergency. The Agency continues to provide information to Member States, through a number of publications, on the application of irradiation for sanitary and phytosanitary purposes.

A project on improving the reliability of pesticide residue sampling and the capabilities of food control laboratories to perform analyses according to international quality standards contributed to the elaboration of Codex Alimentarius maximum residue limits based on reliable acute intake estimates. In addition, a technical cooperation project implemented through regional workshops in Austria, Australia, Chile and South Africa assisted Member States in focusing resources on the analytical detection and control of veterinary drug hazards of concern for human health and the environment, thereby improving their knowledge for reducing technical barriers to trade.

Partnerships to Eradicate Insect Scourges

Ethiopia, in collaboration with major international partners including FAO, developed a "Concept Note" and a road map for joint international fund raising. The aim is to create a tsetse and trypanosomosis free zone, initially of 10 500 km², in the Ethiopian Southern Rift Valley. The OPEC Fund contributed towards equipment for the sterile fly mass rearing facility under construction. Together with others, the Agency assisted in securing funds from the United Nations Fund for International Partnerships and the USA for generating additional baseline information and for joint international fund raising efforts in support of priority areas for tsetse and trypanosomosis intervention.

Human Health

Objective

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

Nuclear Medicine

Treatment strategies against cardiovascular diseases and cancer, which are two of the major causes of death, are making greater use of nuclear medicine techniques (Fig. 1). Additionally, the management of infectious, metabolic, genetic and degenerative diseases are benefiting from molecular nuclear medicine techniques.

A CRP on myocardial viability detection following myocardial infarction has been researching the risks from operations and predictions of improvement. Results from 252 patients enrolled in the CRP are demonstrating increased sensitivity and accuracy in predicting the functional recovery and the rate of future cardiac events.

Another CRP, completed in 2004, focused on intravascular radionuclide therapy using liquid

rhenum-188 perrhenate at the time of coronary artery revascularization in patients with newly detected lesions in the coronary artery. It was proven that brachytherapy with liquid rhenum-188 filled balloons is a feasible and cost effective technique and prevents restenosis with similar results to those reported in the biomedical scientific literature.

The use of radiopharmaceuticals, in particular rhenum-188 Lipiodol for the treatment of liver cancer, continues to show promise. A CRP is showing an apparent increased rate of survival in patients who are otherwise untreatable.

Two CRPs were started on drug resistance in infectious diseases such as HIV and malaria. The first will focus on the development and quality control of radiopharmaceuticals prepared in hospitals and used for infection imaging in HIV positive patients. The second CRP will study the accuracy of molecular and immunological markers for prediction of the efficacy of antimalarial drugs.

The Agency continued to promote professional training, innovative teaching technologies and the application of information and communication tools through technical cooperation projects on telenuclear medicine and on distance assisted teaching. The

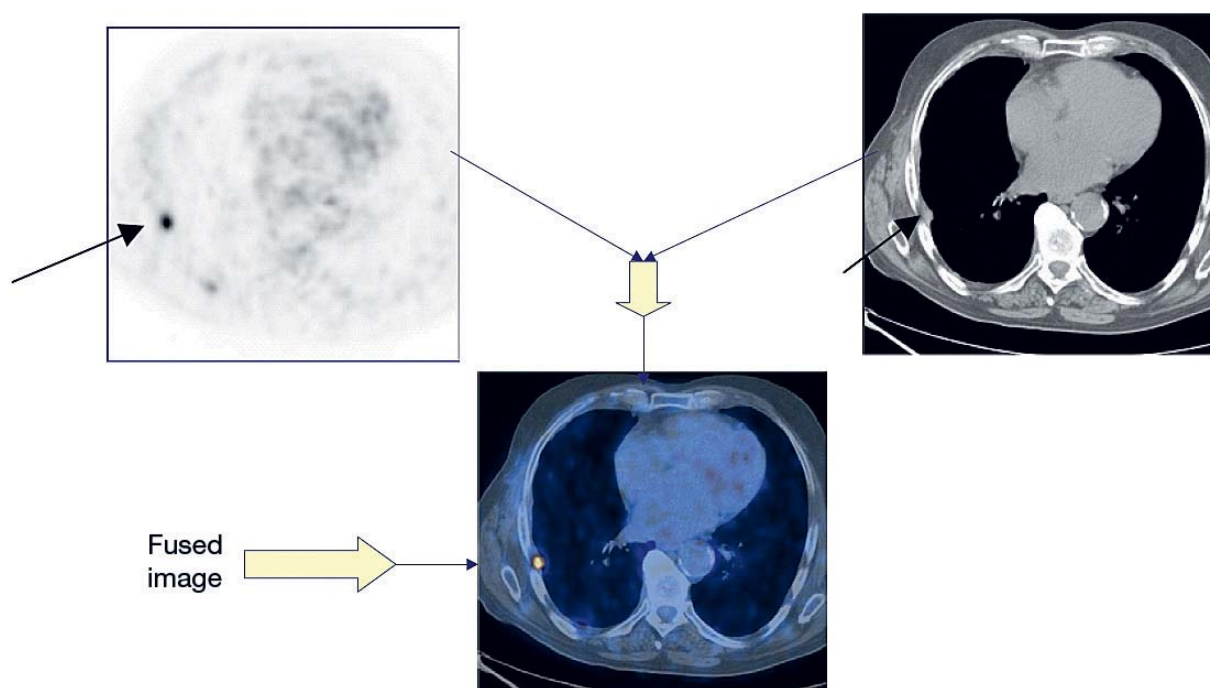


FIG. 1. Improved cancer diagnosis can be achieved by the 'fusion' of positron emission tomography images (left) and computed tomography (right) images. The bottom picture shows the combined image (images courtesy of Dr. S. Fanti, University of Bologna, Italy).

latter is aimed at providing education to nuclear medicine technologists in RCA Member States where formal training is not yet available.

Applied Radiation Biology and Radiotherapy

Cancer of the cervix is one of the most common cancers worldwide. It is strongly related to infection by the Human Papilloma Virus. A CRP on the response of cervix cancer to radiotherapy was initiated. The clinical component will investigate the most economical method of using high dose rate brachytherapy for the treatment of this cancer. The radiobiology component will study molecular markers of tumour response as well as cell lines with relevant molecular characteristics, in order to better understand the response of these tumours.

A technical meeting was held to discuss normal tissue and tumour banking with respect to predictive testing of response to radiotherapy. Molecular based assays are being used increasingly in the hope of tailoring radiotherapy dosage prescriptions to individuals or groups of patients, thereby improving the overall treatment outcome for cancer patients. Another meeting focused on pathways of tumour radioresistance to radiotherapy, identifying those new molecular targeting agents that may be particularly suitable for study in industrialized or in developing countries to improve the effectiveness of radiotherapy against certain cancers. Future CRPs will be planned on the basis of the knowledge gained from these two meetings.

A review at a Technical Committee Meeting on the long term effects on normal tissues of various agents used in radiotherapy recommended the adoption of the most recent Common Toxicity Criteria, from the US National Cancer Institute. The use of this set of criteria would facilitate: harmonization of the reporting of adverse effects in Agency trials; research into modifying those criteria for improved applicability in resource limited settings; and the use of actuarial methodology for more realistic assessment of late adverse effects.

The Agency's distance learning course, the 'Applied Science of Oncology', is aimed at promoting radiotherapy expertise in developing countries. Currently in the validation stage, the course should reduce substantially the expenses incurred by the Agency and Member States in training physicians and other professionals specializing in radiotherapy.

Dosimetry and Medical Radiation Physics

Fostering and maintaining a quality assurance culture, leading to accurate dosimetry, dose delivery and patient protection, are of paramount importance in the successful use of nuclear and radiation techniques in diagnosis and treatment. In addition to radiotherapy assistance projects under the Agency's technical cooperation programme, the Directory of Radiotherapy Centres (DIRAC) database was revised, with an Internet based planning tool that can identify gaps in Member State treatment

Programme of Action for Cancer Therapy — PACT

Today there are more new cancer cases every year in developing countries than in industrialized countries. Indeed, by 2020, two thirds of the projected ten million annual cancer deaths will be in developing countries.

Together with other international organizations, the Agency has continued to offer its expertise in radiotherapy to developing countries. Since 1981, it has provided over \$57 million in radiotherapy services. Over 22% of its technical cooperation programme is devoted to human health, and half of that is allocated to providing or improving the delivery of radiotherapy services. In addition, the Agency invests about \$7–8 million annually on technical cooperation projects focusing on radiotherapy.

However, recognizing the magnitude of the impending cancer crisis in many developing countries, the Agency proposed a Programme of Action for Cancer Therapy (PACT) to address the legal, regulatory, technical and human resources requirements involved in establishing, improving and expanding radiotherapy treatment programmes in the context of national cancer control strategies and according to the priorities and needs of the countries and regions concerned. While the Agency's radiotherapy activities will continue, there will be a shift in emphasis to providing support to PACT. The programme of action was endorsed by the Board of Governors in June 2004, with the General Conference passing it as a resolution in September, paving the way for the Agency to seek and direct funds from a wide range of traditional and non-traditional donors to further enhance its delivery of radiotherapy and related diagnostic techniques to Member States.

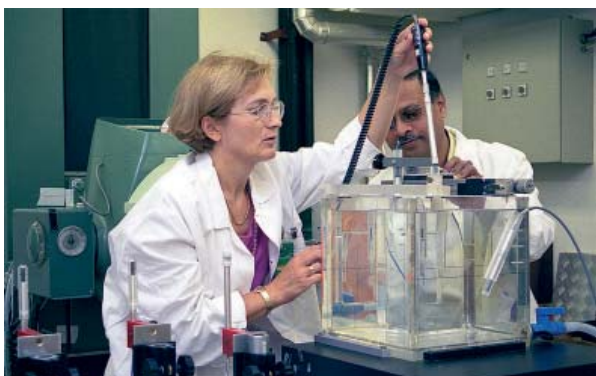


FIG. 2. Agency medical physicists investigating dosimetry discrepancies at a hospital as part of the QUATRO project.

capabilities and human resources. Other activities in this area included:

- Revision of a technical document outlining the components of a basic cancer treatment facility (IAEA-TECDOC-1040);
- Publication of *Commissioning and Quality Assurance of Computerized Planning Systems for Radiation Treatment of Cancer* (Technical Reports Series No. 430), to help Member States verify the accuracy of their treatment planning systems;
- Initiation of a CRP to identify the most appropriate technology to be used for the verification of patient dose during therapy, known as in vivo dosimetry.

In order to assist Member States in the event of potential radiation misadministration, the Agency expanded its activities directed at resolving dosimetry discrepancies in medical physics. The result was the development of the 'Quality Assurance Team in Radiation Oncology' (QUATRO), a comprehensive clinical auditing approach (Fig. 2). As a follow up, QUATRO's mode of operation was defined, and possible funding mechanisms for team missions were explored.

In response to increased demands for the calibration of detectors used to measure the output and to verify the calibration of radiation beams and sources used in diagnostic radiology, nuclear medicine and radiation oncology, the Agency began expansion in 2004 of the Dosimetry Laboratory. The laboratory's quality management system was reviewed by an external peer review panel to strengthen the link between the international measurement system and the radiation standards of the members of the IAEA/WHO Network of Secondary Standards Dosimetry Laboratories (SSDLs). In related work, the Agency continued to



FIG. 3. Accuracy of radiation dose measurements is vital in radiotherapy. Here, a physicist at the Agency's Laboratories at Seibersdorf calibrates a dosimeter to be used in a Member State.

provide Member States with dosimetry calibration and verification services at a rate comparable to previous years, and also participated in two international comparisons as part of its role as the central laboratory of the IAEA/WHO Network of SSDLs (Fig. 3).

Nutrition and Effects of Contaminants on Human Health

The United Nations Millennium Development Goals call for a halving by 2015 of the number of people who suffer from hunger. The Agency is assisting Member States in their efforts to achieve these goals by providing technical support to develop and evaluate strategies to combat hunger and malnutrition.

For example, a new CRP was developed jointly with the International Food Policy Research Institute (IFPRI), based in Washington, D.C., and the Consultative Group on International Agricultural Research to evaluate innovative strategies to combat malnutrition by the introduction of nutritionally improved, 'bio-fortified' crop varieties. The usefulness of bio-fortified staple foods will be evaluated as sources of micronutrients (vitamin A, iron and zinc) using stable isotope techniques.

The Agency is also involved in the development and evaluation of more conventional strategies to combat malnutrition, for example, conventional food fortification and dietary modification. A CRP which provides support to local PhD students showed encouraging results in Sri Lanka on different strategies to enhance iron and zinc bioavailability by the addition of the food additive EDTA to fortified rice flour, and in Pakistan from the addition of

vitamin C to improve iron bioavailability from a traditional complementary food.

Well established stable isotope techniques were used as tools in priority areas in nutrition. The intake of human milk in breastfed infants was evaluated using these techniques in Madagascar and Senegal (Fig. 4). In addition, body composition during pregnancy was evaluated as part of a CRP on foetal development. Stable isotope techniques were also used to determine energy expenditure and body composition in the elderly in several Member States, as well as in adults participating in a regional African project to evaluate the impact of food supplementation on nutritional status in people living with HIV/AIDS.

In support of its collaborative work with other intergovernmental and national organizations, and to promote the Agency's activities in human nutrition, a workshop was held during the International Nutrition Anaemia Consultative Group/International Vitamin A Consultative Group Meetings in Lima. In addition, technical meetings were held with WHO, the US Agency for International Development and IFPRI to investigate the use of stable isotopes in human nutrition. ■



FIG. 4. To monitor milk intake in infants, a (non-radioactive) deuterium dose is administered to the mother, followed by the collection of saliva samples from the baby.

Water Resources

Objective

To improve the integrated management of water resources, geothermal resources and specific water supply infra-structures through the use of isotope technology.

Isotope Methodologies for the Protection and Management of Surface Water, Groundwater and Geothermal Resources

Water resources management continued to be a priority issue on the international agenda during 2004. Following the 2003 International Year of Freshwater, the United Nations declared 2005–2015 as the “Decade for Action: Water for Life” to highlight the critical linkage between water and human development at all levels.

The Agency continues to be active in promoting this key linkage. A major initiative in this regard was the assistance provided to Egypt, Chad, the Libyan Arab Jamahiriya and Sudan for improving the management of the shared Nubian Aquifer system. Within the overall objective of strengthening the institutional, legal and analytical frameworks for the rational management and use of the aquifer, the Agency is assisting in building technical capacity for using isotopes to obtain critical hydrological data. The project is receiving funding from the UNDP/Global Environment Facility, and includes other partners such as UNESCO.

In cooperation with the International Association of Hydrologists, the Agency co-sponsored a roundtable meeting on the “World Groundwater Vision”. Held in Zacatecas, Mexico, in October, the roundtable was an important step in the process through which international organizations will develop a global strategic vision for groundwater use and protection, to be launched at the 4th World Water Forum in 2006. The quantification of the residence time of groundwater and the recharge parameter, for which isotope techniques such as tritium–helium isotope dating provide crucial information, will be among the key elements of this vision and the resulting strategic plans.

A key aspect of the Agency’s work in water resources management is building partnerships with international and national organizations. Notable

efforts to establish or strengthen such cooperation included:

- Collaboration with UNEP to publish a dictionary of analytical methods for the chemical and isotopic analysis of water;
- A joint workshop with the United Nations Economic and Social Commission for Asia and the Pacific to formulate strategies for the assessment and mitigation of groundwater contamination by arsenic and fluoride in the Mekong region of Southeast Asia;
- Participation in special sessions at meetings of the American Geophysical Union at which the Agency’s efforts in the global monitoring of isotopes in river water and precipitation were highlighted and discussed;
- Cooperation in the development and publication of a world hydrological map by the International Association of Hydrogeologists (IAH), German Geological Survey and UNESCO;
- Participation in a new initiative led by UNESCO/IHP, IAH and the United Nations Economic Commission for Europe to develop “Guidelines for Delineation of Protection Zones around Public Groundwater Supplies and Management Policy”;
- Expansion of the operational activities of the IAEA–UNESCO Joint International Isotopes in Hydrology Programme, including the convening of a regional training course in Egypt on the use of isotopic techniques for artificial recharge to address the increasingly critical issue of managing the recharge of aquifers in arid areas for drinking water.

A hydrological database to support Ethiopia’s national groundwater resource assessment programme was completed in cooperation with the US Geological Survey. The database will be a critical tool for groundwater assessment to supplement food production and drinking water supplies in times of drought. In addition, it is expected to help improve the planning and implementation of isotope based investigations through the Agency’s technical cooperation programme.

A regional project in Latin America on the sustainable management of groundwater resources was completed. Using a combination of tools, including isotope techniques, the major hydrogeological characteristics of aquifers in Chile, Colombia, Costa Rica, Ecuador, Nicaragua, Peru and Uruguay were determined. In some of the countries,

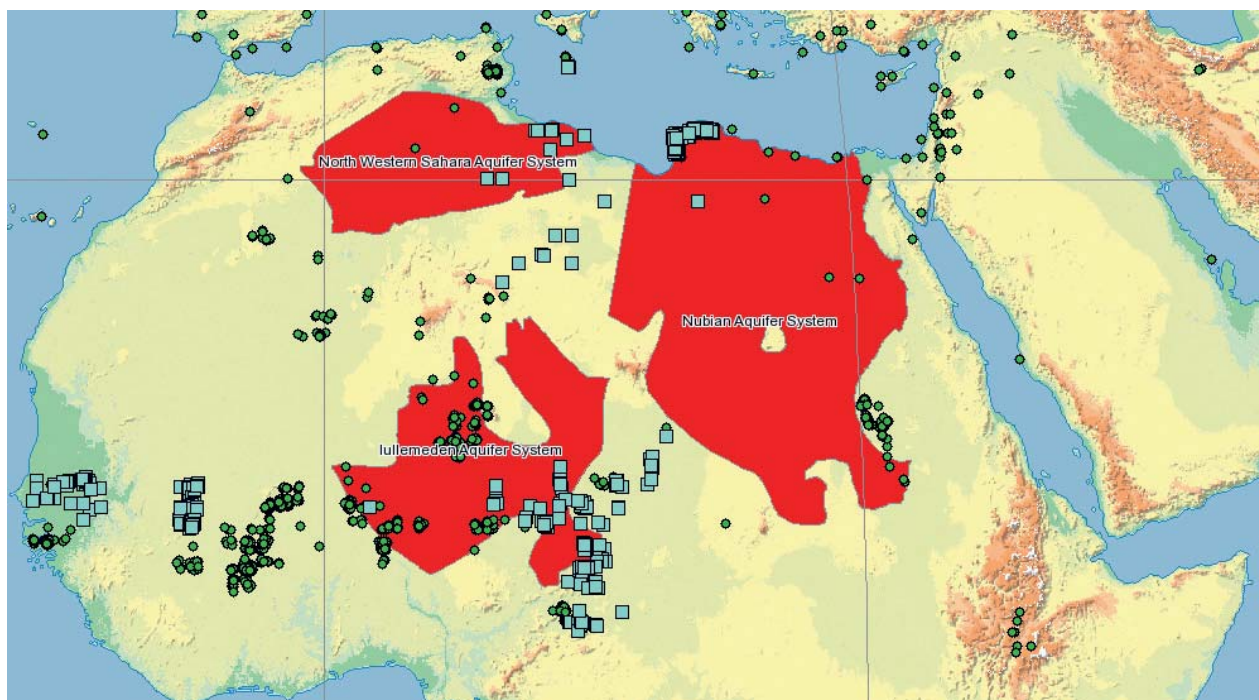


FIG. 1. Major shared aquifers (shown in red) in arid regions of Africa. The green circles represent ISOHIS stations and the greenish-blue squares depict water sampling points from the ISOHIS database that were used to generate this map.

project results were used to construct numerical models of aquifers, while in others information obtained on the aquifer recharge and residence time helped national water managers in their efforts to improve water supply and protection practices.

Eight countries in Asia received assistance in the use of isotope techniques for evaluating geothermal resources. The project strengthened national technical capacity for high quality chemical analysis of geothermal waters and in the planning and implementation of field investigations using isotope techniques. In related work, stable and radioactive isotope tracers were used to monitor reservoir hydrodynamics and inter-well hydraulic connections in China, Indonesia and Philippines.

A preliminary version of an Internet based cartographic system was completed in cooperation with the University of Vienna. The system will facilitate dissemination of the Agency's ISOHIS database for isotopes in precipitation, rivers and groundwater. Figure 1 shows an example of a map generated from the information in ISOHIS, depicting shared aquifers in arid regions of northern Africa, including the Nubian Aquifer system. Another important application of the precipitation isotope data is in improving the performance of global circulation models for simulating the Earth's water cycle.

Reference Isotope Data and Analysis for Hydrological Applications

An international symposium on "Quality Assurance for Analytical Methods in Isotope Hydrology" was held in Vienna in August. This was the first such meeting to focus on the state of the art in analytical techniques in isotope hydrology. The participants agreed that there was a need to expand efforts to ensure data quality through the establishment of laboratory quality systems. The Agency's role in providing international standards for isotope measurements was considered central to this task.

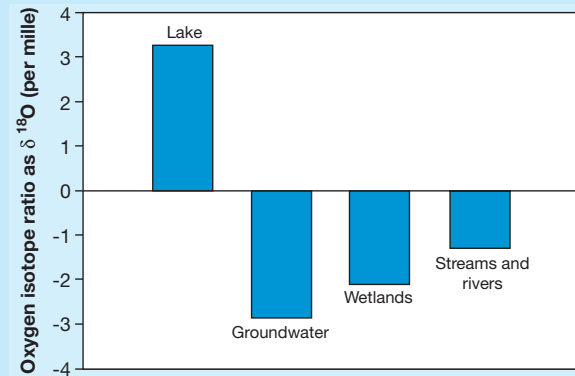
A CRP on the isotopic composition of precipitation in the Mediterranean basin in relation to air circulation patterns and climate was completed. The focus of the research was on providing a relationship between the origins and trajectories of respective air masses and the isotope contents in precipitation and atmospheric water vapour. The results are significant for the investigation of the processes responsible for precipitation and the impact of climate change and its variability on water resources in the Mediterranean region.

A guidebook on the use of chlorofluorocarbons (CFCs) in hydrology was completed, providing an

Isotope Studies for Better Management of Limited Water Resources

A sound understanding of the dynamics of water inflow and outflow is essential in order to better manage limited water resources within the Nile Basin. The Agency, together with the three Lake Victoria riparian countries and within the framework of the Nile Basin Initiatives, is implementing a project to improve capabilities for determining the water balance of Lake Victoria. The project is expected to provide crucial information on the different elements of the water balance, especially the groundwater and swamp components.

Isotope investigations in the Lake Victoria basin provided strong evidence that wetlands in the vicinity of the lake do not originate from lake water (see figure). This information, which was previously unknown, is critical to the understanding of the hydrology of the basin and for sustainable water management.



overview of dating groundwater with CFCs. The publication will help researchers in choosing an appropriate method for dating modern groundwater

under different hydrological environments, thus assisting Member States in their water resources management programmes. ■

Protection of the Marine and Terrestrial Environment

Objective

To enhance the capability of Member States in the use of nuclear techniques for the identification and mitigation of environmental problems caused by radioactive and non-radioactive pollutants.

The Marine Environment

Information on marine environmental levels of radioactive and stable isotopes is important to evaluate trends and to study oceanographic processes. This requires the quantification of natural and anthropogenic sources of radionuclides in the world's oceans and seas, computer modelling of the dispersion of radionuclides, and water and sediment dynamics studies.

In this connection, the Agency convened an international conference at IAEA-MEL, in Monaco, entitled 'Isotopes in Environmental Studies — Aquatic Forum 2004'. Specialized workshops during the conference were held on eastern Mediterranean marine processes, isotopic records of the El Niño phenomenon (for which the Agency recently initiated a CRP), ocean climate coupling (i.e. the processes that control the two way exchange of heat, energy and greenhouse gases), groundwater-seawater interactions and underground laboratories for low level environmental counting. The conference reviewed the latest applications of isotopes to marine geochemistry and biology, including pollution budgeting in coastal zones, marine food chain dynamics, and predictions of regional and global climate change using high resolution isotopic records in dated sediments and corals.

Supporting these applications is the Marine Information System (MARIS) database, developed by IAEA-MEL and launched in 2004. Containing validated data on marine radionuclides, stable isotopes and non-radioactive tracers supplied by Member States and the Agency, MARIS is available on the Internet at <http://maris.iaea.org/>.

In the field of marine radioecology, studies were carried out on seafood bioaccumulation of radionuclides and toxic heavy metals in tropical island species exposed to discharges from metal mining, and in natural and farmed populations of economically important finfish and shellfish. For

example, the bioavailability and impact of arsenic from fertilizer plants in Cuba and of nickel from mining in the French island of New Caledonia on local edible oysters and clams were investigated using radiotracer bioassays. Also, scallops from several European areas have been found to bioaccumulate high levels of cadmium close to or above regulatory thresholds. Radiotracer data will permit science based safety and environmental assessments to be made under actual environmental conditions.

The Agency has developed expertise in the measurement of ratios of naturally occurring uranium-238 and its decay product thorium-234 (U/Th method). These ratios can be used to determine the rates of vertical sinking and sedimentation of carbon in the ocean. IAEA-MEL participated in expeditions to the Antarctic, Mediterranean Sea and Pacific Ocean, organized by France, Germany and the USA, to complete the Agency's interregional comparisons of carbon export fluxes based on the U/Th method. The results will contribute to the first integrated estimate of the global ocean carbon sink for use in climate models.

Within the framework of the Agency's Analytical Quality Control Services programme, IAEA-MEL produced and distributed marine reference materials to over 120 participants in interlaboratory studies (Fig. 1). The results of these studies will be used to assign concentration values for the sample that can then be used as a reference material.



FIG. 1. Research and training at IAEA-MEL on pesticide extraction from marine biota. Shown in the inset is the gas chromatographic separation and detection of individual pesticides.



FIG. 2. Pollution sampling (top inset) and chromatographic analysis (lower inset) of sediments collected at one of the 35 shipwrecks located in and around Iraqi waterways.

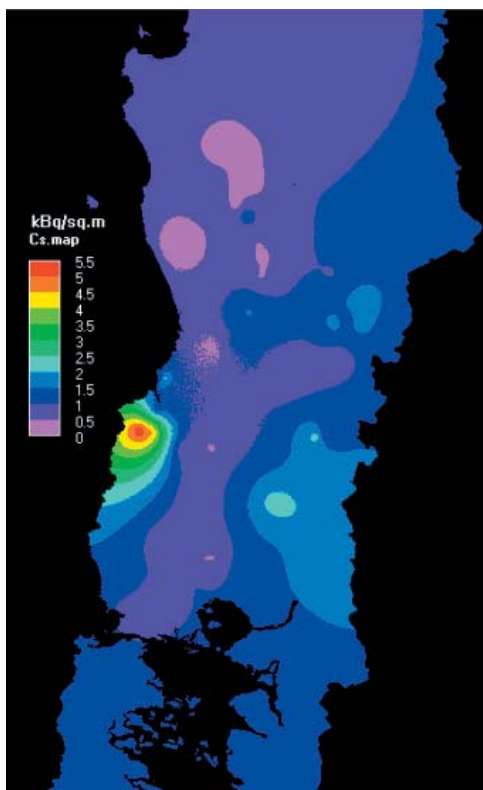


FIG. 3. Using GIS to support environmental decision making. Shown here is a caesium-137 deposition map for Chile produced using contouring techniques, together with data for rainfall and caesium-137 ground measurements.

The Agency assists regional training and marine survey programmes, including: Global Environment Facility–UNDP projects in the Caspian and Black Seas; UNEP’s Programme for the Assessment and Control of Pollution in the Mediterranean Region (MED POL); the Regional Organisation for the Protection of the Marine Environment (ROPME) in the Gulf. It also assists Member States under its technical cooperation programme. For example, the UNDP Iraq Programme provided funding to IAEA-MEL to coordinate an extensive pollution survey of marine sediments from around 35 shipwrecks in Iraq’s waterways. A wide range of persistent and toxic pollutants (heavy metals and petroleum hydrocarbons) were screened in over 190 sediment samples. Detailed analyses of hydrocarbons, pesticides and uranium isotopes were carried out for 20 samples (Fig. 2). The results are being used to ensure that salvage operations are conducted with minimum risk to people and the marine environment.

The Terrestrial Environment

A full assessment of the radiological consequences in the event of releases of radionuclides into the environment requires models and decision making tools that take into account the variable spatial and temporal factors governing the environmental behaviour of radionuclides, and consequently doses to humans. New analytical results were used to update parameter values for the prediction of the transfer of radionuclides, including plutonium, americium and naturally occurring radioactive materials, in different climatic environments and ecosystems in Africa, Antarctica, Asia, Australia, Eastern Europe and South America. However, the majority of currently available radioecological models have been developed for and tested in temperate environments only. As a result, the Agency began the development of models for other potentially important environments. In particular, a radioecological model for the prediction of caesium-137 behaviour in paddy fields and transfer to rice was developed and adapted for the specific conditions of several Asian countries.

The Agency assisted the Southern University of Chile and the German National Research Center for Environment and Health (GSF) in the development of an Environmental Decision Support System (EDSS) to facilitate estimation of the geographical distribution of caesium-137 fallout over defined regions of Chile (Fig. 3). The EDSS uses a Geographic

Information System (GIS) to assess potential contamination scenarios and remediation options adapted to local conditions.

Radionuclide bioavailability in soil-plant systems and transfer factors to plants were evaluated for the Semipalatinsk region of Kazakhstan. The evaluation was in support of the development of an integrated radiological assessment plan, as recommended in a resolution at the UN General Assembly's 57th session in 2002. Some specific parameters, such as those for radionuclide transfer from feed to local breeds of horses and sheep, remain under evaluation. Technical and methodological support was provided for the further development of DECODA (Design, Development and Demonstration of a Comprehensive and Systematic Database of the Semipalatinsk test site), a database compiling past and present data on the radiological situation on the test site. Using this information, an assessment was carried out of the current internal annual doses from caesium-137 and strontium-90 for people living within the test site and of the necessity for intervention. The main conclusion was that there

were some areas that needed to be excluded from agricultural use.

A new decision making framework to optimize forest countermeasures in the long term after contamination was developed. The framework uses a multi-criteria approach based on analysis of the main exposure pathways and the application of radiological, socioeconomic and ecological criteria for the selection of optimal countermeasure strategies for forest and thus terrestrial environments.

A World Bank mission to Belarus investigating the socioeconomic effects of the Chernobyl accident received support from IAEA-MEL in the form of technical guidance on radiological issues. This included assistance in devising agricultural countermeasures to reduce dose exposure and, where feasible, generate increased income. In addition, the findings of pilot studies on clean agricultural production and processing technologies were disseminated, and advice was given on environmental management requirements for the safe use of forest products and associated wastes, including those involving wood burning boilers. ■

Physical and Chemical Applications

Objective

To increase socioeconomic benefits in key sectors of Member States through the application of radioisotopes and radiation technology for producing goods and services which result in improved health care and industrial performance as well as effective quality control services.

Radioisotope Production and Radiopharmaceutical Development

One of the major goals of the Agency is to support Member States in the development of technologies for the local production and use of radioisotopes. In this regard, coordinated research commenced on the technology for the production of yttrium-90 and rhenium-188 for therapeutic use.

Immunoassays that are primarily used for clinical applications are also useful in other fields, such as livestock management, industrial hygiene, environmental surveillance, drug research and forensic applications. A CRP on the development of radioimmunoassays for non-clinical applications was completed during the year, which resulted in the development of three assay procedures. In order to aid livestock management, an immunoassay method was developed for the measurement of progesterone in milk samples. A method to measure aflatoxin B1 in food extracts was developed for monitoring contamination in food products. And an assay was developed to measure atrazine in environmental samples in support of environmental surveillance activities.

Nuclear and Radioanalytical Techniques

The detection, identification and removal of abandoned land mines remain a major challenge, and no new technology has been effectively deployed in the field to complement or replace metal detectors and manual prodding. As a result, clearing operations remain time consuming, costly and dangerous. In the framework of a recently completed CRP on the application of nuclear techniques to anti-personnel land mine identification, 13 research groups from 11 countries published their research

results in a special issue of the international journal *Applied Research and Isotopes*. One of the conclusions was that although individual sensors show promise, no single sensor operating alone appears able to reliably detect and identify land mines. Consultants recommended additional research efforts to determine how different sensors may be combined to enhance the ability to detect and characterize the wide variety of land mines found in the field. A new CRP on this subject is being formulated.

A new CRP on the applications of nuclear analytical techniques for the identification of art objects was initiated. The aim of this CRP is to demonstrate the utility of nuclear analytical techniques in establishing the authenticity of objects in the fields of art and archaeology for cultural heritage investigations and protection.

An expert group was commissioned to prepare a report on the role of nuclear analytical techniques in forensic investigations and the use of these techniques to meet the requirements of law enforcement agencies. Case studies and guidance on the appropriate handling of samples for police investigations will be included in the report.

The Agency continued to receive numerous requests for the training and certification of personnel in non-destructive testing (NDT) techniques. More than 40 scientists participated in Agency training courses in different regions. In addition, an 'NDT society' for AFRA countries was established with the support of the Agency.

Radiation Processing Technology and Applications

Advances were made in the development of new materials using radiolytic methods through a CRP on the radiation synthesis of stimuli responsive membranes, hydrogels and adsorbents for separation purposes. One particular hydrogel that was developed could ensure high efficiency in the removal of zinc, cadmium, cobalt and lead from wastewater. Other sorbents developed in this CRP can be applied for the purification of wastewater for recycling, as well as for the recovery of valuable metals used in electronics and other industries. Sorbents for the investigation of uranium recovery from sea water were also demonstrated. The research generated several proposals for technical cooperation



FIG. 1. Pilot plant for electron beam flue gas treatment at the Maritsa East 2 thermal power plant in Bulgaria.

projects from Member States affected by wastewater contamination problems. Field testing of the newly developed materials is foreseen as the next step.

Radiation treatment, or a combination of radiation technology with conventional biological–chemical–physical processes, can help in the remediation of contaminated surface water and in combating air pollution. In this connection, construction of an industrial scale plant commenced in the Republic of Korea following the successful operation of a pilot plant for wastewater treatment in a dye complex. With regard to atmospheric pollution, the Agency provided support for operation of a pilot plant in Bulgaria for the purification of flue gases from the combustion of high sulphur lignite (Fig. 1). Removal efficiencies of 95% for oxides of sulphur and 80% for oxides of nitrogen were recorded, illustrating the potential of this technology in treating different low grade fossil fuels. The fact that fertilizer is a by-product of the process makes it a particularly attractive technology.

Applications of Industrial Radiotracers

A new CRP was initiated on the use of radioisotopes as tracers to monitor processes for enhancing oil recovery and optimizing geothermal reservoir operation for power production. In the same area, research produced several case studies where radiotracer techniques could be used as a tool for the validation of computational fluid dynamics (CFD) models. The CRP led to the development of an educational software package providing guidance on the basic principles and applications of CFD and residence time distribution technologies.

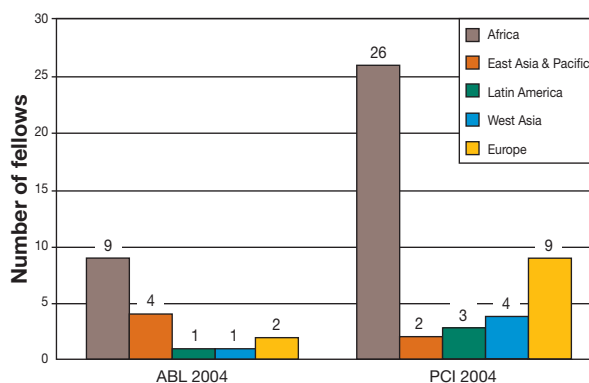


FIG. 2. Number of fellows receiving training in 2004 at the Agency's Laboratories at Seibersdorf, by geographical region (ABL: Agriculture and Biotechnology Laboratory; PCI: Physics, Chemistry and Instrumentation Laboratory).

The Agency's Laboratories at Seibersdorf

Activities at the Agency's Laboratories at Seibersdorf emphasize quality assurance procedures meant to improve confidence in the use of transferred technologies as well as to provide reliance on data generated by national and regional laboratories. The focus is on promoting techniques that contribute to environmental monitoring and



FIG. 3. The microparticle manipulation system assembled at the Agency's Laboratories at Seibersdorf.

assessment for sustainable development, with a strong emphasis on quality management leading to accreditation. The Laboratories also support the scientific and technical programmes of the Agency by providing experimental facilities and services. For example, the Safeguards Analytical Laboratory (SAL) conducts sample analysis for the Agency's safeguards verification programme. In 2004, SAL's Clean Laboratory analysed 620 environmental safeguards samples.

An important mission of the Seibersdorf Laboratories is to train scientists from developing countries in the use of nuclear techniques and

technologies. In 2004, the Agency hosted 61 scientific fellows for training in the various laboratories at Seibersdorf (Fig. 2).

A low-cost microparticle manipulation system was assembled and tested at the Agency's Laboratories at Seibersdorf. The system is based on a stereo microscope and operates in a single step, 'touch and go' mode (Fig. 3). When combined with analytical techniques such as X ray fluorescence or X ray tomography, it can be used for the characterization of individual microparticles and other microscopic objects. ■

Safety and Security



Safety of Nuclear Installations

Objective

To increase the capability of Member States to achieve and maintain a high level of safety and security in nuclear installations under design, construction or in operation.

National Regulatory Infrastructure for Nuclear Installation Safety

The Agency's International Regulatory Review Team (IRRT) service provides advice and assistance to Member States to strengthen and enhance the effectiveness of their nuclear safety regulatory body. In 2004, full scope follow-up IRRT missions were carried out in Armenia and China.

The IAEA–OECD/NEA Incident Reporting System (IRS) was set up to exchange information on unusual events at nuclear power plants, and to increase awareness of actual and potential safety problems. Currently, the IRS system contains about 3200 reports. In 2004, there were 74 new reports, slightly more than in 2003. The trend towards a reduced reporting delay continued in 2004, with the majority of full reports now being sent within one year of the event date. A similar network, the Incident Reporting System for Research Reactors (IRSRR), recorded an increase in the number of participating States — from 38 to 42, covering more than 90% of currently operating research reactors.

Information and Communication Networks and Global Infrastructure for Nuclear Installation Safety

The Agency continues to support a global nuclear safety regime based on strong national safety

infrastructures and widespread subscription to international legal instruments to maintain high levels of safety worldwide. Central to the Agency's role are the establishment of international safety standards and the provision for applying these standards, and the provision of support for the sharing of information. The Agency's involvement in the Asian Nuclear Safety Network (ANSN) is a case in point. This is a regional safety network set up to analyse and share existing and new knowledge and practical experience to further improve the safety of nuclear installations in Asia. The ANSN Steering Committee met in early 2004 and established topical groups on safety analysis, safety culture, education and training, and operational safety. The network entered into regular operation in 2004 with hubs in China, Germany, Japan and the Republic of Korea. A network hub at the Agency hosts the master index database. National centres are under development in Indonesia, Malaysia and Vietnam.

As part of its Strategy for Education and Training in Nuclear Installation Safety, the Agency continued to develop standard training packages in 2004. In addition, a module on self-assessment of nuclear power plants was completed. Distance learning tools for self-study were also developed. In this connection, a module on the operational safety of nuclear power plants was completed, and a special multimedia series on the nuclear safety standards was established.

Use of Advanced Tools for Safety Assessment

The Agency delivered and installed an Integrated Training and Accident Analysis System (ITAAS) for the Kursk nuclear power plant in the Russian Federation. An integrated software and hardware

The Agency's Safety Standards: A Status Report

The following standards dealing with the safety of nuclear installations were published in 2004:

- Format and content of the safety analysis report for nuclear power plants (GS-G-4.1);
- Protection against internal fires and explosions in the design of nuclear power plants (NS-G-1.7);
- Design of emergency power systems for nuclear power plants (NS-G-1.8);
- Design of the reactor coolant system and associated systems in nuclear power plants (NS-G-1.9);
- Design of reactor containment systems for nuclear power plants (NS-G-1.10);
- Protection against internal hazards other than fires and explosions in the design of nuclear power plants (NS-G-1.11).

system that includes deterministic analysis, training, reference and probabilistic analysis modules, ITAAS can be expanded to include other analysis tools. It provides plant personnel, technical support organizations and regulators with a comprehensive accident, safety and potential risk analysis capability. ITAAS can be configured for other nuclear power plants or nuclear installations and is flexible and modular to accommodate changes, modifications and additions that reflect technological and computational advances or new applications.

The development of probabilistic safety assessment (PSA) has become a regular requirement for every nuclear power plant in most countries. The Agency's International Probabilistic Safety Assessment Review Team (IPSART) service provides a peer review service to strengthen PSAs for safety related decision making during plant design and operation. Two IPSART missions were conducted in 2004 to verify the adequacy of modelling data and important methodology issues stemming from the development of the PSAs for the Tianwan plant in China and the Sizewell B plant in the United Kingdom.

Engineering Safety of Existing Nuclear Installations

Re-evaluation of the seismic safety of existing nuclear power plants in countries operating WWER type reactors was completed, along with substantial upgrading of facilities. The most important upgrades and technical fixes were carried out using deterministic approaches as developed mainly in the USA but adapted to the specific conditions of WWERs. The nuclear power plants that were re-evaluated were Kozloduy (Bulgaria), Paks (Hungary), and Mochovce and Bohunice (Slovakia). The Armenia nuclear power plant was also reviewed, focusing on the actions required for a full and comprehensive assessment programme.

The use of probabilistic methods is under way at a number of sites and plants to complement the assessment and upgrades performed using deterministic approaches. In 2004, probabilistic seismic hazard assessments for the Cernavoda nuclear power plant in Romania and the Armenia plant were reviewed as part of the Engineering Safety Review Service provided by the Agency.

The scope and title of the extrabudgetary programme on the safety aspects of the long term operation of PWRs — established in 2003 — were changed to include all water moderated reactors.

The programme's activities are guided by a steering committee, which met once in 2004, and are being implemented through four working groups, which also met during the year. A quality assurance manual was developed and a 'standard review process' was finalized as part of this programme.

Operational Safety

The Agency's Operational Safety Review Team (OSART) service recorded some notable achievements in 2004. Out of the six OSART missions conducted (plus one Pre-Commissioning OSART mission and three follow-up visits), four were to Member States with developed nuclear programmes. Of particular note were the invitations received by the Agency to conduct OSART missions in the Russian Federation and the USA on a three year schedule to coincide with the Convention on Nuclear Safety review process.

OSART mission results have shown overall improvements in the material condition of structures, systems and components, as well as improvements in management goals and staff training programmes. Most OSART recommendations focus on areas of procedure and policy implementation, adherence to and enforcement of industrial safety work practices, management oversight and enforcement of nuclear safety work practices, and implementation of operating experience programmes for low level events and near misses.

Another Agency service, the Peer Review of the Effectiveness of Operational Safety Performance and Experience Review process (PROSPER), serves as a basis for an enhanced review of operating experience as part of OSART missions. In 2004, a PROSPER workshop was held in China, and preparatory meetings and seminars were held in Pakistan and Spain.

Evolutionary and Innovative Reactors

A methodology based on the integration of risk informed concepts for defence in depth was developed to assess the safety of evolutionary and innovative reactors. This methodology has been used to develop a set of safety requirements applicable to any type of reactor. In addition, a technical document was prepared and will be published in 2005. (The Agency's work in the area of innovative nuclear reactors is discussed in greater detail in the Nuclear Power chapter of this report.)

Research Reactor and Fuel Cycle Facility Safety

The Code of Conduct on the Safety of Research Reactors — a non-binding international legal instrument — provides guidance to States on the development and harmonization of policies, laws and regulations, and recommendations on best practices in the management of research reactor safety. It was adopted by the Agency's Board of Governors in March, and endorsed by the General Conference at its regular session in September.

The Agency continued to receive responses to a survey of research reactor safety initiated in 2002. Overall, the responses indicated that operational safety and regulatory supervision were being handled in a reliable and effective manner, and that attention should be focused on quality assurance, radioactive waste management and emergency preparedness. All of the reactors that were reported to be operational or shut down also had some form of independent supervision, mostly from a formal regulatory body. Most of the responses indicated that the shutdown reactors were planned for restart or decommissioning.

The Agency, through its Integrated Safety Assessment of Research Reactors (INSARR) service, conducted a pre-INSARR mission to the Netherlands to define the scope and prepare for a future mission. One full mission was conducted in the Democratic Republic of the Congo and four follow-up missions were conducted to Bangladesh, Chile, Greece and Romania to evaluate progress in the implementation of recommendations from previous missions. In addition, seven safety missions were conducted to address specific topics. Of these 13 missions, six



FIG. 1. Commissioning of the Zaria research reactor in Nigeria.

involved research reactors under Agency project and supply agreements. The Agency also assists Member States in the safe operation of their research reactor facilities (Fig. 1).

The safety of fuel cycle facilities is a relatively new area of activity for the Agency. Guidelines to assist Member States in promoting continuous improvement of the operational safety of their fuel cycle facilities through the use of good practices were developed and validated at a Technical Committee meeting in December. And the Agency, in cooperation with the OECD/NEA, is developing a 'Fuel Incident Notification and Analysis System' (FINAS) for sharing information on significant events, analyses and lessons learned. In December 2004, the first Technical Committee meeting of FINAS national coordinators endorsed the FINAS guidelines, as well as development of an Internet based system. ■

Radiation and Transport Safety

Objective

To achieve global harmonization and raise the levels of protection of people against radiation exposure and of safety and security of radiation sources, and to ensure that the Agency properly discharges its health and safety responsibilities with regard to its own operations.

National and Global Infrastructure Enhancement for Radiation and Transport Safety

Many States have engaged in extensive programmes to enact legislation and establish a regulatory infrastructure that take into account the relevant IAEA Safety Standards and international legal instruments.¹ The importance of the Agency's role in supporting the development of national infrastructures for radiation safety, and in particular national regulatory infrastructures, was highlighted in a number of General Conference resolutions going back to 1999.

A prominent example has been the technical cooperation model project on upgrading radiation protection infrastructure. The total number of Member States participating in projects in their region increased to more than 90 by December 2004. By the end of 2004, 48 participating States (55%) had established a regulatory framework and control of occupational exposure control. In most participating Member States, however, substantial work is still required to establish medical and public exposure

control, and emergency preparedness and response capabilities.

The Agency is substantially strengthening its activities for promoting regulatory infrastructure in Member and non-Member States (mainly using extrabudgetary resources). This is being done primarily through the Radiation Safety Infrastructure Appraisal (RaSIA) service, the Regulatory Authority Information System (RAIS 3.0), training packages for regulators in the most relevant medical and industrial practices, and establishment of the Radiation Safety Regulators Network. Also, an Internet based system to promote the pooling and sharing of radiation safety information among national regulatory authority experts is now operational. RaSIA missions were conducted in 21 States in 2004, and 3 regional workshops on the use and maintenance of RAIS were organized in the African, European and East Asian regions.

After many years of deliberations, international consensus was reached with the publication of a Safety Guide on the application of the concepts of exclusion, exemption and clearance. This publication establishes levels of radionuclide activity concentrations in materials below which regulatory controls need not apply.

Information and Communication Networks for Radiation and Transport Safety

To promote the sharing of knowledge and expertise on nuclear safety, the Agency is assisting in the establishment of regional nuclear and radiation

The Agency's Safety Standards: A Status Report

The following safety standards dealing with radiation and transport safety were published during 2004:

- Regulatory control of radiation sources (co-sponsored by FAO, ILO, PAHO, WHO) (GS-G-1.5);
- Application of the concepts of exclusion, exemption and clearance (RS-G-1.7);
- Regulations for the safe transport of radioactive material 1996 edition (as amended 2003) (TS-R-1).

¹ INTERNATIONAL ATOMIC ENERGY AGENCY, *International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources*, IAEA Safety Standards Series No. 115 (1996); *Legal and Governmental Infrastructure for Nuclear, Radiation, Radioactive Waste and Transport Safety*, IAEA Safety Standards Series No. GS-R-1 (2000); *Code of Conduct on the Safety and Security of Radioactive Sources*, IAEA/CODEOC/2004, special publication, (2004).

safety networks, such as the Ibero-American Radiation Safety Network. In 2004, a preliminary structure for this network was developed and tested.

An inter-centre network to facilitate communication and information exchange among the Agency's regional, national and collaborating training centres is now in operation. Validated training packages, documents, and reports from member training centres are available to the members of this network on its web site.

Occupational Radiation Protection

In September 2003, the Board of Governors approved an *Action Plan for Occupational Radiation Protection*, developed by the Agency in cooperation with the ILO. In addition to assisting States in establishing, maintaining and, where necessary, improving programmes for the radiation protection of workers, the Action Plan includes activities related to exposure to enhanced natural radiation in the workplace. Follow-up activities in 2004 by the Agency and ILO included the convening of the first meeting of a steering committee in Vienna in February to set priorities, with further meetings planned at 12–18 month intervals. In addition, a Safety Reports Series publication on *Occupational Radiation Protection in the Mining and Processing of Raw Materials*, co-sponsored by the Agency and ILO, was published.

In addition, the Agency provided substantial technical support to more than 90 Member States in establishing their occupational exposure control programmes, mainly through its technical cooperation Model Project on upgrading radiation protection infrastructure. More than 80% of the participating States had established a system for individual monitoring that covers workers with the highest exposure risk.

Radiological Protection of Patients

At its 2004 meeting, the steering panel overseeing the Action Plan on the Radiological Protection of Patients decided that the Internet should be used to disseminate patient radiation protection information to those prescribing and using radiation in medical applications. The Agency thereafter developed a prototype web site that will include training material for health professionals. This prototype will be discussed with other international organizations and professional bodies, whose involvement is seen as essential for its success.

In a series of meetings of experts, manufacturers and representatives of the International Electrotechnical Commission, a document was drafted that defines what is needed to standardize, display and record data on patient doses for computed tomography, fluoroscopy and interventional techniques. Other work in the area of radiation protection included:

- Development of a methodology for establishing local guidance (reference) levels for diagnostic radiology, and its application in a regional project involving 11 Latin American Member States.
- Launching of pilot projects on image quality improvement and patient dose reduction in Jordan, Kazakhstan, Kuwait and the Republic of Moldova;
- Convening of a workshop for cardiologists to raise awareness of the importance of managing the high dose procedures involved in interventional radiology;
- Provision of training packages on radiation protection in all medical applications of radiation;
- Research on the proper balance between image quality and patient dose in interventional procedures, digital radiology and computed tomography.

Control of Radioactive Sources

By the end of 2004, 70 States had expressed their support for and intent to work towards following the Code of Conduct on the Safety and Security of Radioactive Sources. One section of the Code is devoted to the import and export of high activity radioactive sources. Guidance on this issue was approved by the Board of Governors in September 2004.

Also in 2004, the Commission on Safety Standards approved a Safety Guide on the categorization of radioactive sources. This categorization had been used as the basis of the Code of Conduct. In September 2004, the Board of Governors approved an Agency policy for promoting effective and sustainable national regulatory infrastructures for the control of radiation sources.

Orphan radioactive sources have caused fatal or serious injuries to the unknowing individuals who have found them. This problem, along with concerns that orphan or vulnerable sources might be acquired for malicious purposes, has led many countries to consider making concerted efforts to improve control over them. An Agency technical document (IAEA-TECDOC-1388) provides an

appropriate methodology for strengthening control over radioactive sources in authorized use and in regaining control over orphan sources. The Agency is assisting Member States in applying this methodology to develop their national strategies for improving control over radioactive sources, including orphan sources. In this regard, missions visited Bolivia, Kazakhstan, Lithuania, Panama, Ukraine and Uruguay in 2004. Follow-up work for earlier missions, such as the provision of technical assistance to secure vulnerable sources, focused on the Philippines and the United Republic of Tanzania.

Under the 'Tripartite Initiative' between the Agency, the Russian Federation and the USA on securing and managing radioactive sources:

- Vulnerable sources were dismantled and transported in safe and secure storage in Estonia, the Republic of Moldova and Tajikistan;
- Technical designs and preparations for similar work were completed in Azerbaijan, Belarus, Kazakhstan and the Republic of Moldova;
- A fact-finding mission was conducted in Uzbekistan.

Safety of Transport of Radioactive Material

In March 2004, the Board of Governors approved an Action Plan for the Safety of Transport of Radioactive Material, which provides direction for the Agency's transport safety activities over the next five years. Action areas include review and revision of the *Regulations for the Safe Transport of Radioactive Material* (Transport Regulations), refining of the review process, compliance and quality assurance considerations, the issue of denial of shipments, emergency response, liability and communication. A number of activities have already taken place under the Action Plan. With regard to the issue of denial of shipments, a fact-finding forum was held in July to identify the reasons and possible solutions. In September, a panel to review the Transport Regulations had its first meeting.

During 2004, a Transport Safety Appraisal Service (TranSAS) mission was completed in France. A

preparatory mission to Japan was also undertaken for a TranSAS mission to be carried out in 2005.

In November, the Board of Governors approved the 2005 edition of the Transport Regulations.

Preparedness for and Response to Nuclear or Radiological Emergencies

The Agency provides a number of services to assist Member States with emergency preparedness and response. It also participates in the Joint Radiation Emergency Management Plan of the International Organizations. In 2004, a new edition of the plan was issued.

The Agency was informed of 38 events involving, or suspected to involve, ionizing radiation in 2004. In 19 of these cases, States notified the Agency of the event, requested that official information be provided, or requested assistance pursuant to the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (Assistance Convention). In the other 19 cases, individuals or the media informed the Agency. In all cases, the Agency carried out the appropriate actions, such as verifying the information, providing official information or assistance to the requesting party, or offering the Agency's good offices. In one case, specialized medicine was provided urgently for the treatment of a victim of an incident at Lia, in Georgia, in response to a request made under the Assistance Convention.

At the second meeting of competent authorities for the Convention on Early Notification of a Nuclear Accident and the Assistance Convention, participants highlighted the need to harmonize communication and assistance among States to allow for the best use of technologies and capabilities. The competent authorities agreed to work with the Secretariat to develop an action plan. Subsequently, such a plan — entitled Strengthening the International Preparedness and Response System for Nuclear and Radiological Emergencies — was approved at the June meeting of the Board of Governors.

Management of Radioactive Waste

Objective

To increase global harmonization in the policies, criteria, standards and provisions for their application, as well as in methods and technologies, for achieving safety in radioactive waste management, in order to protect humans and their environment against health effects attributable to actual or potential exposure to radioactive waste.

Protecting the Public and the Environment

There are clear international standards for controlling releases to protect the public and, according to UNSCEAR estimates, doses to humans from these such releases are negligible. However, public attention is now being focused on protecting non-human biota. Although radiation effects on biota have been studied, the existing international guidance on radioactive discharge control and intervention does not contain explicit recommendations on biota protection. At an international conference on the Protection of the Environment from the Effects of Ionizing Radiation, held in Stockholm in 2003, a framework for protecting non-human biota was established. As a follow up, a number of consultations were held during 2004 for drafting an international action plan on the radiation protection of the environment.

In related work, the Agency set up a project on Environmental Modelling for Radiation Safety (EMRAS). This project will evaluate and optimize the various models of radioactivity transfers from a nuclear source to a member of the public or biota.

The United Nations Chernobyl Forum is an Agency project related to the implementation of the 2002 UN system-wide initiative known as the 'Human Consequences of the Chernobyl Nuclear Accident — A Strategy for Recovery'. Under the framework of this initiative, the Agency organized three meetings of the forum and five meetings of an Expert Group on the environment. In parallel, WHO held a series of meetings of their Expert Group on health. The Forum's technical report was completed in 2004 and submitted for comments to Forum

participants, after which it will be discussed at the April 2005 meeting of the Forum. An international conference entitled 'Chernobyl: Looking Back to Go Forward' is also planned for September 2005.

Safety of Radioactive Waste Management and Disposal

In 2004, the General Committee for the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management reviewed the experience of the First Review Meeting and recommended improved arrangements for adoption by the next meeting of Contracting Parties in 2006.

Work continued on implementing the Action Plan on the Safety of Radioactive Waste Management — approved by the Board of Governors in 2000 and revised in 2003. For example, the Agency and OECD/NEA held meetings on co-sponsoring international safety standards for geological disposal.

Member States are making increasing use of the internationally harmonized safety assessment approach developed within the ISAM¹ project to review the safety of low and intermediate level waste disposal facilities. Applying this methodology to a number of older facilities in Eastern Europe has identified problems with the disposal of long lived and high activity sealed sources in some facilities.

In December 2004, the Agency held an international symposium on the Disposal of Low Activity Radioactive Waste, in Cordoba, Spain, as a forum to discuss policies and strategies for low level waste management. One of the main findings at the symposium is that the Agency classification scheme should be revised to be more closely linked to an overall scheme for managing all types of radioactive waste in which each waste type is identified with a suitable disposal route.

Safety Reports Series No. 35, *Surveillance and Monitoring of Near Surface Repositories for Radioactive Waste*, was published in 2004. It provides Member States with advice and examples of good practices in relation to surveillance and monitoring programmes for near surface disposal facilities.

¹ 'Improvement of Safety Assessment Methodologies for Near Surface Disposal Facilities for Radioactive Waste' (an Agency CRP that ran from 1997 to 2000).

A report on the *Implications of Partitioning and Transmutation in Radioactive Waste Management* (Technical Reports Series No. 435) was published. Focusing on the radioactive waste aspects of partitioning and transmutation, the publication provides technical information for decision makers on the possible long term consequences of current decisions in managing waste.

The final report of a CRP on the long term behaviour of low and intermediate level waste packages under repository conditions was published as IAEA-TECDOC-1397. The CRP helped promote R&D on waste package performance, as well as facilitating information exchange in this area.

In smaller countries without a large legacy of wastes, the concept of regional repositories is appealing. An Agency publication, *Developing Multinational Radioactive Waste Repositories: Infrastructural Framework and Scenarios of Cooperation* (IAEA-TECDOC-1413), reviews various aspects of such repositories for Member States interested in sharing disposal facilities for radioactive waste and/or spent fuel.

Decommissioning

In June 2004, the Board of Governors approved an action plan on the decommissioning of nuclear facilities. One of the first activities completed under the Plan was the publication of a special report on the *Status of the Decommissioning of Nuclear Facilities*

around the World. This report seeks to quantify the level of effort that will be required by the industry in order to safely carry out the necessary decommissioning tasks. As shown in Fig. 1, the total cost of decommissioning all types of nuclear facilities is approximately \$1 trillion over the period 2001–2050.

A point of concern has been the lack of internationally acceptable standards for the release of material from regulatory control following decommissioning activities. In September 2004, the Agency — along with the European Commission — co-sponsored an OECD/NEA workshop hosted by the Nuclear Plant Management Company, in Italy, and the Italian Agency for Environmental Protection and Technical Services on Safe, Efficient and Cost-effective Decommissioning. The participants noted that the IAEA Safety Standards Series publication *Application of the Concepts of Exclusion, Exemption and Clearance* (RS-G-1.7), now provides this guidance.

Safety Reports Series No. 36, *Safety Considerations in the Transition from Operation to Decommissioning of Nuclear Facilities*, and Technical Reports Series No. 420, *Transition from Operation to Decommissioning of Nuclear Installations*, were published in 2004. These reports support and extend the recommendations given in the Agency's Safety Guides. They highlight technical, management and organizational issues arising during the transition period from operation to decommissioning, and provide guidance to minimize delays and undue costs, optimize personnel and

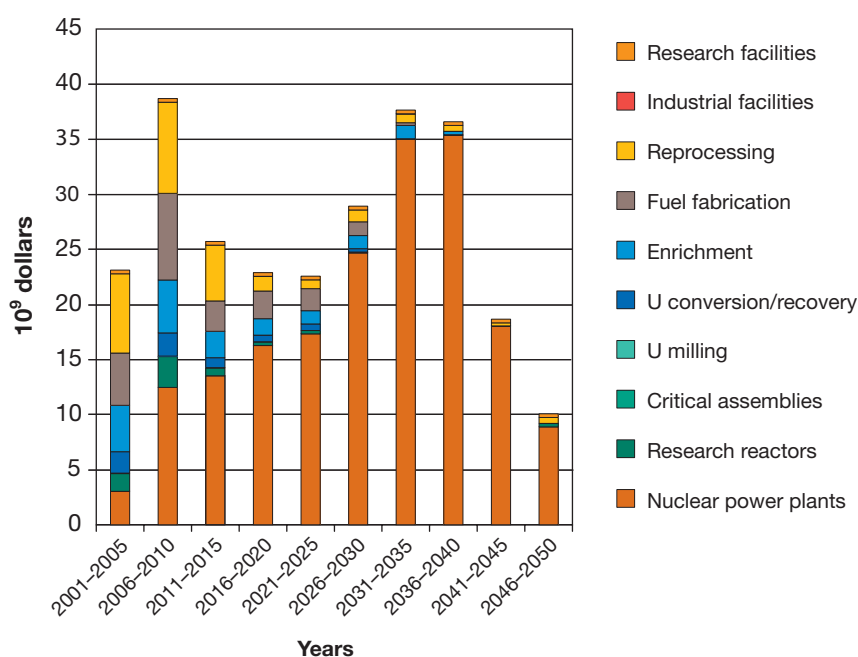


FIG. 1. Decommissioning costs for different types of nuclear facilities over the period 2001 to 2050.

other resources, and initiate preparatory activities for decommissioning.

Many organizational and management needs arise during the course of decommissioning projects. A technical document published in 2004, *Planning, Managing and Organizing the Decommissioning of Nuclear Facilities: Lessons Learned* (IAEA-TECDOC-1394), presents the major issues and practical experience gained in the decommissioning of some large scale nuclear installations.

Restoring Contaminated Sites

Parts of the surface environment in a number of Member States have been contaminated with radioactive residues. Contamination of the environment has also been caused by existing nuclear practices. The affected areas and sites range in size from small areas within industrial premises to large mill tailings piles and weapons test sites that cover hundreds of square kilometres. The Agency is leading an initiative, together with the OECD, EBRD and the World Bank, to assist a number of countries in central Asia in restoring uranium mining and milling sites in their territory. The Agency is also working with the Kazakhstan Government, the European Commission and NATO to identify the remaining radiological concerns at the former nuclear weapons test site at Semipalatinsk. In another mission, the Agency completed a preliminary assessment of the radiological conditions at the former French test sites at In Ekker and Reggane, in Algeria.

Safety Assessment Projects

In 2004, the intercomparison of safety assessment methodologies was extended with the establishment of a new project known as Safety Assessment Driving Radioactive Waste Management Solutions. The goal of this project is to examine different approaches

to the safety assessment of activities involving the predisposal of radioactive waste, including waste conditioning and storage.

Another project initiated in 2004 — Evaluation and Demonstration of the Safety of Decommissioning of Nuclear Facilities — aims to develop a harmonized methodology for evaluating and demonstrating safety during decommissioning and to produce model safety assessments for selected nuclear facilities by applying this methodology.

Radioactive Waste Management Services

At the request of the Australian Government, the Agency undertook an international peer review of the licence application submitted by the Australian Department of Education Science and Training to develop a near surface radioactive waste disposal for low level and short lived intermediate level waste. The Agency's international review team used the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management and the international radioactive waste safety standards as the basis for its assessment. The team concluded that the process of site selection has been thorough and that the selected site offered good prospects of meeting internationally endorsed safety objectives and criteria. However, further work was considered necessary to demonstrate safety before regulatory approval of construction and operation of the facility.

The Agency conducted a mission to review the Czech Radioactive Waste Repository Authority's Deep Geological Repository Development Programme. During the course of the mission, the team of experts met with the authority's senior management and its Board, plus representatives from the Ministry of Trade and Industry and various stakeholders involved in the siting process.



Nuclear Security

Objective

To increase State awareness and ability to control and protect nuclear and other radioactive materials, nuclear installations and transports, from terrorist and other illegal activities, and to detect and respond to such events and provide engineering safety measures, as necessary.

Assessing Nuclear Security Needs, Analysis and Coordination

Integrated Nuclear Security Support Plans (INSSPs) have become central to implementing improvements to nuclear security in States. An INSSP offers a centralized platform for work to be done over an extended period of time. By the end of 2004, 12 INSSPs had been developed and transmitted for agreement, and five States had submitted letters indicating agreement.

The Agency's International Nuclear Security Advisory Service (INSServ), which is available to States upon request, involves missions to States by expert teams to assess the need for additional or improved measures related to nuclear security. The recommendations generated by the INSServ team provide a platform for the more specific nuclear security assistance provided subsequently through Agency programmes, or through bilateral assistance. In 2004, INSServ missions visited Argentina, Colombia, Indonesia, Malaysia, Morocco, Nigeria, Serbia and Montenegro, Tunisia, Uruguay, Venezuela and Yemen.

Another service offered by the Agency, the International Physical Protection Advisory Service (IPPAS), reviews physical protection systems related to nuclear material. In addition, an IPPAS type service to assess the physical protection of other radioactive material is currently under development. Three IPPAS missions were conducted in 2004, in addition to other preparatory and follow-up missions.

The design basis threat (DBT) methodology provides the foundation for a State's system of physical protection. In efforts to promote the DBT concept, the Agency provided State officials responsible for the nuclear security of facilities and for the physical protection of nuclear material with basic information about the DBT and its

development methodology. In addition, the Agency conducted workshops to assist authorities in Brazil, Bulgaria, Islamic Republic of Iran, Mexico, Peru and the Philippines in the development and maintenance of their own DBT concept.

A "Contribution Agreement" was signed in December 2004 with the European Commission establishing the modalities for the European Union's support, through the Nuclear Security Fund, to the Agency's efforts to secure nuclear and other radioactive material, including those in non-nuclear use, and to enhance detection and response capabilities in a number of States across southeastern Europe and Central Asia. Following an evaluation of needs, projects will be implemented in three fields: strengthening the physical protection of nuclear material and of other radioactive material in use, storage and transport, and of nuclear facilities; strengthening the security of radioactive materials in non-nuclear applications; and strengthening State capabilities for the detection of and response to illicit nuclear trafficking.

The nuclear security training programme for 2004 included approximately 40 courses covering nuclear security awareness, combating illicit trafficking, training in the use of detection equipment, physical protection, and nuclear forensics (Fig. 1). Other relevant courses cover State systems of accounting for and control of nuclear material and inventory management systems for radioactive sources. In addition, Ukraine is being assisted in establishing an undergraduate education curriculum in nuclear security, material protection and accountability.

Technical, Administrative and Regulatory Arrangements in States to Protect and Control Nuclear Material

Radioactive sources are used in numerous industries throughout the world and, because of their vast number, their protection is a challenging task. Despite the difficulty of this task, the Agency is actively involved in building awareness internationally about the need to control and physically protect radioactive sources at their locations. As the Code of Conduct on the Safety and Security of Radioactive Sources, which was finalized in 2003, states, "the prime responsibility for the safe



FIG. 1. Participants at a regional training course on the practical operation of physical protection systems, Obninsk, Russian Federation.

management of, and security of, radioactive sources [is] on the persons being granted the relevant authorizations”.

Accordingly, during the 11 INSServ missions performed in 2004, broad assessments were made of the security of sources in the respective countries. The Agency conducted two regional training courses on the security of sources and one regional awareness seminar for managers and decision makers on the Code of Conduct. The Agency also continued an important project on developing national strategies for regaining control of orphan sources by hosting a workshop in October.

The Agency entered into a regional partnership with Australia and the USA to increase awareness of the need for the security of sources and to train regulators and users in Southeast Asia. The Agency also continued its efforts to help States develop regulatory infrastructures for the safety and security of sources. In this regard, approximately 21 missions were conducted during the year. And within the framework of its partnership with the Russian Federation and the USA under the ‘Tripartite Initiative’ to dismantle and relocate high activity, vulnerable sources in the former Soviet Union, the Agency completed one contract and negotiated five others for relocating dangerous sources to more secure locations in this part of the world.

The Agency continued to assist States in drafting national legislation in the field of nuclear security, including the development of a legislative framework featuring the basic requirements and procedures for the control of radioactive sources and the physical protection of nuclear material. To facilitate this process, a technical document on

Strengthening Control over Radioactive Sources in Authorized Use and Regaining Control over Orphan Sources: National Strategies (IAEA-TECDOC-1388) was published. Work on this document began at a time when the primary concern was with providing guidance to States on their strategies for controlling radioactive sources in order to prevent accidents. However, it was later recognized that the methodology for identifying and regaining control over orphan sources also contributes to enhancing nuclear security in States.

A report providing guidelines for the identification of vital areas relevant to the protection of nuclear facilities against sabotage was drafted at a meeting of physical protection and international nuclear safety experts. It describes how vital structures, systems and components can be identified for security review, and presents methodologies for protecting them against malicious acts. Another report on guidelines for the self-assessment of engineering safety aspects of the physical protection of nuclear facilities against sabotage integrates safety and security issues related to sabotage at a nuclear installation. These draft guidelines have already been used at several workshops on this subject.

Physical protection against malicious acts by personnel with authorized access is the subject of a project between France and the USA, and coordinated by the Agency. In 2004, work began on a technical document that includes a methodology for addressing ‘insider threats’, specifically with respect to both physical protection against unauthorized removal and sabotage. This publication is intended to provide the foundation for ‘insider threat workshops’ that are being developed in parallel. Work also began on a technical document on improving the capabilities of a nuclear power plant to respond to conditions created by a terrorist attack. The objective is to plan actions that would prevent a potential release of radioactivity.

Detection and Response to Activities Involving Nuclear and Other Radioactive Material

If protection and control of nuclear or other radioactive material should fail, States need effective capabilities to detect, interdict and respond to theft of and illicit trafficking in these materials, as well as to sabotage and threats thereof. The Agency assisted States in the enhancement of these capabilities by conducting evaluation missions, which frequently

resulted in requests for training courses for front line officers. Additionally, the Agency held awareness seminars for managers and decision makers, addressing such issues as the integration of technology into work environments and the continued support from the Agency that is required in the areas of training and sustainability.

An important benefit of nuclear security training initiatives was feedback on instruments used by the participants. User friendliness and accuracy evaluations were compiled and made available to the designers and manufacturers of the equipment. The Agency also conducted topical seminars on the use of instruments and equipment, such as a course on the use of hand-held isotope identification instruments. As a result of the Agency's evaluation missions, upgrades to border monitoring equipment were initiated in Azerbaijan, Belarus, Bosnia and Herzegovina, Croatia, Georgia, The Former Yugoslav Republic of Macedonia, Serbia and Montenegro, the United Republic of Tanzania and Ukraine.

The Agency continued its efforts to strengthen response measures in States. Training on combating nuclear terrorism and incidents involving illicit trafficking in nuclear and other radioactive materials were held in Azerbaijan, Belarus, Bolivia, Georgia, Malaysia, Poland, Romania, Serbia and Montenegro, the United Republic of Tanzania and Turkey. The Agency also carried out an incident response mission to the Netherlands.

The Illicit Trafficking Database (ITDB) continued to expand, both in the number of participating States and the reported incidents. In 2004, there were 81 States participating in the ITDB; a total of 121 incidents were reported by States, 93 of which occurred during 2004 (Fig. 2). This is the highest number of incidents confirmed to the ITDB in a single year since 1993.

In fact, 2004 saw the first increase in the number of confirmed incidents involving nuclear materials since 2001, demonstrating better reporting by Member States, and highlighting the continuing concern posed by nuclear trafficking. One trafficking incident, which was confirmed to the Agency in 2004 but occurred in 2003, involved about 170 g of high enriched uranium (89%). It is also noteworthy that a number of incidents involved the illegal possession of nuclear material, or the intent to sell it.

The data also indicate a continuation of a gradual increase in the annual number of confirmed incidents involving radioactive sources. This illustrates a persisting problem with the security of radioactive sources worldwide, including high risk, dangerous radioactive sources, and a continuing need: to improve the control and protection of these substances; and for measures to detect and respond to such events. Incidents dealing with theft, illegal possession, or intent to illegally sell radioactive sources point to the potential availability of radioactive sources for malicious use. And incidents

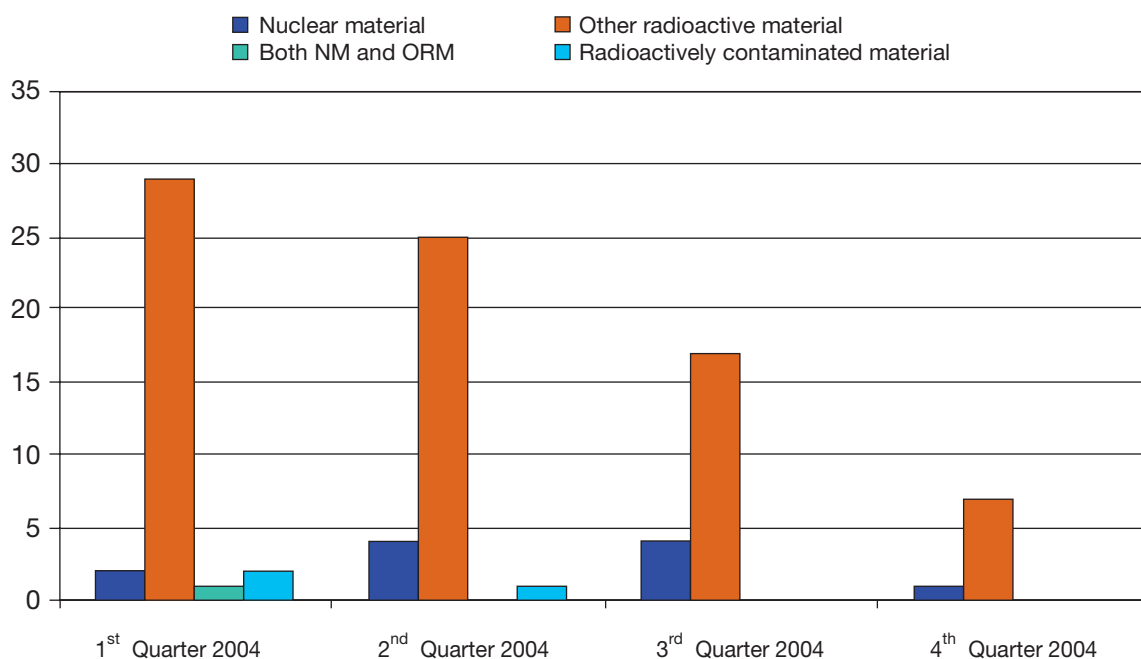


FIG. 2. Confirmed incidents in 2004 as reported to the ITDB (NM: nuclear material; ORM: other radioactive material).

involving the discovery of radioactive sources in metal scrap signify risks to the environment, and may also indicate the attempted breach of environmental regulations through the unauthorized disposal of radioactive sources.

A CD-ROM containing information on illicit trafficking incidents was distributed to participating States and international organizations. Meetings and other exchanges between the Agency and international organizations, including the Organization for Security and Cooperation in Europe and Interpol, established bases for bilateral cooperation and mutual support. Finally, ITDB Quarterly Reports offering evaluation and statistics were issued to States and to international organizations. The importance of the analysis of ITDB information is that it contributes to internal planning and to the prioritization of activities related to nuclear security, in addition to assisting States in preventing, detecting and responding to illicit trafficking in nuclear and other radioactive material.

Convention on the Physical Protection of Nuclear Material

In 2004, a total of 11 additional States became parties to the 1979 Convention on the Physical Protection of Nuclear Material (CPPNM), making a total of 109 States Parties.

The formal process towards amending the CPPNM has started. In July 2004, at the request of the Government of Austria and 24 co-sponsoring States, and in accordance with Article 20, paragraph 1 of the CPPNM, the Director General circulated proposed amendments to all States Parties. These amendments would extend the scope of the CPPNM to also cover the physical protection of nuclear material used for peaceful purposes, in domestic use, storage and transport and the physical protection of nuclear material and the protection of peaceful nuclear facilities against sabotage. At the request of a majority of the States Parties, the Director General will convene a conference to consider the proposed amendments in July 2005. ■

Verification



Safeguards

Objective

To provide credible assurance to the international community that nuclear materials and other items placed under safeguards are not diverted or misused, and, for States with comprehensive safeguards agreements in force, to provide credible assurance on the absence of undeclared material and activities for States as a whole; and to support the efforts of the international community in connection with nuclear disarmament.

The year 2004 was marked by the international community's increased attention to the Agency's verification programme. In particular, there was strong interest in the Agency's inspection activities related to the compliance by a number of States with their safeguards agreements. The discovery of covert nuclear trade networks and continued uncertainty regarding the nuclear capabilities of the Democratic People's Republic of Korea (DPRK) also contributed to a heightened awareness of the risk of nuclear weapons proliferation.

This increased attention prompted several new multinational initiatives to strengthen the nuclear non-proliferation regime. Within the framework of this regime, and through a number of new initiatives, the Agency continues to play a unique role as an independent, impartial international authority in the field of nuclear verification (Fig. 1).

Throughout 2004, Agency safeguards continued to evolve in response to emerging challenges. Thus:

- The Agency moved from rigid, criteria¹ based safeguards implementation and evaluation to a more flexible and effective approach based on State level considerations. This new approach takes into account a wider range of factors and information, such as the scope and extent of a State's nuclear fuel cycle, the cooperation of the State in implementing safeguards and reports on nuclear related research available in open sources. Agency safeguards remain non-discriminatory, as the verification objectives applied are common to all States.
- The Agency began to develop its own capabilities for in-depth analysis and evaluation of nuclear



FIG. 1. Nuclear safeguards inspectors verifying the active length of a fresh fuel assembly using a gamma ray system at the Mochovce nuclear power plant, in Slovakia, during a training exercise.

trade activities on a global scale. These new capabilities involve techniques to enhance the collection and analysis of information about nuclear supply and procurement activities and the investigation of covert nuclear trade networks with a view to assessing whether these networks are supporting undeclared nuclear activities.

The Agency's Safeguards Mandate

Since 1957, the Agency has — in accordance with its statutory mandate — applied safeguards to ensure “that assistance provided by it or at its request or under its supervision or control is not used in such a way as to further any military purpose.”² With the 1968 Treaty for the Prohibition

¹ Safeguards criteria are a set of guidelines for nuclear material verification activities, traditionally considered by the Agency to be an effective means of fulfilling responsibilities under safeguards agreements.

² Article II of the IAEA Statute.

State Undertakings with Regard to Agency Verification

- **Comprehensive safeguards agreements (CSAs):** All non-nuclear-weapon States party to the NPT, as well as States party to the regional nuclear-weapon-free zone treaties, are required to conclude CSAs with the Agency. The structure and content of CSAs concluded pursuant to the NPT are described in document INFCIRC/153 (Corr). In accordance with the terms of such agreements, a State undertakes to accept safeguards on all nuclear material in all peaceful nuclear activities, within its territory, under its jurisdiction or carried out under its control anywhere for the purpose of verifying that such material is not diverted to nuclear weapons or other nuclear explosive devices. Under these agreements, the Agency has the right and obligation to ensure that safeguards are applied on all such nuclear material.
- **Voluntary offer agreements (VOAs):** The five NPT nuclear-weapon States have concluded safeguards agreements covering some or all of their peaceful nuclear activities. Under the VOAs, facilities or nuclear material in facilities notified to the Agency by the State concerned are offered for the application of safeguards. VOAs serve two purposes: to broaden the Agency's safeguards experience by allowing for inspections at advanced facilities; and to demonstrate that nuclear-weapon States are not commercially advantaged by being exempt from safeguards on their peaceful nuclear activities.
- **Item-specific safeguards agreements:** Agreements in this category cover only specified material, facilities and other items placed under safeguards, and are based on the safeguards procedures approved by the Board of Governors and published in INFCIRC/66/Rev.2 and its earlier versions. States parties to such agreements undertake not to use the material, facilities and/or other items under safeguards in such a way as to further any military purpose. The Agency implements such agreements in the three States that are not party to the NPT.
- **Additional protocols (APs):** These were designed for States having a safeguards agreement with the Agency, in order to strengthen the effectiveness and improve the efficiency of the safeguards system as a contribution to global non-proliferation objectives. States with CSAs may only conclude APs that include all provisions of the "Model Protocol Additional to Agreement(s) between State(s) and the IAEA for the Application of Safeguards" (published in INFCIRC/540 (Corr.)), which was approved by the Board in 1997. Other States may accept and implement those measures of the Model Additional Protocol that they choose with a view to contributing to non-proliferation aims or to the effectiveness and efficiency objectives of the Protocol.

of Nuclear Weapons in Latin America³ and the 1970 Treaty on the Non-Proliferation of Nuclear Weapons, the Agency became the designated verification authority for the implementation of safeguards in States party to these treaties. Other nuclear non-proliferation treaties, such as the nuclear-weapon-free zone treaties in certain regions, also call for the Agency to serve in that capacity.

The Agency's Safeguards Conclusions for 2004

At the end of each year, the Agency draws *safeguards conclusions*, for each State in which it applies safeguards, based upon the evaluation of all information available to the Agency for that year. The Agency, through CSAs, seeks to provide

'credible assurance' on two points: (1) that declared nuclear material has not been diverted; and (2) that no undeclared nuclear material or activities exist. When provided with the necessary authority, access and information, the Agency is able to draw the *conclusion* that all nuclear material⁴ in the State remained in peaceful nuclear activities.

For the Agency to draw such a conclusion credibly, both a CSA and an AP must be in force or otherwise applied for that State, *and* the Agency must have been able to conduct all necessary verification and evaluation activities under those agreements. For States that have CSAs in force and no APs, the Agency does not have sufficient means to draw such a conclusion credibly, and therefore generally only draws the *conclusion* that all *declared* nuclear material remained in peaceful nuclear activities.

³ Now called the Treaty for the Prohibition of Nuclear Weapons in Latin America and the Caribbean.

⁴ Material subject to safeguards; namely, all source or special fissionable material in peaceful nuclear activities within a State's territory, under its jurisdiction or carried out under its control anywhere.

In 2004, safeguards were applied for 152 States with safeguards agreements in force with the Agency.⁵

With regard to 21 States with both CSAs and APs in force or otherwise applied, the Agency concluded that *all nuclear material* in those States remained in peaceful nuclear activities. For 40 other such States, the Agency had not yet completed the necessary evaluations, and could therefore only draw the conclusion that the *nuclear material placed under safeguards* remained in peaceful nuclear activities. For 82 States with CSAs in force and no APs, the Agency was, likewise, only able to draw that conclusion.

The Islamic Republic of Iran (Iran), Libyan Arab Jamahiriya (Libya), Republic of Korea (ROK) and Egypt had been found to have been previously engaged in nuclear activities of varying significance, which they had failed to report to the Agency. Corrective actions are being taken by those States. Verification and evaluation of these States' declarations were still in progress at the end of 2004.

The Agency was not able to perform verification activities in the DPRK in 2004 and could not, therefore, draw any safeguards conclusions regarding nuclear material or activities in that State.

For three States with limited scope item-specific safeguards agreements in force, the Agency was able to reach the conclusion that *the nuclear material and other items placed under safeguards* remained in peaceful nuclear activities.

The Agency also carried out inspections in selected facilities in four States with VOAs in force and was able to conclude that *the nuclear material placed under safeguards* in the selected facilities remained in peaceful nuclear activities.

For 40 States party to the NPT that had not yet concluded *any* safeguards agreement with the Agency, no safeguards conclusions could be drawn by the Agency.

Democratic People's Republic of Korea

The DPRK has had a CSA in force with the Agency since 1992. Since 1993, the DPRK has been in non-compliance with its safeguards agreement.

As a result of the unilateral action by the DPRK in December 2002 to terminate the Agency's safeguards

activities in the DPRK, the Agency has been unable to perform any verification activities in that State. Information about the DPRK's nuclear programme has since that time been gained only through open sources and other available information. As a consequence, the Agency is not in a position to assess the extent of the DPRK's nuclear programme.

Given this lack of information, and the unanswered questions concerning the DPRK's nuclear capabilities and its statements that a nuclear weapons capability now exists, the situation in the DPRK continues to pose a serious challenge to the nuclear non-proliferation regime. The Agency, hopeful that a resolution to this situation can be achieved through bilateral and multilateral actions by the international community, has continued to maintain the capability that would be required to resume verification in the DPRK at short notice.

Islamic Republic of Iran

Iran has had a CSA in force with the Agency since 1974. In 2003, the Agency found that, for 18 years, Iran had pursued an undeclared nuclear programme which had included uranium conversion and enrichment.

During 2004, the Director General submitted four reports⁶ to the Board of Governors on the implementation of safeguards in Iran, and the Board adopted four resolutions on this subject⁷. The Agency's verification activities throughout the year further enhanced its understanding of Iran's current and past nuclear programme. The Agency's investigations focused on issues that remain unresolved concerning Iran's past undeclared nuclear programme. The two key outstanding issues are:

- The origin of the enriched uranium contamination found at several locations in Iran;
- The scope of Iran's enrichment programme.

The Agency made some progress towards resolving both of these issues.

With regard to the first issue, Iran has asserted that the uranium contamination originated from components acquired from third parties. At the end of 2004, the Agency's overall assessment with respect to this issue was that the environmental sampling data available tended, on balance, to support Iran's

⁵ For the official text of the safeguards conclusions, see <http://www.iaea.org/OurWork/SV/Safeguards/es2004.html>.

⁶ GOV/2004/11, GOV/2004/34, (GOV/2004/34/Corr.1), GOV/2004/60, GOV/2004/83.

⁷ GOV/2004/21, GOV/2004/49, GOV/2004/79, GOV/2004/90.

statement about the foreign origin of the observed contamination. However, other possible explanations cannot be excluded, and the Agency is continuing its investigations to confirm the actual source of contamination.

With regard to the issue of enrichment, the Agency is continuing its investigation into the covert supply network that provided equipment for Iran's centrifuge enrichment programme, in order for the Agency to be able to conclude its assessment.

The Agency is also still assessing other aspects of Iran's past nuclear programme, including statements made about past plutonium separation experiments.

In December 2003, Iran signed an AP to its safeguards agreement. Although the AP was not ratified as of the end of 2004, Iran has undertaken, since 2003, to act as if it were in force. In May 2004, Iran delivered to the Agency its initial declarations under the AP.

Iran cooperated with the Agency in accordance with the provisions of its CSA and AP by providing access to requested locations. However, information often continued to be slow in coming and was provided in response to Agency requests, rather than proactively.

Another point of Agency focus during 2004 was Iran's voluntary suspension of its enrichment related and reprocessing activities. At the request of both Iran and the Board of Governors, the Agency has been verifying and monitoring this suspension. Containment and surveillance measures were applied at the Uranium Conversion Facility at Esfahan and the Pilot Fuel Enrichment Plant at Natanz. In addition, the suspension of centrifuge component production was verified at declared production locations, and associated essential equipment was placed under containment and surveillance measures.

Progress made during 2004 enabled the Agency to conclude that all declared nuclear material in Iran had been accounted for, and that, therefore, such material was not diverted to prohibited activities. However, the Agency is not yet in a position to conclude that there are no undeclared nuclear material or activities in Iran. The process of drawing such a conclusion, based on the implementation of all safeguards measures including those contained in an AP, is normally a time consuming

process. In view of the past undeclared nature of Iran's nuclear programme, and its past pattern of concealment, drawing this conclusion in the case of Iran can be expected to take longer than in normal circumstances.

Libyan Arab Jamahiriya

Libya has had a CSA in force with the Agency since 1980. Nonetheless, for more than 20 years Libya pursued a clandestine programme aimed at uranium conversion and enrichment, which it has acknowledged was for the production of nuclear weapons. Starting in the early 1980s and continuing until the end of 2003, Libya imported nuclear material and conducted a wide variety of nuclear activities that it concealed from the Agency. Some development work on these technologies had been pursued within Libya, but substantial assistance — including nearly all the equipment involved — had been received from foreign sources, either directly or through intermediaries.

In December 2003, Libya announced its decision to eliminate all materials, equipment and programmes leading to the production of internationally proscribed weapons — including nuclear weapons. Since then, the Agency has conducted a number of verification missions in Libya. During 2004, the Director General provided three reports to the Board of Governors⁸ on the implementation of safeguards in Libya and the Board adopted a resolution on the subject⁹. Libya has cooperated with the Agency by providing prompt and unhindered access to all requested locations.

On 10 March 2004, Libya signed an AP, and in May it submitted its initial declarations under the AP to the Agency. Although the AP was not yet ratified as of the end of 2004, Libya has undertaken, since December 2003, to act as if it were in force.

The Agency's assessment to date is that Libya's declarations concerning its uranium conversion programme, enrichment programme and other past nuclear related activities appear to be consistent with the information available to and verified by the Agency. There are some areas related to the acquisition of uranium hexafluoride, uranium conversion technology, plans for weaponization and enrichment technology that need further

⁸ GOV/2004/12, GOV/2004/33, GOV/2004/59, (GOV/2004/59/Corr.1).

⁹ GOV/2004/18.

investigation in order for the Agency to verify the completeness and correctness of Libya's declarations. These investigations are ongoing.

Other Safeguards Issues

Republic of Korea: The ROK's AP entered into force on 19 February 2004. In August 2004, the ROK began submitting declarations under the protocol. At the time of submission of these declarations, the ROK informed the Agency that ROK scientists had, on a number of occasions, conducted experiments that involved uranium conversion and uranium enrichment. According to the ROK, these activities had been carried out without the Government's knowledge. Earlier in 2004, the Agency had also been informed about the details of an experiment conducted to study the separation of plutonium, in the early 1980s. None of these activities had been declared in a timely manner to the Agency, as required under the ROK's CSA.

The Agency carried out a number of verification missions at various locations in the ROK to clarify the extent of these past undeclared activities. The ROK has actively cooperated with the Agency and provided information and access to personnel and locations.

Based on information provided by the ROK and verified by the Agency, there is no indication to date that these undeclared experiments have continued. However, the Agency is continuing to verify the correctness and completeness of the ROK's declarations.

Egypt: The CSA between Egypt and the Agency has been in force since 1982. In 2004, the Agency identified several open source documents, which indicated the possibility of hitherto unreported nuclear material, activities and facilities in that State. The Agency has sought clarification of these matters and has carried out several inspections and visits in connection with them. Egypt has cooperated with the Agency and provided information and access to personnel and locations. At the end of 2004, the Agency was still in the process of verifying the correctness and completeness of Egypt's declarations.

Implementation of Safeguards

The AP assists the Agency in verifying a State's compliance with its safeguards obligations and helps the Agency reach a broader conclusion regarding the status of nuclear material and activities in a State. Under an AP, the Agency has enhanced rights of access to locations and information and, thus, can obtain a broader range of information regarding a State's nuclear fuel cycle. Throughout 2004, the implementation of APs continued to demonstrate their effectiveness.

With APs entering into force for 24 States (including 15 Member States of the European Union), 2004 saw a record number of new parties to these protocols (Fig. 2). The Agency continued to encourage States to conclude NPT safeguards agreements and APs, and continued to provide assistance to States at their request¹⁰. Australia, Burkina Faso and Namibia hosted regional seminars on the conclusion of APs, and an interregional seminar on this topic was held in Vienna. By the end of the year, the number of States with APs in force had risen to 62¹¹, including three nuclear-weapon States (China, France and the United Kingdom).

Assistance to State Systems of Accounting for and Control of Nuclear Material

A key feature of effective safeguards implementation is the cooperation of the State systems of accounting for and control of nuclear

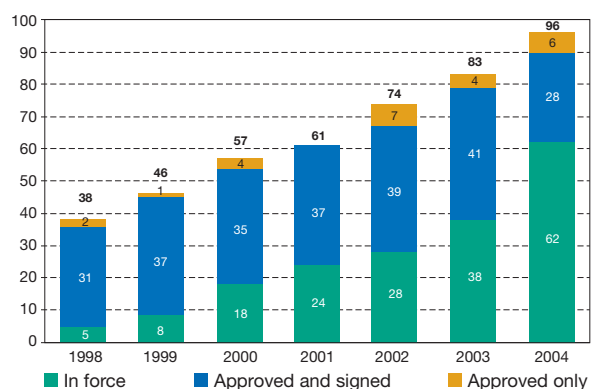


FIG. 2. INFCIRC/540 type additional protocols, 1998–2004.

¹⁰ Further information on the Agency's action plan to encourage the conclusion of safeguards agreements and APs is available at http://www.iaea.org/OurWork/SV/Safeguards/sg_actionplan2005.pdf.

¹¹ Additional protocols were also being provisionally applied in Iran and Libya, pending entry into force. In addition, the Agency applied safeguards, including the measures foreseen in the Model Additional Protocol, in Taiwan, China.

material (SSACs). In 2004, the Agency initiated a number of steps to help Member States upgrade the quality and performance of their SSACs. In this regard, the Agency is revising its guidelines for SSACs, and developing the objectives and basic structure for the new SSAC Advisory Service (ISSAS) missions. The first pilot ISSAS mission was conducted in Indonesia in June 2004.

Information Analysis and Remote Monitoring

The analysis of open source information, including satellite imagery, has played a key role in guiding inspectors to locations relevant to issues of particular safeguards concern, and has made a major contribution to the State evaluation process. Hundreds of satellite images were collected in 2004, and new three-dimensional visualization products were introduced to better support inspections. New arrangements were established with providers of imagery and cartographic information in order to diversify the Agency's sources.

Given recent experience which has demonstrated the value of collecting and analysing open source information, the Agency substantially increased its coverage of scientific and technical information. At the end of 2004, the Agency had access to over 5000 scientific journals and information on thousands of commercial entities. In addition, the Agency extended its capabilities for retrieving information in languages other than English.

The Secretariat continued to work on a four year project budgeted at more than \$20 million to: re-engineer the IAEA Safeguards Information System (ISIS); improve the effectiveness and efficiency of information analysis; and reduce the risk of failure of its antiquated safeguards computer system — much of which is more than 20 years old.

The number of Agency surveillance systems operating with remote transmission capabilities nearly doubled last year. Presently, 60 surveillance systems (with 191 cameras) are operating in remote monitoring (RM) mode in 11 States¹². In addition, 26 unattended spent fuel flow monitoring systems are operating with independent RM capability at facilities in Canada and Lithuania.

Also, during 2004, all RM systems in the ROK¹² were upgraded to enable data transmission over high speed Internet connections secured by virtual private network technology, a more cost effective

approach to the establishment of RM for verification purposes.

Detecting Undeclared Nuclear Material and Activities: New/improved Technological Capabilities and Methodologies

The Agency established a new research and development project to explore, with the advice and support of Member States, the potential use of advanced technologies in detecting undeclared nuclear material and activities. Areas of investigation include: means of detecting undeclared reprocessing plants and reactors and new technologies for monitoring declared enrichment facilities and detecting indications of undeclared enrichment activities.

Environmental sampling is one measure used by the Agency to detect undeclared nuclear activities in a State. Such sampling may be carried out at any location to which the Agency has access under a safeguards agreement or an AP. Through the collection and analysis of environmental samples, the Agency can determine whether nuclear activities and types of nuclear material are consistent with those declared; and whether the presence of undeclared nuclear material and activities is indicated.

A number of factors can have an impact on the efficiency of environmental sampling. The evaluation of 'urgent' samples is usually performed in a timely fashion. However, the evaluation of routine samples is often substantially delayed, at times due to the higher priority given to more urgent samples. To remedy this situation, the Agency is expanding its Network of Analytical Laboratories (NWAL). However, this requires an advanced technological and logistical infrastructure and substantial financial commitments from the States involved.

Implementation of Integrated Safeguards

The term 'integrated safeguards' describes the optimum combination of all safeguards measures available to the Agency under CSAs and APs. A prerequisite for the implementation of integrated safeguards is the broader safeguards conclusion to be drawn by the Agency for the State concerned. Once implemented, the combination of measures

¹² And in Taiwan, China.

The Network of Analytical Laboratories (NWAL)

The NWAL comprises a number of laboratories worldwide that have been qualified to analyse safeguards samples — that is, nuclear material or environmental samples. Several of these laboratories specialize in the measurement of individual micrometre sized particles collected on environmental samples, using methods such as scanning electron microscopy, secondary ion mass spectrometry or fission-track thermal ionization mass spectrometry.

In addition, some laboratories belonging to the NWAL apply ‘bulk analysis’ to environmental samples. This means that the entire sample is dissolved and chemically separated to extract elements of interest (such as uranium, plutonium and americium) for subsequent analysis.

When taking environmental samples, Agency safeguards inspectors typically collect a number of replicate samples so that these can be sent, in parallel, to different laboratories that perform particle or bulk analysis. Monitoring the consistency of results from these replicate samples adds an element of quality control to the entire sampling, handling and analysis process.

Representatives of laboratories meet regularly to review the performance of the NWAL in terms of accuracy, precision, sensitivity and reliability of the data, as well as the response time of the laboratories. Candidate laboratories are invited to send observers to these meetings as a way of preparing them for future membership in the NWAL. A number of safeguards Member State Support Programme tasks are dedicated to assisting laboratories in the development of capabilities that would enable them to join the NWAL. Increasing the number of participating laboratories would improve the overall capability, capacity, throughput and response time of the system.

enables maximum effectiveness and efficiency of safeguards measures. In countries with extensive nuclear fuel cycles, the opportunities for substantial savings due to reduced field verification activities are particularly evident.

An important milestone was reached in 2004 when the Agency was able to draw a broad safeguards conclusion for the first time for Japan, a State with a large and complete nuclear fuel cycle. Following this, the Agency began to implement integrated safeguards as of September 2004, focusing initially on LWRs without mixed oxide plutonium fuel, research reactors and critical assemblies, as well as LWR spent fuel storage facilities.

During 2004, the Agency also began to implement integrated safeguards in Hungary and Uzbekistan.

Status of the Rokkasho Reprocessing Plant Project

The Rokkasho Reprocessing Plant (RRP) in Japan is the biggest commercial reprocessing plant under Agency safeguards. An important milestone was reached in December 2004 with the introduction of uranium into the facility.

Change of Safeguards Approach by Euratom

In December 2004, the European Commission (EC) formally provided the Agency with information

about proposed reductions in its safeguards activities in the countries of the EU. The EC's plans for reducing its safeguards inspection activities would require significant adjustments to the existing cooperation agreement between the Agency and Euratom under which the two organizations have shared inspection activities and associated equipment costs over the past 13 years. Consultations were started on adjustments to these cooperation arrangements. The Agency will seek to ensure that there is no loss of safeguards effectiveness in Member States of the EU should the plans of the EC be further pursued and implemented, and that the necessary resources are available to the Agency to compensate for Euratom's reduced activities.

Review of the Safeguards Programme and Criteria

Two reviews, one covering the effectiveness of safeguards implementation, and the other covering the safeguards criteria, were completed in 2004.

The first review, by an independent panel of external experts, found that the Secretariat had done well in implementing safeguards strengthening measures, particularly given existing resource constraints. The panel concluded that the Agency's ability to provide credible assurance regarding the absence of undeclared nuclear material, as well as ongoing assurance that declared nuclear material has not been diverted, had significantly improved over the past five years.

The second review, carried out by the Agency's Standing Advisory Group on Safeguards Implementation (SAGSI), addressed the role, structure and content of the Agency's safeguards criteria. SAGSI found the safeguards criteria to be essentially sound, but identified areas for improvement, acknowledging that some of the changes it endorsed had already been initiated by the Agency. Both SAGSI and the external panel concluded that wider implementation of integrated safeguards, with its greater effectiveness and efficiency, should remain a programme priority.

Beyond State Borders: Covert Nuclear Trade Networks

During 2004, an extensive covert supply network of sensitive nuclear technology was revealed in connection with Iran's undeclared nuclear activities and Libya's clandestine nuclear weapons programme. The Board of Governors asked the Agency to evaluate further the activities resulting from these revelations, with a view to improving the detection of undeclared nuclear activities in breach of international commitments.

In response, the Secretariat established a new unit focused on documenting, investigating and analysing nuclear trade activities worldwide. The overall aim of this effort is to reveal covert nuclear trade networks that could indicate the existence of undeclared nuclear material and activities.

These activities complement other Agency activities in connection with safeguards, such as its analysis of open source information. The Agency's effectiveness and efficiency can be further enhanced with Member States' support, for example through their making available relevant information on denials of exports and on attempts to procure sensitive nuclear technology.

Additional Initiatives Supporting the Nuclear Non-Proliferation Regime

Illicit Trafficking

In 2004, the Agency continued to receive reports from Member States on events involving trafficking in nuclear and other radioactive material. The number of reported events involving nuclear material increased in 2004. One case of trafficking involved approximately 170 grams of HEU. None involved plutonium other than in trace amounts. Further information on the Agency's work in the area of illicit trafficking can be found in the 'Nuclear Security' chapter of this report.

It is important for Member States to promptly and fully inform the Agency of any case of trafficking involving nuclear material, to facilitate sampling of the seized material for forensic analysis and to provide all relevant information that could help the Agency in its analysis of trafficking routes and potential users.

International Project on Innovative Nuclear Reactors and Fuel Cycles

Determining the proliferation resistance of future nuclear systems continued to be an important component of the Agency's International Project on Innovative Reactors and Fuel Cycles (INPRO). In addition to their work with INPRO, Agency experts continued to participate in the Proliferation Resistance and Physical Protection Evaluation Methodology Expert Group of the Generation IV International Forum (GIF). Proliferation resistance has become an important area of collaboration between INPRO and GIF, and further developments in this area are expected in 2005. (The Agency's work in the area of innovative nuclear reactors is discussed in greater detail in the Nuclear Power chapter of this report.) ■

Verification in Iraq

Pursuant to UNSC Resolutions

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.

Status of Verification Activities

Since 17 March 2003, the Agency has not been in a position to implement its mandate in Iraq under the relevant UNSC resolutions. In resolution 1546 (2004), the UNSC reaffirmed its intention to revisit the Agency's mandate in Iraq.

During the year the Agency focused its activities on:

- Conducting investigations of sensitive and often contaminated items that have been exported from Iraq;
- Analysing the wealth of additional information collected during inspections;
- Consolidating its information assets, collecting and analysing a variety of new information, including satellite imagery, and updating its knowledge of the formerly relevant facilities in Iraq (Fig. 1);
- Refining its plan for resumed verification activities in view of the many uncertainties concerning the situation in Iraq;
- Evaluating lessons learned through its past experience in Iraq.



FIG. 1. An example of satellite imagery used for change detection analysis, which involves comparing a site on two different dates in order to update the Agency's knowledge with regard to the site infrastructure and contents. The picture on the left is from the QuickBird satellite at an altitude of 450 km, while the image on the right is from the Ikonos satellite at an altitude of about 680 km (copyright: QuickBird DigitalGlobe; and Ikonos Space Imaging).

Technical Cooperation



Management of Technical Cooperation for Development

Objective

To further strengthen the technical cooperation programme by contributing to sustainable and significant social and economic benefits in Member States and increased self-reliance in the application of nuclear techniques.

Programme Planning and Coordination

In response to reviews and evaluations by the Office of Internal Oversight Services, the Standing Advisory Group on Technical Assistance and Cooperation (SAGTAC) and decisions and recommendations of the Board of Governors, the Agency began a phased approach to the restructuring of the Department of Technical Cooperation during 2004. A one year plan was developed as a framework for this change initiative. The initial phase, reorganizing the Department's five regional sections into four, has been completed and now covers Africa, Asia and the Pacific, Europe and Latin America.

The second phase of the restructuring, which began in late 2004 and will be completed in 2005, will involve a more efficient grouping of staff responsibilities and tasks. In conjunction with the restructuring, the Secretariat has embarked on a comprehensive review of the main elements of the technical cooperation programme cycle, such as the project planning, formulation, appraisal and approval processes.

At its meeting in March, SAGTAC addressed a range of topics related to the Agency's Medium Term Strategy and its links to the Technical Cooperation Strategy, regional programming issues, self-reliance and sustainability, and strategies for partnership building.

In June 2004, the Board of Governors approved a proposal for the replacement of assessed programme costs with national participation costs, effective 1 January 2005.

Resources for the Technical Cooperation Fund (TCF) recorded a significant increase over 2003, reaching a total of \$75.6 million by the end of the year. It should be noted, however, that approximately \$8.1 million of this total represents

payments or pledges made in 2004 against the TCF target for 2003.

The implementation rate of the programme dropped four percentage points in 2004 to 68%, compared with 2003 figures, due to external factors.

New resources from extrabudgetary donors remained at a level comparable with that of 2003. Funds received in 2004 totalled \$10.9 million, compared with \$11.8 million in 2003. A total of \$3.7 million was contributed as government cost sharing by Member States to support project activities in their own country. The remaining \$7.2 million was received from Member States and organizations for use in specified projects approved under the technical cooperation programme. In total, just under \$7.6 million of the total \$10.9 million was used to upgrade 'footnote a/' projects and project components.

Programme Formulation and Implementation

As a partner in development, the Agency has been active in formulating and supporting activities that address priority national development needs in its Member States. Formulation of the 2005–2006 technical cooperation programme was closely guided by Member State requests, the 2002 review of the Technical Cooperation Strategy and by country programme frameworks (CPFs). Figure 1 represents the 2005–2006 programme as approved by the Board of Governors at its November meeting.

Through its technical cooperation programme, the Agency has helped to enhance the general safety of ageing research reactors and spent fuel storage facilities for more than two decades. For instance, repatriation of HEU research reactor fuel to the country of origin has been taking place through a Tripartite Initiative involving the Agency, the Russian Federation and USA since 1999. This effort seeks to return Russian origin research reactor fuel to Russia for management and disposition. In May 2004, the Global Threat Reduction Initiative (GTRI), which is expected to accelerate fuel repatriation activities, was announced and the US Government pledged an additional \$3 million through the technical cooperation programme for Agency supported activities relevant to the implementation of the GTRI.

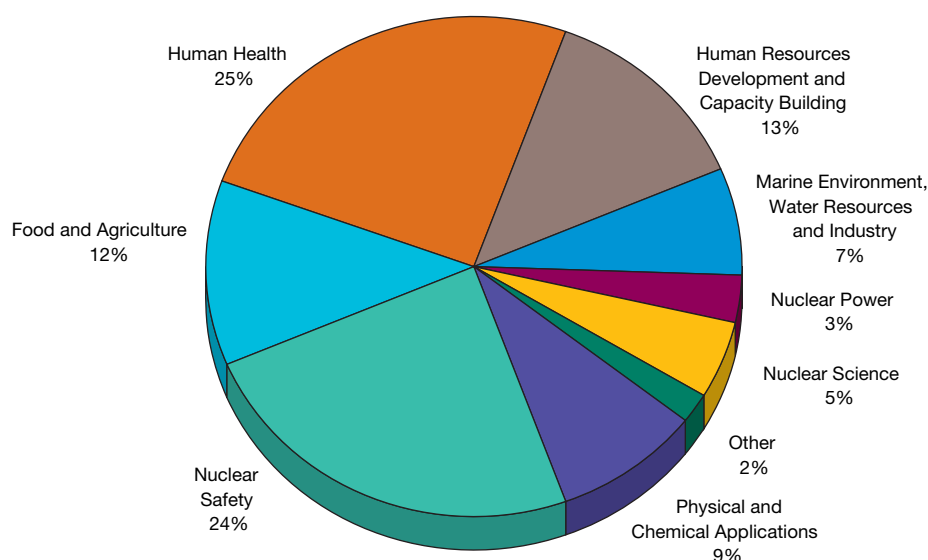


FIG. 1. The Agency's 2005–2006 core funded technical cooperation programme by area of activity.

To date, the Agency, based on Member State requests and within the context of approved technical cooperation projects, has supported activities related to the repatriation, management and possible long term storage of fresh HEU fuel in Bulgaria, Libyan Arab Jamahiriya, Romania and Uzbekistan.

In 2004, the technical cooperation programme included 11 national and 9 regional projects related to nuclear security. The projects were aimed at strengthening national infrastructures to combat illicit trafficking of nuclear and other radioactive material, strengthening national physical protection frameworks and control over radiation sources.

Several regional and national projects in Latin America focused on the utilization of nuclear techniques in the evaluation of nutrition programmes for measuring nutrients in food and human body composition (fat distribution). The evaluation methodology, already successfully verified, will be transferred to other countries in the region during the 2005–2006 programme cycle. In ARCAL Member States, 74% of the expert missions, 70% of fellowships and 63% of scientific visits were executed using the expertise in the region.

The Agency is involved in the global effort aimed at controlling HIV/AIDS through a project on HIV-1 molecular epidemiology and immunology in support of the UNAIDS–WHO African AIDS Vaccine Programme. Isotope techniques are used to assess nutrition intervention programmes related to HIV/AIDS in Africa. In a related development, a memorandum of understanding was signed in 2004 with the WHO Regional Office for Africa to build a strategic partnership around the Agency's work in Africa on human communicable diseases.

The Agency provided assistance under AFRA to help Member States develop national strategic action and business plans for their national nuclear institutions, including training of managers, scientists and decision makers. In addition, training and guidance was provided to the national regulatory authorities and radiation protection institutions to improve their managerial capabilities and interactions with stakeholders, and to enhance their relevance and credibility through better regulatory services and public perception.

To enable African Member States to make full use of information and communication technologies (ICTs) for the training of scientists and technicians, advice, training and ICT tele-centres were provided in 2004 to all AFRA countries. Since the inception of this effort in 2002, 17 ICT training centres have been supported and are currently operational in 13 African Member States.

As in previous years, AFRA continued to build national and regional capacity during 2004, focusing on cancer management, maintenance of equipment and nuclear security. A total of 27 training courses were organized, mainly in regional designated centres, and more than 500 scientists and technicians were trained. In 2004, 78% of the lecturers, including those who ran and supervised the training programme, were drawn from the Africa region.

In the Asia and Pacific region, the RCA Secretariat has devoted considerable time and effort to improving RCA programme formulation and delivery. Following up on a proposed registration of national capacities, a regional resource unit database was developed for Asian countries to maintain data on facilities, services and expertise available for

technical cooperation activities. Plans for similar databases for other regions are being developed.

Legislative Assistance to Member States

To support Member States in their development of a comprehensive nuclear law governing radiation protection, nuclear and radiation safety, nuclear liability, safeguards and physical protection, the Agency provided assistance in drafting national nuclear legislation for 11 Member States. In addition, at the request of Member States, training on issues related to nuclear legislation was also provided

to 13 fellows. Priority continued to be given to the provision of legislative assistance to Member States that are still required to establish a legislative and regulatory framework for the application of adequate health and safety standards. Such activity included, inter alia, assistance in drafting radiation protection laws and the empowerment of a national regulatory authority. The Agency is now working towards the development of detailed guidance for assisting Member States in the development of their national legislation for the safe management of radioactive waste and spent fuel. It is expected that this guidance will be finalized in 2005.



Annex

Table A1.	Allocation and utilization of regular budget resources in 2004
Table A2.	Extrabudgetary funds in support of the regular budget, 2004 (excluding the Nuclear Security Fund)
Table A3.	Technical cooperation disbursements by Agency programme and region in 2004
Table A4.	Status with regard to the conclusion of safeguards agreements and additional protocols as of 31 December 2004
Table A5.	Transport Safety Appraisal Service (TranSAS) missions in 2004
Table A6.	Peer review of radiation safety infrastructure missions in 2004
Table A7.	International PSA Review Team (IPSART) missions in 2004
Table A8.	International Regulatory Review Team (IRRT) missions in 2004
Table A9.	Operational Safety Review Team (OSART) missions in 2004
Table A10.	Peer Review of Operational Safety Performance Experience (PROSPER) missions in 2004
Table A11.	Integrated Safety Assessment of Research Reactors (INSARR) missions in 2004
Table A12.	Safety Review Service missions in 2004
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Table A18.	Approximate quantities of material subject to Agency safeguards at the end of 2004
Table A19.	Number of facilities under Agency safeguards or containing safeguarded material on 31 December 2004
Table A20.	Facilities under Agency safeguards or containing safeguarded material on 31 December 2004
Table A21.	Coordinated Research Projects initiated in 2004
Table A22.	Coordinated Research Projects completed in 2004
Table A23.	Training courses, seminars and workshops in 2004
Table A24.	Publications issued in 2004

Note: Tables A5–A24 are available on the attached CD-ROM.

Table A1. Allocation and utilization of regular budget resources in 2004

Major Programme/Programme	2004 original budget	2004 adjusted budget	Total expenditure		Unused (overexpended)	Balance
	(at €0.9229)	(at €0.8103)	Amount	% of adjusted budget	(overexpended)	
	(in \$)	(in \$)	(3)	(3) / (2)	(2) - (3)	(2) - (3) - (5)
	(1)	(2)	(3)	(4)	(5)	(6)
1. Nuclear Power, Fuel Cycle and Nuclear Science						
Overall Management, Coordination and Common Activities	702 000	782 500	694 669	88.78%	87 831	-
A. Nuclear Power	5 053 700	5 593 000	5 388 567	96.34%	204 433	-
B. Nuclear Fuel Cycle and Materials Technologies	2 498 700	2 763 300	2 746 933	99.41%	16 367	-
C. Capacity Building and Nuclear Knowledge	7 462 000	8 297 100	8 331 883	100.42%	(34 783)	-
Maintenance for Sustainable Energy Development						
D. Nuclear Science	8 452 600	9 120 100	8 839 759	96.93%	280 341	-
Subtotal – Major Programme 1	24 169 000	26 556 000	26 001 811	97.91%	554 189	-
2. Nuclear Techniques for Development and Environmental Protection						
Overall Management, Coordination and Common Activities	767 000	858 400	835 198	97.30%	23 202	-
E. Food and Agriculture	11 836 400	12 946 800	12 910 798	99.72%	36 002	-
F. Human Health	7 079 000	7 699 100	7 285 336	94.63%	413 764	-
G. Water Resources	3 236 000	3 578 400	3 548 879	99.18%	29 521	-
H. Protection of the Marine and Terrestrial Environment	3 863 600	4 314 700	4 200 012	97.34%	114 688	-
I. Physical and Chemical Applications	2 733 000	2 996 600	3 000 654	100.14%	(4 054)	-
Subtotal – Major Programme 2	29 515 000	32 394 000	31 780 877	98.11%	613 123	-
3. Nuclear Safety and Security						
Overall Management, Coordination and Common Activities	952 000	1 053 800	976 586	92.67%	77 214	-
J. Safety of Nuclear Installations	8 279 900	9 222 700	8 927 577	96.80%	295 123	-
K. Radiation and Transport Safety	5 356 900	5 946 600	5 715 704	96.12%	230 896	-
L. Management of Radioactive Waste	6 460 800	7 148 600	6 906 670	96.62%	241 930	-
M. Nuclear Security	1 351 400	1 511 300	1 494 236	98.87%	17 064	-
Subtotal – Major Programme 3	22 401 000	24 883 000	24 020 773	96.53%	862 227	-
4. Nuclear Verification						
Overall Management, Coordination and Common Activities	1 021 900	1 147 200	1 218 593	106.22%	(71 393)	-
N. Safeguards	101 256 100	112 789 800	103 711 488	91.95%	9 078 312	-
O. Verification in Iraq Pursuant to UNSC Resolutions (extrabudgetary funding only)						
Subtotal – Major Programme 4	102 278 000	113 937 000	104 930 081	92.09%	9 006 919	-
5. Information Support Services						
P. Public Information and Communication	3 291 700	3 678 700	3 535 847	96.12%	142 853	-
Q. Information and Communication Technology	7 487 300	8 420 000	7 258 201	86.20%	1 161 799	-
R. Nuclear Information Resources	2 514 000	2 813 700	2 820 742	100.25%	(7 042)	-
S. Conference, Translation and Publishing Services	5 427 000	6 085 600	6 057 411	99.54%	28 189	-
Subtotal – Major Programme 5	18 720 000	20 998 000	19 672 201	93.69%	1 325 799	-
6. Management of Technical Cooperation for Development						
Overall Management, Coordination and Common Activities	558 000	626 400	742 563	118.54%	(116 163)	-
T. Management of Technical Cooperation for Development	15 268 000	17 131 600	15 941 265	93.05%	1 190 335	-
Subtotal – Major Programme 6	15 826 000	17 758 000	16 683 828	93.95%	1 074 172	-
7. Policy and General Management						
U. Executive Management, Policy Making and Coordination	13 725 600	15 255 600	13 711 135	89.88%	1 544 465	-
V. Administration and General Services	37 262 400	41 899 600	42 393 456	101.18%	(493 856)	-
W. Oversight Services and Performance Assessment	1 800 000	2 009 800	1 895 349	94.31%	114 451	-
Subtotal – Major Programme 7	52 788 000	59 165 000	57 999 940	98.03%	1 165 060	-
TOTAL – Agency Programmes	265 697 000	295 691 000	281 089 511	95.06%	14 601 489	-
8. Reimbursable work for others	2 837 000	3 155 000	2 541 143	80.54%	-	613 857
TOTAL	268 534 000	298 846 000	283 630 654	94.91%	14 601 489	-
Supplementary appropriation – V4	4 825 000	5 495 000	338 835	6.17%	5 156 165	-
	273 359 000	304 341 000	283 969 489	93.31%	19 757 654	613 857

*Table A2. Extrabudgetary funds in support of the regular budget, 2004
(excluding Nuclear Security Fund)*

Major Programme / Programme	Extrabudgetary budget figures GC(47) /3 (1)	Resources			Total resources as at 31 Dec 2004 (2)+(3)+(4) (5)	Total expenditure as at 31 Dec 2004 (6)	Unused balance as at 31 Dec 2004 (5)-(6) (7)
		Unused balance as at 1 Jan 2004 (2)	Receipts ¹ as at 31 Dec 2004 (3)	Adjustments as at 31 Dec 2004 (4)			
1. NUCLEAR POWER, FUEL CYCLE AND NUCLEAR SCIENCE							
Overall Management, Coordination and Common Activities	0	153	2 214	0	2 367	0	2 367
A Nuclear Power	1 710 000	820 592	1 198 192	688	2 019 472	1 338 999	680 473
B Nuclear Fuel Cycle and Materials Technology	350 000	455 014	596 729	169	1 051 912	478 683	573 229
C Capacity Building and Nuclear Knowledge Maintenance for Sustainable Energy Development	137 000	178 353	156 997	0	335 350	158 131	177 219
D Nuclear Science	142 000	238 651	207 200	0	445 851	114 676	331 175
Major Programme 1 – Total	2 339 000	1 692 763	2 161 332	857	3 854 952	2 090 489	1 764 463
2. NUCLEAR TECHNIQUES FOR DEVELOPMENT AND ENVIRONMENTAL PROTECTION							
Overall Management, Coordination and Common Activities	0	39 116	269 319	299	308 734	196 673	112 061
E Food and Agriculture (excl. FAO)	924 000	93 121	21 900	9 213	124 234	84 336	39 898
FAO	2 834 000 ¹	196 954	2 289 331	11 380	2 497 665	2 357 285	140 380
Total Programme E	3 758 000	290 075	2 311 231	20 593	2 621 899	2 441 621	180 278
F Human Health	40 000	80 914	300 000	300	381 214	72 897	308 317
G Water Resources	0	0	0	0	0	0	0
H Protection of the Marine and Terrestrial Environment	922 000	544 416	720 942	6 405	1 271 763	753 583	518 180
I Physical and Chemical Applications	0	8 500	0	0	8 500	3 000	5 500
Major Programme 2 – Total	4 720 000	963 021	3 601 492	27 597	4 592 110	3 467 774	1 124 336
3. NUCLEAR SAFETY AND SECURITY							
Overall Management, Coordination and Common Activities	0	285 665	267 088	31	552 784	70 030	482 754
J Safety of Nuclear Installations	3 142 000	4 124 749	3 563 217	5 529	7 693 495	3 096 915	4 596 580
K Radiation and Transport Safety	420 000	2 855 434	3 311 232	14 903	6 181 569	2 018 696	4 162 873
L Management of Radioactive Waste	460 000	635 850	1 321 427	3 321	1 960 598	741 297	1 219 301
M Nuclear Security	1 743 000	8 396 658	14 511 147	46 613	22 954 418	5 580 803	17 373 615
Major Programme 3 – Total	5 765 000	16 298 356	22 974 111	70 397	39 342 864	11 507 741	27 835 123
4. NUCLEAR VERIFICATION							
Overall Management, Coordination and Common Activities	0	588 580	(136 095)	0	452 485	0	452 485
N Safeguards	15 072 000	22 432 442	19 246 012	397 963	42 076 417	16 294 276	25 782 141
O Verification in Iraq Pursuant to UNSC Resolutions (Extrabudgetary Funding only)	11 715 000	901 577	4 000 000	34 993	4 936 570	3 338 660	1 597 910
Major Programme 4 – Total	26 787 000	23 922 599	23 109 917	432 956	47 465 472	19 632 936	27 832 536
5. INFORMATION SUPPORT SERVICES							
P Public Information and Communication	620 000	737 380	719 680	16 766	1 473 826	1 201 128	272 698
Q Information and Communication Technology	0	11 442	8 558	0	20 000	16 005	3 995
R Nuclear Information Resources							
S Conference, Translation and Publishing Services							
Major Programme 5 – Total	620 000	748 822	728 238	16 766	1 493 826	1 217 133	276 693
6. MANAGEMENT OF TECHNICAL COOPERATION FOR DEVELOPMENT							
T Management of Technical Cooperation for Development	128 000	113 440	616 346	0	729 786	432 903	296 883
Major Programme 6 – Total	128 000	113 440	616 346	0	729 786	432 903	296 883
7. POLICY AND GENERAL MANAGEMENT							
U Executive Management, Policy Making and Coordination	0	548 977	370 448	625	920 050	260 548	659 502
V Administration and General Services	0	167 865	745 852	0	913 717	368 538	545 179
W Oversight Services and Performance Assessment	0	141 578	233 500	0	375 078	189 346	185 732
Major Programme 7 – Total	0	858 420	1 349 800	625	2 208 845	818 432	1 390 413
Total Extrabudgetary Programme Funds	40 359 000	44 597 421	54 541 236	549 198	99 687 855	39 167 408	60 520 447

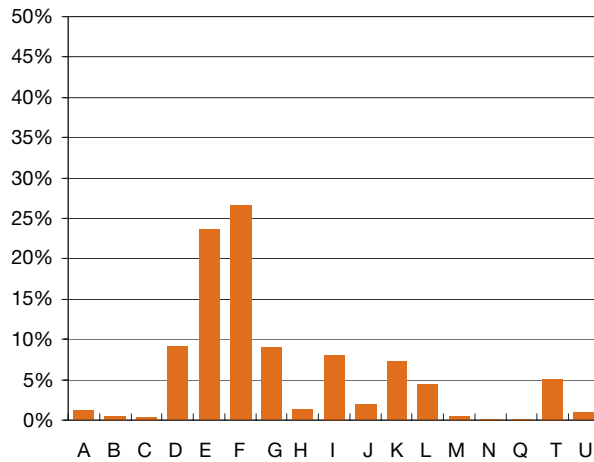
¹ The column "Receipts" includes cash contributions received as well as budgets from FAO, UNEP and UNOPS for approved activities.

Table A3. Technical cooperation disbursements by Agency programme and region in 2004

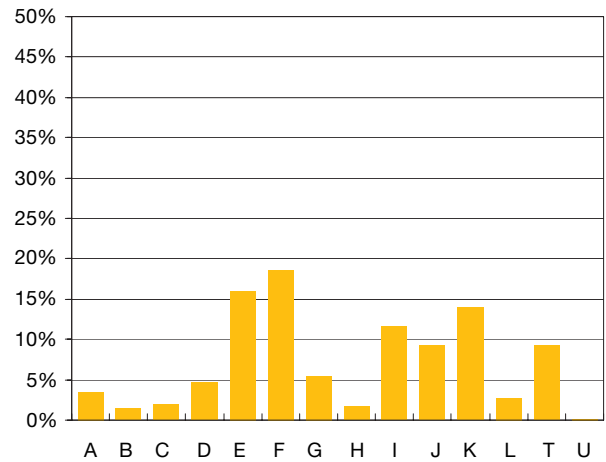
I. Summary of all Regions (in thousands of dollars)							
Programme	Africa	East Asia and the Pacific	Europe	Latin America	West Asia	Global/ inter- regional	Total
Nuclear Power	225.6	403.8	1 463.6	178.0	960.0	189.4	3 420.5
Nuclear Fuel Cycle and Materials Technologies	97.1	164.3	137.2	175.4	0.0	0.0	573.9
Capacity Building and Nuclear Knowledge Maintenance for Sustainable Energy Development	71.5	219.4	179.9	61.3	56.6	124.0	712.7
Nuclear Science	1 746.5	534.9	2 653.3	412.8	346.0	42.2	5 735.7
Food and Agriculture	4 498.7	1 836.4	149.5	1 059.7	746.7	492.2	8 783.2
Human Health	5 049.1	2 155.1	3 232.0	5 689.5	1 145.7	270.3	17 541.7
Water Resources	1 702.9	625.6	143.8	886.2	328.3	0.0	3 686.9
Protection of the Marine and Terrestrial Environment	248.9	190.9	278.1	668.3	399.7	0.8	1 786.7
Physical and Chemical Applications	1 622.1	1 350.4	1 466.1	1 786.9	542.7	0.4	6 768.7
Safety of Nuclear Installations	392.5	1 055.0	3 795.1	90.9	189.3	3.9	5 526.8
Radiation and Transport Safety	1 381.0	1 603.0	1 925.4	1 646.9	1 706.9	0.0	8 263.2
Management of Radioactive Waste	889.5	323.9	2 135.6	123.0	65.7	444.3	3 982.0
Nuclear Security	108.2	0.0	921.1	0.0	14.0	0.0	1 043.3
Safeguards	17.5	0.0	26.8	0.0	12.1	0.0	56.4
Public Information and Communication	0.0	0.0	20.5	31.3	0.0	0.0	51.8
Information and Communication Technology	15.9	0.0	0.0	0.0	0.0	0.0	15.9
Management of Technical Cooperation for Development	738.4	1 002.9	695.1	1 202.2	194.6	1 293.6	5 126.7
Executive Management, Policy-Making and Coordination	169.7	10.1	66.9	10.8	0.0	0.0	257.6
Total	18 975.2	11 475.9	19 290.0	14 023.1	6 708.3	2 861.0	73 333.5

II. Distribution by Region (in thousands of dollars)

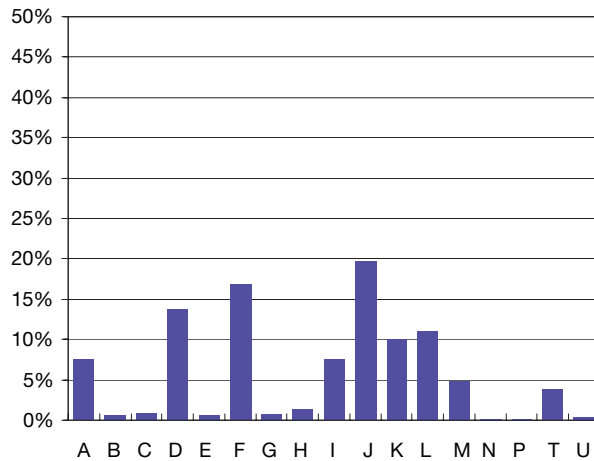
Africa: \$18 975.2



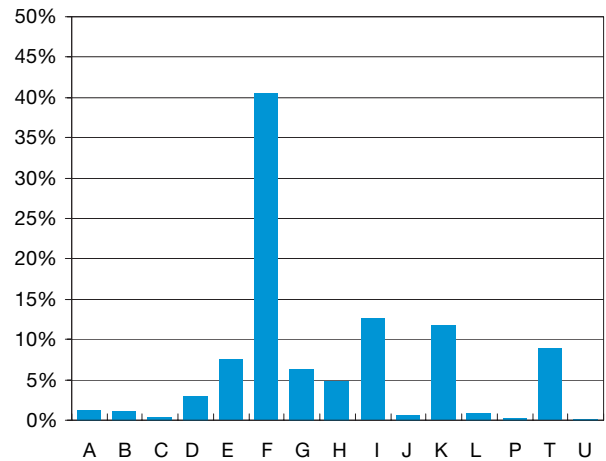
East Asia and the Pacific: \$11 475.9



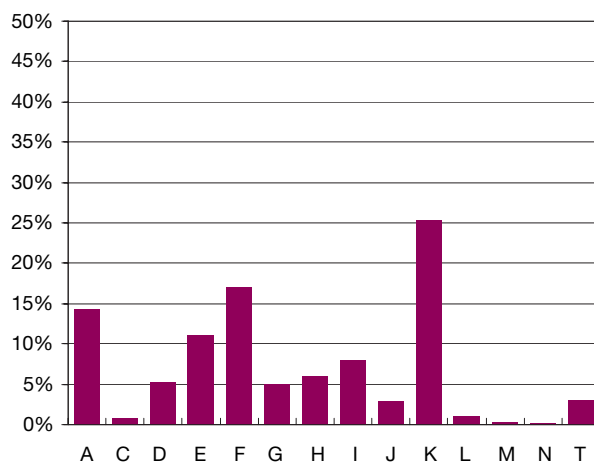
Europe: \$19 290.0



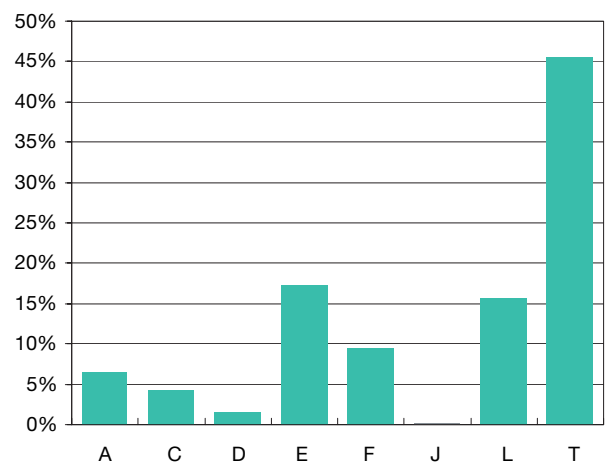
Latin America: \$14 023.1



West Asia: \$6 708.3



Global / Interregional: \$2 861.0



Note: Letters denote Agency programmes, which are explained in the preceding table giving the summary for all regions.

Table A4. Status with regard to the conclusion of safeguards agreements and additional protocols^{a, b}
(as of 31 December 2004)

State	SQP ^c	Status of safeguards agreement(s)	INFCIRC	Status of additional protocol
Afghanistan	X	In force: 20 February 1978	257	
Albania ^d		In force: 28 November 2002	359/Mod.1	Signed: 2 December 2004
Algeria		In force: 7 January 1997	531	Approved: 14 September 2004
Andorra	X	Signed: 9 January 2001		Signed: 9 January 2001
Angola				
Antigua and Barbuda ^e	X	In force: 9 September 1996	528	
Argentina ^f		In force: 4 March 1994	435/Mod.1	
Armenia		In force: 5 May 1994	455	In force: 28 June 2004
Australia		In force: 10 July 1974	217	In force: 12 December 1997
Austria ^g		Accession: 31 July 1996	193	In force: 30 April 2004
Azerbaijan	X	In force: 29 April 1999	580	In force: 29 November 2000
Bahamas ^e	X	In force: 12 September 1997	544	
Bahrain				
Bangladesh		In force: 11 June 1982	301	In force: 30 March 2001
Barbados ^e	X	In force: 14 August 1996	527	
Belarus		In force: 2 August 1995	495	
Belgium		In force: 21 February 1977	193	In force: 30 April 2004
Belize ^e	X	In force: 21 January 1997	532	
Benin	X	Approved: 17 September 2004		Approved 17 September 2004
Bhutan	X	In force: 24 October 1989	371	
Bolivia ^e	X	In force: 6 February 1995	465	
Bosnia and Herzegovina ^h		In force: 28 December 1973	204	
Botswana				
Brazil ⁱ		In force: 4 March 1994	435	
Brunei Darussalam	X	In force: 4 November 1987	365	
Bulgaria		In force: 29 February 1972	178	In force: 10 October 2000
Burkina Faso	X	In force: 17 April 2003	618	In force: 17 April 2003
Burundi				
Cambodia	X	In force: 17 December 1999	586	
Cameroon	X	In force: 17 December 2004		Signed: 16 December 2004
Canada		In force: 21 February 1972	164	In force: 8 September 2000
Cape Verde				
Central African Republic				
Chad				
Chile ^j		In force: 5 April 1995	476	In force: 3 November 2003
China		In force: 18 September 1989	369*	In force: 28 March 2002
Colombia ^j		In force: 22 December 1982	306	Approved: 25 November 2004
Comoros				
Congo, Republic of the				
Costa Rica ^e	X	In force: 22 November 1979	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 3 June 2004	pending	In force: 3 June 2004
Cyprus	X	In force: 26 January 1973	189	In force: 19 February 2003
Czech Republic ^k		In force: 11 September 1997	541	In force: 1 July 2002
Democratic People's Republic of Korea		In force: 10 April 1992	403	
Democratic Republic of the Congo		In force: 9 November 1972	183	In force: 9 April 2003
Denmark ^l		In force: 21 February 1977	193	In force 30 April 2004
Djibouti				

State	SQP ^c	Status of safeguards agreement(s)	INFCIRC	Status of additional protocol
Dominica ^m	X	In force: 3 May 1996	513	
Dominican Republic ^e	X	In force: 11 October 1973	201	
Ecuador ^e	X	In force: 10 March 1975	231	In force: 24 October 2001
Egypt		In force: 30 June 1982	302	
El Salvador ^e	X	In force: 22 April 1975	232	In force: 24 May 2004
Equatorial Guinea	X	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 ⁿ		Accession: 1 October 1995	193	In force: 30 April 2004
France		In force: 12 September 1981	290*	In force: 30 April 2004
		Signed: 26 September 2000 ^o		
Gabon	X	Signed: 3 December 1979		Approved: 18 March 2003
Gambia	X	In force: 8 August 1978	277	
Georgia		In force: 3 June 2003	617	In force: 3 June 2003
Germany ^p		In force: 21 February 1977	193	In force: 30 April 2004
Ghana		In force: 17 February 1975	226	In force: 11 June 2004
Greece ^q		Accession: 17 December 1981	193	In force: 30 April 2004
Grenada ^e	X	In force: 23 July 1996	525	
Guatemala ^e	X	In force: 1 February 1982	299	Signed: 14 December 2001
Guinea				
Guinea-Bissau				
Guyana ^e	X	In force: 23 May 1997	543	
Haiti ^e	X	Signed: 6 January 1975		Signed: 10 July 2002
Holy See	X	In force: 1 August 1972	187	In force: 24 September 1998
Honduras ^e	X	In force: 18 April 1975	235	
Hungary		In force: 30 March 1972	174	In force: 4 April 2000
Iceland	X	In force: 16 October 1974	215	In force: 12 September 2003
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	Signed: 18 December 2003
Iraq		In force: 29 February 1972	172	
Ireland		In force: 21 February 1977	193	In force: 30 April 2004
Israel		In force: 4 April 1975	249/Add.1	
Italy		In force: 21 February 1977	193	In force: 30 April 2004
Jamaica ^e		In force: 6 November 1978	265	In force: 19 March 2003
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	Signed: 6 February 2004
Kenya				
Kiribati	X	In force: 19 December 1990	390	Signed: 09 November 2004
Korea, Republic of		In force: 14 November 1975	236	In force: 19 February 2004
Kuwait	X	In force: 7 March 2002	607	In force: 2 June 2003
Kyrgyzstan	X	In force: 3 February 2004		
Lao Peoples 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				

State	SQP ^c	Status of safeguards agreement(s)	INFCIRC	Status of additional protocol
Libyan Arab Jamahiriya		In force: 8 July 1980	282	Signed: 10 March 2004
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	In force: 30 April 2004
Madagascar	X	In force: 14 June 1973	200	In force: 18 September 2003
Malawi	X	In force: 3 August 1992	409	
Malaysia		In force: 29 February 1972	182	
Maldives	X	In force: 2 October 1977	253	
Mali	X	In force: 12 September 2002	615	In force: 12 September 2002
Malta	X	In force: 13 November 1990	387	Signed: 24 April 2003
<i>Marshall Islands</i>				
Mauritania	X	Signed: 2 June 2003		Signed: 2 June 2003
Mauritius	X	In force: 31 January 1973	190	Signed: 9 December 2004
Mexico ^f		In force: 14 September 1973	197	Signed: 29 March 2004
<i>Micronesia, Federated States of</i>				
Monaco	X	In force: 13 June 1996	524	In force: 30 September 1999
Mongolia	X	In force: 5 September 1972	188	In force: 12 May 2003
Morocco	X	In force: 18 February 1975	228	Signed: 22 September 2004
<i>Mozambique</i>				
Myanmar	X	In force: 20 April 1995	477	
Namibia	X	In force: 15 April 1998	551	Signed: 22 March 2000
Nauru	X	In force: 13 April 1984	317	
Nepal	X	In force: 22 June 1972	186	
Netherlands		In force: 5 June 1975	229	
		In force: 21 February 1977	193	In force: 30 April 2004
New Zealand	X	In force: 29 February 1972	185	In force: 24 September 1998
Nicaragua ^e	X	In force: 29 December 1976	246	Signed: 18 July 2002
Niger		Signed: 11 June 2002		Signed: 11 June 2004
Nigeria		In force: 29 February 1988	358	Signed: 20 September 2001
Norway		In force: 1 March 1972	177	In force: 16 May 2000
Oman	X	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	
<i>Palau, Republic of</i>				
Panama ^e	X	In force: 23 March 1984	316	In force: 11 December 2001
Papua New Guinea	X	In force: 13 October 1983	312	
Paraguay ^e	X	In force: 20 March 1979	279	In force: 17 September 2004
Peru ^e		In force: 1 August 1979	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 ^s		Accession: 1 July 1986	193	In force: 30 April 2004
<i>Qatar</i>				
Republic of Moldova	X	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
<i>Rwanda</i>				
St. Kitts and Nevis ^m	X	In force: 7 May 1996	514	
St. Lucia ^m	X	In force: 2 February 1990	379	
St. Vincent and the Grenadines ^m	X	In force: 8 January 1992	400	

State	SQP ^c	Status of safeguards agreement(s)	INFCIRC	Status of additional protocol
Samoa	X	In force: 22 January 1979	268	
San Marino	X	In force: 21 September 1998	575	
<i>São Tome and Principe</i>				
<i>Saudi Arabia</i>				
Senegal	X	In force: 14 January 1980	276	
Serbia and Montenegro [†]		In force: 28 December 1973	204	Approved: 14 September 2004
Seychelles	X	In force: 19 July 2004	635	In force: 13 October 2004
<i>Sierra Leone</i>	X	<i>Signed: 10 November 1977</i>		
Singapore	X	In force: 18 October 1977	259	
Slovakia ^u		In force: 3 March 1972	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	
<i>Somalia</i>				
South Africa		In force: 16 September 1991	394	In force: 13 September 2002
Spain		Accession: 5 April 1989	193	In force: 30 April 2004
Sri Lanka		In force: 6 August 1984	320	
Sudan	X	In force: 7 January 1977	245	
Suriname ^e	X	In force: 2 February 1979	269	
Swaziland	X	In force: 28 July 1975	227	
Sweden ^v		Accession: 1 June 1995	193	In force: 30 April 2004
Switzerland		In force: 6 September 1978	264	Signed: 16 June 2000
Syrian Arab Republic		In force: 18 May 1992	407	
Tajikistan	X	In force: 14 December 2004	Pending	In force: 14 December 2004
Thailand		In force: 16 May 1974	241	
The Former Yugoslav Rep. Of Macedonia	X	In force: 16 April 2002	610	
<i>Timor-Leste</i>				
<i>Togo</i>	X	<i>Signed: 29 November 1990</i>		<i>Signed: 26 September 2003</i>
Tonga	X	In force: 18 November 1993	426	
Trinidad and Tobago ^e	X	In force: 4 November 1992	414	
Tunisia		In force: 13 March 1990	381	
Turkey		In force: 1 September 1981	295	In force: 17 July 2001
<i>Turkmenistan</i>				
Tuvalu	X	In force: 15 March 1991	391	
<i>Uganda</i>	X	<i>Approved: 25 November 2004</i>		<i>Approved: 25 November 2004</i>
Ukraine		In force: 22 January 1998	550	Signed: 15 August 2000
United Arab Emirates	X	In force: 6 October 2003	622	
United Kingdom		In force: 14 December 1972	175 ^w	
		In force: 14 August 1978	263*	In force: 30 April 2004
		Approved: 16 September 1992 ^o		
<i>United Republic of Tanzania</i>	X	<i>Signed: 26 August 1992</i>		<i>Signed: 23 September 2004</i>
United States of America		In force: 9 December 1980	288*	Signed: 12 June 1998
		In force: 6 April 1989 ^o	366	
Uruguay ^e		In force: 17 September 1976	157	In force: 30 April 2004
Uzbekistan		In force: 8 October 1994	508	In force: 21 December 1998
<i>Vanuatu</i>				
Venezuela ^e		In force: 11 March 1982	300	
Viet Nam		In force: 23 February 1990	376	
Yemen, Republic of	X	In force: 14 August 2002	614	
Zambia	X	In force: 22 September 1994	456	
Zimbabwe	X	In force: 26 June 1995	483	

States: States not party to the NPT whose safeguards agreements are of INFCIRC/66-type.

States: Non-nuclear-weapon States which are party to the NPT but have not brought into force a safeguards agreement pursuant to Article III of that Treaty.

*: Voluntary offer safeguards agreement for NPT nuclear-weapon States.

^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 light of the application of safeguards pursuant to a comprehensive safeguards agreement (CSA). Unless otherwise indicated, the safeguards agreements referred to are CSAs concluded pursuant to the NPT.

^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 with a legal obligation to conclude a CSA, with nuclear material in quantities not exceeding the limits of paragraph 37 of INFCIRC/153 and no nuclear material in a facility, have the option to conclude a Small Quantities Protocol (SQP), thus holding in abeyance the implementation of most of the detailed provisions set out in Part II of a CSA as long as these conditions continue to apply. This column contains countries whose SQPs have been approved by the Board of Governors and for whom, as far as the Secretariat is aware, these conditions continue to apply.

^d Sui generis CSA. On 28 November 2002, upon approval by the Board of Governors, an exchange of letters entered into force confirming that the safeguards agreement satisfies the requirement of Article III of the NPT.

^e Safeguards agreement refers to both the Treaty of Tlatelolco and the NPT.

^f 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 satisfies the requirements of Article 13 of the Treaty of Tlatelolco and Article III of the NPT to conclude a safeguards agreement with the Agency.

^g 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.

^h 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.

ⁱ 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 satisfies 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 satisfies the requirements of Article III of the NPT.

^j 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; for Panama on 21 November 2003) confirming that the safeguards agreement satisfies the requirement of Article III of the NPT.

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

^l The NPT safeguards agreement with Denmark (INFCIRC/176), in force since 1 March 1972, has been replaced by the agreement of 5 April 1973 between the non-nuclear-weapon States of EURATOM, EURATOM and the Agency (INFCIRC/193). Since 1 May 1974, that agreement also 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.

^m An exchange of letters has taken place 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.

ⁿ 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.

^o The safeguards agreement referred to is pursuant to Additional Protocol I to the Treaty of Tlatelolco.

^p 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.

^q 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.

^r 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.

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

^t The NPT safeguards agreement concluded with the Socialist Federal Republic of Yugoslavia (INFCIRC/204), which entered into force on 28 December 1973, continues to be applied in Serbia and Montenegro (formerly the Federal Republic of Yugoslavia) to the extent relevant to the territory of Serbia and Montenegro.

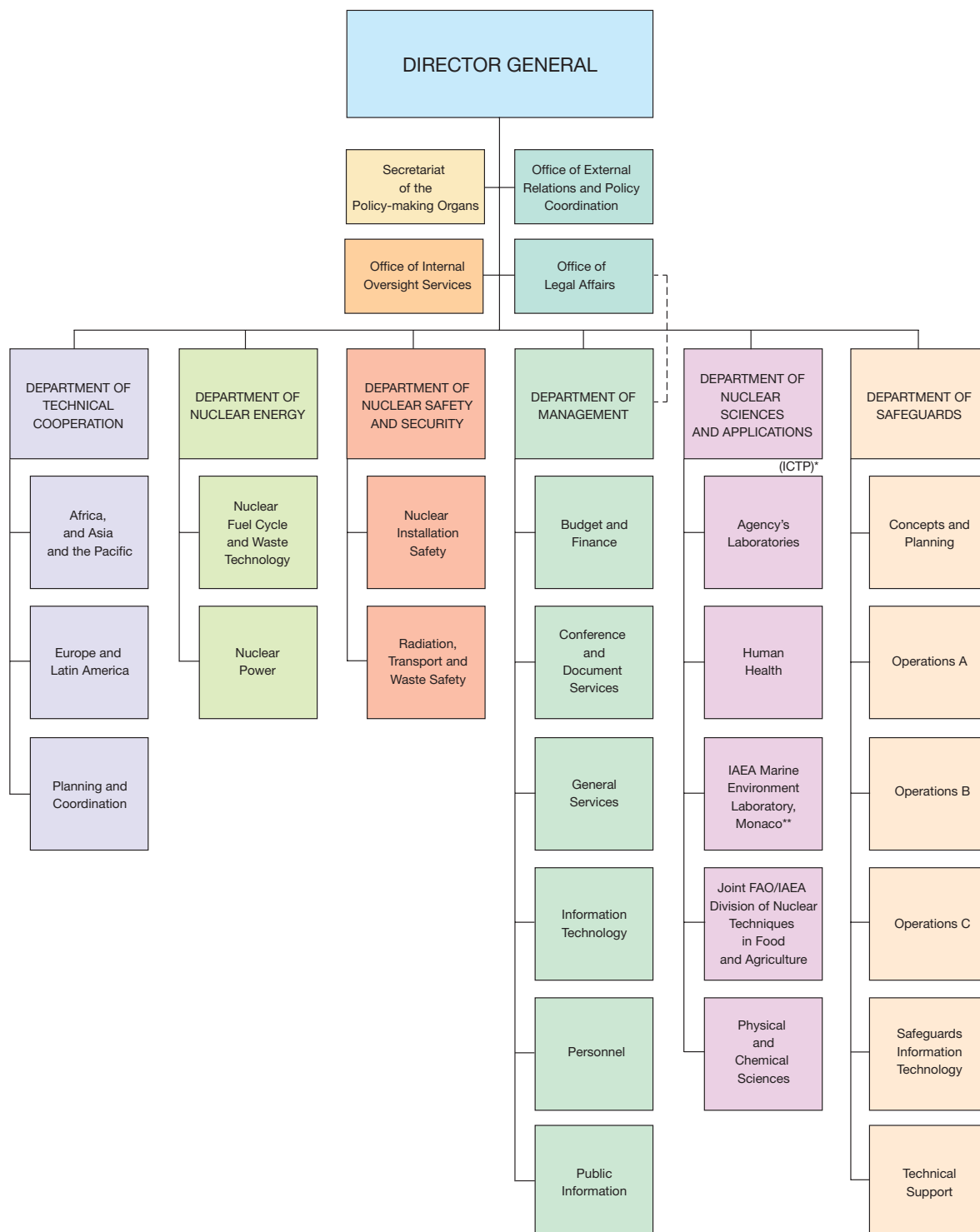
^u The NPT safeguards agreement concluded with the Czechoslovak Socialist Republic (INFCIRC/173), which entered into force on 3 March 1972, continues to be applied in Slovakia to the extent relevant to the territory of Slovakia. A new NPT safeguards agreement concluded with Slovakia and a protocol additional thereto were approved by the Board of Governors on 14 September 1998.

^v 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.

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

ORGANIZATIONAL CHART

(as of 31 December 2004)



* 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.